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Wireless World

Line Standards

IN 1956 the Postmaster General of the day asked the Television Advisory Committee amongst other things to say whether the existing 405-line standards were likely to remain adequate for all purposes for the next 25 years and if there was any reason why the United Kingdom should not adopt 625 lines for Bands IV and V if it were recommended by the C.C.I.R. as the European standard.

To the first question the Committee in its 1960 Report* has given an unequivocal no, on the grounds that a "definite" improvement in picture quality is possible with 625 lines (assuming also an equivalent increase in channel width) and that with the trend towards increasing picture size the line structure will be less visible with 625 than with 405 lines. A direct answer to the second question is avoided and the response takes the form of an inversion and a recommendation that 625 lines *should* be adopted, not only for Bands IV and V but ultimately for Bands I and III also.

Although the evidence for a case *against* 625 lines is included in the Report it is scattered and unco-ordinated, and before the growing compulsion towards a change of standard reaches the proportions of a general obsession, we think that the case for the retention of 405 lines should be made with at least equal emphasis. Briefly it is that the 405-line standard is already capable of giving better picture quality and higher definition than is at present realizable *on the viewer's screen*, and that any improvement which might be obtained from 625 is marginal and not worth the 15 years or more of disruption, the cost of duplicating services and the dual standards receivers which would be necessary to effect a change. When finally Band I and III stations were converted to 625 lines and the last 405-line-only receiver had become obsolete we should finish up with nation-wide dual standards receivers in which the 405 section would be redundant, and for our trouble we should have a slightly better picture but at least one national programme less than we could have enjoyed if we had stuck to 405 lines and 5Mc/s channel spacing.

How much better than 405 would the picture quality of 625 be *in the home on the average commercial receiver?* In our opinion, after seeing both British and Continental performance, not much. But if you do not accept our opinion read the report† of the Working Party of the Technical Sub-Committee of the T.A.C. which says (p.139) ". . . This is not very positive evidence for either the 405-line or 625-line pictures in Band V, but it indicates that the 625-line pictures are not worse than their 405-line counterparts and they are perhaps very slightly better." These tests were made with 7Mc/s channel and 5Mc/s video bandwidth. With the proposed 8Mc/s and 6.75Mc/s respectively the difference in quality would undoubtedly be more "definite," but still, we think, marginal. Such differences as exist can be easily and much more economically accommodated by intelligent camera work and minor adjustments of viewing distance.

Visibility of lines on the larger screens is undoubtedly the strongest argument so far advanced against 405 lines, but the average assessment of observers in the field tests† is Grade 3 (definitely perceptible, but not disturbing) for 405 lines as against Grade 2 (just perceptible) for 625 lines. But there are less expensive ways of overcoming "lininess" than turning the whole broadcasting system into bedlam—at the receiver, for example, by the use of an elliptical scanning spot or "spot-wobble." Some people prefer to see the lines, taking them as an indication of a "sharp" picture, and have been known to switch off spot-wobble in sets in which it is provided. It is entirely a matter of personal opinion.

That a 405-line and 5Mc/s channel standard would put us in an invidious position in our international relations and upset European plans for the general adoption of 625 lines and 8Mc/s channels is not necessarily true. It may be a necessary expedient on the Continent where national boundaries are contiguous, but on this side of the Channel we have the advantage of geographical isolation, particularly on Bands IV and V where, as the field test report confirms, propagation is more difficult and (p.15) "the limits of a Band V service area are somewhat more precisely defined than those of a Band I service." Mutual interference with other European stations is much more likely on Bands I and III. Why then should we have prematurely committed ourselves to 8Mc/s spacing on the higher frequencies, while reserving the right to transmit for an indeterminate period with 5Mc/s spacing on the lower and more easily propagating bands? It would have been much better to forgo "tidymindedness" and to take advantage of our insular position to make the best use of the available bandwidth in providing more alternative programmes, at the same time safeguarding our neighbours' interests by careful attention to aerial directivity in stations near the south and east coasts.

Summarizing the case against a change to 625 we can say that (i) the value to the viewer in terms of picture quality would be negligible; (ii) there are cheaper and easier ways of overcoming "lininess" if it is thought to be objectionable; (iii) a third programme with national coverage would no longer be possible in Band III; (iv) if Bands IV and V were eventually brought into service, more programmes could be established earlier and at less cost with 405 than with 625 lines.

* Report of the Television Advisory Committee 1960, H.M. Stationery Office. Price 1s.

† "Television Field Trials of 405-line and 625-line Systems in the U.H.F. and V.H.F. Bands 1957-1958." Published by the B.B.C. Price 20s.

Instruments, Electronics and Automation

THE I.E.A. EXHIBITION AS SEEN BY THE TECHNICAL STAFF OF *WIRELESS WORLD*

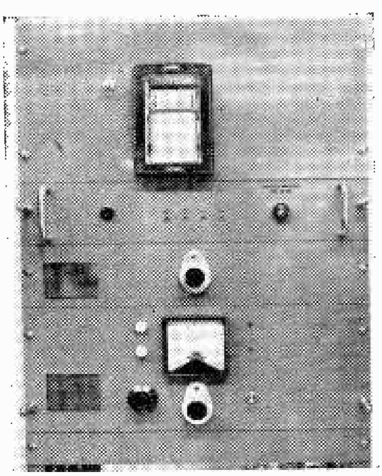
AN ELECTRONICS exhibition is probably the only place where one would find accessories so remotely connected as television aerials and hydraulic valves. On this occasion the great diversity of the show at Olympia was partly due to the inclusion of many radio and electronic component manufacturers (there being no R.E.C.M.F. exhibition this year). Such variety inevitably meant a much larger exhibition than the one held in 1958, and both the Grand and National Halls were occupied. Technical interest, too, was greater—particularly in the field of automatic control, where there were more complete systems to be seen in addition to the isolated bits of apparatus used in these systems.

INDUSTRIAL ELECTRONICS

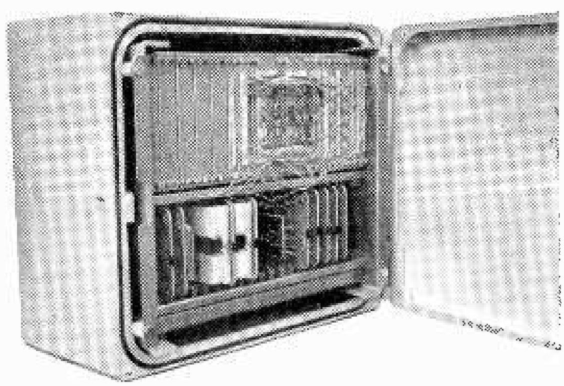
Process Control Systems.—Most of the automatic control equipments on view were intended for continuous-process operations, as, for example, the continuous adjustment of properties of liquids flowing in pipes. This type of application allows the general principle of the servomechanism to be used. A monitoring transducer measures the required property of the material concerned and the measured value is compared with the required value to produce an error signal, which is used to actuate a control device to correct any deviation. An example of this straightforward technique was a temperature controller for electric furnaces, shown, rather appropriately, by the Phœnix Telephone and Electric Works. The input signal is derived from a thermocouple and from a reference signal given by a potential divider connected across a Zener diode voltage source. The difference output from the thermocouple and reference source is amplified by magnetic amplifiers and used to control a saturable reactor which in turn controls the supply of electrical power to the furnace. The feature of this system is that it avoids the use of mechanical contacts which have to be periodically serviced.

In such systems the control signal is usually directly proportional to the amplitude of the error signal. There are certain processes, however, which require the control signal to be a more complex function of the error signal. For example, in some plants a measured deviation in the form of a sudden step might, if fed back as a correcting signal, cause "hunting" in the process control system. It might be necessary, therefore, to integrate the sudden step into the form of a slowly rising control voltage. In many of the controllers on view there were, in fact, facilities for providing these special functions—usually integration and differentiation (to give a control signal depending on the rate-of-change of the error signal). These, in addition to the normal proportional control, give what are commonly known as "three-term" controllers. As an example, Evershed demonstrated a three-term controller being used to control automatically the concentration of mixtures of liquids on the basis of conductivity measurements. The measuring transducer produces an electrical signal proportional to conductivity, and a resistance network gives the difference between this value and the desired value (set manually by a potentiometer from a voltage source). The difference signal then passes through an amplifier system in which its amplitude can be manually set and its waveform modified by adjustable integrating and differentiating circuits — to emerge as a signal which controls the rate of operation of one of the pumps contributing to the mixture of liquids.

An integrating circuit was used for giving a delay effect on the control signal in an interesting equipment shown by Haynes & Haynes on the Lancashire Dynamo stand. This was for controlling the wall thickness of plastic tube during extrusion. Variations of wall thickness are used to regulate the speed of the motor which drives the "haul off" conveyor system for the plastic tube. The measuring transducer is a capacitor with its two plates not parallel but inclined to each other so that a section of the plastic tube can pass between them. The tube wall, therefore, provides part of the capacitor's dielectric and any variations in wall thickness alter the capacitance. This transducer is connected in series with another capacitor of equal value to a 3-Mc/s oscillator, and an output signal is taken from between the two



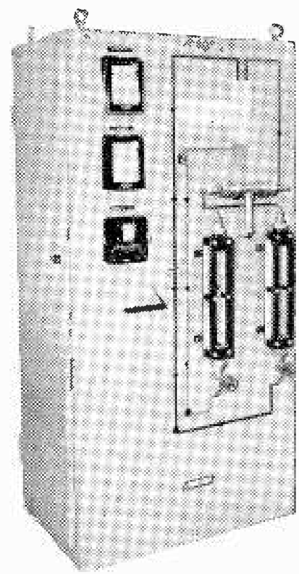
Phoenix Telephone temperature control equipment.



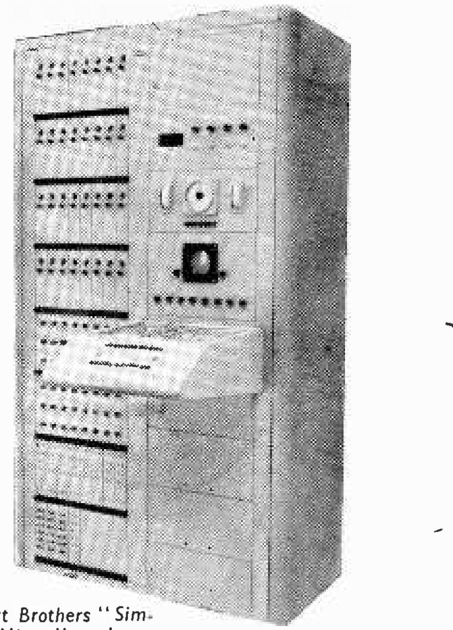
De Havilland "Anatrol" analogue computer for process control.

capacitors. The result is a bridge arrangement in which any unbalance between the two capacitors (due to wall thickness variation) is indicated by the amplitude of the output signal, while the direction of unbalance (increase or decrease of thickness) is indicated by the phase of the output signal relative to a reference signal from the oscillator. These changes are detected and passed to the integrating circuit, the output of which is used to control the variable-speed drive of the plastic tube conveyer.

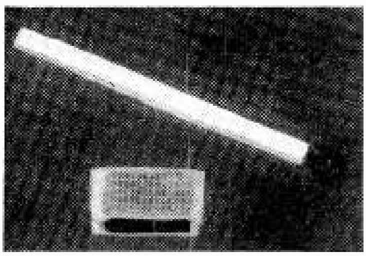
Data Processing.—One could not go very far in the exhibition without seeing some equipment or other for the transmission or conversion of information—for telemetering, communications, computation, or the "logging" of data from transducers in industrial plants. A particularly impressive example was a large equipment shown by Bristol Aircraft for converting tape recordings, obtained from the receiving end of a 24-channel time-multiplex telemetering system, into the form of data on punched cards. By this means the weeks of work normally required for analysing the telemetered information could be reduced to a single day. An electronic analogue-to-digital converter, also shown by Bristol, had the unusual feature of giving a digital output which was corrected for any non-linearity, drift or gain variations in the analogue transducer



Evershed equipment with three-term controller for controlling mixture of liquids.



Short Brothers "Simlac Minor" analogue computer.



Texas Instruments solid-circuit binary adder, compared in size with a safety match.

system providing the input. This correction is achieved by supplying to the converter, along with the analogue input, reference voltages which are a calibration of the analogue signal and are subject to the same unknown variations. The converter works on the well-established principle of comparing the analogue input with a succession of fixed voltages; when equality is reached the action stops and a binary counter registers the number of comparison steps which have been taken. In the Bristol Aircraft system these fixed voltages are provided by the reference voltages mentioned above, so that the unwanted variations in the transducer system are automatically compensated.

Another type of error correction was a feature of many of the telegraph and digital data transmission systems on view. In general, the method consists of transmitting extra digits along with the normal information. These give a special pattern to each of the characters or numbers transmitted so that any mutilations of the signal in transit can be automatically recognized at the receiving end. Great interest was attracted by a G.P.O. demonstration of this principle in which the number of errors detected and the number of characters transmitted were "clocked-up" on counters. In general such correction techniques can reduce the normal error rate of about 1 in 40,000 characters to about 1 in 10^5 characters.

Turning to the computation side of data processing, one of the most interesting exhibits relating to the design of computers was a working binary adder constructed from semiconductor solid-circuits. Demonstrated by Texas Instruments, it consisted of a group of tiny flat plates of silicon, measuring ¼in by ⅛in, each of which was an integrated circuit element formed by diffusion, etching and deposition techniques. Four types of solid circuit elements were used: (1) voltage inverters, each consisting of a transistor, a diode and resistors, (2) diode gates for AND and OR operations, (3) a bi-stable circuit, containing transistors, diodes, resistors and capacitors, for delay purposes, and (4) a diode gate to provide the correct drive for the bi-stable circuit. Interconnections were made with the aid of printed conductors and the whole adder was well spread out for display purposes. In practice, however, the individual circuit elements are packed together face to face into a tiny cube—the incredibly small size of which can be seen from the illustration on this page. The saving in volume over an equivalent adder using conventional semiconductor devices is of the order of 100:1, according to Texas.

Semiconductor circuit elements are now the standard thing for all new digital computing systems, and one particularly interesting example was a digital machine shown by Elliott-Automation, designed for incorporation in process control loops in industrial plant. The machine is called the "Optimat," because it is not a straightforward computer but a device for seeking the optimum performance point within a specified regime of operation of the plant. It does this by making trial-and-error incremental variations in the control signals to the plant until the plant conditions meet the specification (which is laid down in the programme to the machine). In this way optimum performance can be obtained even against the influence of uncontrolled parameters in the operation of the plant. The logical elements, established already under the name "Minilog," are transistor and diode circuits mounted on printed circuit cards which in turn are wired in groups on to larger boards carrying plugs for insertion into a chassis.

For simpler process control applications the analogue computer is particularly suitable, since the control and monitoring signals to and from the plant are necessarily analogue signals. An example at the exhibition was the "Anatrol" analogue computer, developed by de Havilland, which was shown as a means of solving equations necessary to keep the composition of a blended product at some specified value. As

Electromethods Series 5100 miniature chart recorder, showing 2in diameter chart.

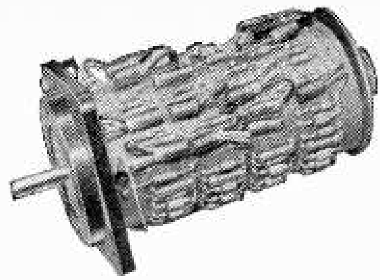
in the "Optimat," the circuitry was based on semiconductor devices.

An analogue computer with some unusual facilities was the "Simlac Minor" shown by Short Brothers & Harland. It has a push-button selection system which enables the d.c. amplifiers and passive circuit elements to be selected and connected to various measuring instruments and also allows the coefficient potentiometers to be automatically set up, by servo control, to an accuracy of 0.1%. A novel "patch-cord" system gives flexibility of interconnection between the units while using the minimum number of cords and avoiding the need for the cords to cross. The computer is actually a small general-purpose machine and uses 32 d.c. amplifiers.

Information Recovery from difficult-to-get-at places is common in these days of "sputniks"; however, many examples are far nearer at hand than an orbiting artificial satellite—the inside of a continuous paint-stoving oven, for instance, or the face of a piston in a running internal-combustion engine.

Shown on the D.S.I.R. stand was a small telemetry transmitter designed to fit inside the piston of an engine. Developed by the British Internal Combustion Engine Research Association, recourse to telemetry was made because the number of slip rings and wiping contacts required could have resulted in false signals and would have been difficult to maintain. The single-transistor transmitter operates at about 2Mc/s, feeding an aerial which projects into the crankcase. A thermistor sensing element on the face of the piston modulates directly the frequency of the transmitter. To withstand the high temperatures built up, and the oil present, the unit is encapsulated. A silicon transistor is used.

Another approach was illustrated by Electromethods, with their series 5100 recorder. This a miniature ($6\frac{1}{2} \times 4\frac{3}{4} \times 3\frac{1}{2}$in) instrument using a clockwork-driven chart of pressure sensitive paper only two inches in diameter. A self-balancing bridge system is used, balance being achieved between the input and a slide wire whose moving contact is coupled to the stylus marking the chart. Periodically the input signal is removed automatically and a second servo system re-balances the zero of the bridge.



Ericsson "Rotapulse" transducer for automatic weighing.

For applications such as monitoring the temperature throughout a stoving oven, the whole recorder, complete with its battery pack, can be put inside a vacuum flask with leads connected to an external resistance thermometer. When used for potential recording the sensitivity is such that signals of 10mV or so may be registered. For use with a resistance sensing element, accuracy figures quoted were ±2% of f.s.d. and variation of zero and sensitivity ±0.25%.

Weighing Automatically materials into bins or sacks is a typical example of how automation can reduce the physical labour of a task, and at the same time cut down clerical work with its opportunities for error. The adaptation of an ordinary weighing machine, too, brings in a common problem—the sensing of rotation without the imposition of a significant load on the apparatus. The general principle is that the rotation of the scale pointer is sensed and converted to pulses, which are counted and registered on a reversible decimal stepping display. Pre-set circuits allow the rate of delivery of the material to be reduced as the correct weight is approached and cut off when the weight is correct. A converter may be fitted, for instance, to operate a teleprinter which would record the weight.

Microcell, in their Type 171 machine, use a radially striped disc coupled to the pointer spindle and another stationary grating. Light shining through the gratings is thus modulated by the passage of the rotating grating, and picked up by photocells. To allow for other than critical damping of the weighing machine, the sense of rotation must be discovered so that the counter can be "instructed" whether to add on or take off pulses. This is done by using two photocells with 90° angular separation.

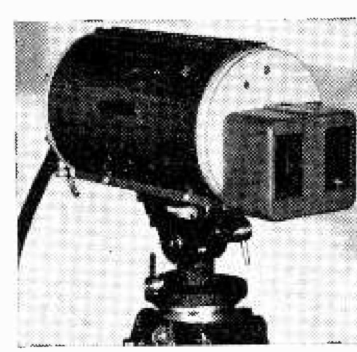
The Rotapulse transducer, shown by Ericsson, is also primarily an optical system: it is offered as an entirely separate unit with low-friction bearings (less than 0.05oz/in torque is required). Four quadrantally positioned phototransistors are used, and with the 250 and 249 segments on the gratings 1,000 pulses are given for each revolution of the spindle. The pulse-forming circuits are transistorized and are built on a flexible printed-wiring board which is wrapped round the rotating mechanism.

A selsyn transmitter is coupled to the weighing-machine pointer in the E.M.I. "Emiway" equipment. This transmits the rotary motion to the remote equipment where analogue to digital conversion is achieved by a coded disc driven by the synchronous receiver motor. The control unit provides for the checking of the machine zero, two reduced rates of feed and the starting of the print-out operation. The accuracy achieved is better than one part in 2000 in 360°, or 0.1% of f.s.d.

Industrial Television.—When direct viewing through windows or by means of large mirrors is impracticable, stereoscopic television may well provide a solution, for instance, when handling radioactive substances behind screening. To give a true solid image two pictures must be presented, one to each eye, from the positions and angles of view that would be occupied by the eyes if they were observing the scene to be transmitted.

E.M.I. were showing a stereo TV system using two small cameras with automatic adjustment of the angle subtended to the subject by the eyes, achieved by coupling to the optical focus control. Display was on two c.r.ts, the images being combined by a half-silvered mirror and the tubes were covered with orthogonally-set sheets of optical polarizing medium. The wearing of similarly polarized spectacles separated the pictures at the eyes.

Pye, however, were showing stereo TV with only one camera, amplifying chain and c.r.t. This was achieved by the use of mirrors to produce the left and right views on halves of the



Stereoscopic television camera showing optical system for producing left- and right-eye views (Pye).

sensitive area on the camera tube. The monitor thus displays side by side the two images, which are directed into the appropriate eyes by an optical system similar to that used on the camera. Of course, the solid picture produced is of only half the area of a "flat" picture, but this is of no importance for industrial purposes.

E.M.I. were demonstrating their new colour camera which uses three vidicon tubes and a novel optical system. The optical system utilizes supplementary lenses in the lens turret to give varying fields of view. Inside the camera the light is split into its red, green and blue components by mirrors and filters, and then individually focused on to the tubes by separate lenses. The smearing of moving objects so often seen with vidicon pick-up tubes has been reduced considerably by the use of new short-lag tubes.

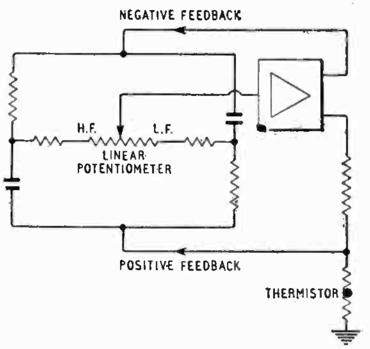
The camera is designed to operate on 625, 525 and 405 line systems. This was a general trend noted throughout the exhibition; for instance, Thorn were showing a picture monitor and waveform generator capable of being switched between these standards and Epsylon, in their range of industrial television equipment also cater for quick changing from one standard to another. The Epsylon equipment incorporates a picture monitoring circuit which adjusts automatically the potential fed to the camera tube for a 50:1 variation in light intensity.

Unit Construction seems to be the main trend in industrial control and automation equipment. The aim of this, of course, is to have available a number of standard blocks, such as amplifiers, counters, timers and power units, which can be fitted together to suit practically any requirement. This must reduce the "electronic" interest of the system, but it must be remembered that the prime requirement for industrial equipment is that it should, in the event of a fault, remain unserviceable for the minimum possible time. The best method of fulfilling this requirement is the use of standard plug-in "blocks," so that only a small number of spares need be kept. This approach was exemplified by, for instance, Mullard, with their Combi-elements and Norbits, Fox Yarborough and Lancashire Dynamo, who were also exhibiting a unit rack assembly developed for naval use. This uses a novel cooling method. Instead of the usual extractor fan and inlet filter drawing air through the actual apparatus, cooling is achieved by mounting heat-producing components on a spring-loaded metal plate. When the unit is forced fully home this plate is pressed into intimate contact with the machined walls of the closed "cell" in which the unit is held. The cell walls are of extruded light alloy, carrying internal finned ducts through which air is drawn. In this way efficient air-cooling is achieved without the fire danger caused by forced-draught cooling of racks of open equipment.

Power-supply units have become more or less standard in their design, but one novelty seen on the stand of International Electronics was a transistor-stabilized 300-V 500-mA unit. Normally transistors are not used for h.t. stabilization because of the danger of damage should the supply be short circuited. However, by designing the error-amplifier so that, in the event of a short circuit, the output transistors are switched hard on, and by including a current-limiting resistor in the unstabilized side of the supply, the dissipation in the transistors can be kept low enough to ensure safety while the output fuse blows. Naturally, the use of transistors achieves a considerable saving in weight and bulk.

MEASURING INSTRUMENTS

Sine Wave Oscillators.—In a transistorized oscillator shown by R.R.E., constant output (within ± 0.1 dB), low distortion (<0.1%) and a wide frequency range (10 to 1) are obtained by means of a basically simple circuit (see diagram) in which a single linear potentiometer controls the oscillation frequency. This potentiometer is connected between two simple CR leading and lagging phase-shift networks



Basic circuit of new R.R.E. oscillator.

so that the phase of the amplifier input can be varied. Oscillations are produced at the frequency at which the input phase is the same as the positive feedback output phase. (In the circuit diagram the "upper" resistor and capacitor should have a higher impedance than the corresponding "lower.") Three transistors are used in the amplifier circuit. If a linear potentiometer is used, the oscillation frequency varies nearly logarithmically with the spindle angle except near the beginning and end of the potentiometer element. A linear potentiometer also gives a more uniform scale graduation spacing than is usually obtained with a logarithmic potentiometer. This is because a logarithmic potentiometer normally approximates to the ideal logarithmic curve in three straight line segments, so that at the two joins of these segments a sudden change in the scale graduation spacing is produced.

An unusual method of sine wave generation is used in the Marconi TF1382 low-frequency (down to 0.0033c/s) sine, square and ramp waveform generator. The latter (ramp) waveform is that basically produced in this generator. This waveform is then shaped in a Zener diode circuit to produce sine waves with a distortion of less than 5%. Square waves are also produced from the triangular waveform *via* a bi-stable circuit.

A tone-burst generator was shown by Ferguson. When fed with a sine-wave input this produces sine waves in bursts whose individual duration and repetition rate can be varied, each burst containing an integral number of sine waves. Such a generator is useful for testing audio amplifiers, since its output provides a simple approximation to the high peak-to-mean power ratio conditions of music and speech. When an amplifier is fed with such bursts its output-stage operating point corresponds more closely with that obtained in practical use than does the operating point obtained with a high-power continuous sine-wave input. Marginal instability is also easier to detect when the high-power signal is cut off at the end of each burst. To obtain such bursts the sine-wave input is gated on and off, the gating being controlled from the sine-wave input so that only an integral number of sine waves is produced in each burst.

Oscilloscopes.—Transistorized instruments were shown by Microcell and Tektronix(L). An unusual feature of the latter instrument is that the flyback trace is suppressed by feeding a suitable signal to a separate deflection plate system in the c.r.t. so that these plates intercept the beam. Intensity modulation of the beam is also possible.

A cathode-ray tube containing a set of deflection plates forming the capacitive elements in a lumped L-C line (travelling-wave deflection) is

Agents in U.K. for foreign instruments: **(C L)**, Claude Lyons Ltd., Valley Works, Hoddesdon, Herts; **(G & G)**, Griffin & George (Sales), Ltd., Ealing Road, Alperton, Wembley, Middx.; **(L)**, Livingston Laboratories, Ltd., Retcar Street, London, N.19; **(N & T)**, Nash & Thompson Ltd., Hook Rise, Tolworth, Surbiton, Surrey; **(R H C)**, R. H. Cole (Overseas), Ltd., 2 Caxton Street, London, S.W.1.

used to obtain a response up to as high as 100Mc/s in the Tektronix(L) Type 585.

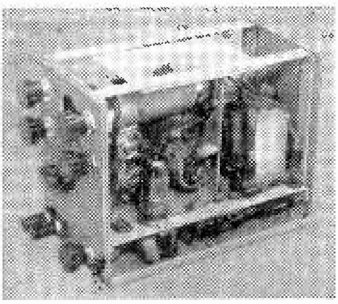
A very small ($5\text{in} \times 3\frac{3}{4}\text{in} \times 6\frac{1}{4}\text{in}$) oscilloscope was shown by Sciaky Electric Welding Machines. A single EF91 is used for the time base and a second EF91 as the d.c. Y-amplifier. The response extends to 300kc/s at a sensitivity of 700mV/cm.

An unusual feature of the oscilloscopes shown by the East-German VEB Funkwerk Kopenick(G & G) is that no internal Y-amplifiers are provided, separate units being available for this purpose.

Switching between as many as five inputs is an unusual facility possible with the Czech Krizik(N & T) K552 oscilloscope. The inputs are switched on and off in turn either by a 100kc/s multivibrator, or alternatively, for viewing high-frequency waveforms, in synchronism with the timebase.

The frequency range of an oscilloscope for recurrent waveforms can effectively be greatly extended by using very fast rise-time pulses to sample various portions of a recurrent waveform, the sampled pulses being stored and amplified in the relatively much larger time between the taking of successive samples. This method was described more fully in our review of the 1959 Physical Society Exhibition (March 1959 issue, p. 131), with reference to an oscilloscope shown by the U.K. Atomic Energy Authority. It was also used in oscilloscopes or attachments for existing oscilloscopes shown this year by Lion Electronic Developments, Hewlett-Packard(L), Tektronix(L), and Lumatron(L). Usually the high-speed sampling pulse is obtained from avalanche-operated transistors and a rise time of about 0.6mμsec is obtained. In the Lumatron(L) Model 12 oscilloscope, however, a dynode secondary-emission valve is used to provide the fast-rise time sampling pulses. The pulses from the dynode are clipped and differentiated to provide a final pulse rise time of only 0.4mμsec.

Transistor Testers.—An unusual measuring meter for such instruments—the quadrant electrometer—is used in the French A.O.I.P. Transistormeter. Input and output resistances, leakage currents and gains can be measured by this instrument. All measurements are referred to measurements of collector current changes. These are carried out by first charging both pairs of quadrants to a voltage proportional to the collector current. One pair of quadrants is then kept at this potential by a high-insulation capacitor, while the other pair is brought to a new potential proportional to the changed collector current. The electrometer deflection is then proportional to the change in collector current. One advantage of this system of measurement is that the initial conditions are stored so that any change can be accurately measured after an interval of time.



Sciaky miniature oscilloscope.

Features of the new Microcell Type 156 are the use of a wide-range (1kc/s-10Mc/s) oscillator as signal source, and a differential valve-voltmeter as indicator. This type of indicator eliminates errors due to spurious voltages developed across the resistive networks. Cut-off frequencies, amplification factors, leakage currents and turnover voltages can be measured with this instrument.

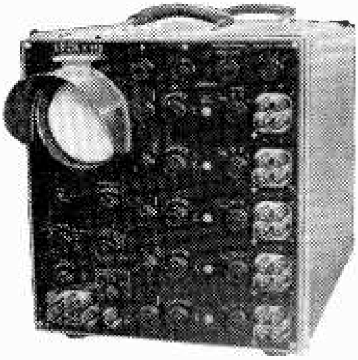
An instrument for service departments—the Type 105C—was shown by Labgear. This can measure current gains and collector leakage currents and turnover voltages.

Collector voltage/collector current characteristics at up to five different base or emitter input currents can be simultaneously presented visually on the Dobbie McInnes Transigraph TG104 oscilloscope. Current gains, output impedances and optimum operating conditions can then be readily determined.

Grid-dip Meters were shown by Grundig Instruments and the Czech firm Kovo(N & T) (Tesla BM342). These consist simply of a calibrated oscillator whose grid current can be measured. They can then be used as an absorbtion resonance-frequency indicator (minimum grid current) or as a signal source. Alternatively, the oscillator valve can be connected as a diode and the instrument used as an absorption wavemeter (maximum current).

Frequency Response curve tracers usually display simply the output variation so that inaccuracies and complications are produced if the input source varies. However, in the Siemens(RHC) ratio tracing receiver Type Rel 3K217c the input is used to alter the gain of the output amplifier so that input variations of up to 10dB are compensated for to within 0.3dB. The amplified output traced on the c.r.t. screen is then proportional (within 0.3dB) to the response.

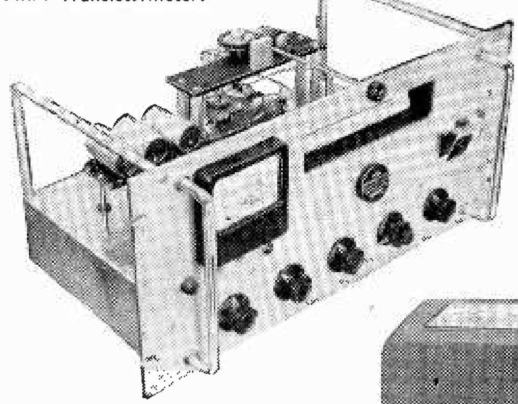
Voltage Measurement.—A precision (0.05% accuracy) r.m.s. decade voltmeter—the D-930-A—was shown by Muirhead. In this instrument the unknown voltage is fed via the range switch to an a.c. amplifier followed by a decade attenuator and second a.c. amplifier. The output of this second a.c. amplifier is fed to a Wheatstone resistor bridge in which a lamp forms one arm. Since the resistance of this lamp depends on the electrical heating power developed in it, the bridge balance is determined by the r.m.s. value of the input. The point at which the bridge balances is first standardized against the direct voltage from three Weston reference cells. This voltage is then reduced by about 80%, and the bridge rebalanced by adding an internally supplied a.c. voltage. This standardizes the a.c. voltage. This voltage is then attenuated and fed to the input of the voltmeter to standardize the a.c. amplifier gains. In the Marconi TF1377 suppressed-zero voltmeter potentials are measured by balancing them off against the output of a potentiometer fed from a standard voltage—the potentiometer setting being shown on a three-digit indicator. Residual unbalance voltages and thus voltage changes can be measured by means of a differential valve voltmeter.



