Literature of Chemical Technology

Based on papers presented at two symposia sponsored by the Division of Chemical Literature of the American Chemical Society at the 143rd Meeting, Cincinnati, Ohio, Jan. 13-14, 1963, and the 145th Meeting, New York, Sept. 9-13, 1963.

Julian F. Smith

Symposium Chairman

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Advances in Chemistry Series

Robert F. Gould, *Editor*

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FOREWORD

Advances in Chemistry Series was founded in 1949 by the American Chemical Society as an outlet for symposia and collections of data in special areas of topical interest that could not be accommodated in the Society's journals. It provides a medium for symposia that would otherwise be fragmented, their papers distributed among several journals or not published at all. Papers are refereed critically according to ACS editorial standards and receive the careful attention and processing characteristic of ACS publications. Papers published in Advances in Chemistry Series are original contributions not published elsewhere in whole or major part and include reports of research as well as reviews since symposia may embrace both types of presentation.

PREFACE

ADVANCES IN CHEMISTRY SERIES Nos. 4, 10, 16, 20, and 30 are aids to literature searching, offering much information of lasting value and some which is now outmoded or outdated. No. 10 contains 59 papers from five symposia and several general sessions of the Division of Chemical Literature in its meetings in 1952 and 1953.

This new ADVANCES volume, pertaining particularly to No. 10, condenses but updates four of the symposium topics, omitting only the one on market research. It modernizes No. 10 but also brings in some new topics and presents some in a different light. It is essentially a resources-for-searchers compilation for the chemical process industries. Emphasis is on sources of current information, but retrospective searching is not neglected.

Since complete homogeneity is impossible among so many topics and authors, it is comforting to remember that uniformity can be deadly dull. One industry, rubber, receives an extra share of attention. The 1956 "Symposium on Rubber Literature" (sponsored jointly by the Division of Rubber Chemistry and Division of Chemical Literature) published by the Division of Rubber Chemistry, received only limited circulation and is long out of print. Much of it is updated here, and a chapter on carbon black is added.

The earlier ADVANCES mentioned above contained mostly invited papers; to round out technology coverage, some new chapters were invited for this volume. ADVANCES No. 16, "A Key to Pharmaceutical and Medicinal Chemistry Literature," represented here by one paper, is still in print and still useful for its attention to the older literature.

A few editorial liberties have been taken. The late T. A. O'Brien's "Patent Searching in Rubber Technology" is reprinted unchanged, but a list of U. S. Patent classes and a list of *Chemical Abstracts* subject sections have been added to other chapters where appropriate. The original authors have updated all other entries from the earlier volumes. ADVANCES No. 20, "Combustion of Petroleum," is represented by one paper, in which the text and the bibliography were originally two separate contributions.

Another editorial change is in treating government publications (chiefly U. S.) as source material. Instead of one article on this subject, it is given attention in single papers. Through its Reference Division, its

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Science and Technology Division, and especially the National Referral Center, the Library of Congress gave potent aid in locating appropriate information.

The extensive contribution on food industries by Virginia Valeri and Bella Wadler (Chapter 40 in this volume) is based on an entire symposium in ADVANCES No. 10. Similarly, two symposia on textiles from ADVANCES No. 10 are combined here as Chapter 15.

This volume has 22 symposium-based papers, including 13 from two symposia at 1963 meetings of the Division of Chemical Literature, and 7 from the 1956 Rubber Symposium. The late T. E. R. Singer was a prime mover in most of the Division's symposia. He was long chairman of the Program Committee and later an active member of the Committee.

Hickory, N. C.
November 1968

JULIAN F. SMITH

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

1

Literature of the Chlor-Alkali Industry

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Reviewed are the development of the chlor-alkali industry; processes for manufacturing the individual chemicals, i.e.—chlorine, sodium hydroxide, sodium carbonate, potassium hydroxide, potassium carbonate, and sodium bicarbonate; and their end uses. The bibliography is not exhaustive but merely a selected list of sources of information on the industry; it includes books, periodicals, reference works and treatises, handbooks, directories, government publications, trade association publications, company trade literature, and abstracting and indexing services.

The chlor-alkali industry, defined by the *Standard Industrial Classification Manual* as product code number 2812, is concerned with producing and utilizing the basic chemicals: chlorine, sodium hydroxide or caustic soda, potassium hydroxide or caustic potash, sodium carbonate or soda ash, potassium carbonate, and sodium bicarbonate.

In the U.S., approximately 40 companies operate over 80 chlor-alkali plants for both captive and merchant production, according to the Department of Commerce, *Review of 1963—Outlook for 1964.*

The chlor-alkalies find wide application in the production of pulp and paper, textiles, glass, solvents, soaps and detergents, plastics, petroleum products, pesticides, rubber, metals and in the treatment of water and wastes. In fact, there is hardly a consumer product that has not required chlorine and/or alkali at some stage of its manufacture.

Because of the magnitude of the industry, its long history, and the diversity of end uses, this survey covers only selected references on the production, properties, and uses of the chlor-alkali chemicals.

Development of the Industry

In 1949, R. L. Murray described the chlor-alkali industry in the U.S. and the basic processes in use (*95*). In 1952, the Electrochemical Society published

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In Literature of Chemical Technology; Smith, J.;
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a review of the industry for the period 1902-1952 (*63*). Since that date there have been annual reports of the chlor-alkali committee (*47, 48, 49, 29, 88, 56, 39, 31, 32, 33, 133*). These reports give number of plants operating, processes used, capacities, expansions, technical developments, markets and end-use patterns, trends, and production and sales figures.

The chlor-alkali industry in Germany prior to World War II was described by Hunter (*65*) and in the so-called "PB Reports" which were made available by the U.S. Dept. of Commerce, Office of Technical Services, now the Clearinghouse for Federal Scientific and Technical Information at Springfield, Va. Following is a selected list of these reports:

PB 394	German Chlorine Industry
PB 7747	Survey of Chlorine and Caustic Plants in Western and Southern Germany
PB 47908	Electrochemical Operations at I. G. Farbenindustrie, A. G. Bitterfeld
PB 81278	Soda Ash Manufacture in Southern and Western Germany

The Chlorine Institute Pamphlet #19 is an index to the Chlor-Fako and Chlor-Uko reports. Translations of the reports are on file at the Institute, and photocopies are furnished at cost.

Economics

In 1961, W. H. Martin discussed factors influencing entry into the chlor-alkali industry, including access to raw materials, technology, capital costs, operating rate, joint products, end-use patterns and vertical integration (*89*). In two of the four recent publications of the Manufacturing Chemists' Association, written by J. Backman, the chemicals in SIC 2812 are compared with those in other groups in capacities, distribution and value of shipments, and value added by manufacture. Concentration ratios comparing the chlor-alkali industry with other industries in value of shipments, etc. are reported for the U.S. Senate in *Concentration Ratios in Manufacturing Industry, 1958 and 1963* and *Concentration in American Industry, 1957.*

Manufacturing Processes

Electrolytic Methods for Producing Chlorine and Caustics. Electrolysis of salt brine solutions in either diaphragm cells or mercury cells is the principal method of producing chlorine and caustics (*5, 77f, 77g, 118, 131*). Diaphragm cells and their operation are described (*54b, 119a*). L. D. Vorce, the inventor of one of the diaphragm cells, traced the development of caustic-chlorine cells in America for a period of over 100 years (*144*). R. L. Murray also described the growth of the electrolytic alkali and chlorine industry in the U.S. and the development of the deposited diaphragm cell (*94*).

Mercury cell design and operation are described (*45, 54a, 113, 119b*). A recent article discusses the De Nora firm whose mercury cells are used throughout the world (*36*). Platzer describes European designs of diaphragm cells and both horizontal and vertical mercury cells (*104*). Exhaustive tabular compilations prepared by H. A. Sommers show chlorine production capacity in the

U.S. and in Europe as of June 1, 1957, by company, plant location, capacity, and type of cell (*128*). These data were recently updated to June 1, 1964 for North America (*130*). Diaphragm cell plants predominate in the U.S., and mercury cell plants predominate in Europe. In the last few years, mercury cells are gaining favor in the U.S. and Canada, particularly where power is cheap and rayon-grade caustic is required (*135*). The two types of cells are compared, and factors influencing the choice of cells are discussed (*46, 77g, 87*).

Electrolytic Methods for Producing Chlorine without Caustic. Electrolysis of fused sodium chloride produces chlorine and sodium metal (*50, 77g, 131*). Electrolysis of fused magnesium chloride produces chlorine and magnesium metal (*54c, 58, 119c,* and Bureau of Mines IC8201). Although the latter process currently does not introduce chlorine into the U.S. merchant market (*77g*), a recently proposed magnesium chloride reduction plant in the Pacific Northwest would introduce a substantial quantity of chlorine into the market (*30*).

Chlorine is also produced by the electrolysis of hydrochloric acid by a process developed by C. P. Roberts (*112*). Schroeder's process electrolyzes a solution of nickel chloride to produce chlorine and nickel (*117*). De Nora and Farbwerke Hoechst are operating plants for the direct electrolysis of hydrochloric acid to produce chlorine (*4, 41, 52, 77g, 108, 119d*). The De Nora process was used in the U.S. by Monsanto Chemical Co. at Anniston, Ala. (*40, 77g, 131*). The Hoechst process is being used by Chemische Werke Hüls (*62*).

Non-Electrolytic Methods for Producing Chlorine. Chlorine was produced from salt by reaction with nitric acid at the Hopewell, Va. plant of Allied Chemical Corp. (*50, 75, 77g, 119e, 131*). Southwest Potash Corp. has developed a similar process starting with potassium chloride (*77g, 131*).

By-product hydrochloric acid is the starting material for the production of chlorine by chemical oxidation processes (*119f*). Catalytic oxidation of hydrogen chloride with air or oxygen, which is a modification of the Deacon process, has been developed by Shell (*4, 27, 28, 42, 75, 77g, 93, 119f, 131*). Oxidation of hydrogen chloride with nitric acid or a mixture of nitric and sulfuric acids has been developed by the Institut Francaise du Petrole (*26, 77g, 100, 131*). Hydrogen chloride can also be oxidized with sulfur trioxide to produce sulfuric acid, chlorine, and sulfur dioxide (*75, 119f, 131*).

Non-electrolytic Methods for Producing Caustics. After electrolysis of salt, the only method that has been used for producing caustic soda is the causticization of sodium carbonate with lime, but this process is decreasing in use (*77g*).

Methods for Producing Carbonates. Synthetic soda ash (sodium carbonate) was first made by the LeBlanc process (*51, 77g*), which was entirely displaced shortly after World War I by the Solvay Process. A review of the work of Solvay on the ammonia-soda process appeared in 1961 on the occasion of the centenary of his first patent (*116*).

Soda ash production from natural sources is described (*96*). Sommers gives a flow sheet of the trona process and a list of soda ash plants in the U.S.

and their capacities, both synthetic and natural (*129*). The trend is to produce soda ash from the less costly and practically unlimited supplies of trona (*129*).

Sodium bicarbonate is manufactured by carbonation of sodium carbonate solution (*77b, 77g*).

The principal method for the production of potassium carbonate is the carbonation of electrolytic potassium hydroxide (*77e*).

Properties and Handling

The physical and chemical properties of all the chlor-alkalies are given in "Kirk-Othmer" (*77g*), "International Critical Tables," and in the "Condensed Chemical Dictionary" edited by Rose. The properties of chlorine are described by Laubusch (*119g*), in the "Chlorine Manual" published by the Chlorine Institute, and in the booklet by Kapoor and Martin entitled "Thermodynamic Properties of Chlorine." Information on toxicity will be found in the Chlorine Institute publications, *Chlorine Manual* and Pamphlet #24, the Manufacturing Chemists' Association (MCA) "Safety Data Sheets" and in "Dangerous Properties of Industrial Materials" by Sax. Properties and toxicity of chlorine, hydrogen chloride, hypochlorites, caustic soda, caustic potash, and soda ash are discussed (*44*). Safety in the handling and storage of chlorine is discussed by Laubusch (*84, 85, 119h*), and in the MCA "Safety Data Sheets." The latter series also discusses the handling and storage of the caustics. Shipping regulations are given in Agent T. C. George's Tariff No. 15, MCA "Safety Data Sheets," the "Condensed Chemical Dictionary," and in Sax.

End Uses

The chlor-alkalies are basic chemicals used principally in the production of other chemicals, both organic and inorganic, and in a number of industries. The diverse end uses for chlorine, caustic soda, and soda ash are listed (*76*) and discussed (*90*).

U.S. end-usage figures, as percent of total, are listed for the individual chemicals (*16, 24, 106, 107, 125, 127*).

Organic Chemicals. The use of chlorine in producing organic chemicals constitutes the largest single end-use category for chlorine. Production of C_1 and C_2 chlorinated hydrocarbons accounts for the largest proportion of chlorine consumption (*77i*).

All of the chlorinated methanes can be produced by thermal or photochemical chlorination of methane (*77i, 119i*). Specific processes are used to produce individual members of this series; for example, methyl chloride is manufactured by the reaction of methanol with hydrochloric acid, and carbon tetrachloride is made by chlorination of carbon bisulfide (*77i*).

Ethyl chloride is produced by the chlorination of ethane or by hydrochlorination of ethylene (*77i, 119j*). 1,2-Dichloroethane (ethylene dichloride), the largest volume chlorinated organic, is manufactured by chlorination of ethylene (*77i, 119j*). Most of the 1,2-dichloroethane produced goes into the manufacture of vinyl chloride, which is formed by dehydrochlorination of the

1,2-dichloroethane (*77i, 119k*). Alternately, vinyl chloride is produced *via* hydrochlorination of acetylene (*77i, 91, 119k*). Large vinyl chloride producers operate integrated processes using the hydrogen chloride formed from 1,2-dichloroethane cracking in the acetylene hydrochlorination (*119k*). In recent years, oxychlorination processes have become increasingly important for 1,2-dichloroethane and vinyl chloride production (*69, 148*). In the oxychlorination process, no by-product hydrochloric acid is generated (*9, 38, 119j*). A recently announced vinyl chloride process uses a light naphtha obtained by cracking petroleum and containing a mixture of ethylene and acetylene, which selectively react with chlorine and hydrogen chloride (*143, 149*). Vinyl chloride is used for making polymers and copolymers for films, fibers, foams, rubbers, etc. (*119k*).

Trichloroethylene is produced by chlorination of acetylene to form tetrachloroethane which is dehydrochlorinated to form the trichloroethylene (*77i, 119l*). Perchloroethylene is produced by chlorination of trichloroethylene to form pentachloroethane which is then cracked to perchloroethylene and hydrogen chloride (*77i, 119l*). Perchloroethylene is also produced by chlorination of hydrocarbons other than acetylene, *e.g.*, propane, propylene, ethane, ethylene, and methane or their mixtures as natural gas or liquefied petroleum gases (*77i, 119l*).

Chlorination of ethylene or acetylene can also form 1,1,2-trichloroethane (*77i*) which, upon dehydrochlorination, produces vinylidene chloride (*77i, 119m*), the monomer for "Saran" thermoplastics (*119m*). Reaction of vinylidene chloride with hydrochloric acid forms 1,1,1-trichloroethane (methyl chloroform), a widely used solvent (*77i*).

Chloroprene, which is 2-chloro-1,3-butadiene, the monomer used in "Neoprene" rubber, is produced by chlorination of butadiene, butene, or butane to form dichlorobutenes which are isomerized to 3,4-dichloro-1-butene. The latter, upon dehydrochlorination, yields chloroprene (*77a*). The classical route to chloroprene is dimerization of acetylene followed by hydrochlorination of the vinyl acetylene formed (*77a*).

Chlorination of longer chain hydrocarbons forms chlorinated paraffins which are used as plasticizers and lubricating oil additives (*77g, 77i*). Chlorinated paraffins also are intermediates in making straight chain alkyl sulfonate biodegradable detergents (*1*).

Substantial quantities of chlorine are consumed in the manufacture of non-chlorine containing end products such as alcohols and glycols. Reaction of ethylene or propylene with aqueous chlorine produces chlorohydrins (*77l, 119n*) which are intermediates in the production of ethylene and propylene oxides. The latter are converted to glycols, whose principal use is in antifreeze (*119n*). The chlorohydrin process is currently used for propylene oxide production; ethylene oxide, however, is now being produced mainly by a direct oxidation process (*77l, 119n*). Vapor phase chlorination of propylene produces allyl chloride which is an intermediate for allyl alcohol and epichlorohydrin (*119o*). Allyl alcohol finds wide application in plastics, and epichlorohydrin is an intermediate for production of synthetic glycerol and epoxy resins (*77l, 119o*).

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Benzene can be chlorinated to form mono, di, and trichlorobenzenes (*77i, 119p*). The major product is monochlorobenzene, which is an intermediate for phenol and aniline (*119p*). Dichlorobenzene and trichlorobenzene are widely used solvents (*119p*). Toluene is selectively chlorinated to produce benzyl chloride, benzal chloride, benzotrichloride as well as a series of chlorotoluenes, useful in plasticizers, dyes, solvents, wetting agents, lubricants, pesticides, to name a few (*119q*).

Many pesticides currently in use are chlorinated derivatives or use chlorine in their manufacture. Chloral, produced by chlorinating ethanol or acetaldehyde, reacts with monochlorobenzene to produce DDT (*119r*). Benzene hexachloride is produced by adding chlorine to benzene (*77i, 119s*). Other widely used chlorine-containing insecticides include: chlordan, aldrin, dieldrin, toxaphene, and the chlorinated phosphoric acid esters (*77v, 119t*). Johnson, in 1963, published a comprehensive review of pesticides, listing chemical name and formula, trade name, producers, properties, toxicity, and major end uses as well as manufacture and market (*74*).

Phosgene, which is carbonyl chloride, is produced by the reaction of carbon monoxide with chlorine (*77k, 131*) and is used as an intermediate for isocyanates and carbamates (*102*). Isocyanates are used to produce the polyurethane plastics (*77q*). Carbamates are widely used in the production of pesticides (*74*).

Inorganic Chemicals. Hydrochloric acid is the most important inorganic chemical made from chlorine. It is made by the reaction of chlorine with hydrogen or sodium chloride with sulfuric acid (*77h, 131*). However, these production methods are decreasing in volume as the availability of by-product hydrochloric acid from chlorination processes is increasing (*131*). 1963 production figures for hydrochloric acid are listed (*141*). Uses of hydrochloric acid are legion; some in the production of organic chemicals have already been mentioned. Other industries using hydrochloric acid include petroleum, metal, food, and leather (*77h*), and the pickling of steel (*67, 68, 105*). A recent paper discusses the substitution of hydrochloric acid for chlorine in processes such as oxychlorination and hydrochlorination of ores (*60*).

Titanium dioxide, used in paints, paper, inks, rubber, etc., is made by a process using chlorine (*8, 131, 138*).

Chlorine is used in the production of a number of metal chlorides useful as catalysts. Until recently, aluminum chloride was the only one of significant use, *e.g.*, in the Friedel-Crafts synthesis. Others, such as the chlorides of titanium, silicon, boron, zirconium, antimony, and vanadium, are becoming important in this area. In addition, silicon tetrachloride is an intermediate for producing silicones (*119u*).

Bromine, made by treating bromide-containing brines with chlorine, is used in the manufacture of gasoline additives (*131*).

Phosphorus trichloride, made by chlorinating phosphorus, is used to make phosphorus oxychloride which is used in plasticizers, gasoline additives, functional fluids, etc. (*131*).

Hydrazine, a major rocket fuel, is manufactured by the Raschig process from ammonia, chlorine and sodium hydroxide (*131*).

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Metallurgy. The light metals industry is a major consumer of chlor-alkalies. Caustic soda and soda ash are used in producing aluminum (*66, 77s, 98,* and Bureau of Mines RI 5997).

Caustic soda and soda ash are also used in the production of beryllium (*55a, 66*), tungsten (*55b, 57*), vanadium (*57*), and uranium (*55c, 121*). The steel industry uses caustic soda ash in ore reduction, in cold forming and in finishing operations (*37*).

The nickel industry uses soda ash and chlorine in electrorefining (*61*).

Chlorination techniques are used in the production of a number of metals, *e.g.*, titanium (*55d, 119v*), zirconium (*55e, 119v*), silicon (*55f*), hafnium (*55g*), niobium (*55h, 59*), tungsten (*59*), and tantalum (*59*).

Pulp and Paper. The pulp and paper industry is one of the biggest users of the chlor-alkalies (*19*). Chlorine and its derivatives, caustic soda and soda ash are used for bleaching purposes (*19, 77j, 119w, 131*), and in pulping (*19, 77j*). The various pulping processes are described (*64, 77j, 109, 114, 115*). A literature survey on the cold soda pulping process, covering the period 1950-August 1959 and containing 119 references, was published in *Tappi* in 1960 (*10*). Tables showing the quantities of soda ash and caustic soda used in wood pulp processes; chlorine, soda ash, and caustic soda used for bleaching by paper and pulp mills; and chlorine, soda ash, and caustic soda used for paper and board manufacture appear in a January 1960 issue of *Paper Trade Journal* (*110*).