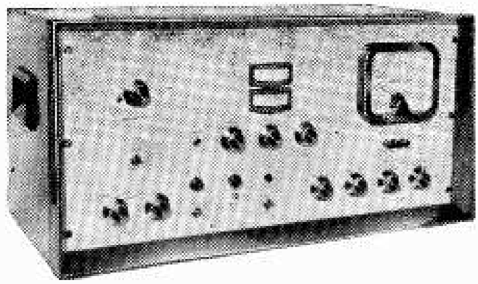
Kovo Krizik (N & T) five-channel oscilloscope.

Both the amplitude and phase of a voltage can be measured by a simple device shown by F. C. Robinson and Partners. In this instrument current is fed from the mains, or from any 15W, 15-Ω output impedance amplifier, through a standard potentiometer P_1 in series with the primary of a mutual inductance. Across the secondary of this inductance is connected a second potentiometer P_2. The voltages developed across the two potentiometers P_1 and P_2 are then 90 degrees out of phase. The phase and amplitude of an unknown voltage can then be measured by balancing this voltage off against the outputs of the potentiometers P_1 and P_2.

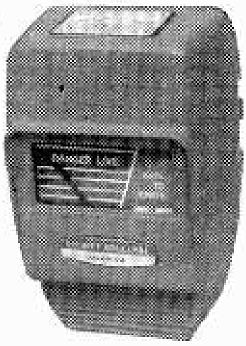
Wires carrying alternating current can be detected without having to make any contact with them by picking up the electrostatic field produced by the current in the Everett Edgcumbe "Metrac" live



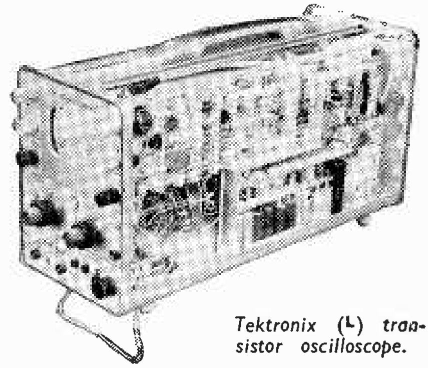
A.O.I.P. Transistormeter.



Microcell transistor test set.



Everett Edgcumbe "Metrac" live line indicator.



Tektronix (L) transistor oscilloscope.

line indicators. These instruments have been developed for use with high-voltage cables and are amply sensitive enough to detect live wires at the standard safe working distance which, for example, is 8½ft for 11kV.

An interesting circuit is used in the Southern Instruments E.R.I.C. Universal Electronic Multimeter which can measure both direct voltages and currents. This circuit is direct-coupled throughput and consists of three cascaded pairs of balanced cathode-coupled amplifiers (the first pair using electrometer valves) followed by a pair of cathode-follower outputs. In use, one of the two inputs is cross-connected to one of the outputs, a different input being connected according to whether voltage or current is being measured. If, in addition, a standard resistor is connected between the other input and output, the impedance between the two inputs is then very low (voltage drop <5mV) so that direct currents are conveniently measured between the two inputs. On the other hand, with the standard resistor disconnected, the impedance between the unconnected input and output is extremely high so that direct voltages are conveniently measured between this input and output. Input voltages can also be stored on a 0.15μF polystyrene capacitor (producing an input impedance of $10^{14}\Omega$) so that a reading can be taken after the probe has been removed from the test point. Resistances can also be measured with this instrument.

Current Measurement.—An unusual photo-electronic chopper technique is used in the prototype Nanoammeter shown by the French firm A.O.I.P. Here the unknown d.c. input is passed through a photoresistor, on which a light is shone. This light is periodically interrupted by a mechanical movement so that the photo-resistance is periodically altered. The d.c. input is thus partially converted into a.c. which is then amplified and measured.

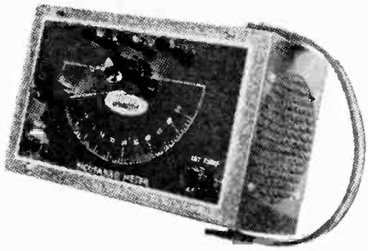
Direct currents can be measured down to 3mA full scale without interrupting the circuit under test in the Hewlett-Packard Model 428A clip-on d.c. milliammeter. In this instrument the magnetic field produced by the current in a probe of magnetic material which is clipped round the current-carrying conductor is measured by a fluxgate technique. In this technique an a.c. signal passed through a coil wound on the probe drives this probe into magnetic saturation on alternate half cycles. The additional field due to the current makes the magnetization curve of the probe slightly asymmetrical with respect to zero field and induction. This results in a second harmonic output being produced in a second coil wound on the probe. This second harmonic output is detected and measured. Interfering effects produced by uniform direct fields (such as the earth's field) can be arranged to cancel out by using the fact that the fields on opposite sides of a current-carrying conductor are in opposite directions. The probe is also magnetically shielded against external a.c. or d.c. fields. An advantage of this method of measuring current is that no resistance and very little inductance (<0.5μH) are introduced into the circuit being measured.

Power Measurement.—In the Burndept BE281 powers can be measured at frequencies up to 1,000Mc/s by feeding them to a 50-Ω coaxial resistor (made up of a carbon film on a cylindrical ceramic core) which is mounted along the axis of exponential cavity to provide broad-band matching. The r.f. voltage developed across a portion of the resistor is rectified and measured. This purely electrical method of measurement gives a much faster response than is obtained when r.f. is measured by using it to produce a heating effect (as in a bolometer).

L, C, R Measurement.—When high-loss reactive components are measured using bridges, the measurements of the reactive and resistive parts of the component usually influence each other so much that many adjustments are needed to obtain a balance point. Two general methods of considerably reducing the number of such adjustments required were seen. In capacitor bridges shown by Rank Cintel and Winston Electronics phase-sensitive detectors are employed so that the resistive and relative out-of-balance voltages (which differ in phase by 90°) can be separately detected and zeroed. In the General Radio(C L) Type 1650-A L, C, R bridge, the resistive and reactive adjustments are mechanically connected by friction clutches such that, when the resistive adjustment is altered, the reactive adjustment is also altered so as to keep the ratio of the resistive and reactive parts constant; but, when the reactive adjustment is altered, the resistive adjustment is not affected.

In capacitance meters shown by E. C. Robinson & Partners and the Czech firm kovo(N & T) (Tesla Model BM271) measurements are made by placing the unknown capacity in a resonant circuit which also contains a calibrated variable capacity. By keeping the resonant frequency fixed by adjusting the calibrated variable capacity, the effect of the unknown capacity can be measured. In the Tesla BM271 the resonant circuit is placed across the output of a fixed-frequency oscillator and adjusted to resonate at the oscillator frequency by maximizing the voltage developed across the circuit. By also adjusting this voltage to a fixed value by means of a variable resistor placed across the unknown capacitor, the loss of the capacitor can be similarly measured. This variable resistor consists of a thermionic diode with a by-passed variable resistor in series with it; this arrangement providing a resistance which is sufficiently non-inductive for use up to 30Mc/s. In the F. C. Robinson and Partners Picofarad Meter the resonant circuit forms part of an oscillator and the resonance is adjusted to a fixed frequency by listening to the audio beats produced with another fixed-frequency oscillator in a loudspeaker. Since the oscillator frequencies are at 1.5Mc/s, such beats produce a very exact indication of correct frequency adjustment.

A very simple method of measuring inductors and capacitors used in radio or television receivers is used in the East-German V.E.B. Werk für Fernmeldewesen(G & G) LCM1. An oscillator with a cathode-follower output stage provides an alternating current which is passed through the component. The voltage developed across the component is then a sufficiently accurate indication of the component reactance, since the resistive loss in components used in radio or television receivers is generally small.



Robinson & Partners Picofarad Meter.

PARTS AND MATERIALS

Strip Wiring is formed from flat copper strips a few thousandths of an inch thick, supported and insulated from each other and external contact by plastics films.

Technograph have been making flexible "printed" wiring for several years, including, for instance, resistive elements on a rubber compound (for the de-icing of aircraft control surfaces), and strain gauges on various films such as Terylene. Their latest strip-wiring cable consists of copper conductors sandwiched between two layers of 0.001-in Melinex film. The Melinex softens sufficiently to be stripped from the copper at about 160°C, so leaving free the ends of the conductors, for connection. T.C.C. introduced a flat-strip cable, called Flexistrip, at the exhibition: in their cable the copper strips are moulded into polythene, and an overall jacket of Melinex is then applied. Possibly the most startling thing about strip cables is their flexibility—Flexistrip, for instance, passes the DEF5000 test, which involves no fewer than 20,000 flexings, and is normally applied to tinsel-braid cables.

Connectors for strip wiring could take practically any form; for instance, it could be soldered directly to a printed-wiring board, or be fitted with eyelets. However, any method requiring individual handling of each wire to achieve a disconnection is not likely to be acceptable where many connections are required. Thus several connectors have made their appearance, each quite different in principle.

Belling and Lee were showing an experimental moulded housing to fit on to either circuit-board connectors or a small piece of board, so forming a socket and plug which can be attached to the cable. The housing itself has three slots through which the cable is passed, to form a cable grip. The ends of the strip are pierced and soldered onto lugs projecting from the socket or plug board and the housing, which has a snap-on cover, can incorporate a finger-release locking clip.

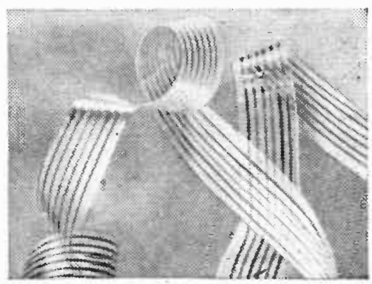
N.S.F. have a modified form of their Varicon interconnection tags, which, when mounted on a printed-wiring board, form both "plug" and "socket" contacts. The modified tag carries on its rear a toothed portion under which the end of the unstripped cable is trapped. On mounting the tags, the teeth cut through the insulation and enter the conductor, so making contact. Slots punched in the board could provide a cable grip. For quick assembly Varicon can be supplied in strips of thermoplastic material, which, after fixing the tags to the board, is warmed and removed.

Continental Connectors, a division of Ultra, were showing a fitting like an ordinary circuit-board socket. However, it accepts only a very thin section—the end of a flexible strip cable, in fact, with the conductors cleaned of insulation and folded back over the cable. For very flexible cables which would not be rigid enough for direct plugging in, a thin piece of board could be used as a supporting member, with the stripped strip conductors folded over the edge of the board. Again, slots in the board could provide for a cable grip and retaining mechanism.

Connection to Printed-wiring boards is made without the use of solder by a new technique shown by Belling and Lee. Known as Prestincert, it depends upon the discovery that a disc or peg can, with the aid of a die and press, be punched into sheets of insulating material or metal without first making a hole for it. Knurling the edges of the insert prevents rotation, and the die can peen over the penetrating end, so forming a strong fixing. For component connection the peg is formed into a lug with a soldering terminal at the top and an oversize collar that seats firmly on the board. A slot, cut diagonally into the peg across a diameter, takes the component lead: on punching, the lead is squeezed into intimate contact with the board and the insert, the excess wire being sheared off. Also insulation on the wire is stripped automatically.

Printed Power resistors, shown by Technograph, consist of a meandered resistive track on an insulating coating on a metal panel. This may then be fixed to another metal plate, possibly the chassis of a piece of apparatus, for dissipation of heat at ratings up to 10W/in². The resistance values and ratings on one of the panels displayed suggested that it was intended for use as the mains-dropping resistors in a television receiver, so we arrive at the paradox of having to put back the chassis to act as a cooling fin for the contact-cooled h.t. rectifier and mains dropper, after eliminating it by the use of printed-wiring panels!

Capacitor Construction has for several years remained largely unchanged, except for the entry to the field of plastics-film dielectrics. However, a development shown by Dubilier may well challenge the ubiquitous wax and paper capacitors. The Dubilier "Blue-cap" employs a paper dielectric, but instead of wax, a synthetic-resin impregnant is used. The absence of wax or oil in the manufacturing process makes possible hermetic sealing in a plastics sleeve without danger of moisture penetration at the lead-in wires. The sleeve material has a high melting point and is designed to withstand any normal soldering operations.



Flat-strip cable, by Technograph.

Another novel construction was shown by Hunts, in their WF49 "Duolectric" capacitors. These are housed in aluminium cans and occupy roughly a third of the volume of the equivalent rating of waxed-paper types. To achieve this reduction polyester film has been used as the dielectric; but to avoid the relatively high cost of metallized film a sandwich construction of plain film with metallized paper electrodes has been employed. The largest Duolectric capacitor ($2\mu F$, 1kV) is only $3\times1\frac{1}{4}$in.

Work on tantalum electrolytic capacitors has resulted in the elimination of liquid sulphuric acid as the electrolyte: the effects of a burst or leaking capacitor containing this can only too easily be imagined. Hunts have developed a chemically inert electrolyte for use in slug-type capacitors, which are, for extra safety, contained in two cans, one inside the other. Dubilier have a range using a solid layer of semiconductor material as the "electrolyte" and a sprayed-zinc coating is used for the second electrode. Other types (Dubilier and Hunts) utilize a construction similar to that of the common "dry" aluminium electrolytic capacitor.

Push-button TV Tuners have many advantages in simplicity of operation; for instance, it is not necessary, as it is with some rotary types, to clank through several unused channels, possibly moving inadvertently the fine tuner as well. A.B. Metal Products had on show a new four-channel push-button unit using a frame-grid cascode triode and triode pentode in the common circuit arrangement. In place of the rotary turret, however, was a push-button mechanism for selecting two Band-I and two Band-III channels. When a button is depressed it allows the appropriate coil strip to rise under spring pressure and engage with several double-leaf contacts projecting from "busbars" joined to the rest of the circuit. A feature of the new tuner is that separate preset fine-tuning controls for each channel are put into circuit by an extra contact on the coil strip.

Wire-less Transformers or, more correctly, piezoelectric transformers, were shown by Brush. These depend for their operation on the mechanical excitation of ceramics such as lead titanate zirconate either by another section of the same ceramic or by the magneto-strictive effect in a ferrite carrying a winding. Demonstrated was one of bar form, used to light a small neon sign needing about 1mA at 2kV. The low-potential part of the bar was excited by 10V applied from an oscillator connected across its "thickness." Here the impedance is relatively low, but by polarizing the other half of the $\lambda/2$-long bar along its length it can be made to oscillate in the lengthways mode, which corresponds to a high impedance between the ends of the $\lambda/4$ section. Thus, by attaching wires to the ends of this bar a high potential at low current may be extracted.

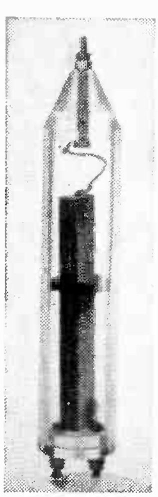
The efficiency of the ceramic-to-ceramic transformer shown was of the order of 50%; but, by driving the lengthways-mode "crystal" from a magneto-strictive transducer cemented to it, greater power can be fed in to the bar, with a consequent increase in both efficiency and output, which may be made as high as 40kV.

Semiconductor Devices.—High-frequency transistors at economical prices is the aim of the alloy diffusion method of manufacture developed by Mullard, and a whole range of new p-n-p types based on this principle was on view. Briefly, the technique uses a wafer of p-type germanium to form the collector, and on one face of this two metal pellets are placed side by side to form the emitter and base. During heat treatment n-type impurities diffuse into the germanium wafer from both pellets to produce an extremely thin base layer between the emitter and base electrodes. At the same time, p-type impurities diffuse relatively slowly out of the emitter pellet only and produce a small p-type layer around this pellet, confined within the n-type base layer. The high-frequency properties are obtained mainly as a result of the extremely thin base layer (about 5 microns) and partly because the graded distribution of impurities gives an accelerating field which reduces the transit time of the current carriers through the base even further.

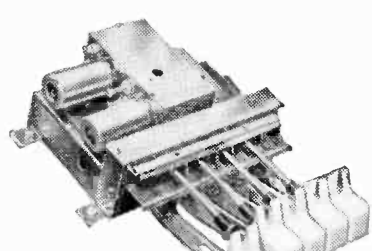
In addition to the established OC170 and OC171 made by this technique, Mullard showed two low-noise transistors for v.h.f. communications which give power gains of 10dB at frequencies of 100Mc/s and 200Mc/s respectively. There was also a switching transistor for use in computers operating with p.r.fs up to 10Mc/s, and a type for driving ferrite core stores which was capable of producing 0.5A output pulses with rise times of less than 40 nanoseconds. A p-n-p-n four-layer switching device made by the same technique had an impedance ratio for its "on" and "off" states of higher than 3 million to one, while an avalanche switching transistor was capable of producing 50mA pulses with a rise time of 1 nanosecond (10^{-9}).

Other manufacturers are using the "mesa" construction and the drift-field technique for their high-frequency transistors. A.E.I., for example, had two new mesa transistors, XA161 and XA162, with minimum cut-off frequencies of 25Mc/s and 35Mc/s respectively, and three drift types, XA141, XA142 and XA143, with minimum cut-off frequencies of 20Mc/s, 40Mc/s and 60Mc/s respectively. This firm has also introduced four power transistors for industrial applications. Two of them, XC155 and XC156, have peak current ratings of 10A and collector-base voltage ratings of 80 and 100 volts respectively. The other two, XC141 and XC142, have peak current ratings of 3A and collector-base voltage ratings of 40V and 60V.

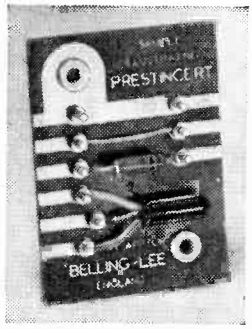
In the field of power control, as distinct from power amplification, the silicon-controlled rectifier is rapidly invading the domain of the industrial thyratron and other large devices. It enables several kilowatts of power to be controlled by a few milliwatts. Examples were shown by Westinghouse and International Rectifier. On the Westinghouse stand an impressive demonstration was given of a 10kW tungsten-lamp sign being turned on and off by two silicon controlled rectifiers connected, in inverse parallel, between the a.c. supply and the load. The r.m.s. output voltage was varied by controlling the proportion of each half cycle for which the rectifiers were conducting.



Left: Brush 2-kV piezoelectric transformer.



Above: Four-channel push-button TV tuner (A.B. Metal Products). Fifth button actuates on/off switch and six-button version can switch in separate f.m. tuner.



Left: Demonstration circuit board with components connected by the Belling-Lee "Prestincert" principle.

T.A.C. REPORT

TECHNICAL FEASIBILITY OF ALTERNATIVE PLANS FOR TV DEVELOPMENT

SINCE the Television Advisory Committee was reconstructed in 1952, under the chairmanship of Admiral Sir Charles Daniel,* it has issued several reports but the most eagerly awaited was that published on June 1st.† Although the broad terms of reference of the committee are "To advise the Postmaster General on the development of television and sound broadcasting at frequencies above 30 megacycles per second and related matters, including competitive television services and television for public showing in cinemas and elsewhere," the committee was asked in March 1956 specifically "for advice on fundamental technical problems of television development." In particular the members were asked whether they would

(a) recommend whether the existing 405-line standards were likely to remain adequate for all purposes for the next 25 years;

(b) say whether there was any reason why the United Kingdom should not adopt 625 lines for Bands IV and V in this country, if it were recommended by the International Radio Consultative Committee (C.C.I.R.) as the European standard;

(c) make recommendations regarding the general principles of a compatible colour system for operation, initially at least only in Bands IV and V;

(d) recommend the best technical means of transmitting the colour signals associated with (c) above, bearing in mind that these need not necessarily be in the same frequency band as the monochrome signals;

(e) take note of, and report on, any proposals by the B.B.C. or I.T.A. for adding colour to transmissions within Bands I and III; and

(f) give their views as to the technical advantages to be gained from the use of higher standards in Bands I and III, if the possibility of extension of television into Bands IV and V were to be disregarded, and taking into account the improvement in receiver and other apparatus that may be expected in the next 25 years.

It is in answer to these specific questions that the present report was presented to the P.M.G.

Because of the widespread interest in the report Mr. Bevins promised Members of Parliament that it would be published. It is, however, stated in the foreword, and the P.M.G. has personally stressed the fact, that the Government has reached no decision as to which of the possible alternatives should be adopted. Furthermore, if any changes in line standards were to be decided upon, they would require to be made in accordance with a long-term phased programme which should take account of the interests of the viewers, the broadcasting organizations, and the radio industry. The committee has emphasized that 405-line services would need to be continued for many years so that there would be no question of 405-line receivers becoming prematurely obsolescent.

It will be appreciated that although the questions posed are technical, there are political and economic factors which enter very largely into the picture. For example:

(a) the number, nature and coverage of the television programmes to be provided;

(b) the method and time-table by which the new standards should be introduced;

(c) the costs of introducing the new standards and the way in which they could be met.

These are, however, mostly outside the committee's terms of reference and the purpose of the report is solely to give the Government the technical information it needs to formulate policy.

Over the past two or three years various technical studies, including propagation tests in Bands IV and V, 625-line test transmissions from a Band V transmitter at Crystal Palace and colour transmissions on 405 lines, have been undertaken by the T.A.C.'s Technical Sub-Committee‡ in collaboration with the D.S.I.R., the radio industry, Post Office and broadcasting organizations.

How Many Programmes?

As is shown in Table I, Bands I and III, if fully exploited on the present 405-line standard, could provide three programmes—two with at least 98% coverage and one with a coverage of over 95%.

Tests have shown that an acceptable television service could be provided in Bands IV and V. Nevertheless, the service area of a transmitter operating in these bands would be more restricted than for the lower bands and more irregular, particularly in mountainous or hilly terrain, and to give a nation-wide service a greater number of transmitters would therefore be needed. The report states that whereas some 20 stations are required in each of the lower bands to provide upwards of

* See Appendix I for list of present members.

† Report of the Television Advisory Committee, 1960, *Stationery Office.* 1s.

‡ See Appendix II for list of present members.

TABLE I

Band	Range (Mc/s)	No. of channels for operation on: 405 lines 5 Mc/s channels	625 lines 8 Mc/s channels	No. of channels per national programme: No.	for estimated population coverage	No. of programmes which could be provided using: 405 lines and 5 Mc/s channels	625 lines and 8 Mc/s channels
I	41—68	5	3	5 (Bands I and III)	98%	2 (98%) & 1(95—98%)	2(95—98%)
III	174—216	8	5				
IV	470—582*	22	14	12/13	95%	3(98%) or 4(95%) & 1(70%)	2(98%) or 2(95%) & 1(90%)
V	606—800*	38	24	17/18	98%		

*As amended at the Geneva Conference, 1959.

98% population coverage, possibly four or five times as many stations would be needed in Bands IV and V to give 95% coverage.

Because of the undoubted advantages of the v.h.f. bands over the u.h.f. bands for television, the Committee sought advice whether any broadening of Band III was practicable within the foreseeable future. The Radio Industry Council, too, feel strongly that any extension of television up to four national or near-national programmes should, if at all possible, be accommodated within Band I and an extended Band III. Both the Committee and the R.I.C. were, however, informed "that the pressure in the v.h.f. portion of the spectrum is immense, and that the Government must hold a balance between desirable broadcasting development and the requirements on these frequencies for other services." That being so, at this stage no hope can be held out that additional frequencies could be made available in the v.h.f. bands for television purposes. Any extension of television must, therefore, be made in the u.h.f. bands.

It is stated in the report, although this may not have been previously generally known, that the T.A.C. advised the P.M.G. early last year that the U.K. delegation attending the C.C.I.R. meeting at Los Angeles (April, 1959) should be empowered to say that "in the interests of frequency planning the United Kingdom would adopt an 8Mc/s channel in Bands IV and V, if Europe generally adopts this, and further that if the United Kingdom should decide to adopt 625-line standards in those Bands a 6Mc/s video bandwidth would be used."

405-line Standard Inadequate

The Committee states that good as the 405-line picture may be for the size of screens now in general use they do not think the 405-line system will be adequate for the next 25 years.

As will be seen from Table II the majority of European countries as well as some in the western hemisphere and Australasia have adopted 625 lines. In field trials in Band V a comparison was made of 405-line and 625-line pictures. The results showed that the overall assessment of the 625-line pictures was not significantly different from that of 405-line although in areas of comparatively high field strength the 625-line pictures generally received a slightly higher assessment. The Technical Sub-Committee felt that the fact that there was not a significant difference in the overall assessment of picture quality was due partly to the nature of the trials and partly to the restriction of the video bandwidth of the 625-line system to 5Mc/s. They considered, however, with one dissentient, that with further development of this system using a 6Mc/s video bandwidth and receivers with improved noise factors 625-line pictures, particularly on larger screens, would show a definite superiority. Following further international discussion the Sub-Committee considered that there would be technical advantages and no loss in picture quality in restricting the video bandwidth to 5.5Mc/s and increasing the width of the vestigial side-band from 0.75Mc/s to 1.25Mc/s.

Assuming it to be the Government's policy to develop television beyond the capacity of the present two bands, the committee points out that the introduction of Bands IV and V will provide the last opportunity of improving the standards of definition. They recommend the use of 625-line with an

TABLE II

	Adopted in		Channel width
405-line	United Kingdom Ireland		5 Mc/s
525-line	Bermuda Brazil Canada Colombia Cuba Dominican Rep. El Salvador Guatemala Iran Korea	Japan Mexico Nicaragua Panama Peru Philippines Puerto Rico Saudi Arabia Thailand Uruguay U.S.A.	– 6 Mc/s
625-line	Argentine† Australia Austria Belgium Bulgaria* Cyprus Czechoslovakia* Denmark Egypt Finland E. Germany W. Germany Hungary* Iraq Italy	Lebanon Netherlands New Zealand Nigeria Norway Poland* Portugal Rumania* Spain Sweden Switzerland Turkey U.S.S.R.* Venezuela† Yugoslavia	7 Mc/s (*8-Mc/s; † 6-Mc/s channel)
819-line	Algeria France Belgium	Monaco Morocco Luxembourg	13 Mc/s 7 Mc/s

8Mc/s channel in these bands and ultimately in Bands I and III. It is pointed out that the maintenance of 405-line operation here would show the United Kingdom to a disadvantage in Eurovision as standard convertors degrade picture quality, particularly for conversion to a higher standard, and this would have its effect in selling United Kingdom programme material to the rest of Europe.

On the question of colour the members of the committee state "we are of the opinion that present technical and economic limitations make it undesirable to introduce a colour television system in the near future. We will report further on the technical details of colour television standards as soon as we are in a position to do so."

APPENDIX I

Present members of T.A.C.

Admiral Sir Charles Daniel, chairman.
B. St. J. Trend (Treasury).
D. W. G. L. Haviland (Ministry of Aviation).
W. A. Wolverson (Post Office).
H. Carleton Greene (B.B.C.).
Sir Robert Fraser (I.T.A.).
G. Darnley Smith } (Radio Industry).
C. O. Stanley
Sir Edward Herbert.
Lord Aberconway.
Sir Walter Puckey.
J. L. Judd (Post Office), secretary.

APPENDIX II

Present members of Technical Sub-Committee

A. H. Mumford (Post Office), chairman.
Sir Harold Bishop (B.B.C.), deputy chairman.
Capt. C. F. Booth (Post Office).
A B. Howe (B.B.C.).
P. A. T. Bevan (I.T.A.).
T. C. Macnamara (Associated Television).
Dr. L. F. Broadway (E.M.I.).
K. I. Jones (Ferguson).
E. P. Wethey (K.B.).
V. J. Cooper (Marconi's).
Dr. R. L. Smith-Rose (D.S.I.R.).
T. M. C. Lance (Rank-Cintel).
C. W. Sowton (Post Office), secretary.

WORLD OF WIRELESS

I.T.A. Plans

FUTURE plans for the extension of the coverage provided by the I.T.A. stations include five new transmitters to be opened next year and further stations the following year. As has already been announced, the Authority is also increasing the height of the masts at Croydon (which with its new aerial will then have an e.r.p. of 200kW) and at Black Hill and Lichfield.

The first three stations, to be brought into service next spring, are the dual transmitters in the south-west—Stockland Hill, Devon (channel 9) and Caradon Hill, Cornwall (12)—and Caldbeck, near Carlisle (11). Towards the end of 1961 a high-powered transmitter will be opened in Kincardineshire, Scotland, on channel 9 and a low-power transmitter at Selkirk, the channel for which has not yet been announced.

Stations planned for 1962 are for Inverness-shire, West Wales, Londonderry and the Channel Islands if the provisions of the Television Act are extended to cover the Islands.

Receiver Production

THE sale of 17-inch television receivers continues to dominate the home market and in 1959 represented 91% of the 2.75M receivers sold. The previous year's figure was 83% of the 2M sets sold. The sale of 21-inch sets rose from about 100,000 in 1958 to 165,000 last year—the percentage of the total sales being 5 and 6 respectively. The demand for 14-inch sets continues to decline.

Receiver exports for 1959, valued at £3,247,000, declined by 8% compared with the previous year. Sweden, for the second successive year, heads the list of receiver importers with a total of £298,796 of which all but £5,000 was for television receivers. Nigeria is second in the list with a value of £248,531, but little of this was for television—the country's first TV stations opened last October. The second highest importer of television receivers was Eire with £101,934 worth.

These figures are given in the annual report of the British Radio Equipment Manufacturers' Association.

Inst.P. and Phys. Soc. Amalgamate

PROPOSALS for the amalgamation of the Institute of Physics and the Physical Society have been a frequent topic of discussion and now a new body under the name "The Institute of Physics and The Physical Society" has been incorporated.

The Physical Society was founded in 1874 and on the initiative of that Society the Institute of Physics was founded 45 years later. The original scheme for the Institute envisaged a kind of federation of societies interested in physics.

Broadly speaking, the scientific meetings and publications of the Institute were confined to applied physics, while those of the Society were concerned more with pure physics. As, however, over the past 20 years or so, the boundary between these two aspects became less defined, there has been increasing overlap in the activities of the two bodies and in their membership.

The three Institute of Physics grades of membership—fellow, associate and graduate—will continue under the new organization but there will also be fellows of the Physical Society.

The first president of the amalgamated body is Sir John Cockcroft.

Birthday Honours

AMONG the recipients of awards in the Queen's Birthday Honours list are the following:—

Knighthood

Dr. Gordon B. B. M. Sutherland, F.R.S., Director, National Physical Laboratory.

Dr. Basil F. J. Schonland, C.B.E., F.R.S., Director, Research Group, U.K. Atomic Energy Authority.

K.B.E.

Dr. Robert Cockburn, C.B., O.B.E., Chief Scientist, Ministry of Aviation.

C.B.

Major-General E. S. Cole, C.B.E., Director of Telecommunications, War Office.

Dr. J. S. McPetrie, Director-General of Electronics Research and Development, Ministry of Aviation.

C.B.E.

Dr. T. E. Allibone, F.R.S., Director, A.E.I. Research Laboratory, Aldermaston.

Dr. R. A. Smith, Chief Scientific Officer, Royal Radar Establishment.

O.B.E.

F. W. Bates, Works Director, Kelvin and Hughes.

Dr. L. F. Broadway, Head of E.M.I. Research Laboratories.

R. J. Clayton, Manager, G.E.C. Applied Electronics Laboratories.

Dr. A. L. Cullen, Professor of Electrical Engineering, University of Sheffield.

F. J. D. Taylor, M.B.E., Staff Engineer, Post Office Research Station.

M.B.E.

F. H. Austen, General Manager, Rediffusion (South East), Ltd.

W. F. Coleman, Deputy Director of Broadcasting (Engineering), Ghana.

W. G. Dickson, Wireless Communications Superintendent, Ministry of Home Affairs for Northern Ireland.

C. A. Green, lately Communications Officer, Office of the U.K. Commissioner for Singapore and Commissioner-General for South-East Asia.

C. H. Pope, Radio Supervisor, War Office.

B.E.M.

Miss S. Holloway, Communications Officer, Birdlip Radio Station, Ministry of Aviation.

Jubilee Lectures.—To mark the 25th anniversary of the formation of the company, Ultra Electric (Holdings), Ltd., is organizing a series of lectures, the first of which will be in the Recital Room of the Royal Festival Hall, London, on September 14th. The speaker will be Professor Arthur Porter, Dean of Electrical Engineering at the University of Saskatchewan, whose subject will be "The evolution of instrumentation." On October 19th, also at the Royal Festival Hall, G. W. A. Dummer, Superintendent of Components Research, Development and Testing at R.R.E., will review the latest developments in components.