A recently announced process, developed by W. H. Rapson, claims to eliminate the need for chlorine and caustic soda in the Kraft pulping and bleaching system (*35, 97, 99, 111*).

Textiles. The textile industry uses chlorine and its derivatives and caustic soda for bleaching, mercerization, and other purposes (*77u, 103, 132*). A very detailed review of the use of alkalies in textile processing, with a table showing the consumption of these chemicals for the year 1958, was presented by Currier (*34*).

One of the largest uses of caustic soda is in the manufacture of rayon (*77d*) and cellophane (*72*) from cellulose by the viscose process.

Bleaches and Sanitizing Agents. Sodium hypochlorite, produced by the chlorination of aqueous caustic soda, is the dominant household liquid bleach (*77o, 77p, 119x, 131*). Calcium hypochlorite, made by the chlorination of slaked lime, is the main form of dry bleach (*119x, 131*). Chlorinated isocyanurates have been developed as solid dry bleaches (*77o, 119x, 131*). In addition to their use as bleaches, the hypochlorites and the chlorinated isocyanurates are used as sanitizing agents for swimming pools, in dairies, hospitals, etc. (*70, 73, 101, 136, 137*). Other chlorinated bleaches and sanitizers include lithium hypochlorite, chlorinated trisodium phosphate and organic *N*-chloro derivatives (chloramines) (*77o, 119x*). Chlorine dioxide and sodium chlorite are used for water purification, as well as for pulp and textile bleaching (*77o, 119x*).

Water and Waste Treatment. Chlorine is used to disinfect and sterilize water for municipal use (*2, 82, 86, 119y, 131*). Water for industrial use is

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treated with chlorine to effect purification and slime control (*2, 131*). Treatment of waste water and sewage also consumes large quantities of chlorine (*81, 83, 119z, 131, 134*). Public swimming pools continue to use elemental chlorine for disinfecting purposes (*131*), and recommendations are discussed by Laubusch (*80*).

Soda ash is used to condition water for both municipal and industrial use to remove hardness (*2*).

Soaps and Detergents. Sodium hydroxide and potassium hydroxide are used in soap manufacture (*77c, 79*). Caustic soda is required in manufacturing alkylbenzene sulfonates used in synthetic detergents (*77n*). Detergent formulations also require builders which usually are alkali phosphates or silicates (*77r*). Soda ash, caustic soda, and caustic potash are used in the production of these builders (*142*). The principal alkali phosphates used as detergent builders are sodium tripolyphosphate, tetrasodium pyrophosphate and tetrapotassium pyrophosphate (*142*).

Glass Manufacture. The major consumer of sodium carbonate in the U.S. is the glass industry (*125*). The glass manufacturing operation is described (*77t*). The soda ash used for glassmaking is almost always the dense form (*43, 51*). Potassium carbonate is also used in glass manufacture, primarily for making television tubes (*77f, 107*).

Petroleum Refining. The petroleum industry uses the chlor-alkalies for treating gases and liquids, for water treating and corrosion inhibition, in drilling muds, and for manufacturing lube oils (*3*). The so-called hot potassium carbonate process is used to remove carbon dioxide and hydrogen sulfide from gas streams (*6*). Consumption of chlorine, caustic soda, caustic potash, and soda ash at U.S. refineries and natural gasoline plants was published in 1961 by the National Petroleum Council of the Department of the Interior.

Miscellaneous End Uses. Chlorinated rubber, made by passing chlorine into a carbon tetrachloride solution of rubber, finds application in the coating field and in foams (*77m*).

Caustic soda is used in reclaiming rubber (*53*).

For refining fats and oils, caustic soda, soda ash and sodium bicarbonate are used to remove free fatty acids and for decolorizing (*78*).

The baking industry uses sodium bicarbonate in baking powders and in mixes; the pharmaceutical industry in antacids. A growing use of sodium bicarbonate is in fire extinguishers (*77b*).

Statistics

Oil, Paint and Drug Reporter regularly publishes "Chemical Profiles" on various chemicals showing, briefly, producers and capacity, price, uses, and outlook. The most recent references for the chlor-alkalies are: chlorine (*24*), caustic soda (*16*), caustic potash (*13*), soda ash (*125*), potassium carbonate (*106*), and sodium bicarbonate (*127*).

Oil, Paint and Drug Reporter also periodically publishes "Depth Reports" which give more detail than the "Chemical Profiles." Some of these refer-

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ences are: chlorine (*140*), caustic soda (*20*), caustic potash (*14*), soda ash (*122*), and sodium bicarbonate (*7*).

Producers and capacities are further listed: for chlorine (*30, 130, 131* and the Chlorine Institute Pamphlet #12); caustic soda (*18*); soda ash (*123, 124, 126*); caustic potash and potassium carbonate (*11, 12, 14, 15*). Production figures for chlorine, caustic soda, soda ash and caustic potash are published annually in the Chlor-Alkali Report (*133*), and in the Standard and Poor's Industry Survey. There are reports on world capacities for chlorine and caustic soda (*71*); world production of caustic soda and soda ash (*146*), and of chlorine (*147*). Canadian consumption of the chlor-alkalies, by specific industries, is reported (*145*). The U.S. Tariff Commission annually publishes production and sales figures for the chlorine-containing organic chemicals in *Synthetic Organic Chemicals, U.S. Production and Sales.* A recent three-part article on chlorine gives production and distribution in Europe, U.S.A. and Canada, and United Kingdom and Japan (*23*). The OECD's annual publication, *Chemical Industry,* gives statistics on production and consumption in Europe and the U.S.; the United Nations' *Statistical Yearbook*—for the countries of the U.N. U.S. statistics for all the chlor-alkalies are given in MCA's *The Chemical Industry Facts Book;* the *Chemical Economics Handbook* by SRI, and in the Bureau of Census publications: *U.S. Census of Manufactures, Annual Survey of Manufactures,* and *Current Industrial Reports.* Figures on soda ash are given in the annual *Statistical Abstracts* by the Bureau of the Census, and by the Bureau of Mines in the annual *Minerals Yearbook, Mineral Industry Surveys* on sodium and sodium compounds, and Bulletin 630, *Mineral Facts and Problems.* Developments relating to soda ash in foreign countries are reported in the section on sodium compounds in the monthly *Mineral Trade Notes.* Chlorine production in the U.S. is listed in the Chlorine Institute Pamphlet #11 which is revised annually.

Growth areas and future trends are discussed (*17, 18, 21, 22, 25, 30, 92, 120, 139*).

Import and Export figures are given in MCA's *Chemical Statistics Handbook* and *Statistical Summary,* in *Chemical Economics Handbook,* and in the Bureau of the Census Foreign Trade Reports FT 410 and 135.

Price histories can be found in *Chemical Economics Handbook,* in Standard and Poor's Industry Survey: *Chemicals, Basic Analysis,* and in *Wilson's Price Data: Inorganic Chemicals.*

Current prices in the U.S. are published weekly in *Oil, Paint and Drug Reporter.* Foreign prices are published weekly in *European Chemical News* and monthly in *Canadian Chemical Processing.*

Directories

Lists of producers with plant location and products manufactured at each can be found in *Fortune's Plant and Product Directory.* SRI's *Directory of Chemical Producers* contains listings by company, product, region, and new plants and expansions. The Bureau of the Census *Directory of Manufacturers of Selected Inorganic Chemicals and Gases* lists producers of the chemicals. The BDSA *Chemical Statistics Directory No. 3* is a guide to U.S. Government

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statistics on chemicals. The Chlorine Institute's Pamphlet #10 lists chlor-alkali producers in North America; Pamphlet #16 lists chlor-alkali producers outside North America; and Pamphlet #15 lists chlor-alkali and hydrochloric acid cells available for purchase.

Abstracting and Indexing Services

The services useful in the chlor-alkali field are, of course, *Chemical Abstracts* and *Chemisches Zentralblatt*, both with worldwide coverage of chemical journals and patents. *Chemical Titles* is a keyword index to titles of world chemical journal literature. *Bibliography of Reviews in Chemistry* contains review abstracts appearing in *Chemical Abstracts* the previous year. *Science Citation Index* lists an author and his work together with all authors and papers who have referred to the same work since its publication. The following *Chemical Abstracts* sections should be checked as well as specific sections on end use.

1912	4.	Electrochemistry
	18.	Acids, Alkalies, Salts & Sundries
1961	4.	Electrochemistry
	18.	Inorganic Industrial Chemicals
1962	15.	Industrial Inorganic Chemicals
	22.	Electrochemistry
1963	15.	Electrochemistry
	17.	Industrial Inorganic Chemicals
1967	49.	Industrial Inorganic Chemicals
	77.	Electrochemistry

Applied Science and Technology Index indexes from current periodicals, mainly from the applied point of view. *Engineering Index* contains abstracts from the world literature, mainly from the engineering point of view.

Services emphasizing the marketing and economic point of view include: *Chemical Market Abstracts*, which indexes news items from English language publications by company, chemical, and industry; *Chemical Horizons*, which summarizes in two 4-page reports: North American and Overseas, and in the Intelligence File available on cards, information from selected periodicals by product, industry or chemical, and country; *Predicasts*, which indexes market data forecasts by SIC code number; *Search*, which abstracts market research information with cumulative monthly subject index; and *Funk and Scott Index of Corporations and Industries*, which indexes by SIC code number and company name.

U.S. chemical patents are indexed by unit terms in *Uniterm Index of U.S. Chemical Patents*. Abstracts of foreign patents, *i.e.* British, German, French, South African, Indian, Belgian, Japanese, Russian, and Dutch, are published by subject classification by Derwent Information Service.

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Issues semi-annually a list of available pamphlets and drawings with prices and order form. Selected publications are:

Chlorine Manual, 3rd ed., 1959.

Pamphlet #10: *Chlor-Alkali Producers and Chlorine Repackagers in North America,* revised annually.

Pamphlet #11: *Chlorine Production in the U. S.,* revised annually.

Pamphlet #12: *History and State of the Chlorine Industry,* by D. L. Taylor, presented before the Chlorine Institute in New York, on Jan. 20, 1960.

Pamphlet #15: *Chlor-Alkali and Hydrochloric Acid Cells Available for Purchase,* April 1964.

Pamphlet #16: *Chlor-Alkali Producers Outside North America,* revised biennially.

Pamphlet #19: *Index to Reports of the Chlorine Manufacturing Commission (Chlor-Fako) I. G. Farbenindustrie A. G. for 1932, 1933, 1936, 1938, 1940, 1943.* Reports of the Subcommission (Chlor-Uko) for 1942.

Pamphlet #24: *Literature on the Physiological Effects of Chlorine and Supplementary Bibliography,* by A. G. Cranch and E. J. Laubusch, 1958.

Manufacturing Chemists' Association, Inc., 1825 Connecticut Avenue, N. W., Washington, D. C. 20009.
Develops and publishes recommended procedures and standards for the manufacture and transportation of chemicals. Selected publications are:

Backman, J., *Chemicals in the National Economy,* 1964.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch001

Backman, J., *Competition in the Chemical Industry,* 1964.
The Chemical Industry Facts Book, 5th ed., 1962.
Chemical Statistics Handbook, 6th ed., 1966.
Safety Data Sheets.

Company Trade Literature

The trade literature and data sheets supplied by the companies who manufacture the products contain valuable information on the properties and uses of the chemicals.

Allied Chemical Corp., Semet-Solvay Division, 40 Rector St., New York, N. Y. 10006.
Chlorine, Caustic Soda, Caustic Potash, Soda Ash, Potassium Carbonate
Church and Dwight Co., Inc., 2 Pennsylvania Plaza, New York, N. Y. 10001.
Sodium Bicarbonate
Diamond Shamrock Corp., 300 Union Commerce Building, Cleveland, Ohio 44115.
Chlorine, Caustic Soda, Soda Ash
Dow Chemical Co., Midland, Mich. 48640.
Caustic Soda, Caustic Potash, Soda Ash
FMC Corp., 633 Third Ave., New York, N. Y. 10017.
Caustic Soda, Caustic Potash, Soda Ash, Chlorinated Dry Bleaches
GAF (General Aniline and Film) Corp., Dyestuff and Chemical Division, 140 W. 51st St., New York, N. Y. 10020.
Chlorine
Hooker Chemical Corp., 277 Park Ave., New York, N. Y. 10017.
Chlorine, Caustic Soda, Caustic Potash, Potassium Carbonate
International Minerals and Chemical Corp., Industrial Chemicals Department, Skokie, Ill. 60076.
Caustic Potash
Mallinckrodt Chemical Works, Second and Mallinckrodt Streets, St. Louis, Mo. 63160.
Potassium Carbonate, Sodium Bicarbonate
Monsanto Co., 800 North Lindbergh Blvd., St. Louis, Mo. 63166.
Chlorinated Cyanuric Acids and Salts
Olin Mathieson Chemical Corp., Chemicals Division, 460 Park Ave., New York, N. Y. 10022.
Chlorine, Caustic Soda, Soda Ash
Pennsalt Chemicals Corp., 3 Penn Center Plaza, Philadelphia, Pa. 19102.
Chlorine, Caustic Soda, Caustic Potash
PPG Industries, Inc., Chemical Division, 1 Gateway Center, Pittsburgh, Pa. 15222.
Chlorine, Caustic Soda, Caustic Potash, Soda Ash
Stauffer Chemical Co., Industrial Chemical Division, 380 Madison Ave., New York, N. Y. 10017.
Caustic Soda, Soda Ash, Chlorinated Hydrocarbons
Wyandotte Chemicals Corp., Industrial Chemicals Division, Wyandotte 8, Mich. 48192.
Chlorine, Caustic Soda, Soda Ash, Sodium Bicarbonate

U. S. Patents

The Patent Office *Manual of Classification* groups patents relating to the chlor-alkalies in the following classes and subclasses:
Class 23: Chemistry
61 Carbonates
63 alkali metal
64 bicarbonates
65 ammonia soda process
183 Bases
184 alkali metal oxides or hydroxides
185 causticizing
Class 204: Chemistry, Electrical and Wave Energy
1 Electrolysis
59 synthesis
60 from fused bath

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87	from aqueous bath-carbonates
96	metallic oxides and hydroxides
98	of alkali metals
99	mercury cathode
193	Apparatus
194	electrolytic
242	cells
243	fused bath
250	liquid electrode
251	diaphragm
252	diaphragm type
279	elements
280	electrodes
295	diaphragms

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2

Literature of Industrial Electrochemistry of Nonmetals and Electro-Organic Chemistry

J. B. HAGLIND

Olin Mathieson Chemical Corp., New Haven, Conn.

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The electrolysis of nonmetallic substances provides an important industrial source for several inorganic materials including chlorine, caustic soda, and sodium chlorate. Electro-organic chemistry is experiencing an accelerated new phase of development. For these two areas of electrochemistry, a selected bibliography has been compiled, which emphasizes commercial developments for the nonmetallic materials and surveys electro-organic chemistry. Reference works, abstracting services, journals, advances and annual surveys, monographs and reviews, and patents are the types of literature covered.

The area of electrochemical literature covered here includes the industrial electrochemistry of nonmetallic substances—*e.g.*, halogens, their acids and salts, hydrogen peroxide, hydrogen and oxygen, and electro-organic chemistry. The nonmetallic substances are among the most important group economically, while electro-organic chemistry is in a state of active development, and contributions to its literature are increasing rapidly.

The production of chlorine and sodium hydroxide is by far the most important electrolytic process commercially for nonmetallic substances. In 1965, 6.44 million tons of chlorine and 6.72 million tons of sodium hydroxide were produced. Of these totals, 99% of the chlorine and over 90% of the sodium hydroxide were obtained by electrolysis of salt. Two types of cells are used: diaphragm cells (Hooker, Diamond Alkali, and Dow are important types) and mercury cells (Olin, Solvay, DeNora, Uhde, and BASF-Krebs are primary examples).

Sodium chlorate, perchlorates (primarily sodium), fluorine, and hydrogen peroxide are other electrolytically produced chemicals of commercial significance. In this country, little hydrogen or oxygen is produced electrolytically. MacMullin (*4*) has listed the economically successful processes in electro-organic chemistry as being dialdehyde starch, *p*-aminophenol by reducing

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

nitrobenzene, pinacone analogs, adiponitrile from acrylonitrile, *N,N*-dimethylaminoethyltetrachloroisoindoline (ecolid), melamine, and aliphatic fluorine compounds.

In addition, details of Nalco Chemical Co.'s electrolytic process for tetraethyl lead and tetramethyl lead have been published (*1*).

While electrochemistry may be considered as a conjunction of physical chemistry and electrical engineering, these latter fields will not be specifically covered here. Publications cited are primarily those issued since 1940. Brief listings of books and journals prior to this period have appeared in the literature guides of Crane, Patterson, and Marr (*3*) and Soule (*6*). Chou has reviewed the electrochemical literature of China and Japan (*2*).

Several publications primarily concerned with theoretical electrochemistry have been included, although those on commercial or industrial developments are stressed.

Literature sources are discussed under the following categories: reference works, abstracting services, journals, advances series and annual surveys, monographs and reviews, and patents. Citations to the publications mentioned and additional sources will be found in the bibliography at the end of this chapter.

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Reference Works

Mellor's and Gmelin's texts, the two major reference works in inorganic chemistry, are important sources for extensive compilations of literature references on the electrochemistry of nonmetallic materials. Mellor's Supplement II, Part I (1956), includes electrolytic preparation of chlorine, chlorates, perchlorates, and fluorine, while Mellor's Volume II, Supplement II (1961) includes the preparation of sodium hydroxide. Gmelin's recent volumes on oxygen (System 3), fluorine (System 5), and sodium (System 21) review the literature through 1949, 1950, and 1960, respectively.

The most extensive reference work in electrochemistry is the "Handbuch der Technischen Elektrochemie." The first three volumes (in six parts), edited by V. Englehardt, were published between 1931 and 1934. Volume 4, edited by G. Eger, was issued in 1956. Parts 1 and 2 of volume 2 cover inorganic and organic electrochemistry respectively.

The "Encyclopedia of Electrochemistry," edited by C. A. Hampel, is a one-volume publication which provides short, authoritative articles on all phases of electrochemistry. Topics of interest include chlorine, hydrochloric acid, chlorates and perchlorates, fluorine, hydrogen peroxide and peroxygen chemicals, water electrolysis, electro-organic chemistry, adiponitrile, fluorocarbons, glucose, and the Kolbe synthesis.

Kirk-Othmer's and Ullmann's encyclopedias are also good sources for surveys on the electrolytic production of nonmetallic materials.

Abstracting Services

Chemical Abstracts, Chemische Zentralblatt, and the chemical section of *Referativnyi Zhurnal* cover articles, books, and patents on electrochemistry.

All three of these major abstracting services have separate sections for electrochemical publications. *Chemical Abstracts* includes articles and patents in its section on electrochemistry (currently No. 77). *Chemisches Zentralblatt* includes only articles in the electrochemistry section and locates patents in the "applied" half of the journal with the industrial inorganic, electrotechnique, and various organic sections being most pertinent to the interests of this paper. The Russian abstract journal has an electrochemistry section for articles and an electrochemical technology section where patents are cited.

Other sources of abstracts are *Electroanalytical Abstracts, Science Abstracts,* Section B (electrical engineering); *Journal of the Electrochemical Society of Japan; Bulletin Signaletique du Centre National de la Recherche Scientifique. Current Chemical Papers,* while not an abstract journal, contains a section on electrochemistry which lists current journal articles. Articles included are primarily theoretical in nature and are located in one of the following categories: reviews, electrolyte processes, electrode processes, and electrolytic cells.

Government-sponsored research is abstracted in *Technical Abstract Bulletin (TAB), Nuclear Science Abstracts,* and *U.S. Government Research Reports.* In *TAB,* sections 7 (chemistry), 9 (electronics and electrical equipment) are the most pertinent. *Nuclear Science Abstracts* includes the important Atomic Energy Commission work, particularly in fluorine production. *U.S. Government Research Reports* and its predecessors, *Bibliography of Technical Reports* and *Bibliography of Scientific and Industrial Reports* are valuable for coverage of German developments during World War II and more recently for nonmilitary oriented government research.

Doctoral theses of interest are included in *Dissertation Abstracts.* These are also referenced in *Chemical Abstracts.* A comprehensive list of U.S. and foreign abstracting services in the electrical and electronic fields has been published by Milek (5).

Journals

The number of journals published which are primarily devoted to electrochemistry are few, but many additional journals include material of interest to the industrial electrochemist.

Two publications of the Electrochemical Society, the *Journal* and *Electrochemical Technology,* rank high in importance in coverage of applied electrochemistry. The *Journal,* formerly the *Transactions of the American Electrochemical Society,* has been issued since 1902, and until the 1950's a large percentage of its articles were in the applied field. Since then it has emphasized theoretical contributions.

In addition to the articles included, mention should be made of the abstracts published in the *Journal* for papers presented at national meetings of the Electrochemical Society. These abstracts are available in two forms: as published in the *Journal* (about 75 words) and as extended abstracts (500–1000 words) available from the Society's divisions. The Industrial Electrolytic and Electro-organic Divisional programs particularly cover the subject of interest to this paper. Cumulative indexes to the *Journal* have been issued.

Electrochemical Technology, first published in 1963, reports commercially important developments formerly covered by the *Journal.*

Denki-Kagaku, the *Journal of the Electrochemical Society of Japan,* was first published in 1933 and first included English excerpts of its papers in 1956. In 1958 the Overseas Edition began providing extensive abstracts in English of papers published in Japanese. Since 1961 the overseas edition, now entitled *Journal of the Electrochemical Society of Japan,* has included original manuscripts in English in addition to the abstracts. These publications are an important source of Japanese work in both theoretical and applied electrochemistry.

Electrochimica Acta was first issued in 1959 as an outgrowth of the publication of papers presented at the annual conference of the International Committee for Electrochemical Thermodynamics and Kinetics. Published by Pergamon Press, it is a valuable journal with articles appearing in English, French, or German.

A new Russian journal, *Elektrokhimiya,* began publication in 1965. Its English translation, *Soviet Electrochemistry,* is available from the Consultants Bureau.

Until recently, *Zeitschrift für Elektrochemie und Angewandte Physikalische Chemie* was important to electrochemistry. In 1963 its title was changed to *Berichte der Bunsengesellschaft für Physikalische Chemie,* reflecting its principal emphasis on physical chemistry. However, articles on electrochemistry are still included. Other journals which frequently publish articles of value are listed in the Bibliography.

Advances and Annual Surveys

Modern Aspects of Electrochemistry and *Advances in Electrochemistry and Electrochemical Engineering* are two series of interest to electrochemists. These volumes include authoritative reviews on four or five topics per volume, with the emphasis on theoretical electrochemistry. *Modern Aspects* is edited by J. O'M. Bockris, and four volumes have been published to date. P. Delahay and C. W. Tobias are editors of the *Advances* series, six volumes have been issued so far.

A chapter on acids, alkalies, and salts has appeared nearly annually for several years in *Reports on the Progress of Applied Chemistry.* This chapter reports developments on chlorine and caustic soda, chlorates, fluorine, and hydrogen peroxide.

Also of value are the sections on solutions of electrolytes (annually) and electrode processes (irregularly) appearing in the *Annual Reviews of Physical Chemistry* and the section on electrochemistry in the *Annual Reports of the Progress of Chemistry,* which recently has been included about every other year.

Monographs and Reviews

General. Mantell's monograph, "Electrochemical Engineering," is probably the best known text on electrochemistry in English. All aspects of the field are covered, and an extensive discussion of alkali halide electrolysis is given. It is now in its fourth edition. Earlier editions were entitled "Industrial Electrochemistry."

Texts on electrochemical processes, by Billiter and Regner include extensive discussion of European electrochemical cells and practices. A good source of earlier patent literature on industrial electrochemistry, particularly German patents, is R. Mueller's volume, which provides detailed information on the electrolysis of water. Two important works on the theoretical aspects of electrode processes are those of Yeager and the Faraday Society.

Chlorine and Sodium Hydroxide. The diaphragm and mercury cell processes for chlorine and caustic soda production are covered in detail in the monograph edited by J. S. Sconce. All aspects of electrolyzing sodium chloride from brine treatment to product purification are covered in the chapters by M. S. Kircher (diaphragm cells) and R. B. MacMullin (mercury cells).

H. A. Sommers has presented two extensive surveys on modern cells, with comparative data for operating characteristics and economic factors for both the diaphragm and mercury cells being used industrially at the present time.

Technical developments in power supplies, electrode shapes, hydrogen overvoltage, and the use of the decomposition energy of amalgam are among the subjects covered in a series of review articles in *Chemie-Ingenieur-Technik.*

Properties of sodium chloride and its solutions are given in Kaufmann's monograph, although the electrolytic process is not covered. The major use for both chlorine and sodium hydroxide is to prepare other chemicals.

Chlorates and Perchlorates. Sodium and potassium chlorates and perchlorates are commercially produced by electrolysis of aqueous solutions of sodium and potassium chlorides. The sodium salts are industrially the most important. Sodium chlorate is used in pulp bleaching as a source of chlorine dioxide and as a herbicide. Sodium perchlorate is used as the starting material for producing other perchlorate salts, particularly ammonium perchlorate.

J. C. Schumacher has been closely connected with electrolytic perchlorate production developments, and his publications, particularly his monograph, are of value.

Fluorine. The need for elemental fluorine to produce uranium hexafluoride for the Atomic Energy Commission spurred fluorine cell development in the early 1940's. This wartime development is discussed in a symposium which appeared in *Industrial and Engineering Chemistry.* Another valuable account of the fluorine work done in connection with the atomic bomb project is given by Slesser and Schramm. More recent developments in technology, particularly in Great Britain, are presented in Rudge's book.

Hydrogen Peroxide, Hydrogen, and Oxygen. In recent years, the electrolytic process for producing hydrogen peroxide has become less important than newer chemical routes in the U.S. The peroxide process starts with the electrolytic production of persulfuric acid and persulfates (ammonium or potassium) and subsequent hydrolysis to give H_2O_2.

Schumb, Satterfield, and Wentworth's book provides a full account of the chemistry and electrolytic commercial processes being used throughout the world in the mid-1950's. A review of important literature sources is also

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In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

included. A discussion of hydrogen peroxide manufacture along with an annotated list of patents is given in Machu's Book.

Vetter has published an extensive review on the kinetics of the electrolytic separation of hydrogen and oxygen. The commercial production of H_2 and O_2 are of little importance in this country, although their generation and consumption in fuel cell technology are receiving much attention.

Electro-Organic Chemistry. Over the years S. Swann, Jr., has reviewed the electrolytic reactions of organic compounds extensively. Particularly useful are the tables of reactions which he has included in the section in "Techniques of Organic Chemistry."

General reviews of the field are also presented in the monographs by Allen, Fichter, and Brockman, and in chapters of Houben-Weyl's "Methoden der Organischen Chemie." The reaction which has been studied most extensively is the Kolbe synthesis. This oxidation reaction has been reviewed by Weedon. Popp and Schultz have provided an extensive compilation on electrolytic reduction reactions while Tomilov has reviewed the reduction of acetylenes. The Russian scientific literature is an important source of reviews in this area, as exemplified by the publications of Khomyakov and Tomilov.

Patents

The patent literature is a vital source for many technical developments in electrochemistry. In the "Manual of Classification," issued by the U.S. Patent Office, class 204 covers electrolytic products and processes. Most of the patents on electroorganic substances will be found in this class. Some of the more important subclasses for chemicals discussed in this paper are listed in the Bibliography.

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Class 204, Chemistry, Electrical, and Wave Energy Processes and Products
1 Electrolysis
59 Synthesis
From aqueous bath
72 Organic compounds
73 Hydrogenation
78 Oxidation
Inorganic compounds
82 Per-compound
83 Peroxides
84 Hydrogen peroxide
86 Metallic salts
94 Halogen containing
95 Oxyhalogen
128 Non-metallic elements
129 Hydrogen or oxygen
Material treatment
131 Organic materials
193 Apparatus
194 Electrolytic
242 Cells
250 Liquid electrode
252 Diaphragm type

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3

The Literature of Industrial Gases

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Industrial gases are finding increasing application in the chemical, medical and allied industries as well as in metal-working, food processing, and the space industry. Information about these gases is scattered throughout the technical literature. Since there are few sources completely devoted to industrial gases, a wide variety of textbooks, journals, handbooks, encyclopedias and reports must be consulted to achieve broad coverage of the subject.

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The industrial gas industry plays a large and important role in modern day technology. It is an industry that is favored by a steady demand which, coupled with the current meteoric rise in the use of cryogens, augurs well for the future. Despite this, the industrial gas literature as a body is poorly defined. Years of discovery and experimentation have produced a sizeable quantity of literature but few comprehensive works. This creates a problem for the compiler; he is faced with a problem of many references and of frequently overlapping information. Pertinent data are often located within some source that from the title would appear to be inapplicable.

The advent of cryogenics has released a flood of scattered information, much of which is connected with the missile and space industry. Much of this literature is security-classified and requires a "need to know" as well as security clearance before copies may be obtained. Unclassified material is generally available through the Clearinghouse for Federal Scientific and Technical Information.

For the purpose of this study, the industrial gases reviewed will be those listed in Code 2813, "Industrial Gases," of the Standard Industrial Classification of the U. S. Bureau of the Budget. They are acetylene, carbon dioxide and dry ice, industrial gases (compressed, liquefied, or solid—not made in petroleum refineries or in natural gasoline plants), helium, hydrogen, inert (noble) gases, nitrogen, nitrous oxide, oxygen, and refrigerant gases except ammonia. We have also included information on the anesthetic gases.

The discussion and bibliography that follow are not presented as being the sum total of the industrial gas literature but rather a significant selection of

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

pertinent references. Only a few references to individual articles have been included.

Industrial Growth

In recent years, the manufacturing output of all the gases reviewed, except carbon dioxide as dry ice, has shown a continuous rise.

Carbon dioxide gas is in a good position to expand its sales because of its close relationship with the advancing soft drink market. It is also being used as a growth accelerator in greenhouses. The rubber industry is using carbon dioxide to freeze flashings on rubber products so they can be tumbled or shot-blasted for flashing removal.

The nitrogen demand boomed in 1962, and except for a temporary deceleration in 1964 has risen steadily. The inert qualities of nitrogen make it attractive for use in aerospace cooling, oil-well stimulation, and for the manufacture of electronic components and space simulators. New increases are forecast because of uses in food processing, food transportation, and medicine.

In contrast to the inertness of nitrogen, it is the reactive properties of oxygen and hydrogen that make them valuable. Production of oxygen, especially high-purity oxygen, continues to rise. The steel industry uses about 40% of all the oxygen produced. Innovations in open hearth and basic oxygen furnaces will increase steel's demand for oxygen for some years to come.

It is expected that by 1970, the chemical process industries will increase their consumption of oxygen by as much as 40%. Missile and space uses continue to consume increasing quantities of oxygen as an oxidizer for liquid-fueled rockets.

Requirements in the space industry are the primary reason for anticipating an increase in hydrogen consumption, although applications in the production of specialty alloys and the manufacture of chemicals account for a portion of the projected increase.

General References

These references are included because of their over-all coverage of the industrial gases. Perhaps the best source of this type is the Kirk-Othmer "Encyclopedia of Chemical Technology," in which each of the gases is covered. Whole articles are devoted to some of the gases while others are given a lesser treatment. Usually included are a brief history, the physical properties, the manufacturing methods, and the economic status of the gases. Lists of references have been provided from which more detailed information may be obtained.

Now in its third edition but again needing revision is "Industrial Chemicals" by Faith, Keyes, and Clark. Industrially important chemicals are discussed. The authors have listed major manufacturers and their plant sites. Flow charts, processes, properties, economic aspects, and production rates are other types of information which is presented.

More specific than "Industrial Chemicals" is the chapter on "Industrial Gases" in "The Chemical Process Industries," which is also now in its third

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In Literature of Chemical Technology; Smith, J.;
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edition. Each of the main gases is covered. In most cases the author, after telling about the uses and economics, presents the various types of manufacturing processes, often with appropriate flow charts.

Out-of-date, but important as historical references, are Friend's "A Text Book of Inorganic Chemistry" and Mellor's classic "A Comprehensive Treatise on Inorganic and Theoretical Chemistry." Supplements to Mellor are now being published. A more recent encyclopedic work containing comprehensive scientific data on several gases is the "Nouveau Traité de Chemie Minéralé." Volume 1 is on hydrogen, deuterium, tritium, air, water, helium, and the inert gases. Volume 2 is on oxygen, sulfur, selenium, tellurium, and polonium.

Industrial gases were reviewed in 1959, 1961, and 1963 in "Reports on the Progress of Applied Chemistry." These timely reviews are international in scope. Most of the information has been culled from the journal literature; it includes production figures, new plant expenditures, new uses and other pertinent developments. The reviews will help the user get a better feel for the entire industrial gas industry than perhaps any other source.

Comprehensive in its coverage is "Gmelins Handbuch der Anorganischen Chemie." It is being published in sections that are issued periodically. Up to now, in the current (8th) edition, volumes on the noble gases, hydrogen, oxygen, and nitrogen have been issued. Although the text is in German, the newer volumes have English tables of contents that simplify information retrieval.

Physical and Chemical Properties

A knowledge of the physical and chemical properties of industrial gases is required by those intending to use them. Several good compilations are available. One is U. S. National Bureau of Standards Circular No. 564, "Tables of Thermal Properties of Gases." It was originally issued in 1955 but has been recently republished by Pergamon Press with Joseph Hilsenrath as the author and with a slightly altered title. It lists the thermodynamic properties of five industrial gases: argon, carbon dioxide, hydrogen, nitrogen, and oxygen. Data are presented in numerical tables over the pressure range 1–100 atm. and to temperatures over 600°K.

There are a few extensive compilations of physical and thermodynamic properties of chemical compounds, many of which are not industrial gases. "Selected Values of Properties of Hydrocarbons and Related Compounds" is perhaps the best known. Printed on loose leaf sheets, it has a filing arrangement that becomes familiar only with repeated use. The technical content is invaluable and a great boon to users of industrial gases. Similar in layout and complementary in scope is "Selected Values of Properties of Chemical Compounds."

In 1962 the National Academy of Sciences–National Research Council published "Consolidated Index of Selected Property Values, Physical Chemistry and Thermodynamics." This index to the compounds and their properties that appear in six important physicochemical and thermodynamic compilations permits quick selection of the proper source.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

The "Data Book," a substantial (over 50 lbs. in weight and still growing) set of tables being published by the Thermophysical Properties Research Center of Purdue University, is an excellent source of data on viscosity, thermal conductivity, diffusivity, and the radiation properties of gases and solids, but the form in which the information is published is very cumbersome and not always reliable.

An industrial contribution is the Matheson Co.'s "Gas Data Book." Its 4th edition was published in 1966. Its information covers physical and chemical properties as well as information on hazards and storage. Information on 124 gases is presented in this handy compilation.

Also published in 1966 is the Compressed Gas Association's "Handbook of Compressed Gases." It contains data on 50 of the most important industrial gases. Half of the book is devoted to safety practices and the making, requalifying, welding, brazing and disposition of cylinders.

Perhaps the most comprehensive coverage for the properties of gases in the liquid, solid, and gaseous state is "A Compendium of the Properties of Materials at Low Temperature" by Stewart and Johnson.

The three volumes of "Thermodynamic Functions of Gases" by F. Din are important for their information on the properties of carbon dioxide, acetylene, argon, and nitrogen. The venerable "Gas Tables" by Keenan and Kaye is an important source of thermodynamic properties of air and products of combustion.

A recent addition from the Government contract literature is "Properties of Principal Cryogenics." Published in 1964, it contains extensive physical property data for oxygen, nitrogen, hydrogen, and fluorine.

Gases of the Atmosphere

General. Commercial air separation, for the last half century at least, has been principally accomplished by liquefaction and distillation. Although production of atmospheric gases has increased tremendously in the last 25 years, basic manufacturing methods have remained much the same. Ruhemann's classic book "The Separation of Gases," first published in 1940, is still referred to by engineers in the air-separation industry as is M. M. Davies' respected "Physical Principles of Gas Liquefaction and Low Temperature Rectification," in which processes in current use are described in detail. More recent, but not nearly as thorough, is J. B. Gardner's chapter in "Chemical Engineering Practice" entitled "Liquefaction and Fractionation of Gases." He covers the fundamental principles, describes specific methods for producing the different gases, and gives plant design and component data.

W. T. Hudson, a geologist in Denver, has published "Non-Hydrocarbon Gases," a report of a study on oxygen, nitrogen, argon, rare gases, carbon dioxide, and hydrogen. Data on the properties, uses, commercial sources, economics, and occurrence in well gases are given for each gas. This is a nice summary, but unfortunately contains a number of errors.

Oxygen. A good report on oxygen and nitrogen was written by Jerome Brewer and issued by the former Aeronautical Systems Division of the Air Force Systems Command at Wright-Patterson Air Force Base.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

The most complete collection on oxygen is given in the oxygen sections of Gmelin. They are "History," 1943; "Occurrence-Technology," 1951; "Elementary Oxygen," 1958; "Air, Active Oxygen, Ozone," 1960. Except for the volume on history, Gmelin's coverage of the literature is complete through 1949 with scattered and unevaluated references thereafter.

A recent NASA report by Svehla gives the thermodynamic and transport properties for the hydrogen-oxygen system ranging from pure oxygen to pure hydrogen at pressures of 0.001 to 1000 atm. and temperatures of 600° to 5000°K. Compilations of the thermodynamic properties of oxygen at temperatures over 2000°K. may be found in a report by C. E. Treanor.

Some 325 references indexed by property, temperature, and pressure ranges have been gathered to form Hust's bibliography on the low temperature thermophysical properties of oxygen.

Nitrogen. Gmelin also has a multivolume system on nitrogen. A volume on "History, Occurrence, The Element" appears in 1954 and comprehensively covers the literature up to 1949. Earlier volumes were: "Compounds with Hydrogen" and "Compounds with Oxygen," both published in 1936.

Mellor's supplementary volume on nitrogen was published in 1964 and gives a good coverage of the literature available since the publication of the original treatise.

"Thermodynamic Properties of Nitrogen from 2000° to 8000°K." by Treanor and Logan is a companion volume to the one on oxygen. Two other sources of similar data, although at different temperatures, are "Tables of the Thermodynamic Properties of Nitrogen from 100° to 1500°K." at pressures from 1 to 10,000 atm. by W. J. Little and C. A. Neel, and "The Thermodynamic Properties of Nitrogen from 64° to 300°K. between 0.1 and 200 Atmospheres" by Stobridge.

Bloomer and Rao from the Institute of Gas Technology collaborated in 1950 to write I.G.T. Research Bulletin No. 18 "Thermodynamic Properties of Nitrogen."

A 1960 thesis by Johannes Van Der Ster of the Technische Hochschule at Delft, is a study of liquid nitrogen production from air by use of a gas-refrigeration machine.

William Jolly's "The Inorganic Chemistry of Nitrogen" covers mostly nitrogen chemistry, but there are some data on the physical properties of solid, liquid, and gas.

"Nitrogen in Industry" by Sittig appeared in 1965. It presents an overall view of the production methods for this fast growing industrial gas. Specific production processes are described and flow charted. Most of the technical information is taken from patents.

Inert (Noble) Gases. The most complete reference work on these gases published in recent years is "Argon, Helium, and the Rare Gases." This two-volume work comprehensively treats these gases from their discovery to their scientific and industrial uses. Written by 14 scientists and engineers, experts in their particular fields, and edited by G. A. Cook of Linde Division of Union Carbide Corporation, these volumes constitute an excellent starting place for any research project in the inert gas area.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

The noble gas volume of Gmelin, which is quite old now, is still a good source of information for historical purposes. Also valuable is "Tables of Thermodynamic Properties of Argon from 100 to 3000°K." by Wanda Little.

Two books on the recent discovery of rare gas compounds are "Noble-Gas Compounds" by Hyman and "Noble Gases and Their Compounds" by Moody and Thomas. Each discusses the preparation of xenon tetrafluoride and its related chemistry, but Moody's book is more comprehensive. It is based upon material that was presented at a technical meeting at the Argonne National Laboratory.

Helium is one of the more important of the noble gases, and there are a number of valuable books devoted to a description of its properties. Two books that must be mentioned together are "Helium" by Keesom and "A Supplement to 'Helium'" by Lifshits and Andronikashvili. The first is a thorough treatise covering the gaseous, liquid, and solid states of helium; the author is from the famed Kamerlingh Onnes Laboratory at Leiden. The second contains two chapters, "Superfluidity (Theory)" and "Superfluidity (Experimental Data)."

A more recent source of helium data is "Design Handbook for Liquid and Gaseous Helium" by V. E. Isakson and I. M. Kroenke. It contains engineering data for transport systems and equipment, physical properties, and the hazards of helium. The three main sections are: (1) liquid helium storage, transport, and transfer, (2) helium liquid-to-gas conversion, and (3) gaseous helium storage, transport, transfer, purification, and compression methods.

Thermodynamic properties of the gas over wide temperature and pressure ranges may be found in several publications. "The Physical and Thermodynamic Properties of Helium" issued by Whittaker Controls, covers gaseous helium from 147 to 6000 p.s.i.a. at temperatures ranging from —440° to 600°F. Another volume is "Thermodynamic Properties of Helium to 50,000°K." by Lick and Emmons, which gives the results of calculations over the pressure range 10^{-4} to 1000 atm. Included with the text are two Mollier diagrams for helium.

Many noble-gas applications have high purity requirements. Cernak's bibliography covers some of the purification methods for argon, helium and xenon.