D.S.I.R. Grants for Radio Astronomy.—In addition to continued support for the Manchester University's Jodrell Bank experimental station with three grants totalling £187,000, it is stated in the D.S.I.R.'s 1959 Report that it has awarded nearly £40,000 to Professor M. Ryle for the development of new techniques and equipment at Cambridge University. Professor Ryle's work will be aimed at new methods of constructing and improving radio-telescopes and new automatic systems of data-recording for automatic computation.

Disc Production.—Figures issued by the Board of Trade show that in the first four months of this year the production of 45 r.p.m. records increased by 41% compared with last year (17.3M against 12.3M) and 33⅓ r.p.m. discs by 22% (5.5M against 4.5M). During the same period 63% fewer 78 r.p.m. discs were produced (1.5M compared with 4.1M a year ago).

Licences.—During April the number of combined television-sound licences in the U.K. increased by 98,932 bringing the total to 10,568,685. Sound-only licences totalled 4,484,063, including 432,790 for car radio. In West Germany (including West Berlin) the number of sound radio licences showed a decrease for the first time during the first four months of the year—15,617,338 compared with 15,899,447 on January 1st. During the same period combined television-sound licences increased from 3,385,003 to 3,883,145.

St. Dunstan's has re-established a scientific committee to study the whole field of sensory reading and guiding devices. This is announced in the charity's latest report. Members of the committee are: Air Commodore G. Bentley Dacre (chairman); Dr. A. M. Uttley, superintendent, control mechanisms and electronics division, N.P.L.; Dr. H. B. Barlow, King's College, Cambridge; Dr. R. L. Beurle, English Electric Valve Co.; Dr. D. E. Broadbent, director of applied psychology research unit of the Medical Research Council, Cambridge, and Lord Fraser of Lonsdale.

Anglesey Radio, the new Post Office coast radio station at Amlwch opened by the P.M.G. on May 23rd, has taken over all the coast station services previously provided by Seaforth Radio, which it replaces.

"Broadcast Entertainment by Wire."—We regret that, due to a printer's error, the name Teleng, Ltd., was misspelt in the acknowledgments on page 214 of the May issue.

Potential-indicating Lamps.—Acru's fluorescent-green indicator lamps require a minimum striking potential of 160V, not 7 160V as stated on p. 301 of our June issue.

Biological Engineering Society is the name of a new group which was formed in June. The society has a distinct bias towards electronics and is intended to bring together doctors, physiologists, electronic engineers, mechanical engineers and physicists to further the applications of engineering to biological and medical problems. The president is Dr. R. Woolmer of the Royal College of Surgeons, and the acting secretary is Dr. A. Nightingale, Physics Laboratory, St. Thomas' Hospital, London, S.E.1.

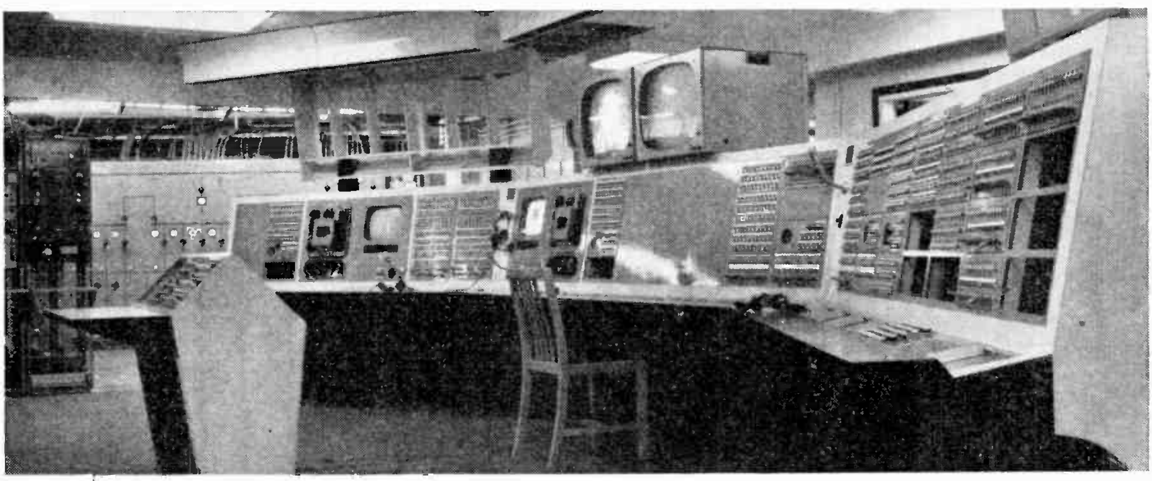
Control Engineering.—A short course providing an introduction to control engineering theory and practice is being conducted by the Loughborough College of Technology from July 18th to 29th. A leaflet, obtainable from the college, gives details of the course. The fee for the course and full residence is 35 gn.

Non-Destructive Testing.—A conference on the "Theory and practice of ultrasonic inspection" is to be held at the Queens Hotel, Cheltenham, from September 22nd to 24th. The arrangements are being made jointly by the Institute of Physics' Non-Destructive Testing Group, the Society of Non-Destructive Examination and the Non-Destructive Testing Society of Great Britain. Details can be obtained from the conference secretary, I. M. Barnes, Materials Laboratory, de Havilland Propellers Ltd., Hatfield, Herts.

Air Traffic Control.—The Guild of Air Traffic Control Officers is to hold its third A.T.C. Convention at Bournemouth on October 18th and 19th. Details are obtainable from the Guild at 118, Mount Street, London, W.1.

Electronic telephone exchanges is the subject of a conference being organized by the I.E.E. for November 22nd to 24th. It is hoped it will provide an opportunity for the interchange of information and experiences of the construction and operation of fully electronic exchanges both in this country and overseas. Further details and a form of registration may be obtained on application to the I.E.E., Savoy Place, London, W.C.2.

"Television Explained."—First published in 1947 under the authorship of W. E. Miller, managing editor of the *Wireless and Electrical Trader,* this book is now in its 7th edition. It includes a new chapter on combined television and f.m. sound receivers. Both this edition and the preceding one were revised by E. A. W. Spreadbury, associate editor of the *Trader*. It is obtainable from our Publishers, price 12s 6d.



FOCAL POINT of the B.B.C. Television Centre, Wood Lane, London, W.12. All sound and vision signals from the nine studios and the telecine and videotape machines are fed to this Central Apparatus Room for distribution. The first transmission from the centre is on June 29th.

Audio Manufacturers' Group of the British Radio Equipment Manufacturers' Association has elected the following member firms (whose representatives names are in parentheses) to form the management committee: A.E.I. Sound Equipment (L. R. Metcalfe); Beam-Echo (H. M. Rahmer); E. K. Cole (J. A. Catchpole); Clarke & Smith (Major J. F. E. Clarke); Electric Audio Reproducers (L. Stone); Gramophone Co. (H. S. Futter); Grampian Reproducers (J. E. Morley); Jason (G. G. Blundell); Lowther (D. M. Chave) and Trix (D. A. Lyons). The Committee has re-elected Major J. F. E. Clarke as chairman and elected D. M. Chave vice-chairman in succession to D. A. Lyons.

Autumn Audio Fair.—The venue for this year's Autumn Audio Fair is to be the Palace Hotel, Southport, Lancs. It is being organized by Audio Fairs Ltd., 22 Orchard Street, London, W.1, and will be held on October 7th, 8th and 9th.

R.I. Club.—The report presented at the annual general meeting of the Radio Industries Club on May 31st recorded a membership of the "parent" club of 996. The membership of the seven affiliated clubs in the provinces is 1,330. F. W. Perks, chairman of Radio Industry Exhibitions Ltd. and immediate past chairman of B.R.E.M.A., is the new president of the club.

Radio Ball.—This annual function organized by the Radio Industries Club during the National Radio Show will be held at Grosvenor House, Park Lane, London, W.1, on August 26th.

I.E.E.—More meetings were held by the Electronics and Communications Section of the I.E.E. than all three other sections of the Institution. The Electronics and Communications Section also has the largest membership (6,171) of any specialized section. During the year ended in March, the Institution membership increased by 1,678 to 46,222. Student members increased by 592 to 4,689 and graduates by 530 to 14,545.

Personalities

Lord Halsbury has been appointed a Governor of the B.B.C. until 1962 in succession to **Sir Edward C. Benthall,** who has resigned. Lord Halsbury was managing director of the National Research Development Corporation for ten years until his retirement in March, 1959. He is now chairman of International Rectifier Co. (G.B.) Ltd., which was formed by the International Rectifier Corporation of the U.S. and the Lancashire Dynamo Company, and also of L.C.E. Ltd. recently formed jointly by G. & E. Bradley (a subsidiary of Joseph Lucas) and Collins Radio Co. of America.

Alan Wolstencroft is the new Director of Radio Services in the Post Office in succession to **W. A. Wolverson,** who, as announced in our last issue, has become a Deputy Director General. Mr. Wolstencroft, who is 46, joined the Post Office in 1936. He was closely associated with the preparations for the setting-up of the Independent Television Authority in 1954 and was in fact its first secretary for a year.

M. L. Jofeh, O.B.E., A.M.I.E.E., manager of the industrial division of Sperry Gyroscope Co., which he joined in 1947, has been appointed an additional director. For several years he headed the engineering unit at the company's Stonehouse, Glos., factory, but in 1954 returned to Brentford as deputy chief engineer. He was appointed chief engineer in 1957 and, with the reorganization of the company in January last year, became manager of the industrial division in which is concentrated the company's interests in industrial control engineering. For eleven years before joining Sperry Mr. Jofeh was in the research laboratories of Cossor.

John D. Clare, M.Sc., A.M.I.E.E., has succeeded **Air Commodore H. B. Wrigley,** C.B.E., as Director of Guided Weapons Research and Development (Air) in the Ministry of Aviation. Born in 1920 and educated at Birmingham University, Mr. Clare was employed throughout the war in the development laboratory of the G.E.C., Coventry. From 1945 to 1950 he was a senior engineer with Sobell Industries. He then entered the Civil Service at what is now the Royal Radar Establishment, and was for five years section leader responsible for the centimetric receiver system on new fin control "radar" and low-altitude guided weapons. Since 1955 he has been superintendent of the surface-to-air guided weapons department.

J. D. Clare

R. I. Kinross

R. I. Kinross, M.I.E.E., managing director of Rediffusion Research, Ltd., is the new president of the Society of Relay Engineers. He was for nine years with E.M.I. and for a year with Philco before the war. During the war he served in the Royal Corps of Signals and was seconded to Military Intelligence. He joined Rediffusion after the war as chief engineer of a region, and subsequently took charge of the company's Development Department. He has been managing director of Rediffusion Research and a director of Television Research since 1958. **R. P. Gabriel,** B.Sc., M.I.E.E., A.M.Brit.I.R.E., the new vice-president of the Society of Relay Engineers, is chief engineer of Rediffusion.

P. W. Faulkner, O.B.E., has joined Rank-Xerox Ltd. as deputy managing director. He joined Plessey in 1952 and for some time was general manager of the company's commercial and metallurgical division at Towcester, Northants. He has been a director of the Plessey International Co. and also an executive director of the Plessey Co. for several years.

J. W. Soulsby, chief radio officer in the British India Steam Navigation Company's vessel *Uganda,* has been re-elected chairman of the Radio Officers' Union for the sixth consecutive year. He joined the Marconi Marine Co. at the age of 18 in 1918. **W. S. Armstrong** is again vice-chairman. It is his fourth term of office. Mr. Armstrong, who is 47, was with the Marconi Company's marine staff until 1947, when he was appointed to the staff of the Inspectors and Technical Employees' Section of the Union.

J. Sykes, M.I.E.E., M.Brit.I.R.E., M.I.N., has left the Ministry of Aviation, in which he was superintendent of the civil aviation communications centre at Croydon Airport, and is setting up as a consultant specializing in technical training and recruitment schemes. He has been with the Ministry and its predecessors for 25 years. Mr. Sykes, whose address is Red Lion Court, Stalbridge, Dorset, serves on the City and Guilds Advisory Committee on Telecommunication Engineering, and the membership committee of the Brit.I.R.E.

P. T. H. Dannahy, A.M.Brit.I.R.E., has joined Radio and Allied Industries Ltd., manufacturers of Sobell and McMichael receivers, as chief radio engineer. He was chief engineer and production manager with Peto-Scott Electrical Instruments until 1945, when he joined the Ferguson Radio Corporation as chief radio engineer.

P. T. H. Dannahy

E. David Parchment, who joined Leevers-Rich Equipment last August as technical sales manager, has been appointed a director in place of **G. W. Parkes,** who has resigned from the directorate of the company. Mr. Parchment was for many years with the Decca Record Co. and subsequently was sales director of Epsilon Sales and Services Ltd.

W. E. C. Varley, Assoc.I.E.E., A.M.Brit.I.R.E., has been appointed by the B.B.C. Superintendent Engineer, Transmitters, in succession to **E. F. Wheeler,** O.B.E., D.L.C., M.I.E.E., who has retired after 17 years in the post and 36 years' service with the Corporation. Mr. Varley joined the Corporation in 1933. During 1943 and 1944 he was chief broadcasting engineer at the Allied Forces Headquarters in North Africa.

M. H. Hall, M.B.E., has become Assistant Superintendent Engineer, B.B.C. London Television Studios, in succession to **H. Walker,** O.B.E., A.M.I.E.E., who is retiring. Mr. Walker joined the B.B.C. in 1931. He was appointed engineer-in-charge of the Alexandra Palace television station in 1950 and since 1953 has been Assistant Superintendent Engineer, London Television Studios. Mr. Hall joined the Corporation in 1927. In 1950 he was appointed engineer-in-charge of the B.B.C. Television Studios at Lime Grove.

W. D. Hatcher, B.Sc.(Eng.), A.M.Brit.I.R.E., who succeeds Mr. Hall as Engineer-in-Charge, London Television Studios, joined the B.B.C. in 1931. During the war he was concerned with the design and equipment of the B.B.C.'s high-power short-wave transmitting stations.

C. Powell, contributor of the article "Radio Aids to Hydrography" in this issue, has been with the Decca Navigator Co. since 1946. He is now in charge of the company's technical information department, but was initially concerned with applications of the Navigator for surveying and originated the two-range Decca technique. Mr. Powell's industrial career began in 1934 when he was personal assistant to P. K. Turner, of Hartley-Turner Radio. For part of the war he was attached to the Army Operational Research Group.

J. H. Mitchell, B.Sc., Ph.D., M.I.E.E., has been appointed to succeed **G. D. Christie** as chairman of the board of directors of Associated Transistors Ltd., which is operated jointly by Automatic Telephone & Electric Co., English Electric, and Ericsson Telephones. Dr. Mitchell, who is director of research of Ericsson Telephones, which he joined in 1947, was at the Bawdsey Research Station in 1936 and for his radar contributions he received an award from the Royal Commission on Awards to Inventors. Mr. Christie, who is a director of A.T. & E., remains a member of the board of Associated Transistors Ltd.

D. M. MacKay, B.Sc., Ph.D., who is in the Wheatstone Physics Laboratory, King's College, London University, has been appointed to the Research Chair in Communication founded by Granada Television in the University College of North Staffordshire.

Wing Commander A. R. Gilding, newly appointed assistant technical secretary of the Electronic Engineering Association, was until recently in charge of the branch of the Air Ministry responsible for airborne radio servicing policy and some aspects of new airborne equipments. Throughout his career in the R.A.F., which he began in 1927 as an aircraft apprentice, Wing Commander Gilding specialized in communications and radar. For two years before being posted to the Air Ministry in 1954, he was at N.A.T.O. headquarters, Oslo.

OBITUARY

Rupert Browne, O.B.E., B.Sc., who, owing to ill-health, resigned from the secretaryship of the Radio Industry Council in 1957, died on May 21st. Born in 1897 and trained as a chemist, Rupert Browne graduated at London University. In 1924 he joined the staff of the National Association of Radio Manufacturers and then, when the Radio Manufacturers' Association was formed, he joined that organization. When in 1945 the Radio Industry Council was born out of the R.M.A. he became its secretary. He was appointed an O.B.E. for his work on a war-time committee, under the chairmanship of Lord Hankey, devising and working a scheme, in collaboration with others in the radio industry, for the training of radio engineers for the Services.

F. G. Robb, A.M.I.E.E., chief of Marconi's Test Division from 1948 until his retirement five years ago, died on May 14th. He was with the company for 36 years except for a period during the last war, when he was seconded to the Admiralty, where he became chief of radar test. He was for some years in the company's design and development section, where at one time he worked on the development of transmitters for the Marconi-Franklin short-wave beam system.

John A. J. Cooper, sales director of Leevers-Rich Equipment since 1954, died on May 16th at the age of 67. After service with the War Department, Mr. Cooper joined the B.B.C. in 1928 and became senior recording engineer in the engineering division.

Philatelists among our readers will be interested in this series of six stamps recently issued by the Czechoslovak Postal Authorities commemorating international pioneers of wireless. They are Tesla (Yugoslavian); Popov (Russian); Branly (French); Marconi (Italian); Hertz (German); and Armstrong (American). Each stamp includes a portrait of the pioneer and an illustration depicting an aspect of his work.

News from the Industry

Relay Exchanges Ltd., record a group trading profit during 1959 of £3,583,311, compared with £2,515,988 the previous year. After deducting over £2M for depreciation and provision for renewal of equipment and £128,182 for taxation, the year's net profit was just over £1M. Sudsidiaries of Relay Exchanges include 16 radio and television relay companies, six Rentaset renting companies, four retail concerns and three manufacturing companies including Goodmans Industries.

Simms Motor and Electronics Corporation have announced a group trading profit for the past year of £1,037,690 before taxation, compared with the previous year's £632,072. Taxation absorbed £548,200 in 1959 and £366,000 the year before. Reference is made in the directors' report to the activities of N.S.F., which in terms of output and profit ranks second in the group, and to the recent acquisition of Cawkell Research and Electronics.

Pye closed-circuit television has been installed in a new plant of the Dunlop Rubber Co. at Fort Dunlop, Birmingham, to facilitate the examination of tyres being tested at speeds of up to 500 m.p.h. Each of the two cameras has two lenses. A calibration grid is electronically superimposed on the television display in the control room from which the cameras are remotely operated.

The Chloride Electrical Storage Co. has opened new central research and development laboratories at Fletcher Avenue, Clifton, Swinton, Manchester, for fundamental research into the physics of electrochemical couples, including fuel cells, and into the problems of extending life and reducing weight and cost in conventional types of cell. The laboratories have a floor space of 41,500 square feet and there is a staff of 180, including 40 qualified specialists.

Du Mont Agents.—Aveley Electric Ltd., of Ayron Road, Aveley Industrial Estate, South Ockendon, Essex, have been appointed U.K. agents for all products of the Allen B. Du Mont Laboratories Inc., of the U.S.A. The Du Mont range of equipment includes the new 425 digital-readout high-frequency oscilloscope, oscilloscope recording cameras and photo-multipliers.

Ferranti announce that they are engaged in the development of another radar fire control system, Airpass II. The original Airpass was shown publicly for the first time at the S.B.A.C. show at Farnborough last September. Airpass II will provide the following facilities:—air-to-air radar search and automatic tracking, computer-controlled approach for blind or visual attacks, and radar-assisted attacks against surface targets.

Britec Ltd., of 17 Charing Cross Road, London, W.C.2 (Tel.: Whitehall 3070), have been appointed distributing agents for Elesta cold-cathode tubes and electronic controls manufactured in Switzerland.

Marconi's are supplying a 50-kW 50-cm airfield control radar, Type S264, with two moving-coil display units and ancillaries, for the Royal Radar Establishment airfield at Pershore, Worcestershire.

R.C.A.—Dr. H. R. L. Lamont, director of R.C.A. European technical relations, has moved his office from Pall Mall to 36 Berkeley Square, London, W.1 (Tel.: Grosvenor 1217).

A new factory for the production of selenium rectifiers and silicon diodes was opened at Oxted, Surrey, on May 25th by the International Rectifier Company (Great Britain) Ltd., which is jointly owned by Metal Industries Ltd. (through its acquisition of Lancashire Dynamo Construction) and the International Rectifier Corporation, of Los Angeles.

Grundig in N. Ireland.—A new company, Grundig Works Ltd., is being formed in Belfast to operate a factory in Dunmurry on the outskirts of the city. The factory, which is planned to begin operation in September, will initially produce one model tape recorder, but eventually other equipment will be made. All products made at the factory will be distributed throughout the U.K. by Grundig (Great Britain) Ltd. The directors of Grundig Works include Max Grundig (founder of the organization), three others from the parent company and G. S. Taylor, chairman and managing director of Grundig (G.B.) and of Wolsey Electronics.

Nash & Thompson Ltd., Hook Rise, Tolworth, Surbiton, Surrey, have been given approval as a Part III Test House (including testing under environmental conditions) by the Director General of Inspection for Functional and Performance Testing of Electronic Components. The company's environmental and electronic testing laboratories have been in existence for over six years and have been approved as a Test House by the Air Registration Board for some time. Any firm or organization may submit components for testing to a specification and a Certificate of Test will then be issued stating that the tests have been carried out in accordance with the requirements of the Air Registration Board or Director General of Inspection.

E.M.I. Electronics Ltd. have supplied the vision equipment and have carried out the "technical" wiring and installation at Associated Rediffusion's new Studio 5, opened recently at Wembley, Middx. They are also supplying 15 cameras for the television studios being constructed at Teddington, Middx. for A.B.C. Television.

Marconi's have been awarded the contract for the supply and installation of the vision and sound transmitters for the new I.T.A. station at Caldbeck to serve the Carlisle area. In addition to the duplicated transmitters and ancillary equipment, Marconi's are supplying the mast and horizontally polarized sixteen-stack quadrant aerial which will give a vision e.r.p. in the direction of maximum propagation of over 100kW.

EXPORT NEWS

Midas range of magnetic tape data recording equipment developed by Royston Instruments Ltd., of Byfleet, Surrey, is to be marketed in the Western Hemisphere and Australasia by Lockheed Aircraft Services Ltd., of Ontario, California.

The Italian hydrofoil, *Freccia dell Adriatico*, which operates a passenger service between Trieste and Venice (a distance of 80 miles) at an average speed of 40-45 knots, carries Kelvin Hughes marine radar type 14/9. Kelvin Hughes have also received orders for radar for Italian-built hydrofoils for operation in Norway and Finland.

Poland.—Three Marconi Mark IV television cameras and ancillary equipment have been ordered for the Warsaw studios of the Katowice station which was equipped by Marconi's. Polish television operates on the 625-line, 8Mc/s standard.

Brazil.—The complete studio and transmission equipment for a new television station at Recife, Brazil, costing in the region of £250,000, has been supplied by Marconi's.

India.—G. S. Dhingra, director of Union Radio & Appliances Private Ltd., of 72 Janpath, New Delhi, will be visiting the U.K. in July to negotiate with firms interested in collaborating in the manufacture in India of components such as fixed and variable resistors and capacitors, loudspeakers and switches.

Wire Broadcasting in Holland

PLANS FOR DISTRIBUTING TELEVISION OVER THE EXISTING SOUND NETWORK

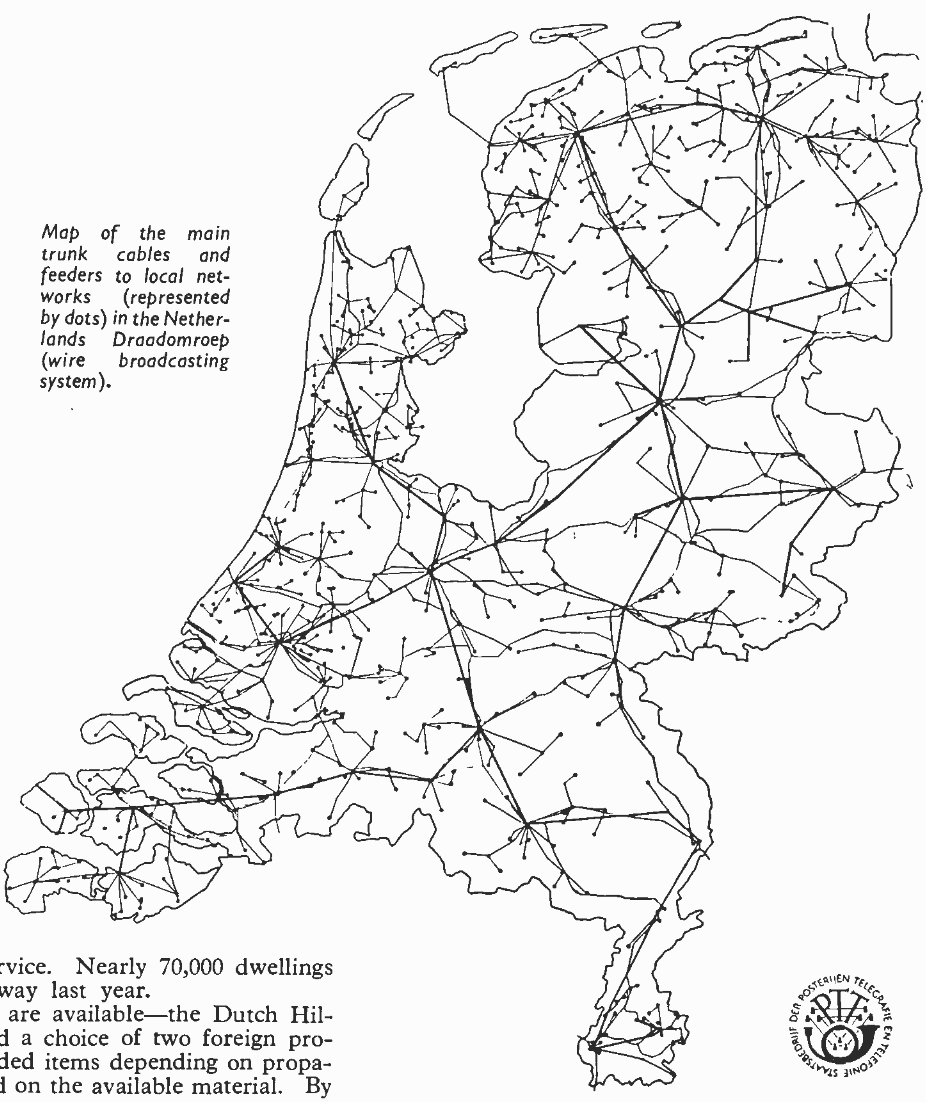
ALTHOUGH Holland is a relatively small country it has always held a high reputation for its contributions to art, science and the social services. In broadcasting its radio stations led the way in Europe in the early days, and today it enjoys one of the most efficient and widely disseminated wire distribution systems in the world.

This is run by the postal telegraph and telephone authorities, the Netherlands PTT, which was made responsible during the war for control of several independent networks and has since continued to develop and extend an integrated system.

The accompanying map gives some indication of the coverage (1959) of the main trunk cables and branches. Points on the map represent one or more power amplifiers feeding local "networks" of anything up to 1,800 houses. The total number of subscribers in Holland is about 500,000 in a population of 11 millions (1 in 22) whereas in Great Britain the ratio is 1 in 50 (1M in a population of 50M). All new housing estates in Holland are now wired in advance for telephone and broadcast relay services, without any obligation on the tenants to become subscribers. Terminal outlets are embedded in the wall plaster and covered by a flush-fitting cover, which is easily replaced by a control panel with stepped volume control and selector switch if the occupants of the house or flat elect to take the relay service. Nearly 70,000 dwellings were fitted in this way last year.

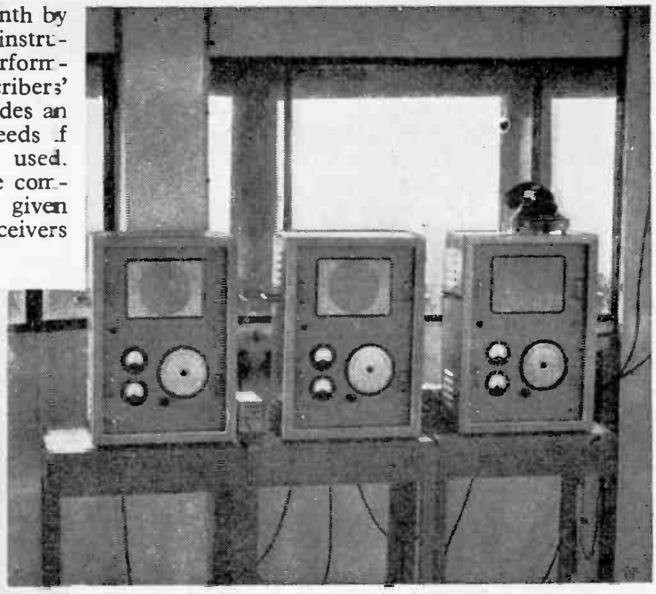
Four programmes are available—the Dutch Hilversum I and II and a choice of two foreign programmes or of recorded items depending on propagating conditions and on the available material. By mutual arrangement with the Belgian authorities, any of their programmes may be selected by remote control and passed direct from Brussels to Rotterdam by land line. Programmes from other countries are picked up by special receivers placed at favourable sites on the borders of Holland. The receivers for the three B.B.C. services are installed in a water tower at Domburg on the island of Walcheren and normally give an acceptable signal/noise ratio from Wrotham (130 miles) or Norwich.

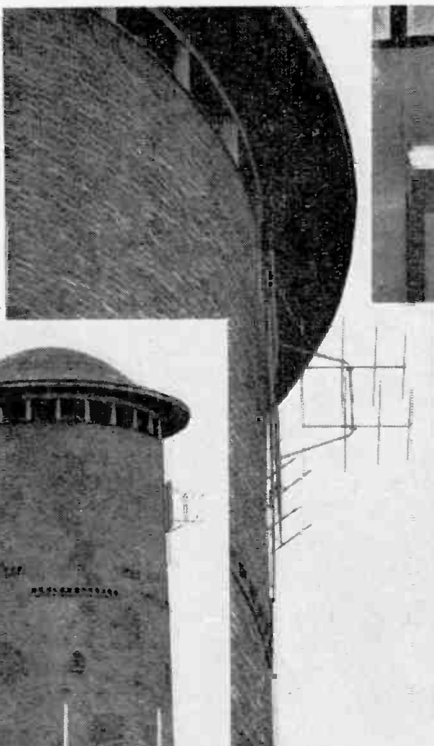
Special care is taken to provide high quality of reproduction and a frequency response of 40c/s to 10kc/s $\pm$ 2dB is guaranteed in all parts of the system. Local distribution amplifiers are housed

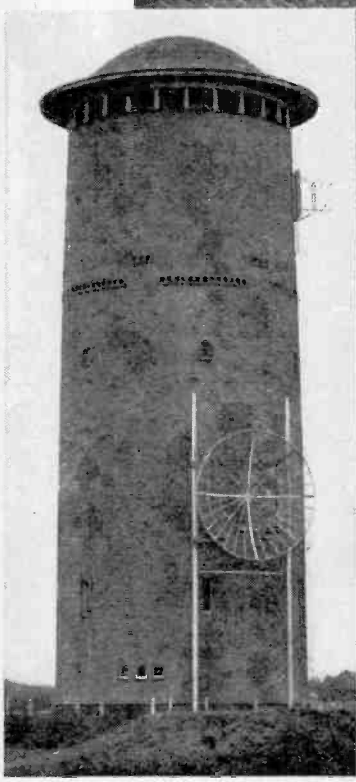


Map of the main trunk cables and feeders to local networks (represented by dots) in the Netherlands Draadomroep (wire broadcasting system).

in kiosks which are visited regularly each month by technical staff in a van specially fitted with the instruments necessary for a thorough check of performance. The audio power available at the subscribers' outputs is of the order of ½ watt which provides an acoustic level sufficient for most people's needs if a loudspeaker of reasonable efficiency is used. Although the authorities do not supply more complicated reproducing equipment, guidance is given for those who may wish to use existing receivers or add high-quality power amplifiers.





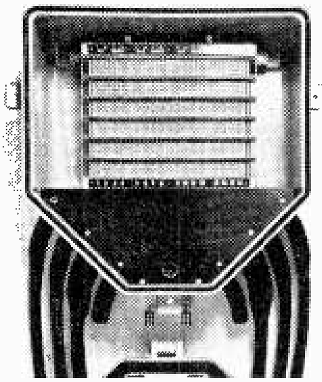


At present there is no regular wire distribution of television in Holland, but a thorough investigation has been made* of the feasibility of using the existing sound broadcasting cables at high frequencies. It has been found that the polythene-insulated, unscreened cables with four pairs, each twisted with different pitches have a good performance at frequencies up to 10Mc/s and that the older paper insulated cables can also be used satisfactorily. The polythene cables used in Holland appear to suffer less from increased attenuation—about 10 to 15% under adverse conditions compared with over 30% for similar types used elsewhere. The average loss per kilometre is between 23 and 57dB at the chosen vision carrier frequency of 7Mc/s depending on the

* See for example "Some Problems Concerning the Experimental Wire Television Service as Realised in the Netherlands," by A. P. Bolle, *Het PTT Bedrijf*, Vol. IX, No. 3, November 1959.