Acetylene

Several books dealing with acetylene appeared over a short period of time. The first was ACS Monograph No. 99, "The Chemistry of Acetylene" by Nieuwland and Vogt. Published in 1945, it is a brief but rather comprehensive account of the preparation, properties, and reactions of acetylene, together with an extensive classified bibliography. Three years later, E. D. Bergmann wrote "The Chemistry of Acetylene and Related Compounds." This book contains papers from three seminars presented at the Polytechnic Institute of Brooklyn, which emphasize recent developments.

"Acetylene and Carbon Monoxide Chemistry" by Copenhaver and Bigelow appeared in 1949. Much of it is taken from the files of J. W. Reppe, a leading

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

German chemist in the field of acetylene chemistry. Reppe was originally given the task of writing this book. He was at best a reluctant author, and the present authors had to complete the job.

Articles from *Chemical Engineering Progress* were collected and issued by the American Institute of Chemical Engineers under the title, "Acetylene Handling."

"Acetylene, Manufacture and Uses" by Hardie was published in 1965 and describes the developments and processes used in acetylene manufacture. European techniques are emphasized. Also published in 1965 is Sittig's "Acetylene" which describes the organic chemistry of foreign and domestic acetylene manufacturing processes. Other topics discussed are principles of safe handling, products and a prospectus for the future. The book depends heavily upon the patent literature for its technical data.

The most up-to-date and comprehensive source of information on acetylene is the two-volume set by Miller of the British Oxygen Company. Volume 1 covers acetylene's physical properties, industrial history, and uses as a source of combustion. The second volume covers chemical properties and chemical uses.

Carbon Dioxide and Dry Ice

Outside of the general references already mentioned, there are only a few additional ones to list. Quinn's book "Carbon Dioxide" is an old (1936) but thorough treatment of the gas. He presents historical background, physical and chemical properties, manufacture of the solid and liquid, and a number of applications. Chen's report gives the thermodynamic and transport properties of carbon dioxide in the gaseous state. Most of the recent pertinent data will be found in journals.

Hydrogen

The principal new interest in hydrogen stems from its use as a rocket fuel and its potential use as a working fluid in nuclear rockets. There are, however, several pre-space books, such as Teed's "The Chemistry and Manufacture of Hydrogen," published in 1919, and Taylor's "Industrial Hydrogen," which cover some of the older uses. In 1935, Farkas' classic "Orthohydrogen, Parahydrogen and Heavy Hydrogen" was published. In this, Farkas describes the preparation, physical properties, and chemical behavior of the different forms of hydrogen. This book is now out of print, but copies are available from University Microfilms in Ann Arbor, Michigan.

A more recent source of information on physical and thermodynamic properties is the "Hydrogen Handbook." The properties of the gases described —hydrogen, helium, and nitrogen—are given for cryogenic temperatures. In addition, there is a section that covers a necessary part of the modern liquid hydrogen business—namely, its storage and handling. Along this same line is a related publication entitled, "Storage, Servicing, Transfer, and Handling of Hydrogen." It is useful mainly to organizations dealing with large amounts of liquid hydrogen. Data are presented for pumping and recondensing systems

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

for liquid hydrogen transfer. "Liquid Hydrogen Technology" is a report issued by General Dynamics.

Liquid hydrogen can be prepared in a number of ways. A good summary of these techniques is disclosed in "Manufacturing Processes for Liquid Hydrogen" by Caras, which includes an excellent bibliography of over 400 references.

"Thermodynamic Properties of 20.4°K.-Equilibrium Hydrogen" by Shaffer, gives properties over a range of temperatures. Mullins *et al.* published a report entitled "The Thermodynamic Properties of Parahydrogen from 1 to 22°K.". Kubin's report also contains the thermodynamic properties and includes a Mollier chart for hydrogen from 300° to 20,000°K.

A number of methods are available for recovering hydrogen from gas streams, and there are two books important because of their treatment of these procedures. Kohl and Risenfield's "Gas Purification" provides good coverage. Katz's "Handbook of Natural Gas Engineering" covers some of the same material but goes more deeply into the business end of the industry; it gives information on oil-field development and operation and on the transmission of gas to the user.

Nitrous Oxide

Although nitrous oxide is known for its use as an anesthetic and an aerosol food propellant, there is no comprehensive source of information on it. Both the Kirk-Othmer Encyclopedia and Gmelin contain some data, as does Mellor. Properties pertinent to the food industry and anesthesiology will be found in books on these subjects. For the most part though, it will be necessary to use the abstract journals to locate desired data.

Refrigerant Gases

The "ASHRAE Guide and Data Book" is probably the best reference source for the properties and uses of refrigerant gases. The latest edition was published in two volumes during 1964 and 1965. Recent refrigeration technology is reviewed and discussed in the International Refrigeration Congresses. The latest one was published in 1960. Publications of the International Institute of Refrigeration (IIR) are also valuable for data. In 1962 the IIR published a "Bibliographic Guide to Refrigeration 1953–1960." It is classified by subject and has entries for refrigerants.

Since the user should know the dangers involved in using refrigerants, the Underwriters' Laboratories' report on hazards of common refrigerants is important.

Information about refrigerant gases is contained in a few journals. The refrigeration journals contain data on refrigeration machinery, and they also contain data on the gases. Some of the more important ones are *ASHRAE Journal, International Institute of Refrigeration Bulletin, Journal of Refrigeration,* and *Kältetechnik.*

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

Anesthetic Gases

Anesthetic gases do not approach the consumption figures of other industrial gases, but they are important enough to deserve consideration. Outstanding coverage of these gases is found in "The Chemistry and Physics of Anesthesia" by Adriani. This book contains chapters on the physical properties of gases and vapors, inorganic gas chemistry, analysis of gases, and flammability of anesthetics. Many anesthetic gases are listed, along with their physical and chemical properties.

Halogenated compounds, such as chloroform, have been widely used as anesthetics and are still important. A short history, properties, and clinical applications of these anesthetics are covered in "Halogenated Anesthetics" by Artusio.

Patent Classification

Much specialized information about industrial gases can be found through patents. The most efficient collection of this information requires thorough knowledge of patents, their literature and classification, but the casual searcher can readily obtain valuable information from several common sources.

For current patents the *Official Gazette* should be used. Another significant source is the "National Catalog of Patents," a collection of U.S. patents from the fields of chemistry and engineering. These are arranged by Patent Office Classification and contain the same material as the *Official Gazette*. Volumes from 1961–1962 are available. The "International Index of Patents" is being issued as a subject index to U.S. and foreign patents. It covers chemical and electrical patents from 1790 to 1960 arranged in order by the Patent Office Classification. The 350,000 foreign patents have been assigned U.S. classification numbers, and a numerical index is also provided.

Other sources of patent information are the journal and patent abstracting services, principally *Chemical Abstracts*.

A unique source of current foreign-patent data is the Derwent Information Service. It publishes abstracts of patents from England, Germany, Belgium, France, South Africa, Japan, Russia, and the Netherlands. Derwent covers primarily chemical patents, although for England and Germany all patents are included.

A newcomer to the scene is the "Science Citation Index." It allows one to find older patents that have been cited in ones recently issued.

Familiarity with the U.S. patent classification system is necessary for a successful search for patents of interest. The patent classification system was designed for arranging patents in a logical subject relationship. It consists of broad subject classes followed by more specific subclasses. One problem with this system is the overlapping subject matter and the lack of cross-filing information on different subjects. Patents on gas separation may be found in Class 55, Gas Separation, as well as in Class 62, Refrigeration, Class 23, Chemistry, and Class 202, Distillation. Considerable cross-checking between classes and subclasses is needed to find all the patents on a given

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

subject. The bibliography lists excerpts from the "Manual of Classification" which are the principal U.S. patent classes that should be searched in a survey on industrial gases. The list is only partial, and the Manual should be consulted before any thorough searches are contemplated.

Journals

References to industrial gases in the journal literature are numerous. However, journals devoted entirely to industrial gases are rare. This presents a minor problem to the researcher. He is apt to find the information he seeks in any one of a number of journals. There are "gas" journals, but in most cases these are concerned with fuel gases. Generally, the chemistry and chemical engineering journals are the best sources for current information about industrial gases. A specific application will, of course, appear in the journal pertinent to that application. Applications run the gamut from food to metallurgy. Examples are *Aerosol Age* and *ASHRAE Journal.*

It would serve little purpose here to list titles of journals that from time to time publish data on industrial gases. Instead, some discussion on the index and abstract journals that may be used to locate wanted information is in order.

The *Applied Science and Technology Index* publishes references to 85,000 English language articles each year. Scientific as well as applied data are covered. There is no author index. A comparative newcomer is the *British Technology Index.* It is also a current subject guide, but gives references only to articles in about 400 British technical journals. *Chemical Abstracts* is the best source with its tremendous coverage of the world's chemical literature. Its author, subject, and keyword indexes provide a variety of avenues for finding desired information. For economic and market data *Chemical Market Abstracts* is useful. Figures for production, sales, and consumption are listed. New products and trade names can also be found.

A current annotated index to the world's engineering literature is the *Engineering Index.* It has an author index, and its monthly issues cumulate annually. Subscription by broad subject category is now offered. Presently available are Plastics and Electrical and Electronics Engineering sections.

The amount of current industrial gas literature that emanates from Government-supported work requires that something be said about applicable indexes. *Technical Abstract Bulletin (TAB), Nuclear Science Abstracts,* and *Scientific and Technical Aerospace Reports (STAR),* cover the bulk of the Government report literature. One must, however, be a Government contractor to be eligible to receive TAB. TAB's unclassified material is listed in *U. S. Government Research and Development Reports* and is available for a price from the Clearinghouse for Federal Scientific and Technical Information. The Clearinghouse provides subject searches of Government technical reports in addition to the sale of these reports. These services are available to the general public. References to the world's published aerospace literature is annotated and indexed in *International Aerospace Abstracts (IAA).*

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

Selected Applications

The recent large growth rate in the use of cryogenic gases has resulted in a corresponding growth of literature. While this literature does not quite fit into the industrial gas category, it depends so heavily upon industrial gases that mention of a few references is in order. Only a few of the more important books published during the last 15 years will be listed.

S. C. Collins, who developed the successful commercial hydrogen and helium liquefier now called the Collins Liquefier, also wrote "Expansion Machines for Low Temperature Processes." He discusses refrigeration systems, engines and turbines for gas liquefaction, and expansion engines used to produce low temperatures.

One of the first books to present the use of low temperature gases for engineering applications is Scott's "Cryogenic Engineering" published in 1959. Engineers find that it is valuable as a handy source of data for their calculations. Of the same vintage is "Experimental Techniques in Low Temperature Physics" by G. K. White. Here the researcher has been provided with details for equipment design and techniques for utilizing liquefied gases.

Not directed to any particular professional field is "Cryogenics, Research and Applications" by Sittig. It discusses the interesting possibilities of working with gases at low temperatures and putting these possibilities to work. Robert W. Vance, co-editor of "Applied Cryogenic Engineering," edited "Cryogenic Technology," a series of lectures given as a graduate course at the University of California. It is more sophisticated than "Applied Cryogenic Engineering" and is directed towards the laboratory scientist or researcher.

Liquid helium is important in cryogenic research as a coolant for specialized equipment. Superconductors, conductors that lose all electrical resistance when cooled to nearly zero degrees absolute temperature, usually are surrounded by a bath of helium to produce a suitably low temperature. Devices that employ superconductors are becoming commercially significant.

Fritz London in 1950 summarized the then-current theories on superconductivity. It was around this time that a renewed interest in this subject took place. Laue's book, "Theory of Superconductivity," was translated by Meyer and Band in 1952. A book by Bogoliubov was translated by the Consultants Bureau in 1959. Other recent books on this subject are Bremer's "Superconductive Devices," Newhouse's "Applied Superconductivity," and Blatt's and Schreiffer's "Theory of Superconductivity."

A family of gases that is enjoying industrial prominence is the fluorocarbons. Their importance has recently increased because of their use in the aerosol industry. Most of the pertinent data are contained in technical bulletins published by the manufacturers, but a good starting place for a literature search is the "Aerosol" chapter in Kirk-Othmer. This chapter lists physical properties and also a capsule description of the industry and how it depends upon compressed gases. The rapid rate of rise in aerosol uses has resulted in an accompanying consumption of propellant gases. Besides the fluorinated hydrocarbons, nitrogen, nitrous oxide, carbon dioxide, and

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch003

some other gases are used in varying amounts as aerosol propellants. Two major volumes on this subject are "Pressurized Packaging" by A. Herzka and "Aerosols: Science and Technology" edited by H. R. Shepherd. Both are good reference texts. Herzka lists formulas for many products. Both provide lists of properties of various propellants and give information about their toxicity and special uses. Further information is given in Milek's "Fluorocarbon Gases." It presents data sheets for the various physical, chemical, and electrical properties of different gases.

The steel industry is a consumer of vast quantities of industrial gases. More and more oxygen is being used to produce a ton of steel. Some less reactive gases are also being used. A few recent references to applications in the steel industry include Jackson's "Oxygen Steelmaking for Steelmakers," Kerr's bibliography, and Tsylev's book.

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Class 48: Gas, Heating and Illuminating

Acetylene
1 Generation and liquefaction
2 Generator and holder
3 Generator and mixer
197 Processes
Hydrogen
199 Carbureting
200 Coal, oil and water

Class 55: Gas Separation (Entire Class)

1 Processes of gas separation

Class 62: Refrigeration

8 Solidified or liquefied gas product manufacturing from a gas
9 Processes, e.g., liquefying per se
11 Extracting a component from a mixture of gases by liquefaction and separation
12 With solidification
15 Retrograde condensation
16 Sorption
22 Obtaining a rare atmosphere gas, e.g., argon, krypton, neon, xenon
23 Plural separations
24 Including rectification
32 Rectification
35 Solidified gas shaping means, e.g., press
36 Liquefied gas producing and separating apparatus
45 Stored solidified or liquefied gas handling

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46 Converting solidified gas to another state. Storing solidified gas
55 Transferring as a liquid
56 Processes
123 Separator for solidified constituent of liquid mixture

Class 23: Chemistry

2 Gas separation and purification
4 Air
14 Compounds
101 Nitrogen
150 Carbon dioxide
157 Of nitrogen
158 From nitrates
159 Treatment
160 Concentration
161 Recovery
162 By oxidation
209 Non-metals
210 Hydrogen
211 Wet
212 Dry
213 Carbon monoxide oxidation
214 Metallic reduction of hydrogen oxide
220 Nitrogen
221 Oxygen
230 Analytical and analytical control methods
232 Gas
252 Apparatus
253 Analytical and analytical control
254 Gas analysis
255 Automatic
256 Volumetric

Class 202: Distillation

2 Processes
39 Separatory
39.5 Extractive distillation
40 Rectification
81 Apparatus
151 Separatory
156 Column
161 Partial reflux condenser
162 Vapor element by-pass

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Sources of Information in the Field of Noble Metals

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Noble metal science and technology has its own considerable literature, a good deal of which is scattered among that of other industries. The literature searcher today must seek articles beyond those referred to in Chemical Abstracts, Metals Abstracts, *and the new terminated "Bibliography of the Platinum Metals." This paper presents a critical and descriptive review of significant noble metal literature sources for practical guidance to workers in this and allied fields. The Bibliography includes Periodicals (including house organs), Books, Bibliographies, Reports, Bulletins and Annuals, Industrial Advertising Literature, selected Review Articles, and Patent Classes.*

The noble metals are generally considered to include silver, gold and the six platinum group metals—platinum, palladium, iridium, rhodium, ruthenium, and osmium. McDonald, in a very readable and amply illustrated book entitled "A History of Platinum," traces developments of the platinum metals—platinum in particular—from the first published reference in 1557 to 1890, the end of the European period of the history of platinum.

Scope of the Industry

Today's applications of the noble metals are, with minor exception, all industrial (*15*). The electrical and electronics industries clearly use the largest quantities of the platinum group metals (and palladium in particular) as make-and-break contacts. Importance of these metals here rests on their reliability in transmitting electrical impulses that control equipment operation, such as telephone relays and electronic components for aerospace vehicles. The chemical industry finds considerable use for the platinum group metals because of their corrosion resistance. This subject is covered for metals and alloys, with a section in Part II on noble metals, in the ACS Monograph No. 158 (*14*). Important uses by the chemical industry derive also from the marked

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

catalytic activity exhibited by the platinum metals. Significant proportions of the platinum group metals are employed in spinnerets for synthetic fiber manufacture, in thermocouples, in laboratory ware, and as industrial protective coating (*29*). The glass industry uses platinum or an alloy with 10% or more rhodium as a material of construction because most other possible materials are attacked more or less by molten glass (*11, 24*). A concise and authoritative chapter on the techno-commercial aspects of the platinum group metals can be consulted in the 1959 "Report of the Committee on Refractory Metals," prepared on request of the Materials Advisory Board of the NAS-NRC. A comprehensive survey of recent technical and economic progress relative to the production and use of the platinum metals in their various forms is presented as Canadian Mineral Report No. 3. For summary articles on industrial applications of the platinum metals the reader is referred to articles by Betteridge and Rhys (*2*), Dowson (*9*), Peckner (*22*), and by personnel of Matthey Bishop, Inc. (*23*). Silver, which for centuries was used for coinage and silverware, has in recent years been extensively applied in industry, e.g. in catalysis, in solders and brazing alloys, in the electrical and electronic industries, as also in the photographic, electroplating, and battery industries (*30*). The dental and medical professions consume important quantities of silver. Gold production continues to be absorbed mostly by governments and central banks as currency backing, while its non-monetary uses are principally industrial, e.g., as protective and decorative coatings for other materials, as coatings on aircraft engine shrouds, and earth satellites to provide protection against heat and corrosion (*31*). With these as examples of some of the end-uses for noble metals, it is little wonder that the literature of the noble metals is equally widespread and affords the searcher a difficult, if not frustrating, path to follow.

General References

Bibliographies. The classical starting point, if one is searching the platinum metal literature through 1950, is the "Bibliography of the Platinum Metals." This "Bibliography," known also as the "Howe-Baker Bibliography of the Metals of the Platinum Group," sought to make the record of the chemistry and physics of these metals as complete as possible. The first of its several volumes, which appeared as Publication No. 1084 of the Smithsonian Miscellaneous Collections, covered the literature for the period 1748-1896. This volume was compiled by Prof. James Lewis Howe of Washington and Lee University. The second volume, compiled jointly by Prof. Howe and Dr. H. C. Holtz, was published as Bulletin 694 of the U. S. Geological Survey. This second volume, which supersedes and extends the references of the first volume to 1917, also cites a most important work omitted at the time of publication of the first volume, namely, C. Claus' posthumous publication entitled "Fragment einer Monographie des Platins und der Platinmetalle, 1865-1883." Claus' work, of which only 300 copies were printed by the St. Petersburg Academie des Sciences, is a critical bibliography; owing to the author's unique knowledge of the platinum metals, it is considered a very valuable work. Later volumes

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch004

of the Howe Bibliography were carried forward jointly by Prof. Howe in collaboration with the technical staff of Baker & Co., now part of Engelhard Industries. These efforts culminated in three decennials, respectively covering the literature for the periods 1918-1930, 1931-1940, and 1941-1950.

An example of a metallurgical bibliographical work is that by Haughton and Prince on the constitutional diagrams of alloys.

Since 1958 *Chemical Abstracts* has prepared a collection of review papers in chemistry. These compilations, originally termed "Bibliography of Chemical Reviews," and later "Bibliography of Reviews in Chemistry," have been searched for coverage of the platinum group metals, silver and gold. Those references which were considered to be of primary interest in the field under consideration are cited as Review Articles in this paper. These annual bibliographical review publications since the start of Vol. III (1960) have included keyword and author indices.

An experimental publication, produced as a prototype of a series of annual indices (each series intended to cover a selected specific topic), entitled "Platinum Metals 1962—An Experiment in Specialized Bibliographies," has been compiled by the American Chemical Society (ACS). Made up of a keyword-out-of context (KWOC) index and a complete author index, this compilation includes a total of 742 titles to the periodical literature encompassing the platinum metals as well as all the appropriate papers covered in the complete 1962 coverage of *Chemical Titles*.

Encyclopedias, Handbooks, Texts. Only those works which include authoritative, informative sections on the platinum group metals and/or silver and gold are reported here.

The Kirk-Othmer, "Encyclopedia of Chemical Technology," now going into its second edition, and the more concise, "Encyclopedia of Engineering Materials and Processes" by Clauser *et al.* are important works.

The ASM's "Metals Handbook," Hampel's "Rare Metals Handbook," Smithells' "Metals Reference Book," "Gmelin's Handbuch der Anorganischen Chemie," and Uhlig's "Corrosion Handbook" are indispensable handbooks.

To the list of texts must be added such noteworthy books as Hansen and Anderko's "Constitution of Binary Alloys," the Vines and Wise book "The Platinum Metals and Their Alloys," and Semchysen and Harwood's book "Refractory Metals and Alloys." Among the foreign sources are Plaskin's 1958 book in Russian, whose translated title is "Metallurgy of the Noble Metals," and three old, but excellent German references: Raub's "Die Edelmetalle und ihre Legierungen," Sterner-Rainer's "Die Edelmetall-Legierungen in Industrie und Gewerbe," and Houben's "Siebert Festschrift."

Periodicals. The periodical literature concerned with noble metals includes two leading house organs and numerous other technical journals, some of which are produced by technical societies.

The term "house organs" has been used variously to embrace literature equivalent to journals, literature containing advertising materials, and literature published for employees and stockholders. Of these, house organs categorized as equivalent to journals are most valuable as sources of technical information. For the platinum metals, and to some extent for gold and silver,

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch004

two quarterly publications are noteworthy. One is *Platinum Metals Review*, undertaken in January 1957 by Matthey Bishop, Inc. The other is *Engelhard Industries Technical Bulletin*, launched in June 1960 by Engelhard Industries. Both publications include a patent-abstracts section and annual indices. The Chamber of Mines of South Africa, in 1968, started publication of the *Gold Bulletin*.

In addition to the house organs cited, the industry can rely on numerous leading technical journals for current awareness in the technology of noble metals. Oldest in the field and devoted exclusively to platinum metals is the Russian publication *Izvestiya Sektora Platiny i Drugikh Blagorodnykh Metallov*. Also in the foreign field is the Italian *Bollettino metallografico. Mensile di Metallurgia dei Preciosi e di Leghe Odontoiatriche*. (The writer could not ascertain whether this publication is still being issued.) There is also the international monthly medium entitled *Journal of the Less-Common Metals* which reports on the advancement of the chemistry and metallurgy of the so-termed less-common metals, and therefore includes references to the platinum group metals. Frequently *Inorganic Chemistry* will carry pertinent articles. For articles on catalysis using platinum metals, the searcher may profitably consult the *Journal of Catalysis, Kinetika i Kataliz,* and *Journal of the Research Institute for Catalysis, Hokkaido University*. Again, catalysis is within the scope of subjects included in the *Journal of the American Chemical Society, Journal of Organic Chemistry, Journal of Chemical Physics, Journal of Physical Chemistry*. The series edited by Chalmers and entitled *Progress in Materials Science* (incorporating *Progress in Metal Physics*) contains a good article by Massalski and King.

Comprehensive metallurgical coverage of the noble metals can be had by referral to *Metals Abstracts,* the result of a merger in 1968 between the British publication *Metallurgical Abstracts* and the American Society for Metals' *Review of Metal Literature*.

Industrial Advertising Literature. The trend in recent years toward more technically-oriented industrial advertising literature is doubtless tied in with the trend toward engaging technically trained sales and purchasing personnel. To the literature searcher this is significant because the end result has been another body of literature to which he can turn. Many advertising brochures and/or data files, as others are termed, are in effect themselves comprehensive literature searches. Others include a section on the literature, supplemented at times by a listing of a company's technical staff papers delivered before learned societies and/or published in the technical journals, and germane to the subject of the brochure. A separate listing enumerates such literature relating to the platinum group metals, gold and silver, and their applications.

Statistical Data. The U. S. Bureau of Mines produces statistical data for the platinum group metals, gold and silver, quarterly and annually as separate sections of the serial *Mineral Industry Surveys*. Additionally, this government body also annually produces mineral commodity reports in these fields, published singly at first in the form of preprints, then later collected with all other mineral commodities in a volume entitled "Mineral Facts and Problems." For silver data, Handy & Harman publish an annual market review. All these statistical data are supplied as well to the publishers of *American Metal Market* who also produce an annual publication entitled "Metal Statistics." The latter reflects statistics of the various other metal industries as well.

Other Guides. A useful annotated guide to metallurgical literature which includes works dealing in part with noble metals is the Special Library Association's world-wide "Guide to Metallurgical Information."

Indispensable for those concerned with general metallurgical classification, is the joint ASM-SLA undertaking entitled "Metallurgical Literature Classification."

A list of pertinent U.S. Patent classes and subclasses is also included in the Bibliography.

Specific Literature and Report References

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch004

A few of the more comprehensive reference sources covering specific areas of the technology of the platinum group metals, silver, and gold are cited here (*20*). These are major works produced as reports, literature surveys, or as articles in learned journals—all of which are characterized by considerable references to prior art in the fields under consideration.

Platinum Group Metals. Considerable material exists on the properties of the platinum group metals (*6, 7*). For tensile properties, ASTM's "Special Technical Publication No. 272" is particularly useful. A group of reports by Carreker at General Electric are of interest to searchers of data in the realm of tensile deformation of platinum, or on creep of platinum. For data and theory concerning electrical conductivity (*5*), oxidation resistance and mechanical properties of pure metals, their alloys and binary compounds (*8,21*), the technical documentary report by Fuschillo and Lindberg is pertinent. Dealing specifically with high-temperature oxidation of the platinum metals and their alloys is a review paper by Betteridge and Rhys (*12*) given at the First International Congress on Metallic Corrosion. Thermoelectric properties of the noble metals and their alloys can be searched in the translation of a paper by Rudnitskii. Physical, chemical, and mechanical properties of rhodium and ruthenium have been dealt with in the literature survey by Love issued as WADC Report 57-666 in connection with a study undertaken on the selection and evaluation of rare or unusual metals for application to advanced weapon systems. Melting point, hardness and ductility of ruthenium, osmium and iridium have been investigated by several organizations searching for metallic materials capable of some degree of useful service at very high temperatures (up to 1200°C). Results have been reported by Baird in Associated Electrical Industries Report No. A-843.

From Battelle Memorial Institute have come some excellent reports concerning platinum group metals. A literature survey, written as a guide to planning experimental work on these metals and as a means for revealing areas in which investigation is needed, was undertaken for the U.S. Office of Naval Research. This first BMI report surveys the literature of the past 50 years on the properties of the metals and on the constitution of their binary alloys. Entitled "High-Temperature Properties and Alloying Behavior of the

Refractory Platinum-Group Metals," this 1959 report by Douglass, annotated with 281 references, was used as a basis for experimental work also reported by Douglass in 1961 under the same title. The latter report is concerned with the strength properties of the more refractory platinum metals—rhodium, iridium, osmium and ruthenium—at high temperatures. Papers related to this program at Battelle have been published by ASTM and AIME; these, along with others still in press, are listed in the 1961 BMI report.

In the analytical field, references to the period 1915 to 1940 covering some 800 papers dealing with the inorganic and analytical chemistry of the platinum metals were included in an extensive review article by Gilchrist (*10*). Smith's 1947 volume entitled "Sampling and Assay of the Precious Metals," may also be consulted along with the more valuable up-to-date three-part "Treatise on Analytical Chemistry" edited by Kolthoff and Elving. Only segments of this multi-volume work have been completed. The section by T. S. Walsh and E. A. Hausman entitled "The Systematic Analytical Chemistry of the Platinum Metal Elements" was published in 1963 as Vol. 8, Part II, Section A of the "Treatise."

Recent metallurgical research has made increasingly exacting demands on the analyst, requiring both closer specification limits within which alloys must be produced and also reduced tolerances towards deleterious trace elements. For platinum, such aspects have been studied and reported in papers by Killick and Morris (*13*), Lincoln and Kohler (*17*), to cite a few. A substantial work of merit includes a chapter by Lewis in F. E. Beamish's book on the spectrochemical analysis of the platinum metals. Although optical emission spectroscopy continues to make a major contribution in these analyses, greater accuracies and sensitivities are being sought. Useful supplementary techniques have been reported by Bills (*3*). Recent research along these lines for silver will be referred to subsequently under that heading. X-ray spectroscopy has been applied by Lincoln and Davis (*16*) in the quantitative determination of platinum in base reforming catalysts.

In the field of catalysis, the searcher will find that most references deal with platinum and, to a lesser extent, with palladium, since these are the two platinum group metals most widely used in various commercial scale reactions. While literature references to catalytic applications are very numerous, there are but two titles which concern themselves with catalysis over platinum metals: the one by Rylander, the other by Augustine. Among short reviews is a published state-of-the-art paper by Rylander and Cohn (*28*). Another older review by Connor (*4*) covers platinum reforming catalysts and includes 280 references to the literature.

Two general works which at times include reports of work on platinum metal catalysis are the Reinhold series entitled "Catalysis" and the Academic Press series entitled "Advances in Catalysis." To these general sources can also be added Bond's book on "Catalysis by Metals"; the periodical literature on catalysis has been referred to previously.

International conferences on catalysis, scheduled over four-year periods, have resulted in collected papers of significance, many of which deal with

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch004

the platinum group metals. The first such conference, held in Philadelphia in 1956, published its papers in Vol. IX of "Advances in Catalysis." The second conference, held in Paris in 1960, produced two volumes entitled "Actes du Deuxième Congrès International de Catalyse" (*1*). The third conference was held in 1964 in Amsterdam; the fourth, in 1968, in Moscow.

A useful source concerned with catalytic reactions with ruthenium, rhodium and iridium is the "Annotated Bibliography on Ruthenium, Rhodium, and Iridium as Catalysts" compiled by Rea and Bebbington. More than 300 selected abstracts of papers and patent specifications covering the period 1881 to mid-1959 are included. They are systematically arranged in sections dealing respectively with the hydrogenation of organic compounds, other reactions of organic compounds, reactions with inorganic compounds, and catalyst properties. Several indices (by catalyst, by author, by patent and by reaction-reactants and products) make this volume easy to use.

Noble metals and their alloys have long been recognized as the most reliable sensing elements for high temperature measurements. The most recent periodic symposia on temperature measurement and control was that sponsored jointly by The American Institute of Physics, The Instrument Society of America, and The National Bureau of Standards (NBS). The collected papers of this Fourth symposium held in 1961 appear in Reinhold's book "Temperature—Its Measurement and Control in Science and Industry." As a definitive source of data on temperature measurement, this work stands alone. Vol. III, Part 2 can be profitably consulted for the most comprehensive literature treatment of the platinum metals in temperature measurement.

The NBS has for many years been associated with various programs carried out in cooperation with scientific and industrial bodies requiring fundamental information in a given field. For several years studies have been in progress in the field of thermocouples. Among NBS's noteworthy reports pertinent to such application of platinum metals are Circular 561 by Shenker *et al.* on temperature-e.m.f. reference tables for thermocouples, Caldwell's Monograph 40 on thermocouple materials, and Monograph 27 entitled "Bibliography of Temperature Measurement."

Corporate publications in this field include the 1961 publication "The Platinum Metals in Thermometry" by Engelhard Industries, Ltd. Data herein are, however, oriented to British standards. Covering this same subject, but oriented to U.S. standards, is a publication in preparation by Engelhard Industries. In addition, "Noble Metal Thermocouples," compiled by Johnson, Matthey & Co., Ltd., also merits mention here as a useful corporate publication.

The field of electrical contacts is served by the general "Bibliography and Abstracts on Electrical Contacts," published by the ASTM in 1944, and covering the period 1835-1943. The work, which includes also references to noble metal contact materials, methods of testing, and on the interruption of electrical circuits, has since been up-dated yearly. Excluded are patents on contact materials and other phases of the operation of contacts. The latter can be found in the appendix of Addicks' book on "Silver in Industry." An engineer-

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch004

ing seminar on electrical contacts held in 1962 at the University of Maine recently published the collection of papers presented; among these is the Vines' paper on "Platinum Metals Plating."

On the subject of "Electrodeposition of the Platinum Group Metals," Reid (*25*) has reported most comprehensively citing 95 references.

Gold and Silver

Compared with the literature of the platinum group metals, that of gold and silver is rather sparse and, for the most part, of not too recent vintage.

Gold. A long-standing reference work on the "Metallurgy of Gold," authored by Rose and Newman, appeared last in its 7th edition in 1937. A most valuable and welcome addition to the literature of gold is the book edited by Wise and entitled "Gold: Recovery, Properties and Applications."

In April 1959, the Canadian Department of Mines and Technical Surveys in conjunction with the Canadian Metal Mining Association jointly sponsored a program aimed at increasing industrial uses of gold. As part of the project, a literature survey was conducted and published as Canadian Mines Branch Information Circular No. 116. This bibliographical survey titled "Physical Metallurgy and Uses of Gold," covers the ten-year period 1950-1959. The survey has been restricted exclusively to the physical metallurgy and uses of gold, and does not include medicinal, nuclear physics, analysis, and extractive metallurgy references except where these fields and that of the survey overlap. Another similarly sponsored publication has issued as Canadian Mines Branch Circular No. 129. The latter presents most of the relevant and currently available physical, chemical, and metallurgical data on gold and its alloys, with over 200 references to sources for these data. The *Gold Bulletin* must be included also.

An interesting field of research using inorganic films of gold for meeting aerospace environment requirements, particularly for solar energy absorption, has provided considerable data collected in Parts I and II of ASD-TDR-62-92 by Langley *et al.*

Lincoln and Kohler, working with emission spectrographic analysis, have reported on the determination of trace impurities in gold (*18*).

Silver. For the literature of silver, apart from that appearing in books on plating, soldering, brazing, electrical contacts, or otherwise related industrial end-use applications, the 1940 book by Addicks on "Silver in Industry" still remains among the classic references. A recent book by Butts and Coxe is of value here. Two review papers on brazing of particular value are referred to here: The one by Rhys and Betteridge (*26*), the other by Rhys and Berry (*27*).

Because of the considerable interest in high-purity fine silver, mention is made here of the Lincoln and Kohler paper on the determination of low concentration impurities in high-purity fine silver (*19*). In the field of tensile deformation of silver, Carreker has reported extensively.

Silver, as well as platinum and palladium, finds use in fuel cells. Four important volumes based on papers presented before the ACS fuel cell symposia are pertinent in this field. A fifth is in press.

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Patents

Material	*Class:subclass*
Platinum	
Alloys	75:172
Compounds	23
Electrolysis	204
Igniting devices	67:5
Pyrometallurgy	75:83
Palladium (see Platinum)	
Rhodium (see Platinum)	
Ruthenium (see Platinum)	
Osmium	
Alloys	75:172
Compound recovery	23:14
Extracting	75:83
Hydrometallurgy	75:121
Iridium	
Alloys	75:172
Compound recovery	23:15*
Filaments	75
Preparation	75:84
Electrolysis	204:109*
Hydrometallurgy	75:121
Silver	
Alloys	75:173
Aluminum-copper	75:145
Coating	117:35
Electrodeposition	204:46
Electrolytic synthesis	204:109*
Mercury alloy	204:126*
Hydrometallurgy	75:118
Metal stock	29:199
Organic compounds	260:430
Proteins	260:114
Pyrometallurgy	75:83
Gold	
Alloys	75:165
Beating	78:100
Carbon compounds	260:430
Electrolysis	
Coating	204:46*
Synthesis	204:109*
Hydrometallurgy	75:118
Leaf applying	41:37
Plate	29:199
Pyrometallurgy	75:83

* The asterisk (*) adjacent a subclass number indicates that the search for the heading includes that subclass and all the subclasses indented thereunder. Further, in some cases where a search embraces all subclasses indented under an un-numbered subclass title, this field is indicated by an asterisk adjacent the number of the first subclass in the group. (U.S. Patent Office "Index to Classification," January 1956.)

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Literature of the Science and Technology of Ceramics, Including Enamels and Glass

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Since the ceramic field has developed to an important materials science within the last century, available sources of literature have expanded proportionately. A general review of ceramic literature is given, followed by more specific coverage of clays, enamels, glass, porcelain, building materials, and electroceramics. Since they are covered elsewhere, cement and concrete and abrasives and refractories are not included. Ceramic literature can be found in the form of books, periodicals, government documents, patents, news media, and translations with reference to the related abstracts, indexes, and bibliographies. Pertinent publications have been included in the selective bibliography supplementing the text. Although brief reviews of most sources are included, the majority of the more significant books have merely been marked with an asterisk in the bibliography.

Chemistry, physics, geology, crystallography, metallurgy, electrochemistry, and many other sciences contribute considerably to the science of ceramics. Owing to this, much pertinent research data must be ferreted from various other sources.

This, however, was not originally the case. Dates of the origin of ceramics and glass are not known, but pottery is shown on Egyptian artifacts dated before 6000 B.C. (*29*), and it is known that glass was being used for utensils and jewelry before 3000 B.C. Even enameling was known in Europe and Asia several centuries before Christ (*15*).

It is from this crude beginning, when ceramic materials were improved by trial and error, that the field of ceramics became a dynamic science. One of the recognized fathers of this science was Hermann August Seger, who spent

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

his short life concentrating on scientific research in ceramics. He contributed many original and extensive papers from 1870 to 1893.

Even the definition of "ceramics" was evasive for many years in this country, until in 1920 a special committee of the American Ceramic Society proposed that ceramic industries include burned clay, cementing materials, glass and glassware, enameled metal products, refractories, abrasives, and electrical and thermal insulating materials (*8*). Recently, the term has been defined as "the technology and art concerned with the manufacture from inorganic, nonmetallic substances and materials of products that are subjected to a high temperature during manufacture or use" (*34*) or "all engineering materials or products that are chemically inorganic, except for metals and metal alloys, and are usually rendered serviceable through high temperature processing" (*27*).

During the last 40 years, the ceramic industry has been changing rapidly. A new field, ceramic-metal systems, is developing from the basic ceramic science. This area now includes ceramic-to-metal seals, vitreous enameled metals, and glass-lined containers, to name only a few. Electronic ceramics is another new field which is arising mainly from whitewares, through developments in such products as spark plugs, electrical porcelain, and dielectric insulators. Other products which are included in this category are semiconductors and ferrimagnetic materials.

With the demand for materials having such properties as high temperature resistance and chemical inertness in this space age, ceramics has expanded from the traditional technology of the silicates to include that of the borides, carbides, nitrides, oxides, and silicides (*20*).

General References

Ceramics is now a broad field to cover, and separate chapters in this book will be devoted to the literature of both abrasives and refractories and cement and concrete. Space does not allow a listing of all pertinent great books here, but a selective bibliography follows, whose entries include references to other recognized literature in each specifically related field.

Several standard reference series have good inclusive sections on the science and technology of the various branches of ceramics like glass, pottery, abrasives, enamels, clay, refractories, etc. Such sources include the "Encyclopedia Americana," the "Encyclopaedia Britannica," the "Encyclopaedia of the Ceramic Industries," and the "Encyclopedia of Engineering Materials and Processes." These are good preliminary sets and generally have pertinent references appended.

Abstracts, Indexes, and Information Services. During the development period, ceramists had the forethought to organize professional societies. The British Ceramic Society, American Ceramic Society, and Society of Glass Technology have been exchanging information since close to the turn of the century. The British Ceramic Society was originally called the Ceramic Society and still publishes *Transactions*, including *British Ceramic Abstracts* and various ceramic papers. In 1964 the Society introduced two additional series: the *Journal*, which releases Society activities in reports, with development surveys

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and book reviews, and the *Proceedings*, which contains "sets of papers presented at certain specialized meetings of the Society" (*30*). The Society also cooperates with the European Ceramic Association in classifying *British Ceramic Abstracts* according to the D.E.C. (Documéntation Éuropenne Céramique) classification system.

Ceramic Abstracts is published separately in the *Journal of the American Ceramic Society* and is indexed annually by author and subject. It contains abstracts of books, periodical articles, ceramic papers, and patents. The *Journal* is published monthly and includes papers "related to the silicate industries" (*17*). The *American Ceramic Society Bulletin* includes the proceedings of Society's conferences and other information related to ceramic industrial development. To simplify usage of these periodicals, the Society has supplied "Indexes to Publications of the American Ceramic Society Journal, 1918–1955, American Ceramic Society Bulletin, 1922–1955."

The American Chemical Society has also contributed greatly to the ceramic field by the services offered in *Chemical Abstracts*. This series contains abstracts of selected literature related to those fields of present-day ceramics which have been previously untapped by the ceramic scientist. Until 1962 ceramic entries were included in Section 19 (Glass, Clay Products, Refractories, and Enameled Metals) and Section 20 (Building Materials—Cement, Concrete, and Other Building Materials). In the current classification of 80 sections (rather than the original 30), this basic information is in Section 57 (Ceramics) and Section 58 (Cement and Concrete Products). The important point is that related ceramic information has become more related to the specific sciences and may be found in sections such as Surface Chemistry and Colloids, Phase Equilibriums, Thermodynamics, Crystallization, Spectra, Inorganic Chemicals, Industrial Inorganic Chemicals, Mineralogical and Geological Chemistry, etc. Annual and cumulative indexes have likewise increased indexing terms and cross-references as the field has expanded.

To speed up the availability of scientific literature, the American Chemical Society initiated an indexing service in 1960, entitled *Chemical Titles*. This covers 600 selected titles including ceramic periodicals such as the *Journal of the American Ceramic Society* and *Steklo i Keramika*. The series includes an author and keyword index and has current "tables-of-contents" of a number of significant journals. This is a useful service although the system does not have the same permanent reference value as *Chemical Abstracts*.