Above: The receiving station for English programmes is situated at the top of the water tower at Domburg in the island of Walcheren.

Right: Control centre at Rotterdam, where programmes are selected and monitored. Level indicators for each of the four programmes are at the back of the control desk.



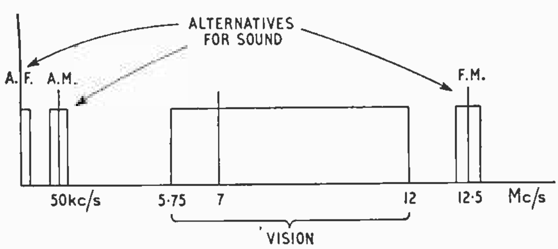
Above: *Distribution box for subscribers' lines. Television and/or sound signals can be applied to any subscriber by the insertion of the appropriate resistive or inductive elements which are encapsulated in foamed polyster resin.*

Right: A mobile laboratory visits each network amplifier once a month for a thorough check of performance.

type of cable under consideration. The cross-view between pairs at a distance of 2km is better than 40dB. With a sending level of 3 volts peak-to-peak the maximum radiated field at a distance of 3 metres is 200μV/m. Interference picked up on the unscreened cable would be of longitudinal character and experience has shown that its magnitude is unlikely to cause trouble unless the signal level falls below 20mV.

The characteristic impedance of the cables at r.f. is of the order of 100 ohms and careful matching at all junctions is necessary to avoid reflections and "ghosts." The ratio of the special transformers used at these points varies according to the number of subscribers which may be up to as many as 16. The impedance "seen" at the secondary is about 1.5 ohm and as each subscriber's loading is of the order 5,000 to 10,000 ohms decoupling is very effective. Separation of sound and vision takes place after the subscriber's selector switch by simple series inductors and capacitors.

By using a vision carrier of 7Mc/s with a complete upper sideband and vestigial lower sideband it is possible to legislate for the use of existing receivers by changing the oscillator frequency and to keep the f.m. sound signal at the normal spacing of 5.5Mc/s, i.e., at 12.5Mc/s. Alternatively, if special simplified television receivers become available for use with the wire system it is proposed to provide the sound accompaniment as a double sideband a.m. signal on a 50kc/s carrier. This is preferable to sending the sound at audio frequency as it enables the original four sound-only programmes still to be distributed. Although the initiation of a regular wire television service in Holland still awaits official sanction and possibly the backing of private enterprise to provide the recommended special receiving equipment, the technical problems of transmission have been solved.



Spectrum of the proposed television transmissions with possible alternatives for the sound accompaniment.

Through the courtesy of the Netherlands PTT *Wireless World* was able recently to witness test transmissions of alternative television programmes over standard four-pair cables carrying the regular sound programmes. The two television signals were using synchronized carriers on adjacent pairs of an experimental circuit installed at the Leidschendam research laboratories. Excellent picture quality was obtained and there was no trace of interference from either sound or the alternative vision programme, even when the modulation of one vision carrier was switched off and the raster examined at full gain.

Similar tests carried out over a period of a year with the collaboration of subscribers in a district of the Hague have proved the reliability of the system in the field. Only one live television programme is at present available in Holland, but satisfactory tests of cross-view were made with the alternative programme supplied by a pattern generator. It was also confirmed that the effect of any external interference picked up by the unscreened feeders is negligible.

European Television Stations

Europe's 680 or more television stations in Bands I, III and IV are tabulated geographically and in order of frequency in the 5th edition of the list of TV stations produced by the Technical Centre of the European Broadcasting Union. A chart showing the stations in each of the channels is included in the publication, which is obtainable from the E.B.U., 32 avenue Albert Lancaster, Brussels 18, Belgium. The list and its supplements costs 50 Belgian francs.

High-gain Video Amplifier*

FURTHER NOTES ON VERSIONS FOR GRID OR CATHODE MODULATION

By ***R. G. YOUNG***

IT is very gratifying to learn from the Editor that there has been a widespread interest in, and requests for, further practical details of a circuit which I should have thought would have been of merely limited interest. Evidently many folk still prefer to make their own television receivers, even in these mass-produced days and in spite of the trouble in getting parts. You almost need a licence to get 110° scanning coils!

The circuit was evolved after many efforts to overcome i.f. instability, bearing in mind that "fringe-area" operation was required. The instability manifested itself partly by bad streaking after bright objects—this was particularly so in scenes containing venetian blinds or staircases. The other effect was a black edge on bright objects, due to overshoot; this was not quite so bad, but looked terrible on Test Card C.

It seemed to me that the trouble arose from excessive signal levels appearing at the detector diode. The only answer could be to get more video-frequency amplification, and this circuit was the result after much trial-and-error experimentation with various arrangements.

It seems a little complicated, but it goes into a space 5in×2½in quite comfortably (see Fig. 1). I put both cathode-bypass capacitors on top of the chassis where they were easy to get at, as a change of 20% in value produces an appreciable difference in the picture, and can make or mar results. It appears that if the first cathode-bypass capacitor is too high in value, a "ring" at about 2Mc/s is caused and too high a capacitance in the second amplifier cathode circuit causes a less-severe ring at about 1Mc/s.

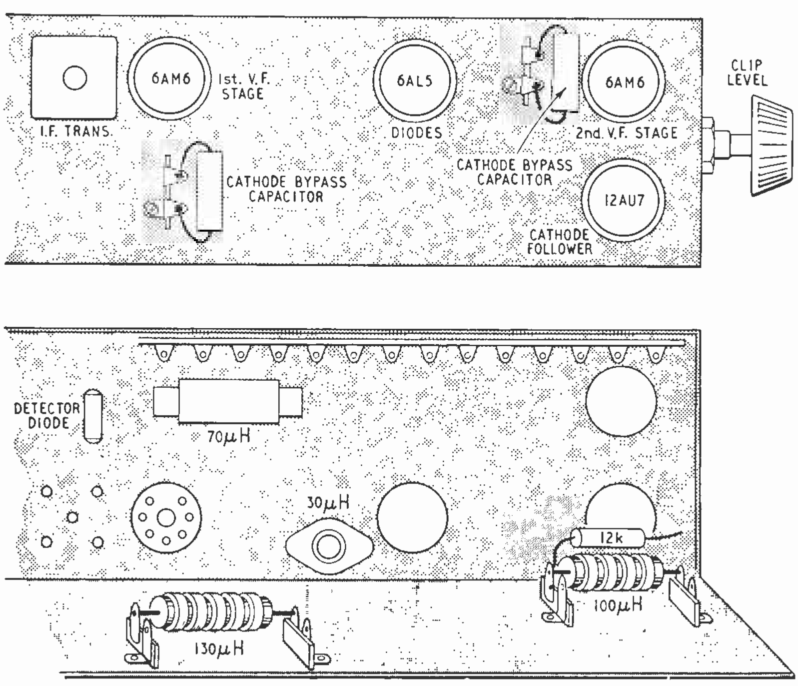
In the original version definition was quite satisfactory with a wideband i.f. amplifier; but it is possible that the circuit might be used with an i.f. amplifier having a narrower pass-band, in extreme fringe conditions. In this case a choke in the second v.f. stage anode circuit can improve the picture.

Fig. 2 is the final result. Shown here is the use of a thermionic diode for the detector—some readers may prefer it—and it does make the polarity quite clear.

If space is very limited a triode-pentode of the ECF82 type can be used for the second amplifier and cathode follower with, however, a loss both of gain and peak-to-peak output (about 30%). Some may wish to eliminate the cathode follower altogether. To do this would mean using a lower-value anode resistor in the second v.f. stage, as the stray capacitance of the c.r.t. and synchronizing separator would then become important. The effect would then be to reduce the available output (peak-to-peak). It could be done, but I do not recommend such a radical change, just to save a single triode; better to use a triode-pentode. Further information about the use of cathode followers in v.f. amplifiers was given in a Mullard technical advertisement (*Wireless World* for August, 1955, p. 90†).

It may be desired to use the amplifier in a receiver designed for grid modulation of the c.r.t. Several changes are needed in addition to the

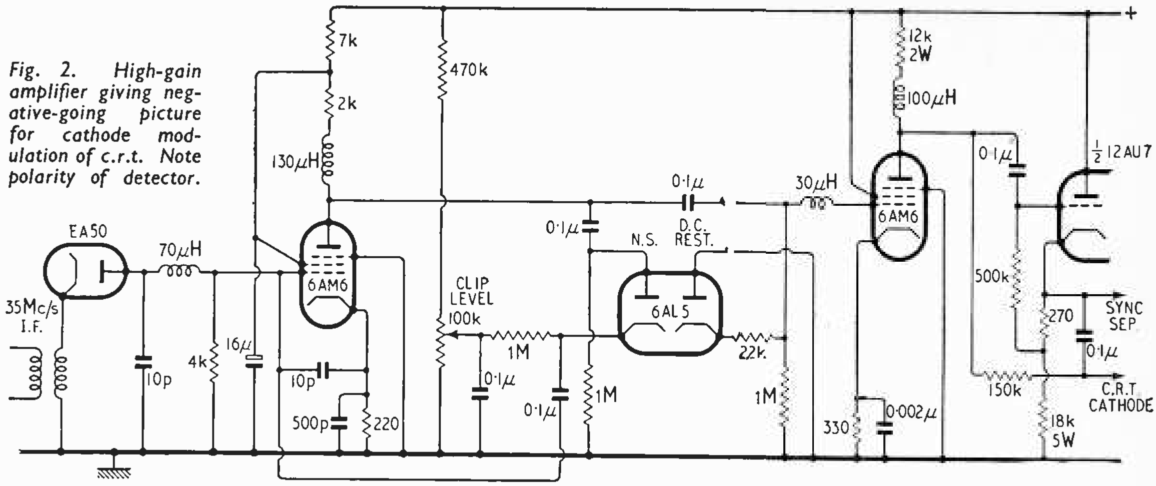
Fig. 1. Top and under-side views of 5 x 2½-in chassis layout used for cathode-modulating version of amplifier. Leads must be kept short and stray coupling avoided.



* See "Letters to the Editor," p. 294, *Wireless World*, June 1960.

† This is an abridged version of a paper published in *Mullard Technical Communications* No. 12 (May 1955), p. 42.

Fig. 2. High-gain amplifier giving negative-going picture for cathode modulation of c.r.t. Note polarity of detector.



changes in polarity. The d.c. restorer becomes superfluous as the second v.f. stage grid will do the same job, by reducing the cathode bias. The purpose of the "safety circuit" round the cathode follower in Fig. 2 is to ensure that, in the event of a valve failure, the c.r.t. beam is cut off. For grid modulation of the tube this is achieved when the feed is taken directly from the cathode follower, so this safety circuit is not necessary. The modified circuit is shown in Fig. 3.

There now remains to be supplied data on choke winding. The coils of 70μH and 30μH are close-wound solenoids, and the 130μH and 100μH inductors employ pile-wound sections. Details are shown in Fig. 4. All the coils were checked on an inductance (audio-frequency) bridge: it would be wise to adopt this procedure because surprising variations in inductance can occur with hand-wound coils.

It must be remembered, too, that when one of these circuits is used to replace the existing video amplifier in a receiver, some adjustment to the brilliance-control network may be necessary to achieve proper range of control.

In conclusion, one unexpected bonus from the use of this circuit is the apparent reduction of "snow"

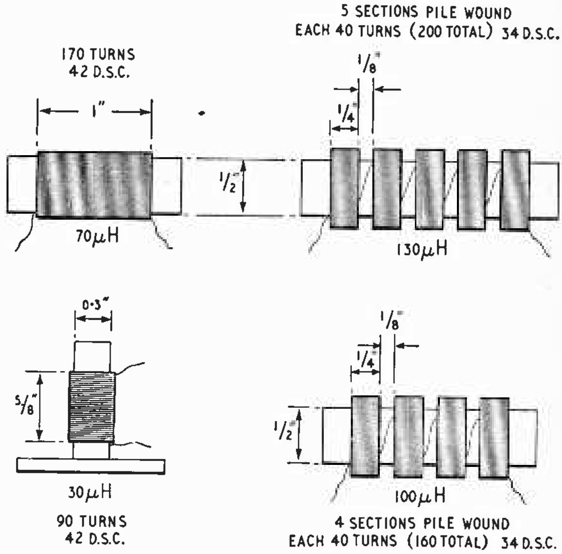
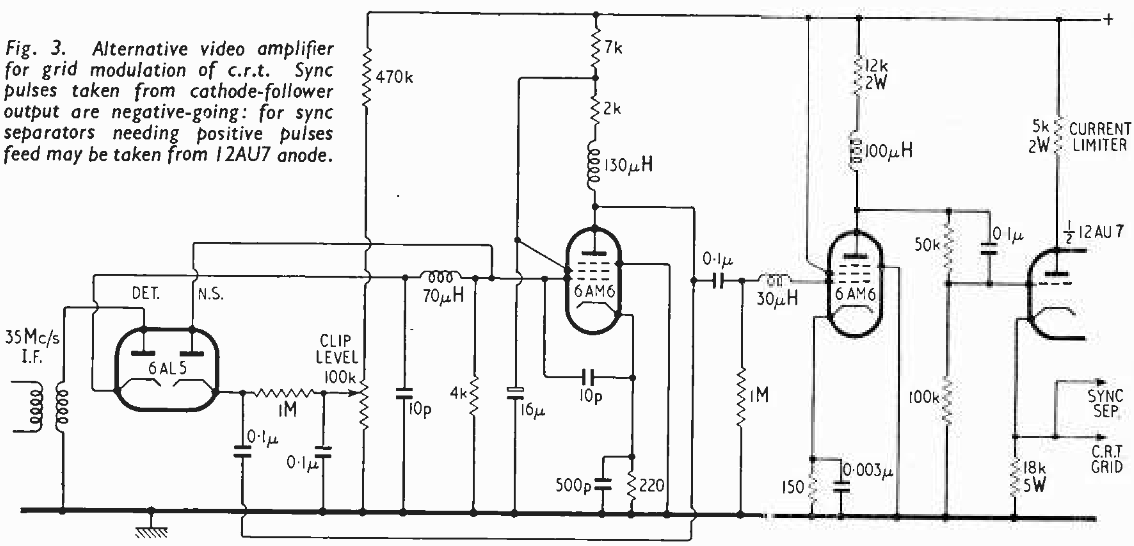


Fig. 4. Coil-winding details (wire gauges given are s.w.g.).

Fig. 3. Alternative video amplifier for grid modulation of c.r.t. Sync pulses taken from cathode-follower output are negative-going: for sync separators needing positive pulses feed may be taken from 12AU7 anode.



on the picture; just why that is, I do not attempt to explain, but just mention it in passing.

Several readers have asked for recommendations of diode type. This is quite unimportant; I have tried Mullard OA10, G.E.C. GEX34 and "unknown" (surplus) types and could perceive no difference in the image obtained.

APPENDIX

For use at i.f. below 35-38Mc/s the filtering is not really satisfactory. As the circuit stands, a small amount of an i.f. below say, 20Mc/s, could appear in the output. This might not cause trouble in all cases, but it would be advisable to connect a 70-μH choke in series with the cathode follower output when using a low i.f.

Where $\frac{1}{2}$-in diameter formers are not available 0.3-in diameter can be used. For the 130-μH and 100-μH coils use wire gauge and spacing as shown in Fig. 4 but increase each section to 65 turns. The 70-μH coil would be sectionally wound with similar dimensions to the 100-μH choke, but each section would contain 50 turns.

Birmingham-London TV Link

SO that programmes, rehearsals and advertisements originating at A.TV Alpha Studios, Aston Road, Birmingham, can be seen at Associated Television's headquarters in London, Pye Telecommunications Ltd. have installed for A.TV a 7Gc/s, 135-mile-long link for both sound and vision. Three automatic repeater stations are used at Meriden, Cold Ashby and Barkway and the terminals are on the C.M.L. building in Birmingham and at Highgate, London.

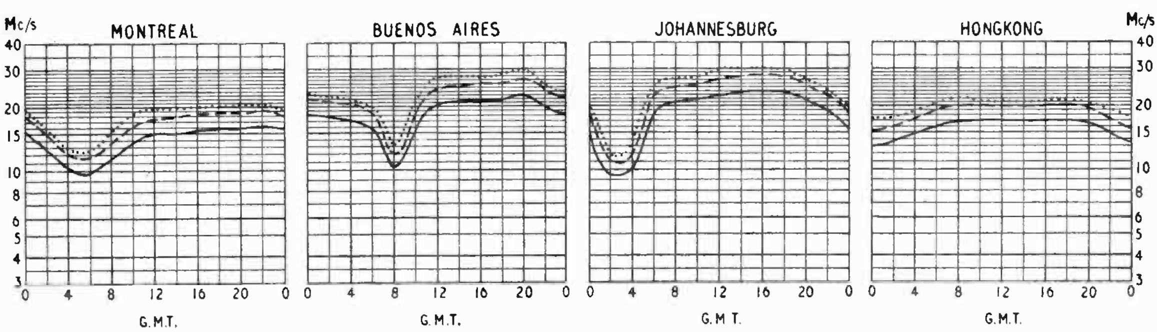
A feature of the Barkway repeater, which has a tower over 200ft high, is the use of passive reflectors on the tower with the microwave transmitter and receiver aerial "dishes" mounted horizontally only a few feet above the ground. Normally both the transmitter and receiver would have to be placed at the top of the tower, or long waveguides would be necessary to feed the aerials, so a considerable saving in both initial and maintenance costs has been made possible by the use of this technique of "mirroring" at the top of the tower the aerials at ground level.

Plane passive reflector on mast reflects to next repeater becm from aerial at ground level.

Faults occurring at any station are automatically indicated on the London control board by telemetry circuits operating over a 450-Mc/s control link. Authority to install and operate the system was granted by the General Post Office, who have recently made available a band of microwave frequencies for such operations.

SHORT-WAVE CONDITIONS

Prediction for July



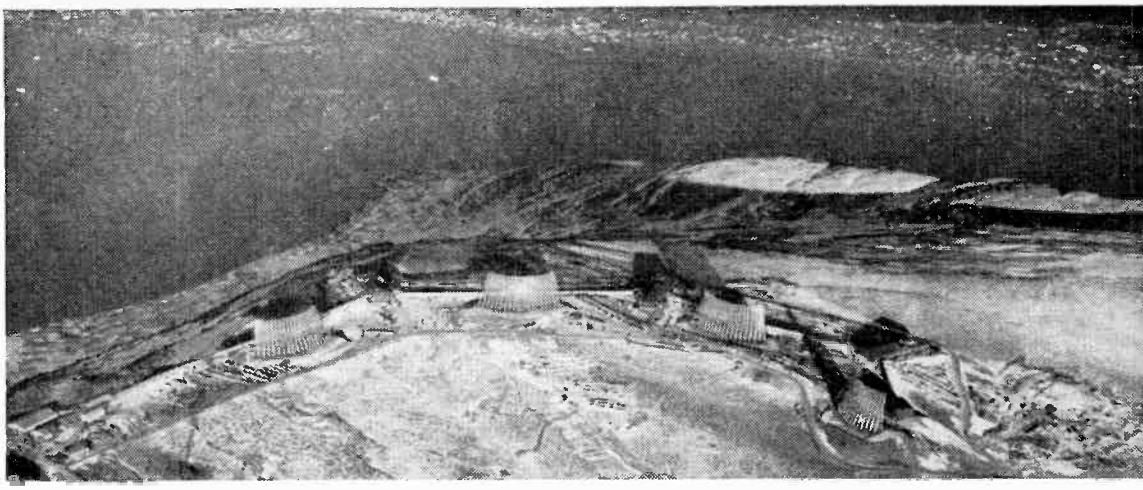
•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during July.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.



General view of the four huge reflectors at Thule, Greenland

BMEWS

American Long-range Radar Warning System

ALTHOUGH primarily a defence project for N. America the ballistic missile early warning system (BMEWS for short) is of more than passing interest to us in the U.K. first for its technical features and secondly because one of the three "forward bases" is to be in this country. Under an agreement between the U.S.A. and the U.K. we are co-operating in setting up and operating a radar tracking station on Fylingdales Moor, Yorkshire. The technical equipment for the station is being provided by the U.S. but the station will be commanded and operated by the R.A.F. The other two bases are at Thule, Greenland, and Clear, Alaska, and all three will be linked by duplicated communication channels, using cables, tropospheric scatter and microwave radio links, to the control centre of the North American Air Defence Command (NORAD) at Colorado Springs, Colorado.

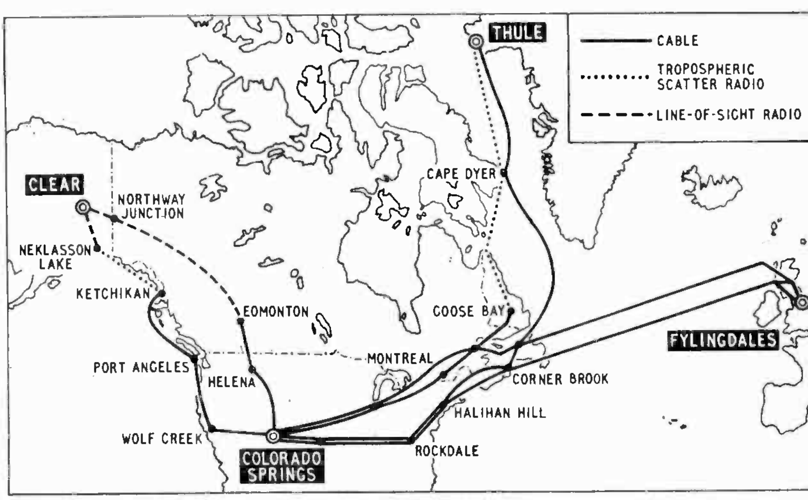
The first base to be completed is at Thule which is planned to come into operation later this year. At this site there are four large rectangular reflectors each measuring 400 feet long and 165 feet high. These are for the pulsed-Doppler detection radar and together they will give a total azimuth coverage of 150 degrees.

Pulsed transmissions, fed into each reflector from horns on its nearby transmitter building, form two stationary horizontal fans at different elevations. Prediction of the probable land fall of a missile will be obtained by extrapolating its path from the range, azimuth, bearing and time sequence data recorded as it passes through the fans. Three similar reflectors, giving a coverage of over 100 degrees are being installed at Clear, Alaska, which is scheduled to come into operation some time next year.

At Thule there will also be a dual purpose tracking radar the paraboloid of which will be housed in a specially treated plastic sphere 140 feet in diameter. It is this type of radar which will be installed in this country. At Fylingdales there will be three of these radomes capable of both detecting and tracking missiles and they will provide azimuth coverage of over 100 degrees.

The paraboloid and its pedestal weigh over 150 tons. The radome of the prototype tracking radar at the R.C.A. establishment at Moorestown, New Jersey, was assembled from 1,646 hexagonal sections

Communication routes linking the three radar bases with the BMEWS control centre in Colorado. It will be seen that all links are duplicated.



each section consisting of a 6in thick "biscuit" of resin-impregnated paper between fibre glass walls.

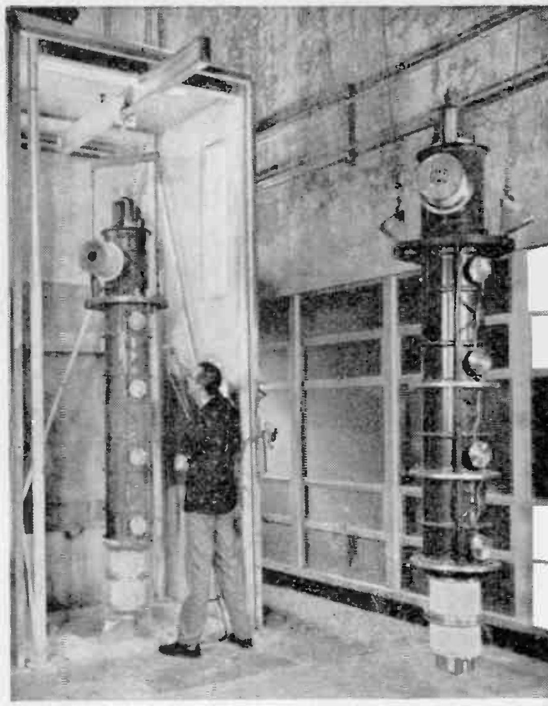
At Thule station staff are protected against possible radiation hazards by the provision of screened passages linking all buildings on the one mile-square site.

The three stations when completed will have an overall range of some 3,000 nautical miles, which is ten times that of the DEW (Distant Early Warning) line which was established across the North American continent some time ago.

Reliability of the whole system is of paramount importance. To ensure continuous operation all equipment is duplicated and there is an elaborate system of checking and monitoring installed.

Some idea of the magnitude of the whole BMEWS project can be gained from the following statistics given by the American Department of Defense. Although R.C.A. is the "prime contractor" for the project with Western Electric responsible for the communications network, there are 2,900 sub-contractors. The permanent staff at Thule when it becomes operational will be about 1,000 and at Clear about 600.

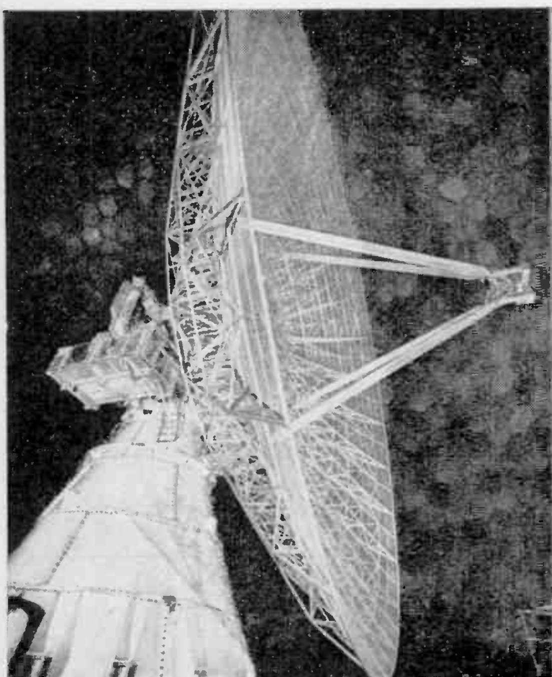
The estimated cost of the whole project is over $950M; about half this sum being for the Thule site.

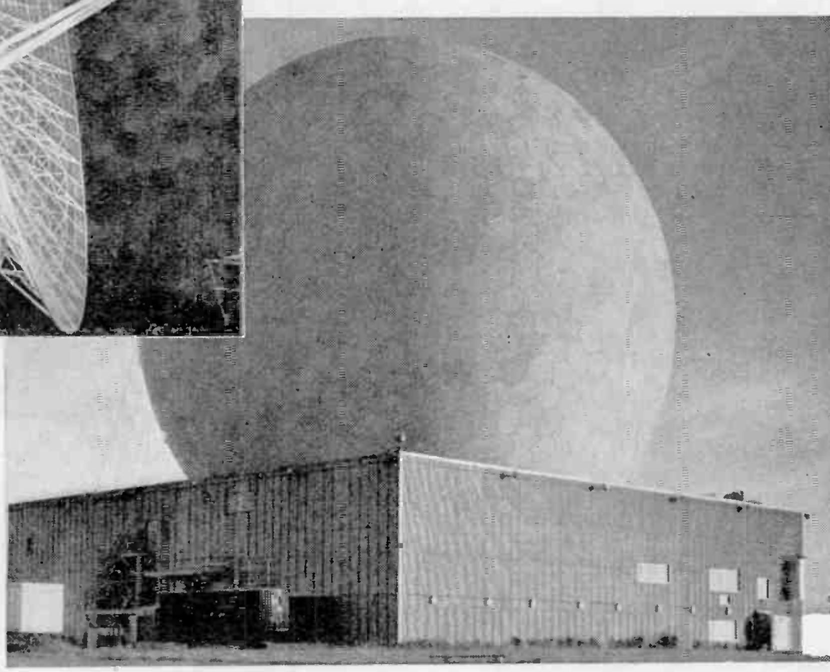


High-power klystrons for the BMEWS project.

The cost to the U.S. Air Force of the Fylingdales site is $114M.

At the Thule site power during the construction of the station and subsequently for the operation of the system is supplied by a U.S. Navy generator ship—incidentally, the heat dissipated by the generating equipment keeps ice from forming in the basin in which the vessel is anchored.





Scanner of the tracking radar inside its 140-foot radome. Note the sectional construction of the sphere. On the right is the prototype radome housing the tracking radar atop its transmitter-computer building at the R.C.A. experimental establishment at Moorestown, New Jersey. The buildings and radome to be built at Fylingdales, Yorkshire, will be of similar construction.

BETTER CIRCUIT DIAGRAMS

By PATRICK HALLIDAY

SHOULD WE ADOPT CONTINENTAL CONVENTIONS ?

ASK any service or maintenance engineer which part of a service manual is the most important: infallibly the answer will be "the circuit diagram." Without it the engineer is like a sailor without a chart; with it—no matter how little other information may be available—the skilled man will be prepared to tackle the most complex unit. But do British equipment manufacturers always make their main circuit diagrams as clear and as informative as possible? Here the answer will be no less certain—in many, too many, cases an unequivocal "no."

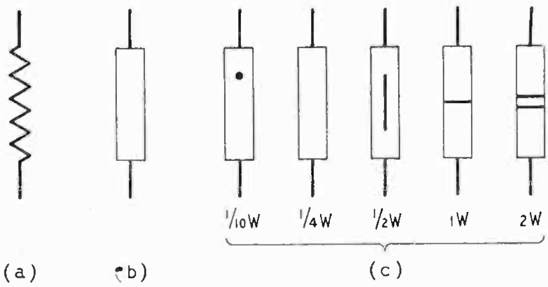


Fig. 1. The "common or garden" fixed resistor, (a) as cultivated in Britain, (b) the less elegant but equally distinctive Continental variety, (c) a Continental bunch, complete with wattage coding.

For more than a decade, drawing offices have had as their guide British Standard 530:1948, "Graphical Symbols for Telecommunications," together with a series of supplements, now six in number. Even the most casual inspection of the circuit diagrams actually used in maintenance manuals by British electronic firms will show, by the great diversity of styles, that so far this Standard is accepted fully by only a small percentage of draughtsmen—or at least of those who determine the house styles. But are the circuit diagrams, even when drawn in accordance with B.S. 530, as informative as they might be? And do they not represent far too much wasted time and effort in the drawing offices? It is illuminating to compare traditional British circuit conventions and symbols with those now coming generally into favour on the Continent, more especially in Austria and Germany. The best European circuit diagrams (and it must be admitted immediately that there are many very bad ones) may look strange and unattractive at first to British eyes, but they offer substantial advantages both to those who must pay for their production and to the ultimate user, once he has familiarized himself with their codes and circuit symbols.

In British practice, the resistor—possibly the most common of all components—requires upwards of nine separate lines (see Fig. 1 (a))—and over-enthusiastic draughtsmen, proud of their ability to produce a mathematically correct zig-zag, not infrequently extend them to as many as seventeen or eighteen bends. If the wattage reading of the resistor is to be indicated, it must be written out alongside the symbol, adding time and clutter to the diagram. The unadorned rectangular box of the Continental diagram, Fig. 1 (b), is not only simpler to produce (particularly with a stencil), but opens the way to providing wattage information with a minimum of effort. Fig. 1 (c) shows a commonly used code which can quickly be added to the box, reproduces well and requires no extra space.

Fixed capacitors or condensers (for, despite all the efforts of the powers that be, the old term still marches gaily on) are drawn basically similar the world over (Fig. 2 (a)); but the overseas draughtsman seems much more inclined to throw in additional information for good measure. In the United States, it is common practice to indicate the correct connection for the "earthy" side (outer foil) by using a curved line on one side: Fig. 2 (b). On the Continent, the correct voltage rating is often indicated by means of simple codes; a representative code is shown in Fig. 2 (c). The objection may be made that, when reproduced by printing processes, small dots may appear or disappear accidentally; in practice this would seem to be no more bothersome than the many other potential sources of error.

The widespread Continental adoption of the nanofarad unit of capacitance (1nF=1000 pF or 10^{-9} farad) is yet another valuable aid in cutting down

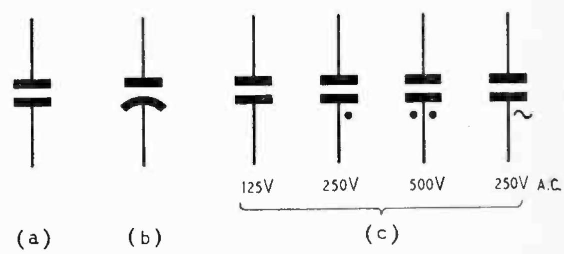


Fig. 2. How the familiar two-line capacitor symbol can be adapted to provide additional information: (a) standard; (b) indication of outer foil connection; (c) a representative voltage rating code as used on the Continent.

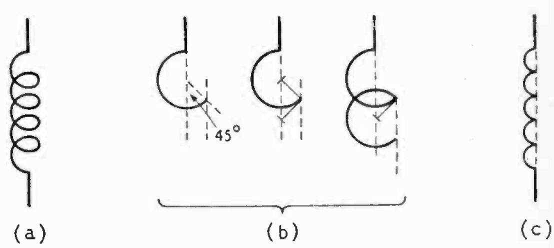


Fig. 3. Coils may look like (a), but to draw this symbol accurately is not simple—one way is shown in (b) which is not so quickly accomplished as the straightforward half-circles (c) now widely used on the Continent and in the United States

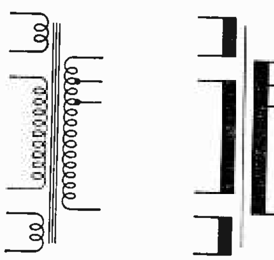
drawing time and circuit clutter when showing component values on circuit diagrams rather than relegating them to a separate component list—a practice which, though leading sometimes to overcrowding of the diagram, is generally popular with service and maintenance engineers, especially where the complete wattage or voltage specification can be given. More and more drawings for service manuals, British and foreign, now include on the main diagram the valve pin numbers and typical check voltages, as well as component values. With the nanofarad, such values as 0·003 μF, 0·02 μF need be shown only as 3n, 20n, retaining μ for values of 0·1 μF and above. Incidentally, why do so many firms persist—despite paragraph 36 of B.S.530—in adding μ, F or H after every value? It is a long time now since even the Royal Navy abandoned its beloved jars of capacitance.

Then there is the question of inductive components. Here Continental and American practice scores on production time, if for no other reason. Fig. 3 (a) shows the traditional British symbol for all forms of inductors. To produce this accurately on the drawing board requires a procedure along the lines indicated in Fig. 3(b). Compare this with the symbol now finding increasing favour on the Continent and in the United States—Fig. 3(c)—which is just a series of half circles but which is every bit as distinctive as the traditional symbol (often, in fact, clearer when reproduced on a small printing block which may cause the small loops of the British symbol to fill in).

Audio-frequency and mains transformers take a considerable time to draw accurately with the loop system of Fig. 4(a), particularly by draughtsmen whose ambition it appears to be to include almost as many symbolic turns as there are real ones. The Continental style, Fig. 4(b) may look a little uglier at first—but how much easier to produce! And immediately distinguishable from other types of transformers.

To come down to earth (or chassis) on the Continent requires only one small line—Fig. 5(a)—compared with our four (Fig. 5 (b)). Indeed the main chassis line is frequently omitted altogether, again simplifying production, though—to some British eyes—often resulting in a rather untidy and difficult to follow circuit diagram.

The sum total of the time spent in British drawing

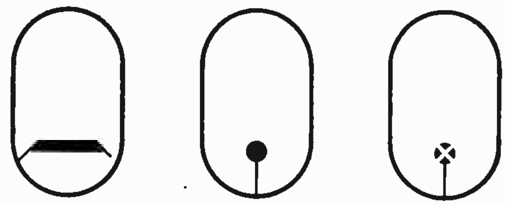


(a) (b)

Fig. 4. Will export orders wait while your drawing office painstakingly produces the mains transformer (a)? Your European rival may beat you to it with the simply produced (b).

(a) (b)

Fig. 5 The single line of (a) takes less time to draw than the four lines of (b).



(a) (b) (c)

Fig. 6. Sketch (a) may seem a distinctive cathode, but (b) is quicker to draw, and in the form (c) provides additional information.

offices in producing carefully shaped valve cathodes (Fig. 6(a)) in accordance with British Standards—sensibly not done, one notices, by *Wireless World*—would surely make any organization and methods man come down heavily in favour of the Continental short-cut (Fig. 6(b)). A useful additional feature of this symbol is that it can easily be adapted to indicate that a particular cathode is common to other parts of a multiple valve (Fig. 6(c)).

One should perhaps not be too hard on British traditional conventions: in the best examples the circuit diagrams look good, are easy to follow, and keep many draughtsmen contentedly exercising their skill—even if so many of the lines they draw are unnecessary and add nothing to the information conveyed to the user. But keep those Time and Motion Study people out of the drawing offices, or many firms may finish up—despite B.S. 530—adopting some at least of the Continental practices.

CLUB NEWS

A mobile rally is being organized jointly by a number of clubs in the southern counties for July 17th. It will be held at Beaulieu Motor Museum, near Southampton. Control stations G3IVP/A (1980kc/s) and G2HIF/A/(144.13Mc/s) will be operating from 10.30 a.m. Programmes of the Southern Counties Mobile Rally, costing 6d, are available from R. Bassett, 42 Northam Avenue, Shirley, Southampton.

Prestatyn.—Meetings of the Flintshire Radio Society are now held at the Ffrith Hotel, Ffrith, Prestatyn, at 7.30. At the meeting on July 4th, T. A. P. Colledge, of the G.P.O., will talk on subscriber trunk dialling. On the 25th the club is holding a 160-metre d.f. hunt.

Tunbridge Wells.—The second of a series of talks on 2-metre operation will be given to members of the West Kent Amateur Radio Society by the president, W. H. Allen (G2UJ), on July 22nd. The club meets on alternate Fridays at 7.30 at Culverden House, St. John's, Tunbridge Wells.

"The Eyes of the Few"

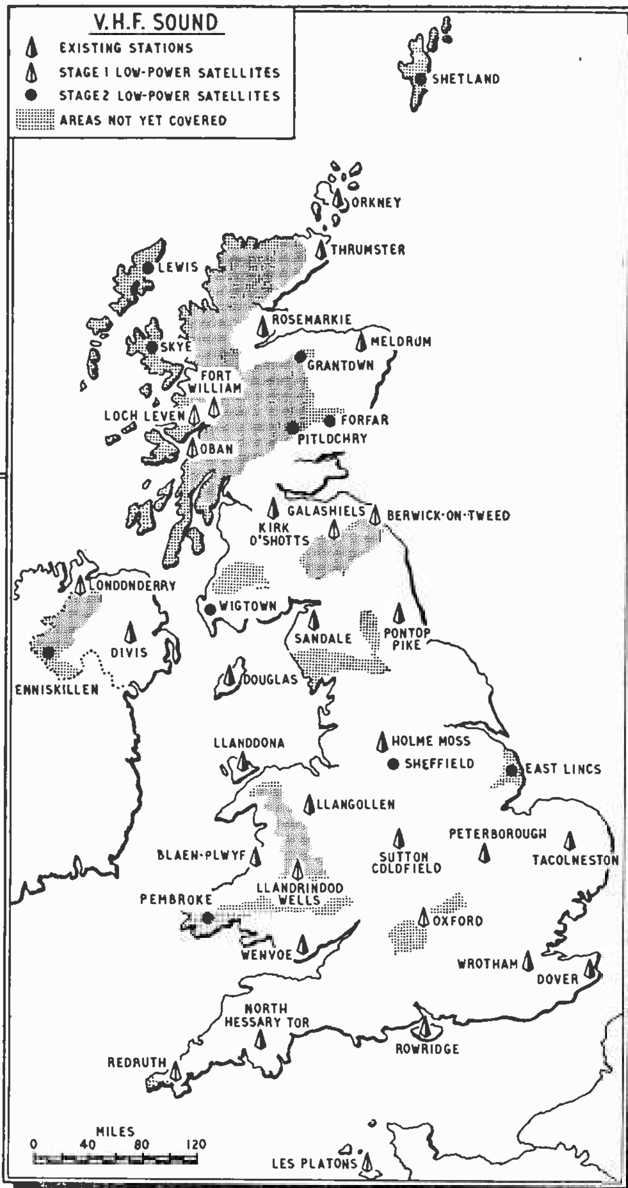
THE many *Wireless World* readers who served in the wartime R.D.F. system (radar to newcomers) would be well advised to take this book* on holiday with them. If, like the author—Daphne Carne, *née* Griffiths—they spent 1940 in the active Kent and Sussex sector, they may find it almost unbearably nostalgic. Unpretentiously told, this account of the experiences of a W.A.A.F. R.D.F. Operator is vivid and exciting. Those who were not there to see for themselves should find it not only entertaining and at times moving but also informative concerning an essential and none-too-well publicized part in the saving of the world from Nazi domination.

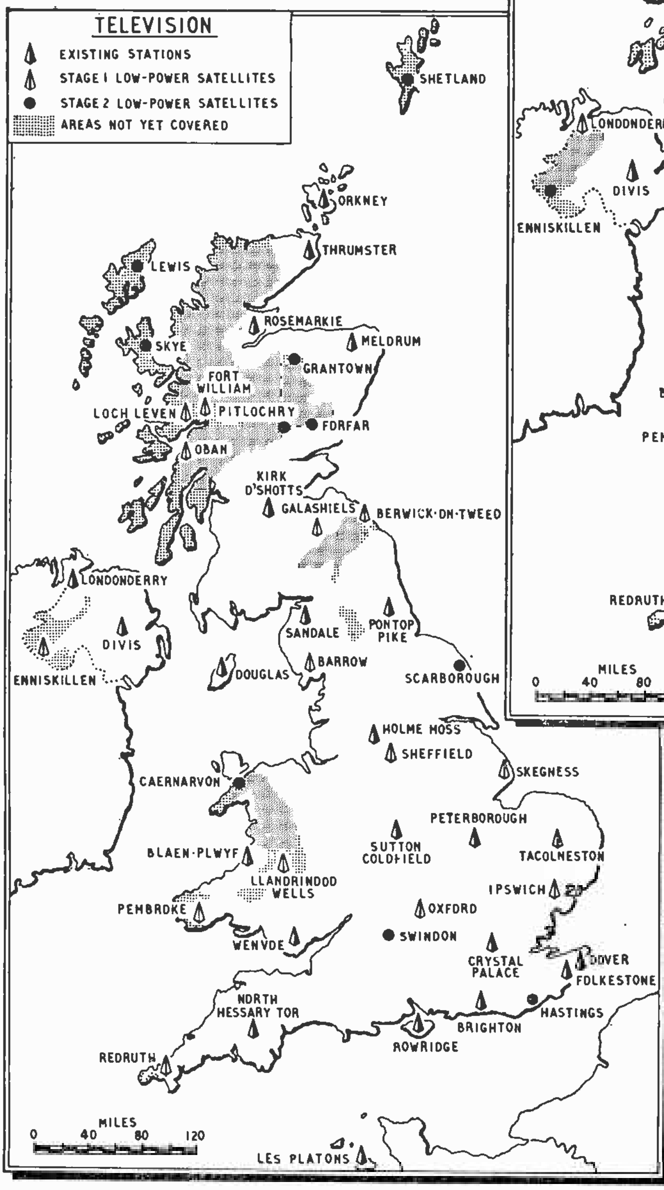
M. G. S.

*P. R. Macmillan Ltd. 15/-. pp. 238. 14 illustrations.

B.B.C. SATELLITE STATIONS

THE coverage of the present 23 B.B.C. television stations is about 98.8% of the population, though this figure includes people in some areas where reception is, at times, subject to severe interference. When the 14 stations (marked stage 1 on the map below) announced last year, come into service by March, 1962, a further 200,000 people will come within the service area and about a million will have an improved service. The P.M.G. has now given "approval in principle" to the second stage of the B.B.C.'s plans for extending and improving





television coverage. This provides for a further 10 satellite stations, which, when completed early in 1964, will bring television to about another 100,000 people and improve the service for a further 400,000.

Plans have also been announced for extending the v.h.f. sound service. The coverage of the existing 20 stations, most of them providing a three-programme service, is a little over 97% of the population. Stage 1 of the v.h.f. satellite scheme (see above map) which is also scheduled to be completed by 1962, adds a further 10 stations bringing the service to a further 640,000 people. The 11 satellites to be erected by 1964 under Stage 2 will bring the service to another 350,000 people.

Pickup Design

By J. WALTON*

RELATIVE IMPORTANCE OF VARIOUS FACTORS

VARIOUS excellent articles have appeared from time to time on one or more of the factors mentioned here, so that it is not proposed to enter deeply into these factors in themselves, but rather to try to indicate their relative importance.

This is attempted as a result of observing how such articles sometimes cause those who do not have the facilities or time to make quantitative comparisons to attend to a particular feature in a manner that is disproportionate to its overall effect on the performance of the gramophone.

Pickup Arm Length and Stylus Tip Radius

I am starting with "tracking error" since this seems to be a common source of care and of a desire for longer pickup arms in systems with a far greater source of distortion, namely the size of stylus tip employed.

Now if we accept the maxim that a chain is as strong as its weakest link, and we also wish to play the last ten minutes or so of our precious l.p. records, then we must consider the fact that the size of the stylus tip is the factor causing the greatest distortion in *any* type of gramophone pickup.

The distortion due to tracking error is given by H. G. Baerwald[1] as

$$\eta_2 = \frac{V\alpha}{u} \times 100$$

where η_2 is the percentage second harmonic distortion, V the peak recorded velocity, α the tracking error in radians and u the groove speed.

Let us then consider a moderately large signal at the *inside* of the record where tracking error will do its worst: say 5 cm/sec r.m.s. lateral velocity when the diameter is $4\frac{3}{4}$in on a record rotating at $33\frac{1}{3}$ r.p.m., and a tracking error of 4 degrees. Then the groove velocity

$$u = \frac{4{\cdot}75 \times 3{\cdot}14 \times 2{\cdot}54 \times 100}{3 \times 60}$$

$$= 21 \text{ cm/sec}$$

$$\text{so that } \eta_2 = \frac{5 \times 1{\cdot}41}{21} \times \frac{4}{57} \times 100$$

$$= 2{\cdot}3\%$$

which, after correcting for the recording characteristic,

$\approx$ **1·3%** (second harmonic)

Now, according to H. E. Roys[2], the main component of the lateral tracing distortion is given by

$$V_{D3} = \frac{3(\pi r f)^2 V^3}{4u^4}$$

where V_{D3} is the third harmonic distortion velocity, r the stylus tip radius and f the frequency.

And, if V_{D3} is small, this is approximately equivalent to

$$\eta_3 = \frac{3\,(\pi r f V)^2 \times 100}{4u^4}$$

where η_3 is the percentage third harmonic distortion.

Take the same signal of 5 cm/sec and the smallest available stylus radius of 0·0005in (which according to usual manufacturing tolerances is likely to be nearer 0·0006in). Since the distortion here depends on frequency, we will take a moderate 3kc/s.

$$\text{Then } \eta_3 = 75\pi^2 \times \frac{(0{\cdot}0006 \times 2{\cdot}54 \times 3000 \times 5 \times 1{\cdot}41)^2}{21^4}$$

$$= 4\%$$

which, after correcting for the recording characteristic,

= **1·6%** (third harmonic)

i.e. with 5 cm/sec r.m.s. velocity at 3kc/s, the distortions from a 4-degree tracking error and from a nominally $\frac{1}{2}$-thou stylus are about the same.

Moreover, we may say that below such figures where tracking and tracing distortions are equal they are both of little importance for practical hi-fi purposes.

Distortion figures above this point, however, are attained at an enormously greater rate in the case of tracing distortion than in the case of tracking error distortion.

For instance by the time one "reaches" even 10cm/sec at 4kc/s, we get 12% tracing distortion and 2·6% tracking-error distortion, even for a nominally $\frac{1}{2}$-thou tip, and a nominally 0·0007-in tip gives 20% tracing distortion. However, I must say that where the values calculated are *extremely* large, they are not *so* large by measurement.

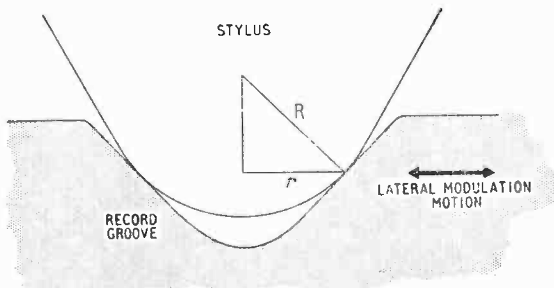


Fig. 1. "Effective stylus tip radius" (r) for lateral modulation.

Since an 8-in arm can give a $2\frac{1}{2}$-degree tracking accuracy, and certainly better than 4 degrees even with manufacturing tolerances, there would appear to be no advantage in exceeding 8in unless the stylus tip radius can also be reduced to well below 0·0005in.

Whilst considering tracing distortion, I would like clarification upon whether or not the change in the effective stylus tip radius with modulation adds another variable to the equations. Lateral modulation motion would appear to me to give

* Decca Record Co. Ltd.

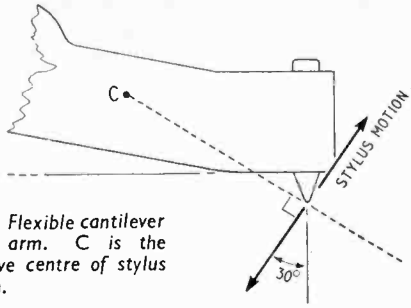


Fig. 2. Flexible cantilever stylus arm. C is the effective centre of stylus motion.

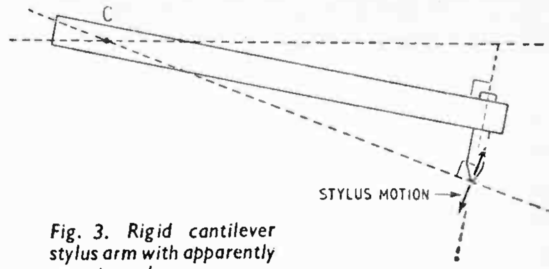


Fig. 3. Rigid cantilever stylus arm with apparently negative rake.

significance to the dimension r (see Fig. 1) which I call the " effective stylus tip radius." This is $1/\sqrt{2}$ times the actual radius R for a 90 degree unmodulated groove, but is modified to a higher value by the pinch effect.

Thus the effective stylus tip radius would appear to me to be an extra variable in the lateral case, but not in the stereo case of a 45 degree movement. However, the effective tip radius is the larger (equalling the actual radius) for stereo, and this must be a factor giving greater distortion in stereo reproduction, unless, of course, the correspondingly smaller actual tip radius is used.

I would conclude this section by saying that since only lighter tracking-weight pickups allow of smaller stylus radii on account of their effect on wear, a gramophone pickup must primarily be assessed on its genuine tracking weight and tip radius.

Needle Trail, Vertical Tracking and Stereo

Again, if the effect of tracking error was serious, we should be in greater trouble with *vertical* tracking errors in stereo pickups than has actually appeared to happen, since a difference of 23 degrees of " vertical " tracking angle occurs between the cutterheads of one manufacturer and another, to say nothing of differences between different pickups, and a further 15 degrees change between the top and bottom records in a changer.

It is not my intention to belittle these discrepancies. On the contrary, I am at present trying to correct the vertical motion of a flexible transmission arm similar to that described in the April 1959 issue of *Wireless World* (p. 182). Since the whole stylus arm flexes here, an effective centre of rotation can be found which determines the instantaneous direction of motion of the stylus tip.

For the arrangement shown in Fig. 2; as used in a typical mono head, the " vertical " motion is at 30 degrees to the vertical. This is unimportant in the mono case since the actual forward movement due to the lift produced by pinch effect is too minute to add any significant further tracing errors, but the departure from vertical motion must be very much reduced in a stereo pickup.

Let me take this opportunity of discussing the effective centre of rotation in relation to cantilever stylus arms in general, and needle trail in particular.

Any normal cantilever arm will have an effective centre for the stylus motion, and not only will this govern the direction of " vertical " motion of the stylus, but it will also give the effective trail of that stylus.

Now it has long been considered advantageous to have a small amount of needle trail, and some cantilever styli have been criticised on this basis when the rondel has been mounted with an apparently " negative rake " (as in Fig. 3). But surely the original purpose of " positive rake " as it was applied to the older type of needle (as in Fig. 4(a)) was to ensure that any forward drag at the stylus tip did not cause the stylus to dig further into the groove (as in Fig. 4(b)) with a cumulative effect upon this drag and its resultant digging.

The cantilever shown in Fig. 3 is, however, completely exonerated if its flexing centre is at C as shown, for it then has in fact an effective positive rake of about 70 degrees. This does not, however, exonerate the cantilever from having a 20 degrees to vertical " vertical " motion if it is to be used for stereo.

Vertical Compliance and Tracking

It could be imagined that the " hill and dale " aspect of stereo where there is no restriction in the vertical *downward* direction could lead to a condition where the groove receded from the stylus at a more rapid rate than that at which the compliance could cause the stylus mass to follow. It might be thought also that mechanical resistance to motion of the stylus arm could give an even more stringent tracking condition, and that all these problems were something not encountered in lateral recording in which two groove walls " direct " the stylus.

It can be shown, however, that there is no essential difference between the lateral and vertical cases, since not only are the groove walls at 45 degrees to both the vertical and horizontal, but also the friction, particularly at low tracking weights, is too low to make any appreciable difference between the lateral force required to make the stylus ride up out of the groove and the vertical force required to make the stylus leave the groove in a frictionless manner as in the " hill and dale " case.

Consider Fig. 5. For static equilibrium the upward reaction force F on the stylus tip of mass m must equal the tracking weight, and m must also be subject to an equal downward force F. If the groove is *suddenly* lowered then the acceleration α of the

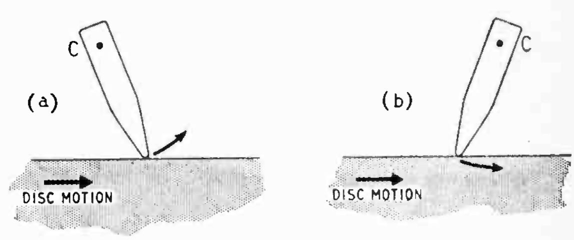


Fig. 4. Older-type styli with positive (a) and negative (b) rakes.

stylus tip mass m is given by $\alpha = F/m$. Thus the acceleration is not dependent upon the compliance but on the tracking weight and stylus mass, provided that the displacement of the stylus is too small to appreciably alter F.

In fact the groove displacement at 8 kc/s and a peak recorded velocity of 22 cm/sec is $22 \div (2\pi \times 8000) =$ **0.00044 cm.** Now consider a 1-gm pickup with an effective stylus tip mass of $\frac{1}{2}$ mgm and a compliance of 25×10^{-6} cm/dyne. The static displacement of the stylus as the pickup is placed on the record is **0.025 cm.** Thus the above condition that the groove displacement be too small to appreciably alter the 1 gm force on the stylus is fulfilled. The stylus acceleration is thus 2000g, which is nearly twice that of the groove ($2\pi \times 8000 \times 22$ cm/sec$^2 \approx 1100$ g), and the tracking possibilities thus remains as for lateral modulation.

Mr. R. W. Bayliff in as yet unpublished work relating to the Decca stereo pickup has pointed out that a *stiffer* vertical movement can give a greater tracking capability, for a given effective stylus tip mass and tracking weight, in that portion of the upper middle register where the vertical compliance

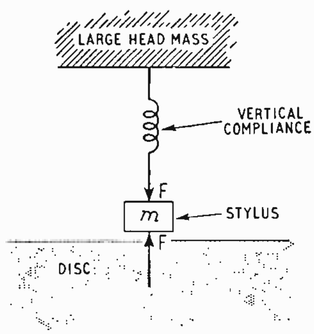


Fig. 5. Stylus tip mass (m) in static equilibrium. F is equal to the tracking weight.

resonates with the effective tip mass. But this does not alter the main argument, nor that a *greater* compliance gives a greater tracking possibility at all frequencies below this resonance and that a lower tip mass gives better tracking above this resonance.

If resistance is now introduced into the stylus arm, this will have its greatest effect at maximum velocity (zero acceleration with a sine wave) and have no effect at zero velocity (maximum acceleration). Thus the vertical tracking condition is as before, and provided that the maximum force due to resistance is not greater than that due to stylus inertia or cantilever stiffness then no additional tracking weight is required.

It might be said, however, that to cope with a peculiar case where the effects of maximum velocity, acceleration and displacement all occurred together, then a tracking force corresponding to the sum total would be required.

There would also appear to be the possibility of an integration of upward signal impulses by the momentum of the head so as to require extra tracking weight thereabouts. This of course applies also in lateral recording in the form of integration of impulses not only of vertical pinch effect movements but also of extra forward drag due to modulation, this integration being converted into side thrust that tends to push the stylus out of the groove so as also to require extra tracking weight. However, due to

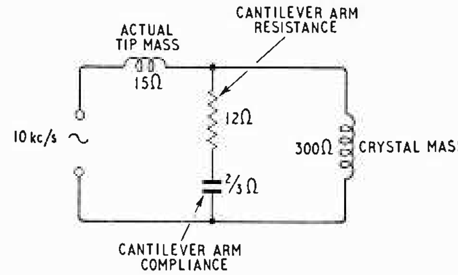


Fig. 6. Simplified mechanical impedance analogue of a flexible cantilever arm pickup. Typical impedance values at 10kc/s are shown.

the pickup arm geometry, the side thrust here will only be about one-fifth of the forward drag. Thus although the stylus arm resistance may be limited in magnitude to, and entirely out of phase with, the other factors of mechanical impedance for sine wave motion, then even in that motion, the resistance and impedance could conceivably have a combined effect in their integrated sum.

And we could probably continue " in ever decreasing circles " discussing this and that smaller and smaller points, but the problems of producing a high-fidelity stereo pickup do not, I think, yet warrant this.

Groove Speed and Record Wear

Since most record deformation normally takes place at points of maximum acceleration or displacement, it would appear therefore that the inclusion of a substantial amount of resistance in the stylus arm will not decrease the life of a record.

I might mention that the increase with age of the resistance of p.v.c. must be taken into account in most of the pickups in use. This increasing resistance may also alter the effective stylus impedance at high frequencies as shown by Fig. 6.

When considering record wear in a theoretical way we have usually started from Hertz's equations for a static indenter in the elastic range, and a conception of record wear is then evolved around the " mean pressure " under the indenter (thus the pressure is assumed to be inversely proportional to the square of the stylus radius). Now not only does this assume a direct relation between mean pressure and wear, and so does not take into account any wear due to the greater impact of a larger stylus radius in a smaller groove curvature (i.e. under conditions of high tracing distortion) but it does not even take into account the linear speed of travel of the stylus in an unmodulated groove.

I hope to be able to present some experimental results in the near future on these last aspects and their general relation to the gramophone record. Results so far obtained indicate that recourse to lower turntable speeds would be severely detrimental not only to quality (distortion varying inversely as the fourth power of the groove speed) but also to record life, and that other means of gaining playing time are both possible and preferable.

REFERENCES

1 *Jour. Soc. Motion Picture and Television Engineers*, Vol. 37, Nov. 1941, p. 591.
2 *R.C.A. Review*, Vol. 10, June 1949, p. 254.

Ohm's Law and Negative Resistance

—AND THE LAW THAT KIRCHHOFF FORGOT TO INVENT

By "CATHODE RAY"

SPECTATORS of the recent duel between D L. Clay and myself in the correspondence columns no doubt noted with interest Mr. Clay's shrewd thrust with my own weapon dated August 1953. To alter the metaphor, he used my own voice to pronounce me dimmer than a beginner. Must I accept this unflattering assessment, or alternatively eat my 1953 words? The dilemma is unattractive. Being a generous opponent, however, Mr. Clay invited further explanation. This course (assuming the Editor is equally generous with space) I elect to adopt. Quite apart from the obvious possibilities of a verbal smokescreen for evasive action, further explanation appears to be justified for the following reasons. With youth now at the helm, what Cathode Ray said in 1953 must seem almost as far-off as what Gladstone said in 1888. Next, in a misguided attempt to be brief, what I said (or didn't say) in last February's issue evidently left room for Mr. Clay—and maybe others—to find obscurities and contradictions. And the whole thing has convinced me that Ohm's law is even more treacherous than I thought, and that is saying a lot.

First of all (summarizing the 1953 contribution) we must say what we mean by "Ohm's law." My guess is that what most people mean is

$$I = \frac{E}{R}$$

(or its equivalent, $E=IR$ or $R=E/I$) in which E is the e.m.f. in volts required to drive a current I amperes through a resistance R ohms. Though undoubtedly a useful piece of information, this would have looked very strange indeed to Dr. Ohm, who would have been at a loss to account for his name being attached to it, since volts and amperes had not been invented in his lifetime and the ohm was a unit of wine, equal to about 40 gallons and therefore presumably beyond the means of a struggling teacher. Even the concepts of e.m.f. and resistance would have been novel to him. So much so that it is not easy for us, saturated in "Ohm's law," to follow just what it was that Ohm discovered. Put into modern terms, it seems to have been that the ratio of e.m.f across a conductor to current through it (i.e., its resistance) does not vary with the amount of current, provided the temperature is constant.

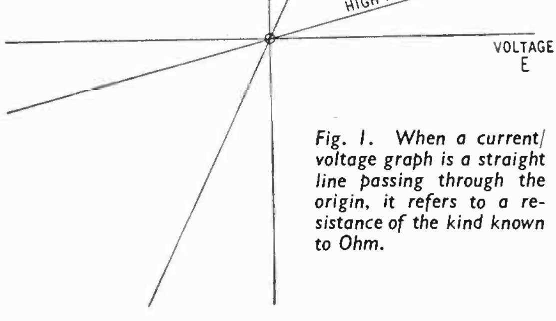


Fig. 1. When a current/voltage graph is a straight line passing through the origin, it refers to a resistance of the kind known to Ohm.

Note that *our* "Ohm's law"—$R=E/I$—says nothing of the kind. For all it knows, R may be variable. In these days of semiconductors it often is. But Ohm's experiments were carried out on metal wires, and the constancy of their resistance has been confirmed within very much closer limits than were possible with his crude apparatus.

It is probably too late to make "Ohm's law" mean what Ohm meant, which is true for metals but not for semiconductors or insulators. We call metallic resistances "ohmic" or "linear" (because their current/voltage graphs are straight lines passing through the origin). But "Ohm's law" in present-day usage is simply a convenient formula, relying on a system of units Ohm never knew, and true for any kind of conductor, linear or otherwise. It can also be regarded as a definition of resistance.

However, the thing is not quite as simple as that, because *sometimes* "Ohm's law" must be understood to imply the "law of Ohm" (as we may call what Ohm meant). For instance, an elementary exam paper might say "The current through a 500-Ω resistor is 0.3A; use Ohm's law to find the voltage across it." This obviously means the well-known formula, and it would make no difference to the answer if the resistor disobeyed the "law of Ohm." But if the question were "When 150V is applied to a resistor the current is 0.3A, what is with 40V?" one would have to assume the resistor obeyed the "law of Ohm" to be able to answer it at all. A knowledge of the system of units used is unnecessary, whereas the answer to the first question would depend on the units (e.g., it could be 150V, 0.15kV, 15,000,000,000 e.m.c.g.s. units, or 0.5004 e.s.c.g.s. unit).

There are some other circumstances to be understood. Ohm's experiments were carried out with d.c., and that is generally taken for granted in connection with "Ohm's law" too. Fig 1 shows current/voltage graphs for two resistances, which can both be recognized as ohmic by their straightness. It doesn't matter how much e.m.f. is applied (so long as the temperature is not altered appreciably); its ratio to the current gives the same resistance every time. Reversing E (i.e., multiplying it by -1) reverses I too, so we have the continuations towards the bottom left.

Fig. 2, which is the sort of result we might get with

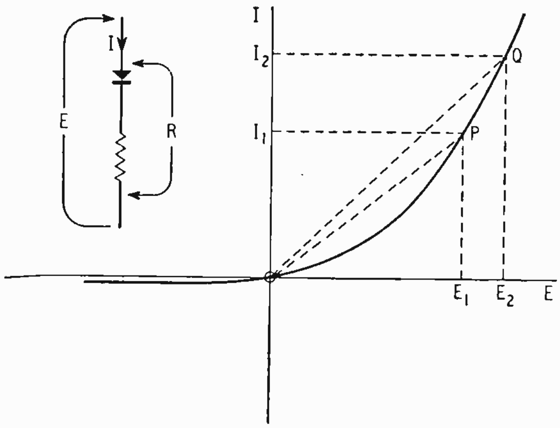


Fig. 2. Many circuit elements now in common use have resistances that do not follow the pattern of Fig. 1. Though non-linear to d.c., they may be at least approximately linear to a.c. within limits, as for example P to Q here.

an ohmic resistor in series with a germanium rectifier, is quite different. E_1/I_1 gives one value of resistance, which anyone ignorant of non-ohmic resistances would assume to be representable by the dotted line OP. Increasing the voltage to E_2 causes a disproportionate current increase to I_2, so the calculated resistance E_2/I_2, represented by OQ, is less. Neither of them is the resistance most likely to interest us in this more sophisticated era, when E might consist of a steady voltage half-way between E_1 and E_2, plus an alternating voltage with peak value $(E_2-E_1)/2$. The latter would alternate between E_1 and E_2, and the corresponding part of the current would alternate between I_1 and I_2. So far as this current is concerned, the resistance (being represented by the nearly straight line PQ passing through the *a.c.* origin) is almost ohmic, and less than either of the d.c. values. It is known as the a.c. or incremental resistance. The poor beginner is usually left to guess from the context whether "resistance" means the d.c. or the a.c. kind.