Like the British Ceramic Society, L'Institut de Céramique Français classifies ceramic literature according to the D.E.C. classification system in a monthly *Bulletin de Documentation Céramique* published in *L'Industrie Céramique*. This service is available in classified card form, and even when the abstracts are written in French, they are still useful. On a similar basis, *Deutsche Keramische Gesellschaft* classifies the abstracts of ceramic literature which are published in their *Berichte*.

It is encouraging to note that the international ceramic organizations are coordinating their abstracting efforts more as time goes on. Comparative organizations which contribute to the professional ceramic literature are the Ceramics Research Association of Haifa, the New Zealand Pottery and Ceramics Re-

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search Association, the Canadian Ceramic Society, the Expanded Shale, Clay, and Slate Institute, the Indian Ceramic Society, the National Lime Association, and the Associacao Brasileira de Cerâmica. In August 1965, the first volume of the *Journal of the Australian Ceramic Society* was started (2). This general list alone shows some of the many sources which can be contacted and which are considered to be the official ceramic authorities.

Periodicals. To discuss the many pertinent trade journals would be a major project, but a few titles must be mentioned. *Ceramic Age* and *Ceramic Industry* are the two recognized news media for the United States. They have monthly advertisers' indexes, annual editorial indexes, technical articles, and convention announcements and reports. Such reports, articles, and activities are published for the western ceramic industries in *Ceramic News.* British industrial news is similarly covered in *Pottery Gazette and Glass Trades Review* and *Ceramics,* a journal of the British Pottery Managers' Association. The merit of several other foreign periodicals should also be considered. Abstracting services are published regularly in *Szklo i Ceramika, Tonindustrie Zeitung und Keramische Rundschau, Silicates Industriels, Sprechsaal für Keramik-Glas-Email-Silikate,* and *Ziegelindustrie.* Several of these journals also include industrial news and abstracts of patents.

The journal field can hardly be abandoned without referring to several good house organs supplied by various industrial concerns. A news media of the ceramic industry, the *Ceramic Forum* is published by the O. Hommel Co., and *Silicate P's & Q's* is available from the Philadelphia Quartz Co. The *Monthly Bulletin for the Ceramic Industry* of C. E. Ramsden & Co. in England is a good little publication containing a ceramic technical or educational review in each issue. More scientific house organs include *Asahi Kasei Seni No Kenkyu* from the Asahi Chemical Co., Japan and *Radex Rundschau* of the Austro-American Magnesite Co. In Austria.

Books. Although ceramic books cannot be reviewed in detail, the recognized basic books are marked with an asterisk in the accompanying bibliography. Of the numerous relevant books published in the last decade, those of Kingery, Kirkendale, Lee (which contains a chapter on dental porcelain), Norton, Salmang, Insley and Fréchette, and Searle must be mentioned. These, together with the three-volume series, "Ceramics," by E. P. McNamara, and "Phase Diagrams for Ceramists," are the well known authorities on ceramic science and technology. Reference to books which were considered appropriate for all fields of ceramics in earlier years, is available in "Reference List of Ceramic Books" (*16*), compiled by the American Ceramic Society.

Proceedings. A number of conferences are also noted in the bibliography, such as the *Transactions of the International Ceramic Congress,* which is a biennial record of progress in the ceramic world. In most cases, only the latest convention has been cited in the bibliography, but all previous proceedings should be considered. Another significant example of this type of literature was shown in 1950 when the British Ceramic Society celebrated its Jubilee with a symposium "to survey the growth of the practice, the technology, and the basic science of ceramics" (*14*) in the words of the eminent British scientist Arnold Trevor Green, who with G. H. Stewart edited the symposium in

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch005

"Ceramics: a Symposium" (*14*). In 1959, Green was honored by the Society with the publication of "The A. T. Green Book." G. H. Stewart also edited reports of two "Science of Ceramics," conferences which were held under the auspices of both the British and Dutch Ceramic Societies in 1961 and 1963.

Dictionaries, Encyclopedias, and Handbooks. Annual reviews of ceramic industrial materials, activities, production, etc., are included in the "Ceramic Data Book," "Pottery Gazette and Glass Trade Review: Reference Book and Directory," and a few other annual issues of related periodicals, such as *Materials in Design Engineering* (*24*) and *Ceramic Industry* (*7*). Similar foreign information and statistics can be located in such publications as "Jahrbuch für Keramik, Glas, Email" and "Sprechsaal Silikat Jahrbuch" by Kalsing.

As in most fields today, the ceramist has the advantage of state-of-the-art reports in his own and related fields. Examples of these would include "Progress in Ceramic Science," edited by J. E. Burke, "Progress in Applied Materials Research," "Progress in Solid State Chemistry," "Reports on the Progress of Applied Chemistry," published by the Society of Chemical Industry (London), "Solid State Physics," and "Special Ceramics," edited by P. Popper (*see* Proceedings). Many other such "Advances in" or "Progress of" series are appropriate and are published by such companies as Interscience (Wiley), Plenum (Consultants), or Pergamon (Macmillan). These publications are now making it much simpler to keep abreast of current developments in the adjoining fields of interest.

Standards and Specifications. Established American standards and specifications have been prepared by many scientific committees of the American Society for Testing and Materials and published in book form. The "ASTM Standards 1964" now has 32 parts consisting of specifications, methods of testing, definitions, and recommended practices needed for the production, procurement, and testing of engineering materials. Parts 8–14 are particularly related to ceramics, Part 13 being entitled "Refractories; Glass; Ceramic Materials." These volumes are revised annually. In addition, compilations of reports, symposium papers, and other technical publications in the materials field are published by the ASTM. Useful standards are also available from the British Standards Institution and U.S. federal and military agencies.

Statistics. In the ceramic industry it is difficult to find true over-all statistics owing to the fact that so many of the products are merely parts of other manufactured items. Household appliance enamels and semiconductors are examples. However, general statistical information is available in the "United States Census of Manufacture" of the U.S. Bureau of Census, and although the coverage is not as detailed, statistics are also reported in "Minerals Yearbook, Mineral Facts and Problems" (which includes bibliographies) and "Commodity Year Book." In any case, it is always wise to contact the appropriate state authorities if detailed local industrial statistics are required. The "Growth and Development of the Nonmetallic Mineral Industries" by Oliver Bowles and C. W. Justice gives a 50-year survey with statistics of various branches of the ceramic industry. E. E. Pratt's "Pottery Industry," though old, includes a good survey of pottery statistics and useful information for industrial manufacture. Incidentally, the Technical Aids Branch of the U.S. International

Cooperation Administration published a series of reports in 1959 which contained plant requirements for the manufacture of various products including ceramic dinnerware, kitchen earthenware, building brick, sanitary ware, glass containers, and others.

To follow the student ceramic research activities in the United States, Ph.D. theses are normally included in *Dissertation Abstracts,* and masters' and Ph.D. theses are listed annually in one of the early issues of the *Ceramic Abstracts* (*4*). The source and availability of these theses are also given. In some cases, bachelors' theses are abstracted at individual colleges, as they are annually at the State University of New York College of Ceramics at Alfred University in the *Monthly Progress Report* (*26*).

Ceramic Art

Even though we are presently considering the literature of ceramic science, information related to ceramic art cannot be neglected. In many available art volumes, materials and technical procedures are discussed. Some of the recognized books in this field are the classic, "A Potter's Book" by Bernard H. Leach, "The Potter's Craft" by C. F. Binns, and "Ceramics for the Artist Potter" by Frederick H. Norton. Other related books which should be mentioned here are "Clay and Glazes for the Potter" by Daniel Rhodes, "China Mending and Restoration" by C. S. M. Parsons and F. H. Curl, and "Mosaics" by Joseph L. Young. For further information in pottery and ceramic art, *Ceramic Abstracts* should be consulted. The *Art Index* is another basic source which has been supplemented by the "Index to Art Periodicals" compiled by the Ryerson Library, Art Institute of Chicago.

In searching for ceramic literature, if one decides that a good book, a library's card catalog, or a pertinent reference such as the "Encyclopedia of Chemical Technology" will not suffice, other sources must be considered. To carry out a complete literature investigation for a research project, no stone may be left unturned. The location of one article reporting research which has already been completed can save an institution thousands of dollars. In addition to the abstracting services published by professional societies, as previously discussed, *Applied Science and Technology Index,* previously known as the *Industrial Arts Index, Engineering Index, Science Abstracts,* and *Solid State Abstracts* should be consulted. Another fairly recent introduction has been the *Science Citation Index,* which is based on an "article reference" principle. This service discloses other references in which a certain article has been cited and lends a new aspect to literature searching. By using these sources and other more specific abstracting or indexing services, such as those included in the *Battelle Technical Review,* related articles will generally be located which will cite further references.

Bibliographies. At the same time, bibliographies may be located which can save many hours of searching time. A supporting title comes to mind entitled "Bibliography of Reviews in Chemistry" of the American Chemical Society. This was an annual series which indexed current scientific papers including good bibliographies (1958-62). Many of the earlier authoritative references in the ceramic field can be found in such bibliographies as those compiled by C. J. West and D. D. Berolzheimer (*37*), T. N. McVay (*25*), and Hewitt Wilson (*38*).

Patents. To locate pertinent international patents, the reliable *Ceramic Abstracts* and *Chemical Abstracts* should still be consulted. *Chemical Abstracts* also has a useful patent index, published annually and cumulatively. The *Uniterm Index to Chemical Patents* and the *Official Gazette* of the U.S. Patent Office conveniently cover the U.S. patents, and one should have an *Index of Patents Issued from the United States Patent Office* available. The U.S. Patent Office will also make available all patents related to specific classified fields as they are published. At a reasonable rate per subject, this is a valuable service.

Government research is another field of interest that may reap dividends. *Nuclear Science Abstracts* reviews all literature in its nominal field, including government documents and research reports. Other sources include *U.S. Government Research Reports, Scientific and Technical Aerospace Reports,* and *Technical Abstract Bulletin*. All unclassified reports included in the latter two series are now included in *U.S. Government Research Reports* and are available for a fee from the Clearinghouse for Federal Scientific and Technical Information (formerly the Office of Technical Services). It may also be possible to use surveys such as L. E. Geyer's "Revised List of Publications on Ceramic Investigations," Norman L. Hecht's "Survey of Ceramic Research Programs Sponsored by Government Agencies," or "Bibliography of Reports on Ceramics," of the U.S. Office of Technical Services. Other series of this agency are entitled "Scientific Bibliography" or "Informal Bibliography," which were replaced by the "Catalog of Technical Reports" series and then superseded by the Selective Bibliography series. This series consists of neat, separate subject listings of government research reports related to many fields, such as "Ceramics and Refractories, 1930–59," and "Ceramics."

One regular problem in the literature field is the variety of languages in which information may be published. To offset this national difficulty, the number of translated journals is increasing continuously. As an example, such journals as the Russian *Steklo i Keramika* and *Ogneupory* are now available in English as *Glass and Ceramics* and *Refractories,* respectively. Available translations are also listed in *Technical Translations* of the Clearinghouse for Federal Scientific and Technical Information, which supersedes both *Translation Monthly* of the Special Libraries Association and *Bibliography of Translations of Russian Scientific and Technical Literature*. In some cases, such as the *Journal of the Ceramic Association of Japan* or *Bulletin de la Société Française de Céramique,* a translation may not be needed. In such cases, an English review is included, and often the tables or graphs will supply sufficient information. Another feature about significant foreign articles is that they are likely to be translated and published in an English or American journal within a reasonable length of time. Translations of scientific literature are indexed and available through the National Research Council of Canada, U.S. Atomic Energy Commission, U.S. Defense Documentation Center, U.S. National Aeronautics and Space Administration (*13*), and the SLA Translations Center, John Crerar Library, Chicago. Commercial translation agencies

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are listed in "Scientific Translations" (*28*) of the U.S. Department of Health, Education, and Welfare.

One good source of translations in the field of glass was started with the American Ceramic Society's "Translations of Foreign Articles on Glass Technology" (*5*). This cooperative venture on the part of the Glass Division of the Society, has also been supported by the Corning Glass Works Research and Development Laboratory, the Owens-Illinois Technical Center, and the Owens-Corning Fiberglas Corp. Glass Research Laboratory. Such efforts have been continued by these and other institutions by supplying translated articles for publication in *Technical Translations* (*12*). In recent years the British Glass Industry Research Association has been listing translations in glass science and technology which are now made available for indexing in *Technical Translations*. A list of the intermediary BGIRA translations is being prepared for distribution by the American Ceramic Society.

Up to this point we have covered the sources of information in the overall field of ceramics. It is expected that pertinent books in related fields of interest will be adequately reviewed in *Ceramic Abstracts* or *Chemical Abstracts* and that all recognized reference sources and periodicals of the physical sciences can be made available to carry out adequate research in ceramics.

Clay

Since the origin of ceramics rested on utilitarian principles with materials from the earth and since three-fourths of the total production of clay is used in the ceramic industry (*33*), information on clay should be considered here. From prehistoric times, the content of clay has been of prime importance to pottery and ceramics. An old, but useful "Bibliography of Clay Deposits" was compiled by Heinrich Ries in 1925, which was supplemented in 1953 by "Clay Bibliography," prepared at Bowling Green State University. Scientific progress in the field is reported annually in the proceedings of the National conference on clays and clay minerals and "Proceedings of the International Clay Conference."

Interesting U.S. Government research monographs to consult are "Clay" by P. M. Tyler, and the "Chemical Analysis of Clay" by Haskiel R. Shell. Reliable books have been written by Ralph E. Grim, George Brown, and H. Van Olphen. *Pit and Quarry, Clay Minerals Bulletin,* and the *British Clayworker* are the regular journals for the clay industry.

Building Materials

Building materials is another branch of industry in which ceramics takes a part. Brick, tile, and lightweight agglomerate materials are good examples of this interest. In the United States, various good serials are published such as *Technical Notes on Brick and Tile Construction,* and the *Structural Clay Products Research Foundation Research Report.* The Associated Brick Manufacturers of Southern California publish *Technical Bulletin on Brick Masonry,* and a review of British road and building materials is available in annual *Reports on the Progress of Applied Chemistry.* Other trade magazines in this field are *Brick and Clay Record* and the non-technical, but well illustrated, *Brick and Tile* of the Structural Clay Products Institute. "Clay Preparation and Shaping" by F. J. Goodson is a recent review of brick plant machinery, and a U.S. Bureau of Labor Statistics publication on "Brick and Tile (By Stiff Mud Process)" is a good survey of this industry in the United States. The recognized books on this branch of the structural clay products industry are those by B. H. and R. G. Knight, C. C. Handisyde, and Alfred B. Searle. Information on lightweight clay products can be found with the bibliographies by Metzger and Fuess and in the reports by Greaves-Walker, and Bole.

Enamels

To locate information on enamels, it is appropriate to start by using the bibliographic series which has been continuously supported by the American Ceramic Society. This series was first entitled "Enamel Bibliography and Abstracts" from 1929 to 1959 when it was changed to "Ceramic-Metal Systems and Enamel Bibliography." These are well-organized bibliographies which are now being published in loose-leaf form. Other related bibliographies which have been published in the American Ceramic Society periodicals are "A Reading List on Vitreous Enameling on Iron and Steel, 1907–1920" (*36*) by Clarence J. West, "Bibliography of Literature on Plasticity and Setting Up of Enamel Slips" (*10*) by R. D. Cooke, and "A Bibliography of Literature on Enamel Tests and Methods of Control" (*31*) by Bryan A. Rice. For translating, "Enamels, Emails, Emaux, Smalti: ein Wörterbuch in Vier Sprachen" by J. Brandt and others is a German, English, French, and Italian dictionary of enamels. Other noted books on enamels are those by Bryant, Andrews, Petzold, Vielhaber, Huminik, and Lokshin. To review the developments in the enamels field, the *Bulletin of the Institute of Vitreous Enamellers* and "Proceedings of the International Congress on Vitreous Enameling" should be followed as well as the annual *Forum Proceedings of the Porcelain Enamel Institute,* which constitutes the basic American series related to enamels. In addition to the regular ceramic journals containing papers on enamels, the German *Mitteilungen des Vereins Deutscher Emailfachleute e.V.* should be scanned regularly. Books for an enamels craft collection might include the interesting titles by Hans Günther Marek and C. Hasenohr.

Glass

Glass is the largest and most diversified field in ceramic science, and the Society of Glass Technology was established in Great Britain in 1917 with its own journal, including abstracts. The journal is now published under two titles, *Glass Technology* and *Physics and Chemistry of Glasses,* and each of these is published bimonthly with abstracts related to its respective interests. Other periodicals related to the glass branch of ceramics are *Glaces et Verres* of France, the *Central Glass and Ceramic Research Institute Bulletin* of India, *Glass* of England, *Glastechnische Berichte* of Germany, *Glasteknisk Tidskrift* of Sweden, *Verres et Réfractaires* of France, and *Vetro e Silicati* of Italy. Supplemented by these journals are several American titles which keep the

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glass industry posted on current affairs and activities. These include *Glass Industry,* which also reviews the glass patents each month, *American Glass Review*, which publishes an annual *Glass Factory Directory Issue,* and *National Glass Budget,* which is a weekly review of the industry with a biography and portrait of some prominent person in the glass field almost every week. *Stained Glass* is the professional quarterly of the Stained Glass Association which lists current stained glass references. Noted authors in the glass sciences include Günther, Scholes, Tooley, Morey, Mackenzie, Weyl and Marboe, and Weyl.

Bibliographies can be found in the literature on various aspects of the glass industry, including a good survey of books (*1*) by the American Ceramic Society, a "Bibliography on Glass Structures" edited by W. G. Lawrence (*21*), and other articles such as "List of U.S. Patents Pertaining to Laminated Glass" by James F. Walsh (*35*). Well known bibliographical compilations such as those by the Carnegie Institute of Technology, D. C. Cornish, Catherine D. Mack, and Owens-Corning Fiberglas Corporation, are also quite appropriate.

Government research reports on glass are well covered by the Selective Bibliography series of the Clearinghouse for Federal Scientific and Technical Information. One significant report entitled "Ordnance Materials Handbook: Glass," prepared by the U.S. Ordnance Corps, is a fairly recent collection of engineering information and data. Other useful reviews with good bibliographies have been prepared by Condon (*9*), Dimbleby (*11*), MacKenzie (*23*), and Kauzmann (*18*).

Current scientific developments in glass research are reported occasionally at international conferences and are subsequently published in book form. A number of these are listed in the bibliography.

A few examples of books regarding the art and history of glass, written with a point of view more akin to the scientific field, are those by Buckley, Caley, Eisen, Heddle, Kinney, and Plant.

One branch of glass which has not been covered in this text is the practice of glassblowing, which is required in most laboratory research. Several books are currently available in this field, together with the periodical, *Fusion*, of the American Scientific Glassblowers' Society. The pertinent books are by Parr and Hendley, Robertson *et al.,* Wheeler, and Waugh.

A glaze is not glass in the commercial sense, although it is a glassy coating which is used over earthenware, brick, pottery, etc., in the field of ceramics. Good bibliographies on glazes can be found in "Literature Abstracts of Ceramic Glazes" by John Henry Koenig and W. H. Earhart, and "Pottery Glazes" (*6*) published in *Ceramic Industry*. Worthwhile books have also been written by Viehweger, Green, and Singer and German. The well known and authoritative "Ceramic Glazes" of Cullen W. Parmelee, has since been edited and revised by E. D. Lynch and A. L. Friedberg.

Porcelain

Another important branch of ceramics is the porcelain field. It includes fine whiteware or china and manufactured items such as sanitary ware and electric insulators. There are several important books related specifically to porcelain, including "Kaolin Clays and Their Industrial Uses" of the J. M.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch005

Huber Corp., "The Evolution of a Lump of Clay" of the Coors Porcelain Co., Lundin's "Studies on Triaxial Whiteware Bodies," and the two well known titles: "Ceramic Whitewares by Rexford Newcomb and "Making True Porcelain Dinnerware" by Robert E. Gould. In 1951, a bibliography entitled "Porcelain and Pottery" was published by the U.S. National Bureau of Standards.

To approach the present uncertain ceramic developments in the space age, a well recommended book entitled "Refractory Hard Metals" was written by Paul Schwartzkopf in 1953. By 1958, several articles were published showing the rapid progress in this area. These articles were "What Can Ceramics Do in Missiles" (*3*), "New Developments in Ceramics" (*19*), and "Investigation of Ceramic Materials in a Laboratory Rocket Motor" (*22*). It is significant that the literature is extending to these expanding fields today. Books which have been published since that time include "Materials for Rockets and Missiles" by Robert G. Frank and William F. Zimmerman, "Volatile Silicon Compounds" by E. A. V. Ebsworth, "Metal Spraying and the Flame Deposition of Ceramics and Plastics" by W. E. Ballard, and "Physical Ceramics for Engineers" by Lawrence H. Van Vlack.