The next complication is that the circuit may contain reactance. In point of fact, it is bound to; but what I mean is that the reactance may be enough to have an appreciable effect on the amount of a.c. flowing. Now there are various ways of handling this. A common one in elementary textbooks is to produce the following (or something equivalent) as "Ohm's law for A.C.":

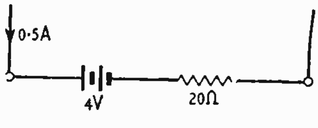
$$I = \frac{E}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

Having now gone on record as accepting, however reluctantly, "Ohm's law" as meaning "I= E/R", I will no doubt be exposing myself to attack from Mr. Clay if I object to the above on the ground of its being outside the experience of Dr. Ohm. In self-defence I might claim that it is wildly remote from his experience. But my main objection is that it brings in a new principle. To teach beginners that reactance is just a special kind of resistance that applies only to a.c. (as some books do) may make it look easier at first but is likely to make things more difficult later on. I would be inclined to emphasize that reactance is something quite different from resistance, even though it is reckoned in ohms and mixed up with it in impedance. The reason is that resistance is essentially something that takes any electrical energy it can lay its hand on as an outright gift, whereas reactance accepts it only as a short-term loan, scrupulously paying it back in full within a single a.c. cycle. (Idea for a chapter title in Cathode Ray's Monster Nursery Book of Electrical Theory—"The Story of the Bad Mr. R and the Good Mr. X." Including, of course, "Pat-a-cake, pat-a-cake, Vector's Man; Turn it through half pi and mark it with 'j'"). Anyway, just now resistance is enough to be thinking about, without complicating the issue with reactance.

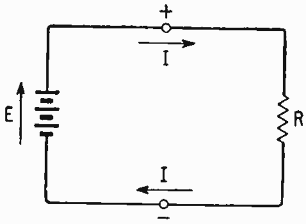
For we are coming to the bit that was turned against me. I said (in 1953) "that it is no good trying to apply Ohm's law to a circuit containing an e.m.f.—at least, not without allowing for the e.m.f. If E=IR were applied to find the voltage between the terminals [in Fig. 3 here] the answer would be 0.5×20=10. But the measured voltage would be 14. The reason for this discrepancy is obvious, and even a beginner would have to be rather dim to fall into the trap." So I suppose it really was asking for trouble to offer (in 1960) the diagram reproduced here as Fig. 4, and, having requested the audience to look between the terminals eastwards to see a positive resistance R, proceed to turn them around facing the battery and suggest that it appears to be a negative resistance—even with the proviso "not an ohmic one in this case!". Being more modest than you might think, I had not imagined the possibility of anyone following my utterances with such attention as to be able instantly to quote any of them made within at least the last seven years. I hope it will be a lesson to me.

Mr. Clay—for none other than he is the prodigy alluded to—skilfully turned aside my defensive stroke (which was to ask what gave him the idea that I was applying "Ohm's law" to Fig. 4) by a thrust cunningly disguised as an apology. He said he was sorry he had incorrectly assumed I had used "Ohm's law" to show that a generator is equivalent to a negative resistance, but it was the only way he knew of obtaining a value of resistance from a voltage and current. And to increase my discomfiture he added that he also assumed "non-ohmic" meant "non-linear," but, as the current did not affect the voltage in any way, perhaps "non-resistive" would have been better.

"Touché," I believe, is the appropriate expression. Not that I concede having said anything actually wrong, but an explanation which left room for such



Left: Fig. 3. In measuring the real d.c. resistance between the terminals, one would have to exclude the 4-V battery



Right: Fig. 4. This is the controversial diagram. Is it legitimate to regard the battery as a negative resistance?

comments can't have been a very good (i.e., fool-proof) explanation of negative resistance. The fault was not in what I said but in what in my haste I didn't say to guard readers against the treacheries of "Ohm's law."

So let us begin with Fig. 4 again. Looking at what we have between the terminals on the right-hand side, we recognize exactly the situation we met in Fig. 1. We measure the voltage between the terminals, and find it to be equal to E. We also find a current I flowing from the positive to the negative terminal, which is conventionally the same direction. So the current has the same sign (+ or −, depending on which terminal we choose as our reference) as the voltage. We therefore have the data for plotting the two points P and P′ in Fig. 5. If we had the opportunity to vary E we would be able to plot more points, which (assuming R to be "ohmic," in the sense already defined) would all fall on the sloping straight line marked "R."

Now let us about-turn and consider the same pair of terminals from the opposite direction. Performing the same two measurements, we would find the

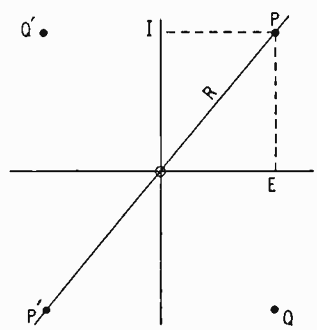


Fig. 5. P and P′ are points on a current/voltage graph of R in Fig. 4. Q and Q′ are points measured in the same way on E.

direction of the current reversed relative to the voltage, so the results would have to be represented in Fig. 5 by Q and Q′. Since P and P′ represented R, Q and Q′ must represent −R. That is what I meant by saying that the battery was equivalent to a negative resistance. The logic of the conclusion seems inescapable. Moreover, the positive resistance R is a dissipator of power; its opposite or negative should therefore be a source of an equal amount of power, and that is precisely what the battery is. And, just as according to Kirchhoff's Second Law the total voltage around a circuit (reckoning a current-carrying resistance as a negative voltage source) must be zero, in an alternative view

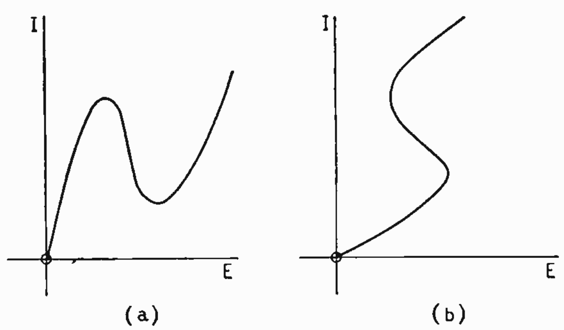


Fig. 6. Two types of current/voltage curve showing negative resistance.

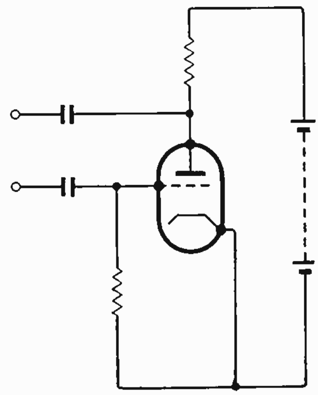


Fig. 7. A practical "negative resistor."

the total resistance around a circuit (reckoning a voltage source as a negative resistance) must be zero. And, just as the negative voltage source in Kirchhoff's law is a rather peculiar one, depending entirely on the current, so my negative resistance is (as Mr. Clay pointed out) an analogously peculiar one. If we had the opportunity to vary R, the additional points would not lie on the straight line joining Q′ to Q. They would, of course, be on vertical lines through Q′ and Q. That was why I warned readers not to expect an ohmic resistance. And since this is only an extreme case of the sort of thing we found in Fig. 2, I am sticking to that, rather than Mr. Clay's "non-resistive." For the equivalent negative resistance of the battery is found by "Ohm's law," in just the way he is used to. But I ought to have warned him (and less knowledgeable readers) that an *equivalent* resistance is one calculated by applying "Ohm's law" without regard for the rule (needed for finding *real* resistances) about excluding sources of e.m.f. For example, the equivalent or apparent resistance between the terminals in Fig. 3 is 14/0.5=28Ω. The 4-V battery absorbs the same power and has the same voltage across its terminals as an 8-Ω resistor *at that current.* In fact, unless one was allowed to vary the current one could not distinguish between the battery and a resistor by any electrical test.

Just as the source of current-opposing e.m.f. in Fig. 3 is thus equivalent to a positive resistance, the source of current-assisting e.m.f. in Fig. 4 is equivalent to a negative resistance, as I hope all can now see. The point I was trying to make in this way is that a negative resistance is in effect a power source. I did not intend to convey that all negative resistances vary with current in the same way as the battery in Fig. 4 does. Practical negative resistances are negative over only a limited range of current and voltage, and fall into the two classes shown in Fig. 6, distinguished for obvious reasons as "N" and "S" types. Because of this limited range they are of interest chiefly as regards a.c. (Compare Fig. 2.) Certain valves and semiconductor devices* have characteristic curves of one or other of these types. Similar effects can be produced artificially by positive feedback in an amplifier. For instance, an a.c. negative resistance is found between the terminals in Fig. 7, and a tuned circuit connected to them is set into oscillation thereby, provided that its positive resistance isn't enough to make the total resistance positive.

* A new example is coming up for attention next month.

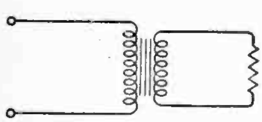
Mr. Clay and perhaps spectators around the ring may be thinking—even openly saying—that in order to get myself out of an awkward position I have been making up the rules as I go along. In 1953 I said any fool can see that one mustn't include e.m.fs when applying "Ohm's law," and in 1960 I said of course that is only for "real" resistances; for "equivalent" resistances one can. Where is there a rule about there being different sorts of resistance?

The British Standard definition of resistance (B.S.205:1943, No. 1276) says "That property of a body by virtue of which it resists the flow of electricity through it, causing a dissipation of electrical energy as heat. It is equal to the constant difference of potential applied to the ends of the body divided by the current which it produces when the body has no e.m.f. acting therein."

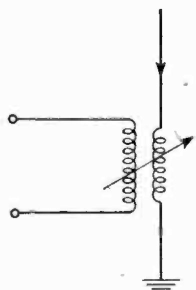
That is not only resistance in the strictly real sense, but is confined to d.c.—note the *constant* d. of p. That obviously doesn't get us very far in these days, but lower down (No. 1283) there is a definition of "effective resistance":

"Of a circuit element with alternating current. The component of the terminal voltage in phase with the current divided by the current. The power dissipated in heat divided by the square of the current."

This is really two definitions, defining quite different things. The second one agrees with No. 1276, and in fact could be substituted for it as an a.c./d.c. definition. For the power P in a d.c. resistance is given by EI, and dividing that by I^2 leaves E/I, which is "Ohm's law" again. I am assuming that the definers meant strictly the power dissipated as heat *in the circuit element* referred to. That is rather an important point, as we see if we consider Fig. 8. What is the "circuit element" to which the terminals are connected? The primary winding? The whole transformer? Or the transformer and its load regarded as one element?



Above: Fig. 8. What is the a.c. resistance between the terminals?



Right: Fig. 9. And what is the resistance between these terminals?

With any reasonably efficient transformer, the heat dissipated in the primary, or even the whole transformer, should be small. Most of the power fed in at the terminals would be dissipated in the load resistance. But if that is reckoned as a separate circuit element, its heat mustn't be counted. Its effect on the circuit between the terminals *is solely as an e.m.f.*—the e.m.f. induced in the primary by current flowing in the secondary circuit, which depends mainly on the load resistance. However, if the whole of Fig. 8 is deemed to be "a circuit element," then this e.m.f. is a purely internal arrangement for distributing the dissipation, and the definition is of the strict kind.

Note that heat is also dissipated in the iron core, because currents are induced therein, and in the insulation because of charging currents between wires, and extra "skin-effect" heat in the wires because of e.m.fs induced in them. It would be hopeless to try to find the a.c. resistance of the whole thing accurately by counting up the ohms due to all these different effects; hence the idea of doing it in one by measuring the power and dividing it by the current squared. This gives the single resistance that would run away with the same power when the same current was flowing.

How do we measure this power? Since the definition refers to power dissipated as heat, we are committed to a calorimeter measurement, which is a messy, time-consuming and (except perhaps in the N.P.L.) inaccurate business. So we are strongly attracted to the first No. 1283 definition, which allows us to measure the electrical power fed in. In this circuit it would give the right answer. But not everywhere. Consider Fig. 9. Here, if the thing is doing its stuff, most of the power is radiated. To make the two definitions agree it would then be necessary to stretch the "circuit element" to include the entire universe, which seems rather far-fetched. Or, in case the heavy old electrical engineers who composed this definition begin to murmur that of course they didn't mean this new-fangled wireless telegraphy, we can quickly silence them by passing on to the example of an a.c. circuit feeding an electric motor. The second No. 1283 definition would include only the power dissipated as heat in the motor, which should be quite small; the second would include also all the mechanical power developed by the said motor, which could be many times greater.

These are only a few of the recognized varieties of resistance, more of which are defined in B.S.204.

To sum up: It seems that in its strictest sense the resistance of any circuit or part of a circuit concerns the power dissipated as heat therein. Measuring amounts of heat is something we definitely don't want to do. With d.c. we can avoid it by using "Ohm's law," provided we carry out a preliminary frisking to make sure the thing being measured has no concealed e.m.fs. With a.c. we measure the current in phase with the applied e.m.f., but if we exclude all e.m.fs we will find ourselves excluding almost everything but standard resistors. Most often, we want to include at least all the losses, whether they come into our circuit as e.m.fs or not. We *may* want to include all permanent departures of power, such as radio waves, light, sound, etc.

No doubt it was naughty of me—even with the praiseworthy object of reducing the thing to ultimate simplicity—to begin with a d.c. circuit, Fig. 4, without explaining unmistakably that this was just as a step towards the a.c. circuits of commerce, in which "equivalent" and "effective" resistances are established conventions. Another point is that even with a.c. resistance, counting effects brought in by e.m.fs, these e.m.fs usually bear some relationship to the input current, whereas E in Fig 4 is completely independent, like the battery in Fig. 3 (apart from its internal resistance). As I have shown, the principle involved here is not fundamental, but it would have been better to have pointed out that the battery didn't behave like a practical negative resistor if the current was varied. I hope, however, that it has been justified by the bringing to light of Kirchhoff's hitherto unknown Third Law.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents

Demonstrating Electron-spin Resonance

FOLLOWING the description[1] by G. B. Clayton of a demonstration apparatus for electron-spin magnetic resonance absorption, readers may like to know of a simple modification to the circuit which enables a satisfactory estimate of the magnetogyric ratio, γ, to be made. The time required for the observation is such that it may easily be carried out in the course of a lecture, thus adding greatly to the value of the demonstration.

γ is given by the relation $2\pi f = \omega = \gamma B$ and it is the ratio of the magnetic moment to the angular momentum of the electron, not the reciprocal of this ratio as given in the article. f is the frequency of the radio-frequency oscillator, B the magnetic flux density at the sample. If f is expressed in Mc/s and B in weber/m^2 we have

$$\gamma = (2\pi f/B) \times 10^6 \text{ coulombs/kgm}$$

The frequency, f, may be measured in a convincing manner by means of a short-wave wireless receiver. A characteristic purring tone will be heard, representing a pair of absorption pulses repeated at 100 c/s.

For the measurement of the resonance value, B, of the magnetic flux density an ammeter (reading r.m.s. current) is inserted in series with the Helmholtz coils and some provision is made for varying the current continuously. This can most conveniently be done by use of a " Variac." but failing that a rheostat will do. As the current is reduced the trace on the oscilloscope screen shrinks until, for a certain value, i, of the r.m.s. current, the extremes of the trace coincide with the peaks of the absorption line. Then the field, B, is given by

$$B = 4\pi \times 10^{-7} \times (8N/5\sqrt{5}R) \times \sqrt{2}\, i \text{ weber/m}^2$$

where N is the number of turns on each coil and R is the radius of the coils in metres.

The resulting value of γ may be compared with the known value of the charge-to-mass ratio, e/m, for the free electron, namely 1.76×10^{11} coulomb/kgm, since for the unpaired electrons in diphenyl picryl hydrazyl at frequencies above 5 Mc/s,

$$\gamma = e/m$$

to a very good approximation[3].

In an actual demonstration, with an oscillator frequency of about 24 Mc/s, I obtained

$$\gamma = 1.7 \times 10^{11} \text{ coulomb/kgm.}$$

The oscillator[2] was found to work very well at this frequency without the capacitors C_1 and C_2, adjustment of the amplitude being made by varying C_0.

The University, Edinburgh. A. G. A. RAE

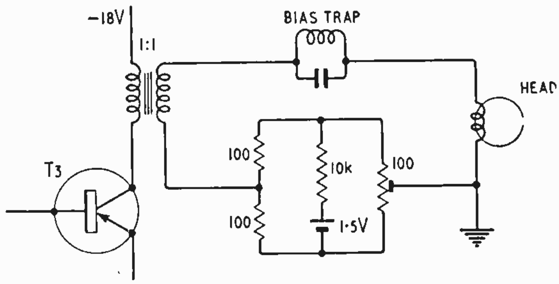
[1] *Wireless World*, Feb., 1960, p. 68.
[2] *Wireless World*, Feb., 1960, p. 70, Fig. 8.
[3] Garstens, Singer and Ryan, *Phys. Rev.* Vol. 96 (1954), p. 53.

Transistor Tape Recorder Amplifier

I HAVE just read Mr. Blick's article in your April issue and I congratulate him on an elegant solution to the problem of the recording amplifier.

Although the leakage of modern electrolytic capacitors is reasonably low, the small residual magnetization of the head would be enough to introduce noise in the recording process and harmonic distortion in the playback process. A solution which avoids this is to use a double-wound transformer in place of the reactor L, in Mr. Blick's Fig. 1. The recording head directly connected across the secondary eliminates the leakage current although not, of course, switching transients.

It is probably worth while for high-quality work including a variable direct e.m.f. in the secondary circuit



(see accompanying diagram) and to adjust this for minimum noise when playing a virgin tape. This is also the condition for minimum distortion.

Salisbury Polytechnic, S. Rhodesia. PHILIP F. RIDLER

Deeper Amplitude Modulation

MR. BLANCHARD (June issue) is no doubt correct in his facts and I have myself noticed all the effects, including the distortion. Increased percentage modulation and clipping also reduce the dynamic range, which is also observable. Furthermore, the operation of the a.g.c. system in normal sets will be affected by the increased modulation and is likely to reduce even further the dynamic range.

The practical result, in my view, would be unfortunate as it would be the fashioning of another nail ready for the coffin for medium- and long-wave amplitude modulation.

No medium- or long-wave service hinders international contacts and aids the spread of extremist nationalism but on a purely personal level I, and presumably Mr. Blanchard, find the Continental broadcasts more entertaining than those of the B.B.C. or else why roam the ether? If we really want entertainment why surrender to the evidently ever-selfish motorists?

London, N.W.11. L. STREATFIELD

V.H.F./F.M. Car Radio

R. V. TAYLOR'S article in the June issue on v.h.f./f.m. reception in a car was interesting, but having experimented extensively with this myself, and decided that it was not the answer unless operating only in small areas relatively near to a transmitter, perhaps my remarks would be of interest.

I first started some eighteen months ago, exactly as Mr. Taylor suggests, by using a standard commercial tuner feeding into the a.f. and power pack unit of an ordinary car radio. The alterations necessary to do this were very simple, consisting merely of re-wiring the valve heater. The adjustable car-radio whip aerial was set at 2½ feet, and was in what was then the normal position for such an aerial—on the offside front wing.

One of the first things I discovered was the need for far better interference suppression on the car than was ever necessary for good medium- and long-wave reception, the main trouble coming from the voltage regulation. After quite a lot of trouble, this was cured, as were other sundry crackles coming from unbonded parts of the car, although generator whine was never quite eliminated. Surprisingly enough, the ignition gave no trouble at all! When all this had been done, I found that the level of interference from other traffic was too high for comfort, but, of course, nothing could be done about it. However, the receiver worked fairly well, and was used for some time to find out whether the service area of the v.h.f. transmissions was large enough to warrant making up a receiver with better amplitude limiting. It was found with this tuner that the area within which the v.h.f. programme was of use (i.e., little fading or interference) was only a circle of about 20 miles radius. Outside this radius, in towns, flutter and distortion were much in evidence, although in the country reception was naturally better, but outside 30 miles reception was pretty poor anywhere, except, of course, on the tops of hills. Modifications were made to the tuner to improve limiting, but this only gave an increase of the good usable range to 25 miles, and the maximum usable range to 40 miles. If circles of these radii are drawn round the major transmitters on a map, the large gaps in coverage will be noted. Of course, these radii take no account of the topography, so that ranges in some directions may be better than others, but this will not materially affect the overall result.

The sensitivity of the tuner was not in question, it being possible to hear Sutton Coldfield on the South Coast, although the signal was quite useless for entertainment.

Another difficulty was that of tuning accurately, which had to be done if maximum a.m. rejection was to be achieved. Since it was obviously impossible to use visual indicators of any sort, tuning had to be done by ear, and with the slight fading experienced even in the best areas of coverage, this was quite difficult. In fact, I usually found it best to stop the car and then tune accurately.

Several Continental journeys were made with the v.h.f. tuner installed, and the situation there was even worse, due to the widespread use of low-power repeater stations. These had an effective range of about only 10 miles and when travelling on a motor-road this meant that it was necessary to re-tune (if a new station were available, that is!) every 15-20 minutes.

All these factors contrast very unfavourably with medium- and long-wave reception, about the only advantage v.h.f. having over these for car use being that when a good signal is obtainable, it is free from interference from other transmitters. The fact that better quality is to be obtained from v.h.f. is not significant for mobile reception, unless listening is confined to periods when the car is stationary—hardly mobile reception! Fading on medium waves is not a problem until ranges of 100-150 miles are reached, and then only at night, and so there are no gaps in the B.B.C. coverage of the U.K. If one can tolerate a little noise, it is possible to listen to Home or Light programmes while holidaying on the Continent, which certainly cannot be done with v.h.f. And tuning is far easier with a.m. than with f.m. if it has to be done aurally.

For these reasons I took the v.h.f. tuner out of the car some months ago, and reverted to the usual frequencies, with a certain amount of relief. Experiment with v.h.f./f.m. in a car by all means, but I don't think it's nearly as much use there as it is at home!

Tangmere, Sussex. W. BLANCHARD

WHILST many of the considerations involved have been dealt with adequately in Mr. R. V. Taylor's article, this cannot be said of the treatment of interference generated by the vehicle itself. However effective the a.m. interference rejection of the sets may be, the remainder of the set must be very prone to interference conveyed by the power supply lead and probably interference radiated from the ignition system and other electrical components of the vehicle. Mr. Taylor makes no mention of this and from long experience of this I can say that it is a very difficult problem.

Mr. Taylor is also, probably unintentionally, misleading regarding the B.B.C. v.h.f./f.m. coverage. At chimney-pot height what he says regarding the field strength laid down by the B.B.C. transmitters is no doubt true, but it is certainly not true of the field strength at car radio aerial height. It is, for instance, quite impossible to get an adequate signal on the road between London and Birmingham, and the same applies in many other places, and a thorough survey of this has shown that for a satisfactory car radio set, it is necessary, however effective may be the v.h.f./f.m. car radio, for medium- and long-wave a.m. reception facilities to be provided as well.

Pinner, Middlesex. W. CROSSLAND

Power Transformer Design

IN his article on small power transformer design (June issue) Mr. Saull seems to have made an error in his example of a practical design. In step (*c*) he uses a figure of 216 T/in^2 for the LT1 winding whereas Table II shows that 17 s.w.g. enamelled copper wire winds 289 T/in^2. Consequently the remainder of his calculations for the example are wrong.

Using the figure shown in Table II the LT1 winding will occupy 0.125 sq in, making the total for the two l.t. windings 0.24 sq in. The remaining space for the h.t. winding is then 0.39 sq in, from which it is found in step (*e*) that the T/in^2 is 9,168. The nearest wire gauge from Table II is therefore 34 s.w.g., having a current carrying capacity of 66.5 mA. In consequence this winding will have a slightly lower copper loss, resulting in a small improvement in regulation and efficiency.

St. Leonards-on-Sea, Sussex. W. E. THOMPSON

MAY I comment upon a statement by Mr. D. Saull in his article (June issue) "Power Transformer Design"?

Whilst not disputing that for mechanical reasons it may be preferable to wind the heavier gauge windings of a transformer first, an improved voltage regulation is not necessarily obtained for this winding arrangement.

The voltage regulation is a function of the sum of the primary resistance, R_p, referred to the secondary terminals, and the secondary resistance, R_s, that is, the effective secondary voltage drop $= I_s (R_p/n^2 + R_s)$ where $n = I_s/I_p$ = turns ratio.

The shorter mean length of turn of the secondary winding will reduce R_s, however the resultant longer mean length of turn of the primary winding will increase R_p, and, for equal primary and secondary winding areas, the effective secondary voltage drop will be unchanged.

Weymouth. A. D. WAITE

The author replies:

Mr. W. E. Thompson is perfectly correct; I apologise for the error quoted by him which came about through misreading the comprehensive wire tables that I normally use when transformer designing. These tables include single and double silk and cotton covered wire, in addition to enamelled wire. The turns/in^2 I quoted for 17 s.w.g. wire was 216 which is, of course, for double-cotton-covered wires. As Mr. Thompson points out, I should have used 289 turns/in^2 in my example.

It is refreshing to see that Mr. Thompson has read my article with a discriminating mind and eye and is not prepared to accept all he sees in print without first agreeing. I like to see this quality in a reader—it keeps up the standard of technical literature. Once again, sorry for my error Mr. Thompson!

The point brought up by Mr. A. D. Waite is, I believe, a controversial one amongst transformer designers. Some say the winding sequence should be h.t. winding, primary winding, and l.t. windings on the outside; others say a winding sequence of primary winding first, followed by the h.t. windings, and finally the l.t. windings on the outside; a third group, which I support, believe that the best results are obtained by winding the l.t. windings on first, the h.t. windings last, and positioning the primary in the centre of the transformer.

In support of the windings sequence I have chosen I will make these points—it is up to the reader to make his final choice.

(1) The purpose of my article was to produce a quick method of design; one that contained a minimum of variables; one that the design engineer could " get into " without too much preliminary digesting—otherwise he might just as well read a standard text book on transformer design.

(2) Positioning the primary between the l.t. and the h.t. windings, and consequently more to the centre of the lamination window, gives a smaller flux gradient across the window area. This results in a lower leakage inductance—consistent with the growing requirements of power supplies for transistorized, or partly transistorized, equipment.

(3) For design simplicity, the l.t. windings are required to carry current densities up to 2,000 A/sq in. A winding on the extreme inside is approximately half the length of one of the extreme outside, hence approximately half the resistance. However, if the primary is in the centre its resistance will not alter a great deal if moved slightly inwards or outwards. Primary current is a function of secondary wattage and, with small power transformers, the l.t. windings are responsible for the lion's share.

H.t. windings are operated at lower current densities, and in the smaller variety of power transformers, their resultant primary wattage is the lamb's share.

Heating effects are also a consideration: I^2R, if R is small, is half the answer that would have resulted if R became 2R. L.t. windings placed near to the core will lose heat, through the large surface area of the laminations, quicker than directly from a smaller surface area in contact with air, had the l.t. windings been placed on the extreme outside.

Now reflected resistance, $n = \sqrt{R_1/R_2}$, only holds good at 100% efficiency. With 86% efficiency, which is an average for small power transformers, not all of the secondary resistance is reflected into the primary winding!

We haven't discussed leakage currents between windings when the transformer is connected in circuit. These currents produce a chemical effect resulting in the enamel coating on the wire and other insulation deteriorating, an important factor in long-term installations such as instrumentation equipment used in atomic power stations.

My article was based on simplicity and therefore generalized. It contained a little error—perhaps inexcusable, but I have, I hope, tried to lead the engineer to the meat, cutting away the fat; and I say, " Brother, put these turns on and you will produce a transformer that is reasonable. You might be able to improve on it—but if time is money to you—I think that you will find it acceptable."

D. SAULL

Wire Broadcasting

IN your article in the May issue describing the TV relay equipment you mentioned Capt. P. P. Eckersley's experimental sound relay where the electric light supply mains were used for programme transmission. Some years before Capt. Eckersley's experiments I applied to the Post Office, in association with Charles Melhuish, at that time proprietor of the Crapstone and Yelverton Electricity Supply Co., for permission to install on the company's supply a Multi-Programme Broadcast Relay using an h.f. carrier modulated by a number of lower frequency sub-carriers each accommodating a separate radio programme. Our plans were well advanced including the special mains spacing and h.f.c. arrangements required, and one of the receivers even included a form of a.g.c. which varied the gain by altering the h.t. voltage. It was not very effective!

Although we had the support of the late Sir Arthur de Freece then living at Dunster, our plans were turned down by the Post Office as they were held to infringe the B.B.C. monopoly. I bring this to your notice as, although there may have been previous proposals along these lines, of which I am not aware, ours did precede Capt. Eckersley's.

Haverfordwest. K. F. PONTTING-BAKER

Radio Telescope

" UNBIASED " by " Free Grid," in your May 1960 issue, finds the name radio telescope inadequate and confusing and suggests that an entirely new word should be given to this instrument. I quite agree with him and since he has asked your readers to help in this matter, I would suggest " electronic cosmoscope " or " radio cosmoscope."

Mombasa, Kenya. K. C. FOLEY

Medical Electronics

THE third International Conference on Medical Electronics opens at Olympia on July 21st for a week. Some 100 papers will be presented at this conference which is being organized by the Electronics and Communications Section of the I.E.E. in association with the International Federation for Medical Electronics.

About 80 exhibitors are participating in the exhibition which is being held at Olympia throughout the conference. In the following list of exhibitors we have indicated the country of origin of those from overseas. The exhibition will be open daily from 9.30 to 6.0; admission is 3s 6d.

A.E.I.
Air-Shields (*U.S.A.*)
Allen & Hanburys
Alvar-Electronic (*France*)
Amplivox
Antares (*France*)
Ateliers de Construction Beaudouin (*France*)
Atlas-Werke (*W. Germany*)
Atomic Weapons Res. Estab.
Bailey, I. G., & Co.
Barr & Stroud
Becker, J. (*Holland*)
Belling & Lee
Bird Oxygen Co. (*U.S.A.*)
Chiba Electric Works (*Japan*)
Coulter Electronics
Cox, Stanley
Dawe Instruments
Disa Elektronic (*Denmark*)
Ekco Electronics
Electronic & X-Ray Applications
Electronic Industries Assoc. (*Japan*)
Electronic Machine Co.
Elektrolaboratoriet (*Denmark*)
Elema-Schonander (*Sweden*)
Elga Products
Endometrics
English Electric Valve Co.
Etudes et Constructions Electro-Medicales (*France*)
Faraday Electronic Insts.
Frieseke & Hoepfner (*W. Germany*)
Fukuda Electro Co. (*Japan*)
Fukuda Medical Electric Co. (*Japan*)
G.H.S. Electronics
Godart & Mijnhardt
Godart-Mijnhardt (*Holland*)
Heiwa Electronic Institute (*Japan*)
Hellige & Co. (*W. Germany*)
Heywood & Co.
Hilger & Watts
Hitachi (*Japan*)
Infra Red Development Co.
Japan Radio Co. (*Japan*)
Leitz, E. (Instruments)
Leitz, E. (*W. Germany*)
Leland Instruments
Marconi Instruments
Medische Apparaten (*Holland*)
Mullard Equipment
Multitone Electric Co.
Nagard
New Electronic Products
Nikkoh Electronic Instrument Co. (*Japan*)
Nippon Electric Co. (*Japan*)
Nuclear Enterprises (G.B.)
Officine Toscane Elettromeccaniche (*Italy*)
Offner Electronics (*U.S.A.*)
Ossa (*Switzerland*)
Picker International Corp. (*U.S.A.*)
Purtschert, M. J., & Co. (*Switzerland*)
R.C.A. Great Britain
S.S. Electronics
Sanborn Co. (*U.S.A.*)
San'ei Instrument Co. (*Japan*)
Sanyei Manfg. Co. (*Japan*)
Saunders-Roe & Nuclear Enterprises
Schwarzer, F. (*W. Germany*)
Selig Electromagnetics
Shimazu Seisakusho (*Japan*)
Siemens-Reiniger-Werke (*W. Germany*)
Sierex
South London Electrical Equipment Co.
Telco (*France*)
Telefunken (*W. Germany*)
Tinsley & Co.
Tokyo Shibaura Electric Co. (*Japan*)
Dr. Ing. J. F. Tonnies (*W. Germany*)
Townson & Mercer
Winston Electronics

Electronics in Israel

STEADY GROWTH EXEMPLIFIED AT THE RECENT EXHIBITION IN TEL AVIV

By R. DANZIGER, M.Brit.I.R.E.

THE first Electronics Exhibition was held recently in Tel Aviv and was organized by the IEMA (Israel Electronics Manufacturers Association) and the trade schools. Since its modest start in 1950 the electronics industry has increased the value of its annual output from 350,000 to 8,000,000 IL (Israel Pounds).

The 1960 exhibition was the first of what is intended to be a series of annual events. The main part of the show was devoted to domestic radio receivers which ranged from tiny transistorized sets through car radios to elaborate "hi-fi" equipment for rooms with special acoustic arrangements. Wood was still the favourite material for the Continental styled cabinets of most makers with plastic materials being the exception. Some firms showed prototypes of their future production programme including TV sets, stereo amplifiers, tape recorders and d.c. record players.

An important part of the exhibition was the components show. Except for valves, transistors and certain types of condensers and resistors all parts are manufactured in Israel. A wide range of components was shown including piano-type waveband switches, polystyrene condensers, several types of variable condensers, many types of loudspeakers and tweeters and a wide range of all types of transformers and coils.

Perhaps the most interesting part of the show was that devoted to the professional exhibits. Whilst the manufacture of professional electronics equipment is still at its beginning, it is backed by considerable know-how. Outstanding in this section were electronic fire alarms and counters made by ELCO (Ramat Gan), printed circuits, epoxy castings and pulse equipment by Israel Electronics Co. (Rishon Lezion) and quartz crystals by Tadir (Holon). All being up to a high standard both in respect of specification and finish. Other items in the professional section included timers, miniature pulse transformers, measuring gear, electro-medical equipment, loud hailers and of course a large variety of office and industrial intercommunication systems.

In addition to the commercial exhibits one wing of the show was devoted to training aids and the work of the students of the trade schools. There are seven major trade schools in Israel with 4-year courses in electronics. They have a combined capacity for 500 students and turn out about 200 qualified technicians per year. The demand for places at those schools is considerable and stiff entrance examinations are held, resulting eventually in a high standard of training. The exhibits in this section included many student-built equipments such as oscillators, amplifiers, transmitters, etc., but also more advanced equipment such as u.h.f. waveguides, pulse-shaping circuits nicely demonstrated by means of several oscilloscopes, and even a radio-controlled model aeroplane.

The most sophisticated equipments were shown by the two leading academic teaching institutions, The Hebrew University, Jerusalem, and the Technion, Haifa. They exhibited an analogue computor, pulse generators, coincidence plug-in units and even a 24-channel pulse height analyser.

One leaves the exhibition with the definite impression that the local electronics industry has left the "music box" stage for good and is embarking on a serious domestic and professional production programme in the electronics field.

The exhibition, with a floor space of 500m^2, comprised 27 stands and was open for four days (4 hours per day) during which time the number of visitors was of the order of 2,000.

Radio Aids to Hydrography

DECCA TWO-RANGE AND LAMBDA POSITION-FIXING SYSTEMS

By C. POWELL*

This article describes the latest version of one of the radio aids to survey at sea. The aid is used extensively throughout the British Commonwealth and in ships of the Royal Navy

"THE science of Hydrography", says the Admiralty textbook on that subject, "originated in the need for the production of maps specially designed for the use of the mariner. . . . During the nineteenth century nearly every specialised maritime country founded a department for the sole purposes of dealing with the issue and publication of charts and for the co-ordination and execution of marine surveys, and immense progress has been achieved in the production of charts"[1]. An important contribution to that progress, since the Second World War, has been made by radio position-fixing systems, and these are now accepted as standard surveying equipment in hydrographic work.

A radio position-fixing system can be used to fix the position of the survey ship, so that observations can be assigned to their correct geographical positions; to hold the ship on the survey tracks, and to navigate the ship to the survey area with the minimum delay and wasted steaming. It can be used when haze or mist prevent shore marks from being used for fixing and running lines by the classical methods; also at distances such that shore marks are beyond the limit of visibility. This has brought radio aids into the field of oceanographic surveying, involving ship-to-shore distances of several hundred miles. A widely-used radio aid to surveying at sea is Two-range Decca; as this is derived from the Decca Navigator[2, 3] some aspects of the latter should be noted.

Decca Navigator.—Decca employs unmodulated c.w. transmissions occupying spot frequencies in the 70-130 kc/s band. At these frequencies, the attenuation of the surface wave is sufficiently small to permit use of the system by ships at distances greatly exceeding that of the "radio horizon" and the stability of propagation condition during the hours of daylight, coupled with the potentialities of the phase-comparison method of obtaining a position line, make possible a degree of accuracy appropriate to most hydrographic-survey requirements. A chain of Decca stations normally comprises a central master with two or three outlying slave stations disposed about it. The slave transmissions are phase-locked to the master and the basic function of the receiver carried by each user of the system is to compare the phase of the master transmission with that of each slave. The phase differences are displayed on three pointer-type phasemeters, known as Decometers (one for each master/slave combination) and each reading locates the user on one of a family of hyperbolic constant phase-difference lines focussed on the master station and the appropriate slave. A position fix is given by the intersection of two such position-lines: on board ship the readings are usually plotted manually on a chart overprinted with correspondingly-numbered Decca-grid lines. In aircraft, and in certain special-duty ships, the fix is continuously displayed on an automatic plotter (Flight Log[4] or Track Plotter) which provides a pictorial presentation of position by a pen, representing the user vehicle, moving across a map.

Two-range Decca.—Soon after its commercial introduction in 1946, the Decca Navigator became established as an aid to hydrographic surveying by use of the permanent European coverage as it then existed, supplemented by mobile chains in Greenland, Sweden and the Persian Gulf. In 1950, however, there arose an operational requirement which the conventional Decca station layout could not meet; a survey organization operating in the Antarctic required a radio position-fixing system having the characteristics of Decca; but using only two shore stations instead of three because three suitably-disposed and habitable sites could not be found in the area of the proposed survey. As a solution the survey department of the Decca Navigator Company proposed a layout in which the two slave stations would remain on the shore, the master being installed on the survey ship together with the receiver. While confining the use of the chain to a single ship at a time, this arrangement overcame the siting difficulty and also introduced other advantages, notably the fact that the Decometers now indicated the direct distances to the shore stations rather than the distance-differences of the conventional system.

The ensuing development of the Two-range system into an operational hydrographic-survey tool was undertaken in close co-operation between the Hydrographic Department of the Royal Navy, the Admiralty Signal and Radar Establishment (now the Admiralty Surface Weapons Establishment) and the manufacturers.

Principles of Two-range System

The layout of a Two-range chain is shown diagrammatically in Fig. 1. The master transmitter on the ship radiates a c.w. signal of frequency $12f$ where f is approximately 14 kc/s. As all the radiated and phase-comparison frequencies are harmonically related, as in conventional Decca, it is more convenient to refer to them in a harmonic notation rather than in numerical terms. The "red" slave station ashore receives the master transmission and radiates a signal of frequency $8f$, in a manner such that the slave and master signals have a constant phase relationship at the common multiplied-up frequency value of $24f$; a stable pattern of constant-phase-difference lines is therefore generated about

*Decca Navigator Co. Ltd.

the two stations (broken lines in Fig. 1) this pattern being identical with that which would be produced if signals frequency 24f (about 340 kc/s) were actually radiated from master and slave. In the shipborne receiver the signals are received and multiplied for phase comparison at 24f, and the phase-difference meter (Decometer) makes one rotation if the ship-to-slave distance alters by one phase-difference cycle or "lane". Along the line between master and slave, the lanes recur at uniform intervals each equal to half a wavelength at the comparison frequency, and the lane pattern that the ship uses therefore takes the form of a family of concentric circles centred on the slave station. At 24f, the lanewidth is roughly 420 metres and the Decometer, which can be read to less than half-a-hundredth of a revolution, will therefore respond to a change of a metre or two in the ship's distance from the slave. A similar process takes place in the "green" co-ordinate (9f slave frequency) at a common comparison frequency of 36f, giving in this case a lanewidth rather less than 300 metres as shown in the accompanying table.

Each Decometer embodies a lane-counting pointer geared down from the phasemeter rotor, together with a subsidiary indicator driven through a further stage of gearing and recording groups of lanes ("zones") passed through. Assuming a value for the speed of propagation of electromagnetic radiation, these readings can be converted into distance units: this is generally done by plotting them on a chart overprinted with the two patterns of circular position lines, numbered to correspond with the Decometer readings and drawn at constant radial intervals of one or more lanewidths. A "two-range" fix of the ship's position with respect to the shore stations is given by the intersection point of the two circles (interpolating between the lines on the chart as required) indicated by the meter readings.

If a second receiver were placed close to, say, the red-slave station, the red Decometer reading of this receiver would show no change even if the ship

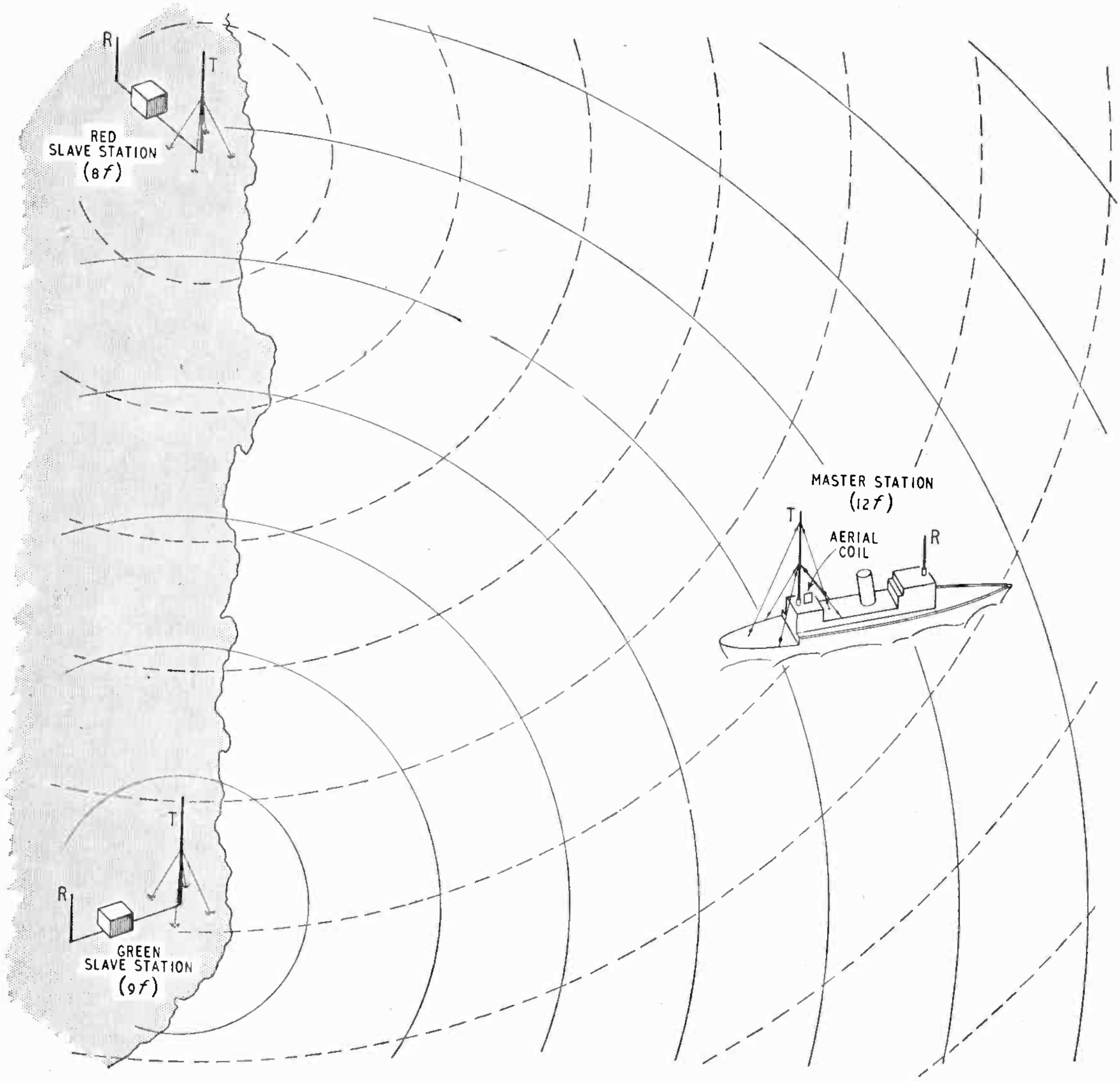


Fig. 1. Diagram of layout of Two-range Decca Hydrographic-survey system.

TABLE
Typical values for frequency and lane width

Function	Carrier Frequencies		Phase Comparison Frequencies		Lane Width
	kc/s	harmonic	kc/s	harmonic	(v = 299,650 km/sec) metres
Master	177.6	$12f$	—	—	—
Master Identification (Lambda system only)	162.8	$11f$	—	—	—
Green	133.2	$9f$	532.8	$36f$	281.2
Red	118.4	$8f$	355.2	$24f$	421.8

Note: All frequencies are harmonically related to a non-transmitted fundamental value f.

altered her position by several hundred miles; this is because the slave station's function is to radiate a signal having a constant phase relationship with the incoming master transmission. The shipborne Decometer indicating the master/slave phase difference is, however, sensitive to any change in the ship-to-shore distance, as this alters the length of the transmission paths from the master to the slave and back without a corresponding change in the direct path from the master to the ship receiver.

If maximum accuracy is to be secured from the system, corrections have to be applied for the non-uniform speed of propagation of radio waves in the groundwave mode and for fixed phase shifts. The full expression for measurement of the distance between the ship and a slave station therefore becomes:

$$d = (\lambda c f/2)\,(\phi - \alpha - \psi)$$

where d is the distance from the "electrical centre" of the ship to the mid-point between the receiving and transmitting aerials at the slave station, $\lambda cf/2$ is the lanewidth in metres for the appropriate pattern, assuming free-space velocity, ϕ is the observed Decometer reading (whole lane number plus fraction), α is the "locking constant," and ψ is a correction to the free-space value of the speed of propagation.

The exact location of the electrical centre of the ship in the above formula is found by calibration at a known distance and on a number of different headings. The locking constant is the name given to the overall phase shift due to the close proximity of the receiver to the master transmitter (placing the former in the "induction field") and, at the slave station, a possible fixed displacement from the nominal zero phase-difference condition that is assumed to exist between the received master signal and the outgoing slave transmission. The value of the locking constant for each pattern is found at the start of a survey by observations at exactly known distances from the slaves, and is thereafter subtracted from all observed Decometer readings.

The quantity ψ refers to the dependence of the effective speed of propagation upon the nature of the medium over which the signals are transmitted—an aspect of the groundwave mode of propagation which is of fundamental importance when the transit time of low-frequency signals forms the basis of position or distance determination. This phase lag with distance results from absorption of energy by an imperfectly conducting earth* and Fig. 2 shows a practical set of phase-lag correction curves for the red and green patterns. The increase in the correction value at short ranges is the result of the complex field existing around the transmitter, and the increase beyond 100 km or thereabouts is the effect of the phase lag. The mean speed of propagation resulting from the phase lag varies widely with the electrical characteristics of the medium over which the signals are transmitted; e.g., the sum of experience so far with Two-range Decca points to a mean velocity of 299,650 km/sec over seawater transmission paths, while a corresponding figure for land paths of the lowest soil conductivity yet encountered (of the order of $\sigma = 5 \times 10^{-15}$ e.m.u.) amounts to about 298,400 km/sec. If no steps were taken to correct for this variation, an uncertainty of 1 part in 240 could exist in the range determination (assuming the possibility of a Two-range chain being operated over land as well as over sea) which would render the system completely unacceptable as a survey instrument. Fortunately it is possible to apply corrections for different path conductivities; also for paths of mixed conductivity such as the case where a large island or promontory intervenes between the ship and the shore.

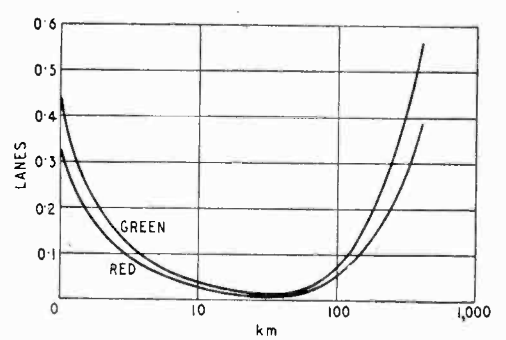


Fig. 2. Phase correction (expressed in lanes) for seawater transmission path.

Application of the corrections shown in Fig. 2 for transmissions over seawater leaves, with present knowledge, a residual uncertainty amounting only to one or two parts in ten thousand. The curves were constructed on a theoretical basis, but have been confirmed by observations with the conventional Decca system as well as with the Two-range version at distances up to about 200 km: beyond this distance it is hoped to obtain practical

* This has been the subject of theoretical work, notably by Sommerfeld, Bremmer and Norton, which is described in detail in a paper by A. B. Schneider[5]. Extensive work has also been carried out by Dr. B. G. Pressey and his associates at the Radio Research Station (D.S.I.R.).

confirmation from trials specially designed for this purpose. Here we encounter a familiar problem in the practical deployment of modern radio aids to surveying and navigation: to check the radio aid satisfactorily it is necessary to know distances and positions with an accuracy several times greater than that of which the aid itself is capable, and this is liable to tax present survey resources to the utmost. For example, if the correct value of ψ over seawater could be determined experimentally without error, the Two-range technique should then be capable of measuring, say, the distance from a point on the north coast of East Anglia to a point near Aberdeen with an accuracy of one or two parts in 50,000, yet this is not far short of the accuracy with which the actual distance between the two points in question can be stated from present survey knowledge.

Random Errors.—The phase errors so far described can be partly or wholly corrected. Rather more important are errors of a random character, which may be due to instability associated with wave propagation or with instrumental variations, or both. From sunset until sunrise at all seasons, and also during daylight in winter, random variations due to skywave interference start to become detectable at ship-to-shore distances of about 40 miles, and thereafter increase in magnitude with range. The actual survey operations requiring accurate fixing are, therefore, generally confined to daytime, but this does not apply to incidental manœuvres such as journeys between different survey areas, which call for a lower degree of accuracy than the survey itself. Typical random-error contours for the use of the system by day are indicated in Fig. 3. In practice, the overall accuracy of Two-range Decca has been such as to permit plotting of the results at a chart scale of 1:70,000 (about one inch per nautical mile) without the errors or variations due to the system itself being detectable at this map scale.

A geometrical characteristic of the Two-range layout is the relatively large proportion of the coverage, compared with a hyperbolic system having the same distance between the slave stations, within which a high fix accuracy can be obtained. The angle of cut between the two circular position-line patterns is good (i.e., near 90°) over a wide area, and the layout is favourable in that there is no lane expansion such as occurs when similar equipment is operated as a hyperbolic chain.

Referencing.—A potential source of error in the receiver itself arises from the differential phase shifts between the master and slave channels. To check and correct these, the receiver incorporates a reference source, whose output is a 0.5μsec pulse having a recurrence frequency equal to the fundamental value f, to which all the transmitted and phase-comparison frequencies in the system are harmonically related. Applying this pulse to the input of the receiver, each channel extracts its harmonic frequency. As the harmonics are related to a common fundamental, the two Decometers would read zero if there were no differential phase shifts in the channels. If a reading other than zero is observed, a compensating phase shift is applied so that a zero reading is restored.

Frequencies.—The transmissions are of the pure continuous-wave type with no modulation. This characteristic enables receiver bandwidths of a few c/s to be employed, which in turn secures the required performance from transmissions of low radiated power. The shipborne master transmitter installation radiates approximately two watts and the slave stations (in the standard version of the system) approximately four watts. The use of low-power transmissions having no modulation sidebands minimises the problems of frequency allocation and of mutual interference with other services.

Those familiar with conventional Decca will have noticed from the table that a different harmonic relationship for the transmitted frequencies is used in the Two-range version of the system, the master frequency having twice the normal harmonic value. This is in order to secure maximum strength of radiated signal from a shipborne aerial mast which is necessarily of restricted size. On the frigate-type survey ships of the R.N. Hydrographic Service, for example, the height of the mast is limited by the available staying radius to about 45 feet. Early Two-range chains used a master frequency $6f$, i.e., a spot value between 85 and 90 kc/s, which resulted in a radiated power of approximately one-third of a watt for an input to the aerial of 350 watts. By doubling the frequency an approximately eight-fold gain in radiated power for the same input is achieved, and this has permitted operation in tropical regions, where the noise level is high, at distances well in excess of 150 miles.

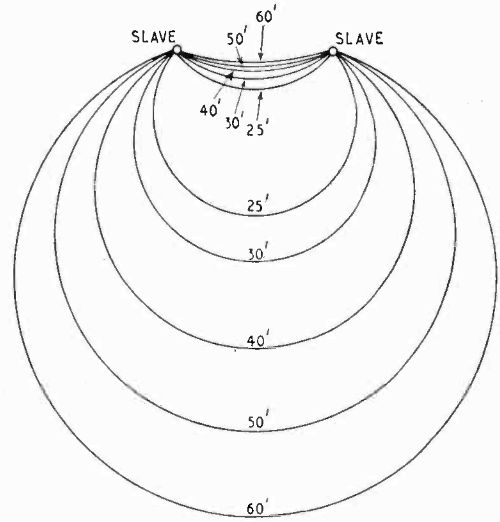


Fig. 3. Fixing-accuracy contours in feet for summer daylight operation. Contours are drawn for a 0.01 lane deviation.

Equipment.—Briefly reviewing the items of equipment comprising a Two-range Decca chain, the shipborne master installation consists of a duplicated unit containing a stable crystal oscillator which provides the source of the master signal, feeding a 350-watt c.w. transmitter. The 45-foot tubular transmitting aerial mast (Fig. 4) is base-insulated and is supported at three heights by stays insulated at their lower ends.

The shipborne receiver is generally installed in or near the chart room and uses a standard Decca receiving aerial which is a vertical fibreglass tube containing a length of insulated wire. The receiver

(Continued on page 355)

is of the Decca "survey" type which is capable of use with either the hyperbolic or the Two-range layout, the latter necessitating two small adjustments: a reduction in the gain of the master channel because of the proximity of the master transmitter, and a reversal of the sense of Decometer rotation so that the readings increase instead of decrease with distance from the slave station. The Decometers are supplemented, when necessary, by the Track Plotter which is the marine counterpart of the Flight Log. Ashore, each slave station comprises, in duplicate, a "control unit" which contains the oscillator forming the signal source, together with the equipment for phase-locking the outgoing slave transmission to the received master signal. The second "standby" control unit, as it compares the phase of the master and slave transmissions and displays their phase difference, acts as an independent monitor of the phase pattern. The transmitter is similar to that used at the master, and a similar transmitting aerial system is employed except that, in general, its height is approximately twice that of the shipborne mast.

Lane Ambiguity.—From a practical point of view, Two-range Decca as so far described has a serious limitation in the form of a high degree of pattern ambiguity. From the above table it will be seen that typical lanewidths for the two co-ordinates are about 420 and 280 metres respectively, which means that before starting work, or after an interruption, the user must know his distance from the red shore station to better than ± 210 metres and from the green to better than ± 140 metres. At moderate ranges this has not given rise to any serious difficulty; the ship usually starts from a known point in any case, appropriate plotting procedures can reveal the development of a whole-lane error should this occur and, if the journey to a check point where the lane values are known should have to be made this may not be a major undertaking when surveying within a small area. At distances greater than about 100 miles from the stations, however, the lane ambiguity becomes an increasingly serious problem, and some form of lane identification, such as is provided on all the permanent Decca navigational chains, would greatly improve the system. The conventional Decca lane-identification method does not lend itself to use with mobile transmitting equipment where light weight and compactness are paramount, but a modified technique known as the "Lambda" method (Low-AMBiguity DeccA) which overcomes this difficulty has recently been evolved and is incorporated in a new Decca survey system based on the Two-range principle.

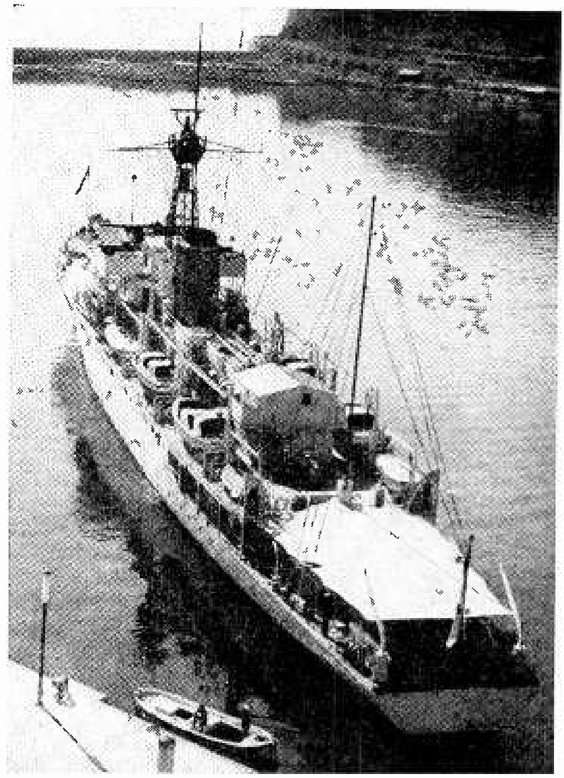


Fig. 4. British Naval Survey Ship equipped with Two-range Decca showing tubular aerial mast for transmission of the master signal.

Lane Identification in the Lambda System

In essence, any lane-identification system consists in superimposing upon the ambiguous lanes a coarse pattern in which one "lane" or phase-difference cycle embraces a number of the fine lanes. Thus, if a pattern resulting from phase comparison at a frequency $1f$, using the previous notation, is superimposed upon the $24f$ red pattern, a phasemeter responding to the coarse pattern would make one revolution for 24 red lanes passed through, and would indicate the correct red lane number for the ship's position in a group of 24. Similarly, a $1f$ pattern will identify the correct green ($36f$) lane out of a group of 36. As there will be many more than 24 or 36 lanes in the total fine patterns, some ambiguity will still remain; but, remembering that the "$1f$" lanes are about 10km wide measured along the master-to-slave line, this requires only that the user should know his distance from the slave station initially to ± 5km in order to be able to make use of the coarse patterns for setting correctly the Decometers. In practice, this remaining degree of ambiguity causes no difficulty since the ship's position can be found accurately enough by an astronomical fix or other standard practice.

Since it is out of the question actually to transmit $1f$ (14kc/s) from the stations, this frequency must be extracted from them by other means. In the Lambda system, the shipborne receiver obtains a $1f$ master signal direct from the appropriate circuit in the master-transmitter control unit. For the receiver to obtain a $1f$ signal from the slave stations, which normally transmit $8f$ and $9f$ for red and green respectively, the slave frequencies are momentarily counter-changed so that, given a means of "memorising" the original phases of the signals, a $1f$ beat note can be derived from each station. Comparing the $1f$ transmission thus obtained from the slave with the $1f$ signal from the master results in the generation of the $1f$ phase pattern necessary for lane identification.

Lane identification is initiated in the Lambda system by stopping the $12f$ transmission from the ship and replacing it, for about 1.3 sec, by an $11f$ signal. This triggers the changeover of frequencies at the slave stations and provides the slave with a "notching" datum, to be described later.

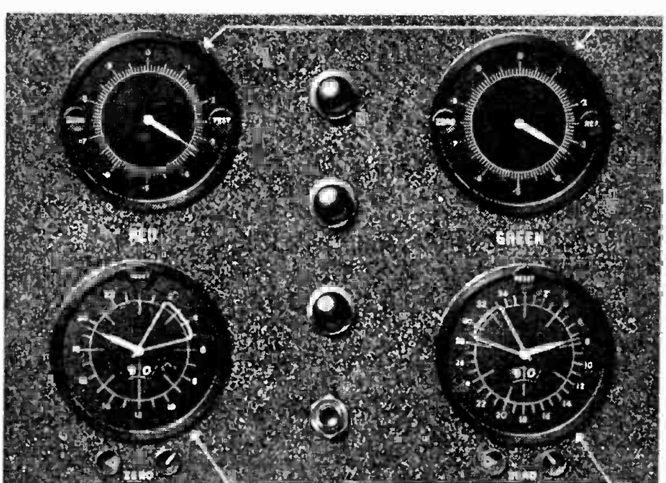
A locked-oscillator technique is used at the shipborne receiver to extract the required $1f$ beat note from each slave station. (Fig. 6(b)). At the receiver on board, the $8f$ and $9f$ locked oscillators preserve the phase of the signals that normally control them, and $1f$ beat notes are extracted for each slave by mixing the oscillator outputs with the signals received during lane identification. The phase difference between the master and each slave at the frequency $1f$ is displayed by a sector-shaped pointer on the coarse Decometers (lower dials in Fig. 5). If the lane-identification pointer moves so as to enclose the lane-counting pointer, the latter is reading correctly. If this does not occur, the lane-counting pointer is reset manually to the position indicated. After the one-second lane identification transmissions the normal transmissions are resumed until the user again decides to check or identify the lanes. The actual indications are "frozen" for several seconds, for ease of reading.

Lambda Lane Patterns.—In a system designed for oceanographic surveying several hundred miles from land, every possible precaution must be taken to ensure continuity of operation. The ambiguity which the lane-identification system is designed to resolve should be made less severe, if this is feasible, and the possibility of a whole lane error occurring should be reduced to the absolute minimum. Accordingly, in the Lambda system the basic patterns are produced by comparing phase at the frequency of the slave transmission without multiplication. This results in a greater discrimination against noise interference than when frequency multiplication takes place, leading to a greater range for a given probability of lane loss. At the same time the lanes thus generated by phase comparison at the relatively low slave frequency are correspondingly wider and less ambiguous.

The basic Decometers (the two lower dials on the display unit shown in Fig. 5) respond to these slave-frequency patterns and the movements are so geared to the lane-counting pointers that the latter make one revolution per zone, i.e., one revolution for 8 red slave-frequency lanes and 9 green slave-frequency lanes. On turning manually the red meter with the reset button, therefore, it will be found that the lane pointer can take up any one of eight equally spaced positions around the dial. The lane-identification pointer is coaxial with the lane-counting pointer, so that the basic function of the former is to indicate which of these eight positions is the correct one, i.e., to identify the correct slave-frequency lane within a zone of 8 or 9 such lanes for red and green respectively. As already mentioned, a rough fix serves to tell the user which zone of each pattern he is in. The individual zones are counted, as in normal Decca practice, by additional dials appropriately geared to the lane-counting pointers.

Unhappily, technological achievements do not include the extraction of something from nothing, and owing to its wide lanes the system as described so far would be three times less sensitive to a change in the distance from the ship to the red slave station than the earlier version of Two-range Decca, and four times less sensitive in the green co-ordinate. To remedy this, narrower lanes are interpolated between the slave-frequency lanes simply by carrying out a further phase-comparison at a higher frequency. This requires further frequency-multiplication in the receiver, together with additional discriminators and a pair of fine Decometers, as shown in the block diagram of Fig. 6 (a). The fine meters, which are the upper pair on the display unit, make one revolution per $24f$ (red) and $36f$ (green) lanes, and thus restore the pattern sensitivity to the same level as that of the previous system. Except in the strictly arithmetical sense, no extra ambiguity is introduced by this measure; the lower Decometers have scales marked in fine-lane units and can be read to a fraction of a fine lane, and a glance at the upper meters which are calibrated in hundredths furnishes the second digit. In effect, therefore, the upper meters operate simply as expanded scales for the coarse meters, and present no individual setting-up problem apart from the necessity that they should periodically be "referenced" to zero together with all the other meter movements in the system.

"Notching."—Reverting to the generation of slave-frequency lanes, it will be realized that these contain an additional ambiguity of their own, which is true of any Decca pattern in which phase is compared at a frequency lower than one or both of the radio transmissions involved; this is the result of frequency-division which, even if it does not take place literally in a dividing circuit, is nonetheless carried out in effect when slave-frequency lanes are produced. Here we need consider only the phase relationship between a slave station such as the red (frequency $8f$) and the $12f$ master transmission to which it is phase-locked. Granted that the phase-control circuit at the red slave holds the outgoing $8f$ signal at zero phase difference with an $8f$ signal derived from the master, it can do this for three different relationships between the $8f$ and $12f$ master signals. In other words, the $4f$ frequency corre-



FINE PATTERN METERS

COARSE PATTERN METERS

Fig. 5. Display unit of Lambda-type installation. Upper meters indicate fine pattern readings (comparison frequencies 24f and 36f). Whole lanes and lane identification are given by lower dials.