Electroceramics

To touch the electro ceramic field as a final topic, there are a few books which have been published fairly recently. These are "Optical Properties of Semi-Conductors" by Trevor S. Moss, "Imperfections and Active Centres in Semiconductors" by R. G. Rhodes, "Studies on Electroceramics and Their Applications" by the Murata Manufacturing Co. of Kyoto, Japan, and "Elektrokeramik" by Alfred Hecht and others.

Having attempted to give a sound approach to the location of literature in the ceramic field, it might be appropriate to close with the observation that there seems to be a dispersion developing in the publication of pertinent literature. It has become necessary to examine the literature in all scientific journals to maintain a clear picture of the progress in ceramic science. This causes more difficulty to the literature searcher but indicates a closer cooperation with the other physical scientists in basic research.

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1961	19. Glass, Clay Products, Refractories, & Enameled Metals (*see also* Section 20)
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Material	*Class: Subclass*
Ceramics	13: 1–33; 18: 59; 25: 5, 22, 143, 156; 41: 34; 49: 78.1; 73: 15, 15.4, 15.6, 16, 17, 19, 54; 75: 3, 10, 200–214, 221–227; 106: 39–123, 313–315; 117: 70, 100, 123–126; 263: 20; D18
Pipes and Tubular	138: 66+; 138: 80+
Clays	25: 157+; 117
Enamels	106: 48+, 312; 117: 125, 129, 169
Porcelain	25: 156+; 106: 45+
Brick	25
Mosaic	41: 23; 72: 26; 117: 20
Tile	25: 41+; 72: 41+, 65+, 73; 125
Design	41; 117: 37+; D4; D18; D36; D45; D51
Glass	13: 6; 49; 51: 282–284; 88; 106: 47–54; 117: 16+, 124; 154: 2.7+, 96; 214: 3.1; 215; D36

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6

Literature of Refractories

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About 70% of the refractories manufactured are used in the iron and steel industry and public utilities. Among the other users are the nuclear and aerospace industries. The types of refractories manufactured include fire clay, silica, zircon, zirconia, magnesite, chrome, dolmite, high alumina, carbon, and silicon carbide. From the use of siliceous rock to construct iron furnaces in 1645 to the present day use of borides and nitrides, the refractory industry has grown steadily and diversified its raw materials and production techniques to meet the ever changing needs of modern technology. The literature of the refractory industry reflects these changes and advancements.

The term "refractory" stems from the Latin word "refractarius" meaning to oppose or resist. It implies a material that is difficult to fuse or corrode—one which is capable of enduring high temperatures. A current industrial definition of a refractory is a nonmetallic material capable of resisting high temperatures and other destructive forces present in furnaces such as slag corrosion, abrasion, load, and thermal shock.

The refractory industry is composed primarily of materials manufacturers who supply linings to withstand and contain severe conditions. These conditions may be only high temperatures, but they frequently involve abrasion and chemical attack also. The linings are supplied largely as fired bricks, blocks, plates, and as many special shapes. They also may be supplied as a monolith-forming material of which plastic refractories, gunning mixes, and castables are the principal types.

Processes involving high temperature include: iron, steel, and nonferrous metallurgy; glass, ceramic, and cement manufacture; the steam generating plants of the large electric utilities, industrial heating units, and even the home oil burner. Municipal incinerators lined with refractories are used to dispose of the mountains of refuse our civilization generates daily.

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Refractories manufacturers also supply linings for vessels used in the chemical industry. These conditions involve moderate temperatures, but the linings must resist the corrosive action of chemicals.

The bulk of the industry is concerned with supplying the needs of the iron and steel industry. Indeed, about 70% of the total refractories' consumption is accounted for by the combination of the iron and steel industry and public utilities. The remaining 30% is divided among other users.

Included in this group are many of the special refractory users, including the more exotic applications in the nuclear and aerospace industries, where extreme environmental conditions demand the durable refractories. Intensive research and new development effort in refractories since the mid 1940's have been directed toward solving the problems of these fields although much effort continues to be directed toward the problems of the conventional refractory user.

History

There are few records of the early history of refractories in North America. Undoubtedly the earliest type of refractory used was quarried mica schist or siliceous rock. It was used to construct the first successful iron furnaces in 1645. The earliest use of clay refractories was for glass pots in 1638. These probably were made from imported English or German clays. Domestic clay was first used for furnace firebrick shortly after 1793 in Boston. In the early 1800's firebrick manufacturing plants were established first at Boston and Baltimore, then in New Jersey, Vermont, and Connecticut. Before the Civil War refractories manufacture had spread westward through Pennsylvania and Ohio to the Mississippi River and south to Georgia.

The first silica bricks were manufactured in the United States about 1860 although they had been manufactured in England earlier. The area around Mt. Union, Pa. became a center for manufacturing modern lime-bonded ganister silica brick.

Magnesite was first used in Europe for steel melting about 1880. It was used successfully in this country about 1888, and domestic manufacture of magnesite refractories began soon after.

High alumina refractories from bauxite were introduced in 1890. Missouri diaspore was used first about 1920 for super-refractories. Gibbsite and kaolin are also used to manufacture these refractories.

The investigation, manufacture, and use of high purity oxide refractories began in Europe about 1930. This special refractory technology had spread to the United States by the advent of World War II. It has expanded since then because the demands have become so exacting that only certain high purity materials possess the extreme high melting points and high temperature strengths demanded by these applications. Alumina, zirconia, and magnesia are all consumed in considerable quantity today.

Non-oxidic refractories have greatly increased in use with the more severe use requirements of modern technology. The most widely used is silicon carbide, first produced in 1891. Its high thermal conductivity and high hot strength result in its application in many furnaces where abrasion resistance or good heat transfer is demanded. Its semiconductor properties result in its use as electrical heating elements.

The refractory industry has grown along with heavy manufacturing, especially iron and steel. The changing technologies of the principal consumers of refractories have been reflected in changes in types of refractories produced. As steel plant operating temperatures increased, silica brick replaced fireclay brick in applications, only to be replaced in turn by basic brick of the magnesite-chrome type. Fireclay refractories used in the hearth of blast furnaces have been replaced by carbon refractories. The recent technological revolution in steel making has increased the use of tar-bonded or tar-impregnated refractories of magnesite, either alone or in combination with dolomite.

Glass tanks, the large furnaces used to melt the quantities of glass consumed today have gone to denser refractories to minimize the corrosion which occurs between the glass melt and the furnace wall. This has led to the extensive use of fused-cast refractories.

The high cost of labor needed to build refractory structures has led recently to the increased use of monolithic walls. These monolithic walls, instead of being laid up as bricks, are cast, rammed, or gunned, using refractory specialty products.

As the demands of the users of refractories have increased, the technical level of the refractories industry has increased. A scientific basis for the industry was laid in the early 1920's with the beginning of much of the research on refractories.

This technical and scientific approach to the problems of the refractories industry, both in manufacturing and applications, has intensified since the 1940's until today the refractories segment of the ceramic field is one of the most technically advanced. The field today actively utilizes the latest advances in sintering, hot pressing, and high temperature solid state chemistry. The latest investigative methods and tools are employed in this technical effort. Automated mass production techniques are used in manufacturing refractories to an increasing extent.

The literature of the refractories industry reflects all these changes and the great technological and scientific growth of the industry.

Materials Used as Refractories

The majority of industrial refractories is composed of aluminum silicates. Silica and semi-silica refractories constitute the silica-rich end of this system. Fireclay refractories lie midway between the two end members of the system, alumina and silica. Mullite refractories are about 60 to 70% alumina, the balance being silica. High alumina refractories range up to the top of the scale on the alumina end of the system.

Refractories based on magnesia either alone or in combination with chrome ore are being used in increasing quantities, particularly in open hearth furnaces. For the lining of the newer basic oxygen furnaces used for steel pro-

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duction, tar-bonded magnesia or magnesia-dolomite compositions have been used.

Pure oxides are valuable as refractories because they are stable both in air and less active atmospheres. High purity alumina refractories have been used widely for 35 years. Other oxide refractories of significant importance are zircon, zirconia, beryllia, and thoria.

Carbon and graphite have been used as refractories for centuries. High temperature strength, inertness to many molten metals and slags, electrical conductivity, and low rate of thermal expansion make carbon and graphite unique.

Carbides are used as refractories because of their extremely high melting points, some above 3500°C. Lack of stability in air limits their applications. Silicon carbide is the exception. The viscous silica film developed on the surfaces of the carbide's grains protect the silicon carbide beneath.

Borides of the high melting metals of the fourth, fifth, and sixth periodic groups have properties making them valuable as refractories. Their melting points range from 2000° to 3000°C., and they have low volatility. Their oxidation resistance is fair, and they maintain their strength up to extremely high temperatures.

Nitrides, having high melting points and thus considered refractories, are formed by transition elements of the third, fourth, and fifth groups of the periodic chart. Stable, high melting nitrides are also formed by beryllium, boron, aluminum, and silicon. Nitride-bonded carbides now are available commercially.

Literature

Books. Because the term refractories comprises such a broad scope of materials, processes, products, and industries, there is a tremendous volume of literature available. For a comprehensive look at refractories, the reader should begin with the standard textbook in this field for many years. This is F. H. Norton's "Refractories" which covers the range of refractories from the fireclay brick to the thoria crucible, from clay-graphite shapes to yttrium carbide, and from bauxite to fused cast alumina blocks. Besides about 2000 references to these refractory subjects, the author also lists some 54 books on refractories published prior to 1949. This book is an excellent reference source on any phase of refractories up to 1949, including refractories history, raw materials, manufacturing methods, testing, and physical and chemical properties, as well as the uses of refractories in industry.

Another basic text of refractories technology is "Phase Diagrams for Ceramists" which is a compendium of phase equilibria of primarily the oxide systems. The 2066 phase diagrams are in themselves a bibliography of references for the refractory oxides.

The American Ceramic Society has also published "Refractories Bibliography, 1928–1947" and "Refractories Bibliography, 1947–1956," which are ready reference sources to a large volume of the literature.

For more recent literature of a general nature on refractories (and ceramics as well), the books "Elements of Ceramics" and "Introduction to

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Ceramics" are recommended. The majority of other reference books given in this bibliography were selected as recent additions to the refractories technology which show current technical trends and involve more specific segments of refractories technology.

Periodicals and Journals. The majority of the technical literature published in the United States can be found in the *Journal, Bulletin,* and *Abstracts* of the American Ceramic Society. Many other domestic and foreign journals publish articles on refractories, and the abstracts of the American and British Ceramic Societies provide excellent coverage of world-wide literature. *Chemical Abstracts* is also useful for specific materials.

A number of other publications included in the bibliography are likely to be found in a good technical library.

Patents. Patent references can be found in the bibliographies discussed previously or in *Ceramic Abstracts*. U.S. patent literature can be located through the "Manual of Classification" and its accompanying index. Pertinent classes and subclasses are listed in the Bibliography.

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1961	19. Glass, Clay Products, Refractories, & Enameled Metals
1962	17. Ceramics
1963	21. Ceramics
1967	57. Ceramics

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Ceramic Age, Ceramic Publications, Inc., 2728 Euclid Ave., Cleveland, Ohio 44115, monthly.
Ceramic Industry, Industrial Publications, Inc., 5 S. Wabash Ave., Chicago, Ill. 60603, monthly.
Industrial Heating, National Industrial Publishing Co., Union Trust Bldg., Pittsburgh, Pa. 15219, monthly.
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Refractory Material	*Class: Subclass*
Checker brick furnace structure	263:51
Compositions	106:43 through 122
Gas generator	48:74
Kilns, Saggers	25:153
Fire	
brick	75:95

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7

Literature of the Abrasive Industry

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The literature of the abrasive industry is widely dispersed, and there are few good reviews available. Much of the record of the industry may be found in patent literature. The remainder is dispersed through a wide variety of sources, including trade journals and house organs. Some pertinent information is scattered through the general literature.

The modern abrasive industry is concerned with the manufacture and processing of abrasive materials for grinding, cutting, and polishing. The major materials used are aluminum oxide (*7*), silicon carbide (*3*) and diamond (*4*). All of these are now made artificially, although natural diamonds are still an important factor. These items along with some naturally occurring abrasives are used in grinding wheels, as coated abrasives, or in loose form for tumbling or lapping. Metal-clad or coated diamonds have recently improved diamond wheels to a marked degree. Wheels made from metal-clad diamonds have been particularly effective in grinding carbide tools with steel shanks. There have been also remarkable improvements in the hub materials for diamond wheels, such as fiber-filled Bakelite resin, and in diamond form tools, the single-layer diamond form wheel, and diamond abrasive belts.

History

The first metal objects made by man were sharpened and polished with sand or other natural abrasives, either loose or in the form of stones. Indeed, it is probable that some of the stone implements were also polished or shaped with sand or with other stone materials. Pliny records the use of emery in the first century A.D. Down through the centuries sand and sandstone have been used for polishing and sharpening, culminating in the use of the familiar grindstone for sharpening axes and other cutting tools.

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The modern history of abrasives begins with attempts to bond natural emery with glue to other materials so that it might be applied to rotating machinery. About 100 years ago some silicate or water-glass bonded wheels were made. These were soon followed by wheels made with vitrified or clay bonds. Other bonding materials which gradually came into use were cement, rubber, shellac, sodium silicate, magnesium oxychloride, and phenolic resins. The development of artificial abrasives, such as silicon carbide and fused aluminum oxide, greatly improved quality and reproducibility (*3, 20*).

Sandpaper, initially made with glue, and emery cloth, also bonded with glue, have been augmented more recently for coated abrasives with other bonds based on plastics and with a wide variety of backings and fillers. Flint, garnet, silicon carbide, and aluminum oxide have been the usual abrasives in this service and have recently been joined by diamond.

General Literature

Abstracts concerning abrasives may be found in *Chemical Abstracts, Ceramic Abstracts*, and the *Industrial Diamond Review*. In *Ceramic Abstracts* these are concentrated mainly in the abrasive section, but in *Chemical Abstracts* the references may well be scattered throughout many sections.

The Grinding Wheel Institute and the Abrasive Grain Association are responsible for much of the general literature in this field and may be considered to represent the whole industry on the North American continent. A historical record is provided by "The Saga of the Abrasives Industry." This volume was prepared by Muriel F. Collie and published by the Grinding Wheel Institute in 1951. Similarly, information on coated abrasives is available in "Coated Abrasives, Modern Tool of Industry." Data on the abrasive uses of diamonds are offered by Engelhard Hanovia, Inc. and by the Diamond Research Laboratory in Johannesburg.

Information on specific topics and various types of grinding is provided in the trade literature of the various abrasive companies; a list of these companies is included in the bibliography.

Books. There is no general treatise covering the field of abrasives. The best summaries are provided on an annual basis by the Minerals Yearbooks of the United States and Canada, respectively. Both of these contain information on the industry which lags about two years behind the date.

There are good individual books on grinding wheels (such as Lewis' book), on coated abrasives, on diamonds, and on bauxite, which is included here since it is the raw material for producing aluminous abrasives.

Periodicals and Journals. The major journal in this field is *Grinding and Finishing*. It has been in publication since 1954 and contains a number of important articles in the field. *Industrial Diamond Review* is devoted to articles on the use of diamonds and a broad summary on abstracts and trade literature covering the whole field of abrasives.

Grits and Grinds is a trade journal which has been published by the Norton Co. since 1909. Its major contribution is in the field of techniques for grinding operations.

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Patents. The patent literature of the abrasive industry is quite voluminous considering its brief span in time. Patents may cover abrasive materials (*11, 21*), bonds, designs, and techniques of fabricating wheels or coated abrasives. Nearly all relevant patents are abstracted in *Industrial Diamond Review* or *Ceramic Abstracts.*

Other Literature

Reports and suggestions on grinding wheel safety are available through the Grinding Wheel Institute or from individual manufacturers.

Analytical methods for abrasives are fully described in Scott's "Standard Methods of Chemical Analysis" under the appropriate material. (Methods for analysis are also described in the chapter on "Abrasives" in the "Encyclopaedia of Industrial Chemical Analysis" published in 1966 by Interscience.) Control methods used by individual manufacturers are usually kept as trade secrets.

The unit processes involved in dealing with abrasives are periodically described in the open literature. There have been recent articles on crushing and comminution in a number of journals (*9*). Screening of abrasive grain is a special art and is frequently done with silk or nylon screens. Standards for sizing of abrasive grain have been set up by the U. S. Department of Commerce.

The furnacing procedures used in the industry have been reviewed by McMullen (*17*) and Upper (*28*). Sandmeyer and Miller describe associated technology (*22*) (*see* also references *8, 29, 30*).

The geographical concentration of the crude abrasive industry in the Niagara Frontier area is reviewed by Finlay and Upper (*9*).

The petrology of aluminous abrasives has been considered by Baumann (*1*) and by Schrewelius (*23*). The crystallography and manufacture of silicon carbide have been considered (*24, 25*). Data on hardness of abrasive materials is cited by Thibault and Nyquist (*26*) and by Schrewelius (*23*).

A standard system for marking grinding wheels has been established by the industry in the United States and Canada. Detailed information on the system and its interpretation may be obtained either from the individual manufacturers or from the Grinding Wheel Institute.

A romanticized account of the origin and growth of the Norton Co. is given by Tymeson. This history of the largest company in the industry provides background information not available elsewhere.

The close relationship of the abrasive industry to the steel and automotive industries has been reviewed by Forchheimer (*10*).

Large grinding wheels are used in the pulp and paper industry to produce ground wood pulp.

Recent Technology Advances

The major recent advances may be listed as: (1) man-made diamonds, (2) sintered abrasives, (3) alumina-zirconia abrasives, (4) micro-crystalline abrasives, (5) abrasive machining, and, (6) electrolytic grinding. The appli-

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cation of synthetic diamonds to grinding wheels has been rapid (*2, 12, 31*). Reviews by Bovenkerk and by Kay may be helpful.

Recently, Carborundum Co., Norton Co., and Universal Grinding Wheel Co. have marketed snagging wheels made from sintered bauxite or alumina materials (*5*). A typical material in this field is described by Ueltz (*27*).

Still another new snagging abrasive depends on zirconia additions to fused alumina in amounts ranging from 10 to 50% zirconia by weight. Such compositions are now produced by Norton, Carborundum, Exolon, and General Abrasives. Relevant patents are by Marshall and Roschuk (*11, 12*) and Cutt (*6*).

Micro-crystalline abrasives, so called, are extremely fine-grained materials produced by fusion and chill-casting of various aluminous materials. The product may be cast either as small ingots or as slabs to induce the fine crystalline structure. In general this material is most useful in the fields of snagging and tumbling abrasives, but little information has yet been published.

The new concept of abrasive machining, whereby metal is removed rapidly using grinding wheels rather than by conventional machining methods involving tool bits, has been adequately described by Mowry and Smith (*18*). The new types of abrasives described above have helped to expand the application of grinding wheels to heavy stock removal.

A new technique of grinding called electrolytic grinding is gradually finding application particularly on cemented carbide tools (tungsten carbide, etc.). In this process, electrically conductive grinding wheels are used along with an electrolytic metal removal process. The combination of mechanical abrasion with electrolytic solution of the anodic work-piece is said to produce better surface at a lower cost. Reinhardt and Grunwald is an illustrative reference (*19*). Further advances in electrolytic grinding have also been made. These apply in particular to work on cemented carbides.

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American Ceramic Society Bulletin, American Ceramic Society, 4055 North High St., Columbus, Ohio 43214, monthly.

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Chemical Abstracts, American Chemical Society, 1155 Sixteenth St., N. W., Washington, D. C. 20036, weekly.

Year	*Section*
1912	4. Electrochemistry
	8. Mineralogical & Geological Chemistry
	9. Metallurgy & Metallography
	19. Glass & Ceramics
	20. Cement & Other Building Materials
1961	4. Electrochemistry
	8. Mineralogical & Geological Chemistry
	9. Metallurgy
	13. Chemical Industry & Miscellaneous Industrial Products
	19. Glass, Clay Products, Refractories, & Enameled Metals
	20. Cement, Concrete, & Other Building Materials
	29. Leather & Glue
1962	16. Cement & Concrete Products
	17. Ceramics
	18. Mineralogical & Geological Chemistry
	19. Extractive Metallurgy
	20. Ferrous Metals & Alloys
	21. Nonferrous Metals & Alloys
	22. Electrochemistry
	45. Leather & Glue

Year		*Section*
1965	15.	Electrochemistry
	18.	Extractive Metallurgy
	19.	Ferrous Metals & Alloys
	20.	Nonferrous Metals & Alloys
	21.	Ceramics
	22.	Cement & Concrete Products
	25.	Mineralogical & Geological Chemistry
	55.	Leather & Related Materials
1967	41.	Leather & Related Materials
	53.	Mineralogical & Geological Chemistry
	54.	Extractive Metallurgy
	55.	Ferrous Metals & Alloys
	56.	Nonferrous Metals & Alloys
	57.	Ceramics
	58.	Cement & Concrete Products
	77.	Electrochemistry

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Grits and Grinds, Norton Co., 3 New Bond St., Worcester, Mass. 01606, monthly.