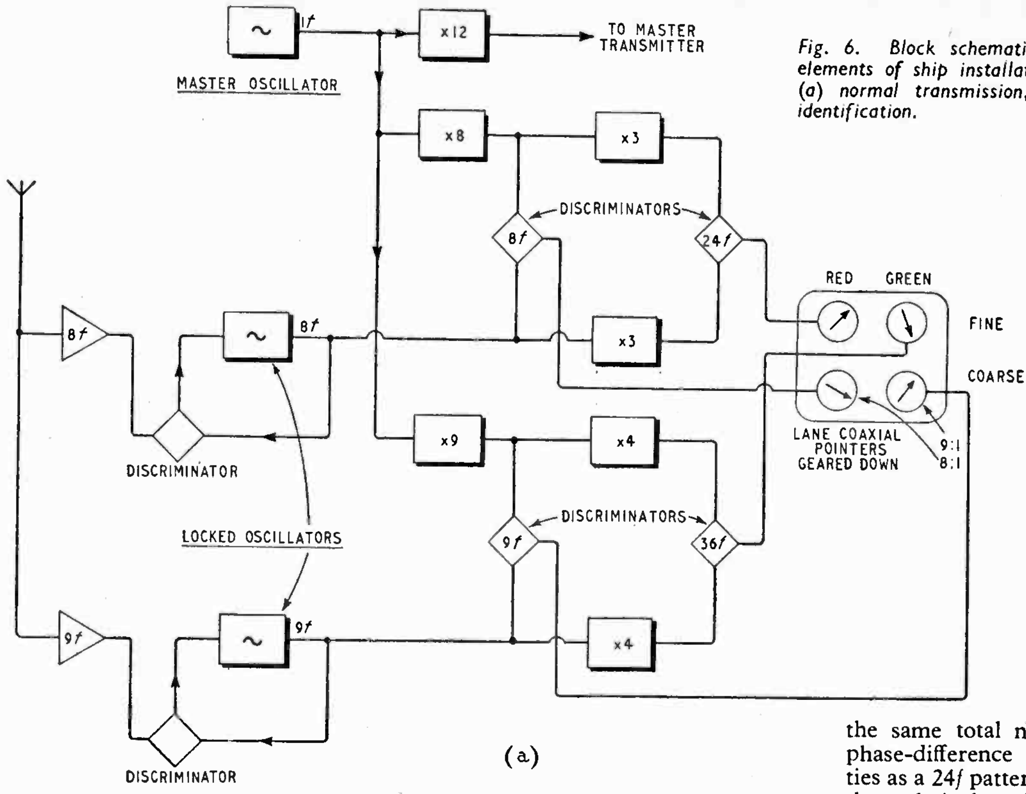
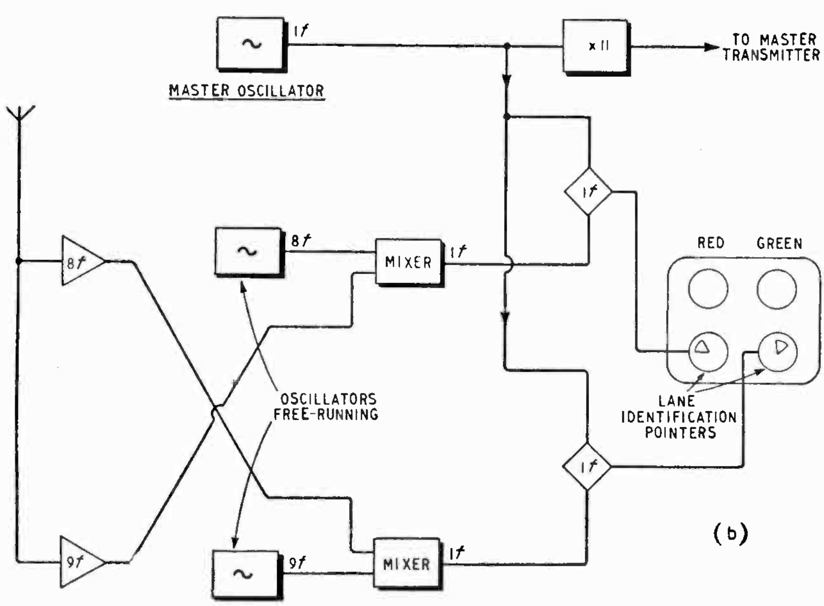


Fig. 6. *Block schematic of main elements of ship installation during (a) normal transmission, (b) lane identification.*



sponding to division of the $12f$ by 3 can start on any $12f$ cycle it likes without affecting the phase comparison at $8f$, but for every one such cycle giving the correct pattern phasing, there are two which produce pattern errors of either one- or two-thirds of an $8f$ lane. These "notch" errors, as they are called, are equivalent to shifts of one or two fine ($24f$) red lanes respectively, so that if nothing were done about them the $8f$ pattern that we have gone to so much trouble to generate would have exactly the same total number of phase-difference ambiguities as a $24f$ pattern, despite the relatively wide slave-frequency lanes. Further, if there is a potential notch error in counting down $12f$ to $8f$, there must also be a greater uncertainty in extracting $1f$ signals from the various stations for lane-identification purposes in the manner already described. In practice, all such ambiguities are dealt with by the single notch-correcting facility embodied in the equipment.

Ship Installation.—Fig. 6(a) is a rudimentary block diagram of the receiver in its normal state (i.e., in the absence of lane-identification transmissions). The master transmitter circuits, other than the output stages, are incorporated in the same box as the receiver, and the $1f$ oscillator which forms the basis of the master transmission also provides the receiver with its master phase datum. For the latter reason, there is no notch ambiguity problem at the receiver, since the slave-frequency master signals required by the receiver are derived direct by selecting the eighth and ninth harmonic from the pulse output of the $1f$ oscillator, and no uncertainty therefore exists as to the relationship of these signals with the $12f$ transmitted signal which is also derived directly from the same oscillator.

The functioning of the two receiving channels by which the shipborne equipment obtains the red and green slave signals depends upon the use of locked oscillators; that is to say, stable crystal oscillators in temperature-controlled "ovens" whose outputs are compared in frequency and phase with the received slave signals and locked to them by servo loops involving phase discriminators and reactance circuits. The oscillator outputs therefore provide noise-free replicas of the incoming signals, an arrangement which decreases the effective bandwidth of the receiver, as well as furnishing the phase memory required by the method of lane identification shown in Fig. 6(b).

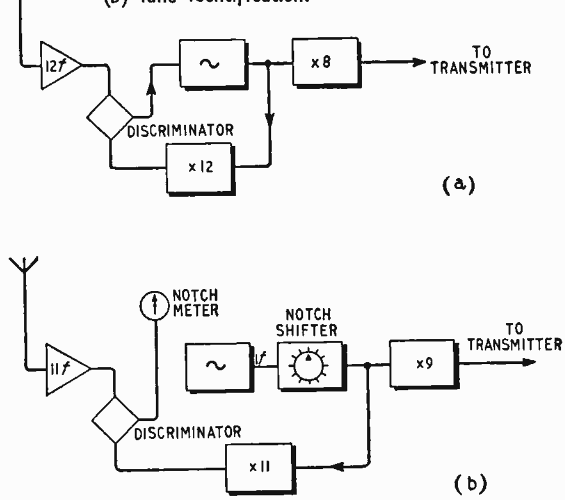
Slave Stations.—Figure 7 shows the essentials of a slave station. The signal source is an oscillator of frequency $1f$ which is locked at its twelfth harmonic to the incoming $12f$ master signal. The equipment is identical at the two slave stations; if we assume that it is switched to operate as a "red" slave, the eighth harmonic of the basic $1f$ oscillator is amplified and transmitted continuously, except during lane identification. The locking of the slave to the master, upon which the generation of a stable pattern of position line circles depends, is carried out in two stages. The incoming master signal, having been passed through a two-stage crystal filter also in the "oven," is amplified and phase-compared with the twelfth harmonic of the slave's oscillator. The discriminator output controls the phase of the oscillator to keep the $12f$ signals phase-locked. The second stage of phase-locking (not shown in the diagram) is between the radiated output from the aerial and the input to the transmitter. The $8f$ output of the oscillator passes to the transmitter through a reactance stage. This is controlled, in turn, from an $8f$ phase discriminator, in which the drive and radiated $8f$ signals are phase-compared, to keep the radiated signal locked to the drive signal, irrespective of capacity changes in the transmitting aerial. This whole arrangement is duplicated at $9f$ so that the slave transmission at that frequency during lane identification shall be similarly phase-stable with respect to the master.

Elimination of the notch ambiguities is simply a matter of ensuring that the slave $1f$ oscillator has the correct phase relationship with the master $1f$ oscillator and this relationship is displayed to the slave-station operator every time the ship initiates a lane-identification transmission. The "notch meter" indicates the phase-difference between the $11f$ signal from the master (i.e., the eleventh harmonic of the master oscillator) and the eleventh harmonic of the slave oscillator. The latter is sufficiently stable for it still to be considered as locked to the interrupted $12f$ master signal, so that the twelfth harmonics of the two oscillators are already in phase; if the eleventh harmonics are seen by the notch meter to be also in phase the master and slave oscillator outputs will have the correct (i.e., zero) phase relationship at their fundamental frequency. If one of the eleven other possible readings is observed, a 12-position notch control, which operates a phase-shifting network, is turned a sufficient number of clicks in the appropriate direction to bring the eleventh harmonic of the oscillator into the right phase. The use of a click device on the phase control simplifies the setting up process as correction can then be made after the lane-identification period ($\approx$ 1 sec) has finished.

When the meter reads zero, the whole system is correctly notched, i.e., the slave transmissions have the correct phase relationship with the master at the fundamental frequency $1f$ and hence also at the transmitted harmonic frequencies. The probability of a notch error developing during a day's work has been shown to be extremely remote. However, to enable the slave operator to check the notch in the event of an interruption in transmission, provision is made for him to request the ship to initiate a lane-identification transmission. The signal takes the form of a momentary phase shift in the slave transmission which is too rapid to introduce a Decometer error, but which serves to trigger a "slave-call" lamp on the receiver display unit.

On the survey ship, the receiver and the input sections of the master transmitter are now housed in a bulkhead-mounted container similar in size to that of the familiar Decca Navigator Mark 5 shipborne

Fig. 7. Simplified block schematic of slave-station control system during (a) normal transmission, (b) lane identification.



set; the transmitter itself and the aerial system are disposed in the same way as before (Figs. 1 and 4). The slave stations are stowed on board the ship in transit, and are then taken ashore in small boats or helicopters and set up for the duration of the survey. To assist stowage and transport, the units are housed in standardised boxes of the type used for Army signals equipment: hydrographic surveys are in the nature of military operations, and every possible effort has to be made to ensure mobility as well as reliability in the equipment that the modern surveyor employs.

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Elements of Electronic Circuits

15.—THE "BOOTSTRAP" TIMEBASE

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E.

A TIMEBASE circuit which uses both positive and negative feedback is shown in Fig. 1. Known commonly as a "bootstrap" timebase, it comprises:—(i) A switch, consisting of a triode V1 operated by a negative-going square pulse, shunting the timebase capacitor C. (ii) A charging resistor, R, across which a constant potential is maintained. (iii) A triode, V2, connected as a cathode-follower amplifier, i.e., with current negative feedback, and developing unity gain. (iv) A capacitor, C_1, providing positive feedback to V2, the feedback voltage being developed across the timebase charging resistor R.

The operation of the circuit is as follows. An initial quiescent state is assumed with V1 conducting and V1 anode at a low potential. A negative-going square wave cuts off V1, and the timebase capacitor C starts to charge via R. If point X in Fig. 1 had been connected to a fixed h.t. potential C would have charged in an exponential fashion. To provide *linear* charging we endeavour to keep the potential across R constant so that the current through it is constant also. In other words, the waveform generated at Y must also appear at X. (Hence the description "bootstrap" timebase—derived from the notion of pulling oneself up by one's bootstraps.)

This type of action is achieved in the following way. The V2 stage is arranged to have approximately unity gain by operating it as a cathode follower. The timebase waveform developed at Y, if applied to V2 grid, therefore appears in phase at V2 cathode. We now connect the cathode of V2 via C_1 to point X, which (by cathode follower action) will follow the potential of Y. Thus, by positive feedback via C_1, a constant potential can be maintained across R, through which the timebase capacitor C is being charged. As a result C charges linearly.

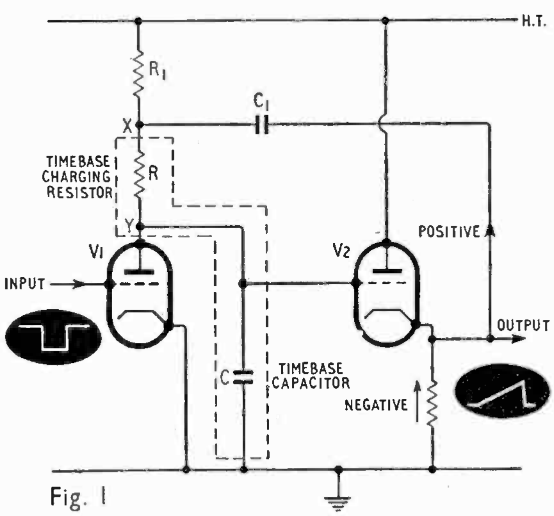


Fig. 1

The potential levels during the quiescent period are maintained by C_1 and R_1. Capacitor C_1 does not discharge appreciably during the period of the sweep provided that:

(a) the value of C_1 is very much greater than C;

(b) the time constant C_1R_1 is large compared with the duration of the sweep. Voltage changes across C_1 during the sweep must be small, otherwise the voltage across R will not be constant, thus causing non-linearity;

(c) the time constant C_1R is also large compared with the duration of the sweep.

Ideally the voltage across R should be exactly constant, but this cannot be attained in practice on account of the gain of V2 departing from unity. With a gain of less than 1 the voltage at X lags slightly on that at Y, the current through R falls slightly and the timebase sweep voltage becomes non-linear.

During the quiescent period (i.e., absence of input voltage at V1 grid) current flows through R_1, R and V1 to earth. During the period of the sweep, the current through R remains constant but the decrease in current through R_1 is made up by that flowing through C_1.

B.S.R.A. Constructors' Competition

THIS year's competition, held in conjunction with the annual dinner of the British Sound Recording Association, was notable for the exceptionally high standard reached by all the competitors, not only in design but in the workmanship and finish of the sound recording and reproducing equipment shown.

The President's Trophy was awarded to L. Widger, A.M.I.E.E., for a fully automatic system of sound accompaniment for a cine film in which commentary from tape and background music from discs are blended through mechanically-operated faders by notch cues on the film and conducting strips on the magnetic tape. The system includes means of precise speed control of the film and facilities for recording the combined sound effects on a single tape if required.

A neat v.h.f./f.m. receiver with pulse-counter-type discriminator won the *Wireless World* prize. This was designed by R. N. Baldock, B.Sc., in cylindrical form (2in diameter × 8in long) for mounting behind existing panels where space may be limited. Another tuner, with a similar discriminator, also of very compact design was entered by A. Robinson and was runner-up in the section for non-members of the Association.

A. J. Harper was awarded the Guy Fountain Prize with a neat turntable and pickup mounting incorporating an unusually smooth pickup lowering mechanism, most of which is below the motor board.

A prize for non-members of B.S.R.A. has been donated by *Hi Fi News* and was won this year by J. T. Gilbert for a stereo tape recorder using a modified commercial mono deck and with an unusually wide range of facilities, including dual level indicators and a built-in oscillator for balance adjustments.

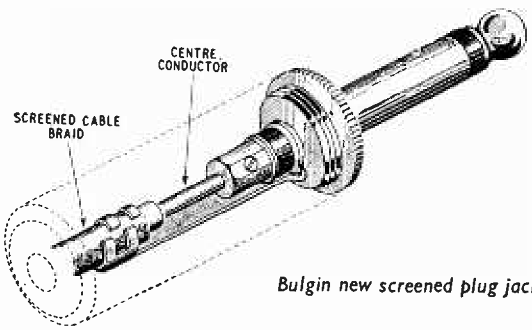
Manufacturers' Products

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Screened Jack Plug

A FULLY screened telephone or microphone plug with standard $\frac{1}{4}$-in-diameter shank, has been introduced by A. F. Bulgin and Co. Ltd., Bye-Pass Road, Barking, Essex, primarily for use with tape recorders, but it has also applications wherever screened concentric or co-axial cables are terminated in a plug of this kind. It takes cables up to $\frac{7}{32}$-in outside diameter and the screw-on metal cover, which is electrically connected to the shank electrode of the plug, is available with either polished chrome (P538) or 22ct gold plate (P539) finish. The price is 4s 6d in either finish.

No soldering is required, the centre conductor of the cable is secured by a grub screw to a terminal block and



Bulgin new screened plug jack.

the screened sheath is gripped in a claw-like clamp, which serves also to take any strain on the cable.

A companion 6-mm model, for use with "Continental" equipment, is available also.

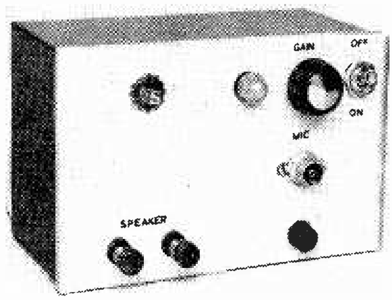
Flexible Wood-veneer Strips

THE processed forms of wood—from plywood to veneered chipboard—have very definite advantages for the construction of equipment and loudspeaker cabinets; but, if it is desired to "finish" as polished wood, inferior or complicated construction of the edge joints often has to be adopted to cover the multi-layer or chip nature of the material. To avoid the need for difficult construction Flexible Veneers Ltd. offer the $\frac{3}{4}$-in-wide Agastrip and Agatape paper-backed, flexible-veneer edging strips in light oak, mahogany and walnut. Agastrips are supplied in four- and ten-yard-long coils with the grain across the strip and with along-the-strip grain in 3-ft lengths. These have to be glued on; but the self-adhesive Agatape ($19\frac{1}{2}$-in lengthwise-grain strips) has only to be pressed on to the clean, dust-free surface.

The address of Flexible Veneers Ltd is: Cobbs Court Buildings, Carter Lane, London, E.C.4.

Transistorized Public-address Amplifier

WITH the new WS Electronics "Lilliput" amplifier a maximum output power of 12W r.m.s. into an impedance of 3 or 15Ω may be obtained from an input of 2mV r.m.s. at 30Ω impedance. The average current consumption when amplifying speech to maximum power output is about 1.5A (at 12V d.c.). The amplifier may be operated from 12, 24 or 28V d.c. supplies. Fuses in the amplifier protect the battery supply against being shorted out and also prevent the transistors being



WS Electronics "Lilliput" transistor public-address amplifier.

damaged by the application of a reversed voltage. The weight of the "Lilliput" amplifier is 5lb and its size $6\frac{1}{2}$in by 4in by 4in. It costs £19 10s and is manufactured by W.S. Electronics Ltd., of Brunel Road, East Acton, London, W.3.

High-resistance Kilovoltmeter

THE E.I.R. Instruments kilovoltmeter has a sensitivity of 250kΩ/V and indicates over the ranges 0 to 100V, 0 to 20kV (direct only) and 0 to 300MΩ on a 4-in scale. Using a 100-μA basic movement, the 4-μA f.s.d. sensitivity is achieved by the use of a cathode-follower current amplifier. This has a high-value cathode resistor, thus stabilizing the meter against mains-supply variations and the effective grid-to-earth resistance is 25MΩ, corresponding to the 100-V range. To change to the 20kV range a 5-GΩ (5,000MΩ) series resistor mounted in an insulated tube is used: this resistor is a single unit of a special type rated at 30kV. To measure resistance the unknown resistor forms a potential divider from h.t. with the input resistance of the meter.

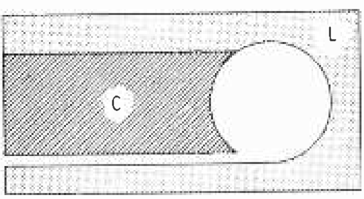
Capable of operating from 110 or 200 to 250-V a.c. supplies the meter is available in several forms (skeleton for incorporation in equipment, wooden or metal case, with or without megohm range) and it costs between £20 and £23.

Manufacturers: E.I.R. Instruments Ltd., 329 Kilburn Lane, London, W.9.

100-V and 25-kV meter has sensitivity of 250kΩ/V.

Technical Notebook

Industrial R.F. Generators usually employ large tank circuits in which the losses have to be kept to a minimum. This implies the use of a high-Q circuit with a small value of tuning capacitance; but then the variable reactance imposed by the work may "pull" their frequency outside the set limits. A large tank-circuit capacitance can overcome this effect by swamping the imposed variations, but the losses in a circuit of normal construction are then increased. In *Mullard Technical Communications*, Vol. 5, No. 41, F. Dittrich describes the design of "laminated circuits," the aim of which is to combine the inductive and capacitive components of the tuned circuit, at the same time avoiding joints and sharp corners in the path of current flow. The tuned circuit is made up from a set of plates of the form shown in the sketch, stacked and spaced, alternate plates being reversed to make the cross-hatched portions overlap from alternate edges and form the capacitance. This forms a parallel-plate capacitor with an integral single-turn inductor

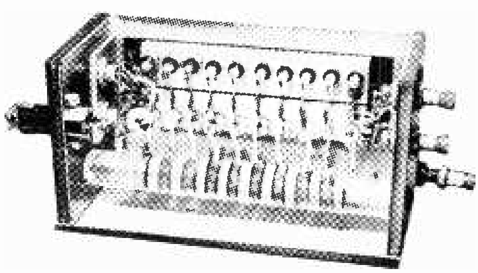


—the inductor being split into many sections so that each section carries only the circulating current associated with its own capacitor plate. Another advantage is that, outside the cross-hatched area on the sketch, adjacent plates are at the same r.f. potential so that metallic spacers and bolts may be used for assembly.

Adjacent-Channel Interference due to multiplex signals may not be so great in practice as simple theoretical considerations would indicate, according to a letter from L. B. Arguimbau published in *Proc. I.R.E.* for August 1959. Measurements on two commercial v.h.f./f.m. receivers were made—one nominally broad-band and the other nominally narrow-band. In both cases there was little change in adjacent-channel interference when an ordinary f.m. signal was replaced by an f.m. signal which included a sub-carrier such that the maximum total deviation was increased (although at the same time the main-carrier deviation was reduced and the amplitude of the added sub-carrier was made less than that of the main carrier). The reason for this small change in adjacent-channel interference with increasing deviation is probably due to the fact that in any practical receiver the response outside the passband does not fall off immediately to zero. In this latter simple theoretical case where the response outside the passband does immediately fal off to zero, if the deviation of a signal normally just outside the passband is increased, the interference, of course, increases from zero to some finite value, so that the proportionate increase in adjacent-channel interference is theoretically infinite.

Drop-outs and Noise due to imperfections in the tape are problems besetting any type of magnetic-tape recording, but for digital work either can result in false information. Many precautions are thus taken to reduce the effect of these distortions. The Telegraph Construction & Maintenance Company have attacked the root of the problem by, surprisingly enough, returning to the *Blattnerphone* idea, replacing the oxide-coated tape by 0.001-in thick Vicalloy. This material is a malleable and ductile permanent-magnet alloy with a saturation flux density of about 12,000 gauss. It is claimed that, due to the lower incidence of drop-outs and noise, much more information can be packed on the tape, so saving space in compact instrumentation.

Pulse Shortener developed by the Admiralty Surface Weapons Establishment uses variable-capacitance diodes as the capacitors in a lumped-constant transmission line. To shorten a pulse the bias on the diodes is altered so as to decrease their capacitance as the pulse is travelling down the line. This decrease in the diode capacitance produces an increase in the velocity of propagation down the line. Since the pulse continues to occupy the same physical length of line, this increase in the pulse velocity decreases the pulse period. Decreasing the diode capacitances also increases the pulse energy stored.



RANDOM RADIATIONS

By "DIALLIST"

It's Worked in New Zealand

A READER in New Zealand tells me that the term radiotrician, which I mentioned in the April issue, is in fairly common use in his country, but the official word is serviceman. Official? Yes, in New Zealand it is illegal for anyone who has not served a specified term as a trainee and subsequently passed an official examination to undertake the servicing of any mains-operated electronic equipment. Having served his time and passed the exam, he is registered as a serviceman and receives his certificate of competence. To become a trainee, a man must obtain a "permit to assist" a certificated tradesman for so many years, after which he can present himself as a candidate for the exam. We have, of course, in this country the R.T.R.A. exams and certificates in both sound radio and television servicing; but it isn't agin the law to undertake such work if you haven't got these certificates. Whether or not it should be is a moot point. I wonder what readers think about it?

Wire or Wireless?

WHICH, I wonder, will win the race to provide better television and v.h.f. sound reception in places where they're not now too good? Stage 2 of the B.B.C.'s expansion programme is scheduled for completion by March 1964 and the additional 21 satellites will bring in an important number of new viewers and listeners, as well as improving reception for many thousands more. But the piped services people are getting on fast with the job of providing strong "clean" signals in places where they're now weak, or interference-ridden, or both. Myself, I'm rather inclined to believe that piping is the only certain way of providing good services in built-up areas in which interference, ghosting and so on are bad. But it probably would be uneconomic to extend it to remote country districts and it's the villages and isolated houses that satellite transmitters and translators can do most to help.

V.H.F. DX

FROM Aylesbury comes further news of successful long-distance reception on the very high frequencies. The reader who sends it tells me that in the four years in which he's been at it he has logged all bar one of the B.B.C.'s v.h.f. stations. He has also logged nearly 60 European stations, including thirty-six in Italy. He points out how heavily the v.h.f. DX-er scores over his medium-wave opposite number. On the very high frequencies good, clear reception of Continental stations can be obtained; but that's too often far from being the case on the crowded medium- and long-wave bands.

The Dry Cell Problem

IN the May issue of *Wireless World* I mentioned the possibility of serious damage through the puncturing of one or more cells of a partly run down dry battery left in a transistor receiver, a hearing aid, or an ohmmeter. Several suggestions for making things safe have come along; wrap the battery with Sellotape or with insulating tape, or place it in a polythene bag in the set and should it spring a leak, throw it away bag and all. So long as there's room for a wrapped battery and provided you can contrive watertight exits for the connecting leads, any of these should answer. But the real answer is surely that dry batteries meant for use in such apparatus should be made up of leakproof cells. They cost a bit more, but in my view it's jolly well worth it, for I have never known a leakproof cell of good make to belie its name, even though badly treated. Just to see what would happen, I once kept a trio of run-down leakproof cells on the shelf for a whole year. They weren't leaking when I threw them away.

V.H.F. and Polarization

AS you know, the B.B.C.'s v.h.f. sound transmissions are horizontally polarized and I have been surprised to find that with an horizontal dipole I have often picked up vertically polarized signals sent out by non-broadcasting stations. This so intrigued me that one day I tried the experiment of changing my aerial from the horizontal to the vertical position. Reception from the local broadcasting station wasn't so good; but I *did* get a signal of some kind with the dipole in any position between the horizontal and the vertical. A friend who often listens to European v.h.f. stations tells me that with his horizontal Band III dipole he is frequently able to receive vertically polarized transmissions—or at any rate, transmissions emanating from vertical aerials—from other countries. It must be, I suppose, that as they journey these very short waves tend to twist a little.

Electron Beam Welding

SINCE writing the note in the June issue on electron beam welding and cutting I have learned that the originator of the technique in Europe was J. A. Stohr, of the French Atomic Energy Authority. I am interested to learn also that Edwards High Vacuum Ltd. have obtained a licence to manufacture in this country vacuum welding equipment using an electron bombardment heat source. Edwards also kindly sent me a reprint of a paper on the subject presented by two members of their research staff, M. E. Harper and E. G. Nunn, at a recent meeting of the Institute of Welding.

Getting Down to It

THE striking and animated picture entitled "TV," which attracted so much attention at this year's Royal Academy Exhibition, might well have had a sub-title "How not to watch it," for nearly every method of obtaining a poor picture and straining the eyes is being practised by the viewers. To begin with, the receiver is on the floor, which means that except for the children and the dog, who are themselves on the carpet, everyone must look right down at the screen—a most uncomfortable business and hard on the eyesight. The children, poor mites, have their eyes within inches of the screen. Despite the fact that they're already so close to the set all the grown-up viewers are leaning forward. It's a question of artistic licence, I suppose.

Without the Book

AMAZING—isn't it?—what a mess a ham-handed fellow who tries to adjust a television receiver can make of things. I don't mean by taking the back off and poking about inside but just by messing with the external controls. A friend of mine recently acquired a first-rate set, capable of showing an excellent picture, which was put in and adjusted by his dealer. When I dropped in a few days later to see how it was doing I found that it was showing just about as bad a picture as you can imagine. Surely the dealer hadn't left it like that, I suggested. No, I was told, it wasn't quite like that: but the owner thought that he could make it just a tiny bit better, so he tried his hand. No, he hadn't bothered about the instruction book; just tried altering one knob's setting after another. Afraid he hadn't made much of a job of it; could I be so kind . . .?

UNBIASED

By FREE GRID

Radar in 1896?

IF I were to state that radar was invented before radio communication, it would probably result in strong letters of protest being sent to the Editor. Yet this is stated almost daily in the popular Press and even, I'm sorry to say, in some so-called technical journals.

The writers do not make this statement directly but they certainly do in effect when they tell us, for instance, that radar was used at Jodrell Bank to switch on and off the transmitter of one of the American space probes. We also often hear that "radar waves" are used to control guided missiles, and to destroy American rockets in mid-flight when it has been found necessary owing to something having failed to work out according to plan.

This grievous perversion of the word radar is obviously due to the fact that these offending writers imagine it to mean control at a distance or, in other words, telearchics. To some extent this is the fault of people in responsible positions who coined the expression "secondary radar" to describe what was really a special application of telearchics. No doubt the expression secondary radar is highly convenient for those who know what they are talking about but it was bound to cause confusion and trouble among the less well-informed who at once proceeded to apply the term radar to any other application of telearchics.

Now if we are going to allow the word radar to be used as a synonym for telearchics we must, to be logical, be prepared to admit that radar was invented before radio communication. A moment's thought will make this clear.

Everybody will admit that before it was possible to establish radio communication, Marconi and others had to find some means of causing incoming radio waves to waggle the diaphragms of a pair of headphones or trigger off a local source of power to operate the armature of a morse inker. In other words, telearchics, which is loosely and falsely called radar-control by certain writers, had to precede radio communication, as is made abundantly clear in Marconi's patent specification of June, 1896.

However, telearchics—and therefore wrongly so-called radar—was established long before 1896. I have been reading a book published in 1917 and written by B. F. Meissner, of the U.S. Navy. It is mainly about the control of torpedoes by telearchics—which the author calls teledynamics or radiodynamics.

In this book Meissner stresses that the first instance of the electrical control of mechanisms from a distance was when Le Sage, of Geneva, established his electrostatic telegraph nearly two centuries ago in 1774. Its wireless counterpart—using the word wireless in its literal sense—was in 1838, when Steinheil obtained deflections of a galvanometer needle over a distance of fifty feet by means of earth currents.

I will cap this by pointing out that in 600 B.C., Thales of Miletus demonstrated wireless control at a distance when he caused amber to attract pieces of paper. Obviously, even in pre-electrical days, telearchics always preceded communication, for no matter whether we receive a message aurally or visually, it is first necessary for the incoming signals to waggle our eardrums or agitate our retinæ.

Music Hath Charms . . .

EVERBODY has heard of Congreve's famous words:—

"Music hath charms to soothe a savage breast,
To soften rocks, or bend a knotted oak,",

and it is for this reason that in days of old, young men used to serenade their lady loves, and try to soften their hard hearts by fiddling beneath their bedroom windows. This technique is, of course, exactly the same as that employed by a snake charmer who can, by a suitable tune, bend the most savage serpent to his will.

In the jargon of present-day psychological science, this musical mesmerizing of a maiden would be called conditioning her to accept a proposal.

I hear that this old technique has been adopted by some go-ahead dentists to soothe their patients and "condition" them to accept pain. So far I have only heard of it being employed in the case of a young lady of my acquaintance, but it may be used on some men also, for certain of our sex are undoubtedly as susceptible to the strains of Orpheus' lute as were any of the other beasts of the field.

The lady who supplied me with the information, told me her dentist used the very latest technique in supplying the mesmerizing music. He had installed a modern stereophonic system which ground out a scherzo as his drill ground into her carious cavity.

I am wondering if the choice of music is always left to the dentist's professional judgment or whether the patient can have a say in the matter. A scherzo is, of course, a light, quick and animated movement; in fact, just the sort of movement the patient herself would make when the drill lighted on a nerve.

The whole thing is thus reminiscent of the technique of the ancient Chinese dentist who, so Marco Polo would have us believe, used to employ thumbscrews on the patient when extracting a tooth. The idea was, of course, that the pain of the thumbscrews acted as a counter-irritant to the oral pain inflicted by the dentist. The thumbscrew agony was so excruciating that the dental pain paled into insignificance.

That being so, I think that if I had my choice, I would pick as my counter irritant something by Bartok or Hindemith as I cannot think of anything more painful than being forced to listen to their efforts. Modernists will naturally not agree with me and would probably choose Bach or Beethoven as their counter irritants. But for a tooth extraction,

Counter-irritant to oral pain

of course, nothing would be so effective as the Eton boating song with the swinging melody which accompanies the words "we all pull together."