Industrial Diamond Abstracts (Sections B–W), published with *Industrial Diamond Review,* which see.

Industrial Diamond Review (including *Industrial Diamond Abstracts*), Industrial Diamond Information Bureau, Arundel House, Kirby St., London EC1, monthly.

Journal of the American Ceramic Society (including *Ceramic Abstracts*), American Ceramic Society, monthly.

Journal of the Electrochemical Society (combining the *Journal* and *Transactions*), The Electrochemical Society, 1860 Broadway, New York 10023, monthly.

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Patent Classes and Subclasses

	Class/Subclass
Alumina	
Abrasive materials, compositions, and tool making processes	51/293+ *
Dry methods (of production)	23/141
Wet methods (of production)	23/142
In refractory compositions	106/62
	106/65
	106/55+
Silicon Carbide	23/208
Abrasive materials, compositions, and tool making processes	51/293+
In ceramic compositions	106/44
Diamond	
Abrasive materials, compositions, and tool making processes	51/293+
Diamond tools for stone working	125/39
Synthesis	23/209.1
Tool Making	76/101
Boring Bit	175/329

* + means and all indented subclasses.

Leading Manufacturers as Sources of Abrasive Literature

Industrial advertising literature is available from the following companies:
American Abrasive Co., Inc., 100 Union St., Westfield, Mass.
Armour Abrasives Co., 16123 Armour St., Alliance, Ohio
Armour Alliance Industries, Adhesive Division and Coated Abrasives Division, 16123 Armour St., N. E. Alliance, Ohio
Frank Bancroft Co., Inc., 23841 Kean Ave., Dearborn, Mich.

Bay State Abrasives Co., 15 Union St., Westboro, Mass.
Behr-Manning Co., Howe St., Troy, N. Y.
Brown and Sharpe Manufacturing Co., 250 Promenade, Providence, R. I.
Carborundum Co., Niagara Falls, N. Y.
Carborundum Co., Refractories Division, Dept. T. R. 62R, Perth Amboy, N. J.
Chicago Wheel and Mfg. Co., Dept. TR, 1101 W. Monroe St., Chicago, Ill.
Cincinnati Milling Machines Co., 4701 Marbury Ave., Cincinnati, Ohio
Colonial Abrasive Products Co., Union Hill Rd., Conshohocken, Pa.
Engelhard Hanovia, Inc., Industrial Diamond Division, 113 Astor St., Newark, N. J.
Electro Refractories & Abrasives Corp., 213 Vars Bldg., Buffalo, N. Y.
Engis Equipment Co., 431 S. Dearborn St., Chicago, Ill.
The Exolon Co., 950 E. Niagara St., Tonawanda, N. Y.
Gardner Machine Co., State Line, Beloit, Wisc.
General Abrasive Co., Inc., 2100 College Ave., Niagara Falls, N. Y.
Heald Machine Co., 10 New Bond St., Worcester, Mass.
Macklin Co., 2917 Wildwood Rd., Jackson, Mich.
Mattison Machine Works, 200 Blackhawk Park Ave., Rockford, Ill.
Micromatic Hone Corp., Schoolcraft at Greenlawn, Detroit, Mich.
Mid-West Abrasive Co., Owosso, Mich.
Minnesota Mining & Mfg. Co., 2501 Hudson Rd., St. Paul, Minn.
Norton Co., 50 New Bond St., Worcester, Mass.
Pangborn Corp., 10 Pangborn Blvd., Hagerstown, Md.
Peninsular Grinding Wheel Co., 729 Meldrum Ave., Detroit, Mich.
Precision Diamond Tool Co., Lake and Bluff Sts., Elgin, Ill.
Rampe Mfg. Co., 14918 Woodworth Ave., Cleveland, Ohio
Setco Industries Inc., 5890 Hillside Ave., Cincinnati, Ohio 45233
The Sheffield Corp., Springfield and Thomas Sts., Dayton, Ohio
Simonds Abrasive Co., 5510 Tacony St., Philadelphia, Pa.
Speedlap Corp., 3634 W. Oakton St., Skokie, Ill.
Sterling Grinding Wheel Co., 58 Wall, Tiffin, Ohio
The Thompson Grinder Co., 1534 W. Main, Springfield, Ohio
Ty-sa-man Machine Co., 998 White Ave., Knoxville, Tenn.
Wallace Supplies Mfg. Co., 1308 Diversey Parkway, Chicago, Ill.

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8

The Literature of Cement, Lime, Plaster, and Gypsum

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Cements and mortars are mentioned in the literature of ancient times. Information on these and on lime, plaster, and gypsum and on the materials from which they are made is widely distributed. General sources are noted along with sources of abstracts and indexes, translations, patents, statistics, and price information on the general field as well as particularly for each topic, including also concrete and stucco.

Cements and mortars have been used in building since ancient times. The mortar used between the stone blocks in the Egyptian pyramids was made by calcining gypsum which probably contained limestone impurities. Later, the Greeks used mortars of lime produced by burning limestone. Cato, writing two centuries B.C., discussed the properties of lime and lime-burning kilns. Greek builders learned to add volcanic tuff from Santorin island to slaked lime and sand to make a superior mortar. Vitruvius mentioned the Roman use of lime mixed with volcanic ash from Mt. Vesuvius in the construction of dwellings, and the slaking of lime for stucco on vaultings. The volcanic tuff from Pozzuoli was siliceous material which reacted with the slaked lime to form a cement that hardened under water. Such mixtures of lime and pozzolana were used as mortars in the construction of the Roman Pantheon, the Colosseum and the aqueducts. Spackman gathered the manuscripts and books of the early writers on lime and cement and his reviews provide excellent historical records of the production and use of lime and cements. Znatchko-Javorsky's book gives a history of gypsum and calcareous cementing materials with emphasis on the USSR.

Limestone, clay, and gypsum occur in many parts of the earth. The oxides of calcium, aluminum and silicon are among the most common earth materials. Lime derived from limestone, and cement manufactured from limestone and clay or shale are among the most widely used building materials throughout the world.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Lime, plaster, gypsum, and most cements are usually discussed together because they are all calcium compounds and all are used in the building industry. Their greatest difference lies in the manner in which they set and harden. Lime mortars absorb carbon dioxide from the air, which reacts with the calcium hydroxide forming calcium carbonate; these mortars set upon drying and the calcium carbonate gives added strength. Calcined gypsum or plaster of Paris sets by reaction with water and crystallization. Hydraulic cements, such as portland, natural and slag cements, set by chemical reactions with water, forming hydrated calcium silicates and aluminates, principally. Only hydraulic cements will harden under water and do not require the absorption of CO_2 or drying in air.

General Literature

The chapters on lime, cement, and gypsum in the annual "Minerals Yearbook" are excellent starting points for a current literature search. The text briefly describes new plants and processes, changes in existing plants and mentions industrial conferences or meetings and their publications. All new technological developments within the year are carefully referenced. The individual chapters are often ready and may be purchased separately several months before the bound volumes are published.

Excellent survey articles by leading authorities on cement, lime, and gypsum have appeared in collected volumes, compilations, and encyclopedias. Both "Industrial Minerals and Rocks" and Kirk-Othmer's "Encyclopedia of Chemical Technology" have chapters on each of these products. The "ASTM Standards" cover all these materials.

Books by individual authors as Eckel and Ladoo cover cement, lime, and gypsum. Petzold's small book was used as a text for the Institut für Silikathüttenkunde and covers lime, gypsum, and manufacturing and properties of plaster, as well as anhydrite binders, magnesium binders, and portland cement.

In all the industries under discussion, crushing and grinding operations and the methods of particle size and surface area determination are important. The British bibliography on "Crushing and Grinding" includes annotations on cement, chalk and limestone, and gypsum.

Abstracts and Indexes. Several important abstract journals collectively cover these related materials. Other abstract journals dealing more specifically with one commodity are mentioned later in this text.

Chemical Abstracts (*CA*)—Section 22—Cement and Concrete Products gives comprehensive abstracts on the literature of cement, lime, plaster, and gypsum. Related materials may appear in other sections. The abstracts of Russian and Japanese and other foreign language papers and patents makes *CA* especially useful to the average chemist. *CA* includes abstracts translated from the Russian abstract journal *Referativnyi Zhurnal*, which would otherwise not be available to many chemists. The Russian text of articles other than those abstracted from *Referativnyi Zhurnal* may be obtained as photocopies from Chemical Abstract Services.

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Ceramic Abstracts—Section III—Cements, Limes, and Plasters is an additional very useful source of information about the literature of these materials.

Chemisches Zentralblatt places abstracts of these materials under Section H-4—Glas, Keramik, Baustoffe.

Building Science Abstracts, produced by the Building Research Station and published by Her Majesty's Stationery Office, includes the chemistry of these materials, their manufacture, and the use of their finished products in the building fields, often making BSA one of the most useful services.

Chemical Titles is not an abstract service but serves as an announcement of the newest papers in a large number of important journals. Checking the words anhydrite, calcium sulfate, gypsum, hemihydrate, plaster of Paris, plasters, etc., in the permuted title column might turn up new work in unsuspected journals, or reveal a paper on gypsum before the chemist could normally see that journal. Translated titles of foreign language papers are available before the chemist could see the abstract in *Chemical Abstracts*. Sometimes after the paper itself is obtained it isn't as exciting as the title promised! If this happens often, wait for an abstract before ordering new papers on the basis of the title alone.

CSIRO Abstracts covers the Australian government research program including lime and cement, and the current Australian work on gypsum plasters.

Canadian Building Abstracts are annotated in French and English. The British Ministry of Public Buildings and Works publishes the *Consolidated Building Reference to Articles in Periodicals*.

The Library Accession lists of large libraries when available provide "double check points" for literature which might otherwise be missed.

Foreign language abstract journals also collectively cover these products. *Tonindustrie-Zeitung und Keramische Rundschau* published in Germany contains abstracts in each issue and some issues are entirely devoted to abstracts. The section "Bindemittel, Mortel, Beton" covers European and American publications.

"Engineering Index" includes many foreign papers under the headings: cement, cement plants, gypsum, gypsum plants, lime and lime kilns. *Applied Science & Technology Index* covers fewer publications and has no author indexes.

Languages and Translations. Dr. Kurt Gingold in *C&EN* for August 17, 1964 discussed "Translations for the U. S. Scientist." He has written of the growing importance and volume of the non-English literature and the inability of most chemists to cope with foreign languages. This language inability also hampers the chemists and engineers in the areas of the cement, lime, gypsum, and plaster industries. Abstracts of the foreign language papers in *CA* are often the only contact the American chemist has with the non-English literature.

An almost universal rule is that if you need a translation of a paper, that paper has not been translated. *Technical Translations* listed and often annotated, government and privately donated translations as well as those for sale by commercial translators. The donated translations may be obtained for the cost

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of photocopying from the Special Libraries Association's Translation Center at John Crerar Library, Chicago. *Technical Translations,* issued jointly with the Clearinghouse for Federal Scientific and Technical Information, ceased publication in 1967. *Translation Register-Index* was started solely by the SLA Translation Center in 1967.

The Library of Congress' *Monthly Index of Russian Accessions* prints translated titles of Russian journals and monographs. Monographic works are arranged in broad subject areas, and periodicals are arranged by classes as Science-Chemistry, Technology-Chemical technology, and Civil and Construction engineering. About half of each issue is devoted to a subject index with papers and monographs listed under headings: cement clinkers, gypsum, lime, liming of soils, plastering, precast concrete construction, etc. The *Monthly Index* is especially useful for manufacturing, product, or engineering information which is not in *CA* and which might otherwise be almost completely unknown to the industries.

The Library of Congress' "Serial Publications of the Soviet Union, 1937-1957" lists in its subject index 12 serials on cement, 4 on concrete, 5 on gypsum, 1 on plastering, none on lime, but many serials devoted to building materials. Some of these serials have now ceased publication, but *Tsement,* and *Beton i Zhelezobeton* are currently important Russian journals.

The Russians have worked with lime, gypsum, slags, mineral waste products, conventional and non-conventional raw materials for cements, and done original work in developing cellular and foamed products which are precast and autoclaved. These developments may be followed in *CA*. Occasionally a paper given by a Russian author at an international meeting may be printed in English, and this often includes a summary of Russian research achievements. A large volume of Russian literature appears as journal articles and monographs which are not easily obtained.

An unusual and especially valuable translation service is given by the Japan Cement Engineering Association, which publishes its annual volume, *Semento Gijutso Nenpo*. Later they publish a small book of rather detailed English abstracts of the cement research and manufacturing papers entitled, "Review of General Meeting."

The only U. S. journal in the building materials field which prepares foreign language abstracts for its articles on cement and concrete is the *Journal of the American Concrete Institute*. The *JACI* started including French, German, and Spanish abstracts in 1963.

Patents. The *Official Gazette* of the U. S. Patent Office, in the back of each weekly issue, lists the new patent numbers in a table "Classification of Patents." The pertinent classes, as shown in the bibliography are from the U. S. Patent Offices "Manual of Classification."

U. S. and foreign chemical patents from 23 countries are listed or abstracted in *Chemical Abstracts*. A front page in each issue of *CA* details prices and sources for obtaining U. S. and foreign patents. Also the Library of the U. S. Patent Office usually is able to furnish photocopies of foreign patents.

The Patent Concordance for all national patents appears in the back pages of each *CA* issue starting in 1963. Thus, checking a patent number in the Belgium column may reveal that the same patent has also been issued as a British and French patent, and the *CA* reference to the original abstract will be in the adjacent column. This is an extremely useful service.

Some journals have a section in the back of the magazine which prints one claim from selected patents. Examples—*Revue des Materiaux—Ciments & Betons* under Brevets abstracts French patents. *Zement-Kalk-Gips* in the monthly Patentschau section prints mainly German and Austrian patent information listed under cement, lime, gypsum, or general.

The foreign language patent journals for many countries may be followed, but a London firm provides a useful translation service. Derwent Publications, Ltd., produces a separate *Patent Report* for British, Belgian, German, and Japanese patents and the *Soviet Inventions Illustrated.* The *Patent Report* groupings, Class F: building, mining, mechanical handling, and Class 6: general inorganic, appear to include gypsum processing, cement clinker production, reinforced concrete, etc.

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Statistics. "Minerals Yearbook" contains detailed statistics on nonmetallic minerals: production, mine and products-plant development, consumption and use, stocks, prices, foreign trade, prefabricated products, and world review by country. The Bureau of Mines also produces "Mineral Facts and Problems."

The Canadian Dominion Bureau of Statistics publishes monthly data on gypsum products, annual data on lime manufacturers, and both monthly and annual data on cement.

Price Information. *Engineering News-Record,* in each weekly issue, publishes a different portion of a tabular "Monthly Market Quotations by ENR Field Reporters." Three pertinent weekly quotations are: (1) Cement, aggregate, ready mixed concrete; (2) Building board and lath and insulations; (3) Clay products, lime, plaster, paint, roofing. This current price information for commodities in the building industry is gathered for over twenty major U. S. and Canadian cities.

Portland Cement

Cement Manufacture. Portland cement is a manufactured product made from a calcareous and an argillaceous material. A source of lime, as limestone, marl, or oyster shells is combined with a source of silica, alumina, and iron oxide, as clay, shale, or blast furnace slag. According to the "Minerals Yearbook" (Vol. I) "Approximately 71 percent of the domestic output of portland cement in 1961 was made from limestone and clay or shale. Argillaceous limestone (cement rock) or a mixture of cement rock and limestone was used for 22 percent of the portland cement produced. Three plants used marl instead of limestone and nine plants used shells."

Clausen's chapter in "Industrial Minerals and Rocks" (2nd edition) offers a complete summary and description of the wet and dry manufacturing process and cement manufacturing equipment.

Minerals Processing features new developments in cement automation progress. Much of this material on automation in cement plants appears as separate articles, and no compilation has yet appeared. Articles, as by Lyons (*18*), are occasionally scattered throughout instrument and engineering journals.

The 1962 "Minerals Yearbook" discusses, in its cement chapter under Technology, developments in kiln feed, slurries, calcination, vertical kilns, clinker grinding, dust control, additives, high-alumina cements, special concretes.

For the chemist or engineer in the cement plant Labahn and Craddock offer practical working instructions. Martin's book and the translation of Jaspers' articles (*12*) provide essential thermodynamic data on the burning process. For the cement chemist, analytical methods for the control lab have been described by Seidel in his handbook. ASTM provides standard test procedures. Insley and Frechette elaborate on the microscopic and laboratory techniques used in the examination of cements and concretes. The first thorough exploration of the CaO-SiO_2-Al_2O_3 system was done by Rankin and Wright of the Carnegie Foundation Geophysical Laboratory and published in 1915 (*23*).

Copeland and Kantro's chapter in Taylor's "The Chemistry of Cements" explains the chemistry of hydration of portland cement at ordinary temperatures. Brunauer's chapter in Goldman's "Science of Engineering Materials" provides an excellent summary of the fundamental aspects of the physics and chemistry of cement, and a good bibliography.

Power and Brownyard's classic, "Studies of the Physical Properties of Hardened Portland Cement Paste," (*22*) summarizes the role of water in portland cement, the density of the solid cement, and the porosity of the paste. A more recent summary appears in Taylor (*supra*).

Portland Cement Types. ASTM Standard C 150-63 describes five basic types of portland cement. Air-entraining portland cements are covered by ASTM Standard C 175-63. A discussion of the value of air-entrainment to the durability of concrete under severe conditions of freezing and thawing is given by Klieger (*14*).

ASTM also issues standards for portland blast-furnace cement, ASTM C 205-63T, portland-pozzolan cement, ASTM C 340-63T, and masonry cements. Malquori, at the Fourth International Symposium on the Chemistry of Cement, outlined research on pozzolans.

White portland cements have been investigated by Malhotra of the Canadian Department of Mines.

Oil-well cements and cement additives are covered in specifications by the American Petroleum Institute and by Hansen in the "Proceedings of the Third International Symposium on the Chemistry of Cement."

Most of the expansive cements which have been reported depend upon the formation of hydrated calcium sulfoaluminates. See Klein and Troxell (*13*), Monfore (*20*), and Halstead's chapter in Taylor's "Chemistry of Cements" (Vol. 2).

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch008

The ASTM also issues specifications for other cements, including natural cement, slag cement, and the magnesium oxychloride and magnesium oxysulfate cements.

Keil in the "Proceedings of the Third International Symposium on the Chemistry of Cement" and Czernin in his "Cement Chemistry and Physics for Civil Engineers" describe slag cements.

Taylor's second volume on non-portland cements contains chapters on aluminous cement and refractory castables, slag cements, pozzolans, expanding and stressing cements, and hydrated calcium silicate products. Each chapter has a bibliography.

Fink describes magnesium oxide and oxychloride cements and their properties in Vol. 3 of Kirk-Othmer's Encyclopedia.

Miner and Ashton discuss calcium aluminate cement (also called aluminous cements and high alumina cement) in Vol. 3 of Kirk-Othmer's Encyclopedia. Robson's book details the manufacture of aluminate cements from limestone and bauxite.

Bessey in a chapter in Taylor's book describes hydrated calcium silicate products, as sandlime bricks, foamed materials, and high strength autoclaved products.

Books. Two books that are considered indispensable to a cement reference collection are the review volume of Bogue and the Lea and Desch treatise. The Taylor volumes, the International Symposiums on the Chemistry of Cement, and the annual cement chapters that have been written by Kennedy and Moore in "Minerals Yearbook" might also be considered indispensable. Other books include Czernin's book for engineers, which is a concise summary of the chemistry of hydraulic limes, and portland, slag, pozzolanic, and aluminous cements. Kühl's three-volume set is a standard German language text. The books of Papadakis and Venuat on manufacture and use of cement and by Dreyfus are French texts. Meade, Witt, Barta, and Blanks and Kennedy are additional useful books. There are many older books on cement manufacture both in English and foreign languages, but these are now mainly of historical interest, and may actually be misleading.

Bibliographies. Wecke's "Handbuch der Zementliteratur" abstracts the cement literature up to the middle of 1925. Slate's bibliography picks up the literature from 1925 to 1947 listing the cement references under subject headings. Ruhl reviewed the 1945-1960 cement and concrete literature covering experimental methods, properties, portland and special cements. The OTS Selective Bibliography SB-502 "Concrete and Cements" is a very miscellaneous list of government research reports and translations for the period 1940 to July 1962. Gonnerman in his bibliography on autoclaving concrete products, Part III, annotates the publications on cement reactions taking place at high temperatures. The Bureau of Reclamation compiled a bibliography on special cements for dams.

Abstracts. The previously mentioned general abstract services, as *Building Science Abstracts*, *Ceramic Abstracts* and especially *Chemical Abstracts*, give excellent coverage of cement literature. The French *Documentation Bibliographique* concentrates on cement and concrete abstracts. *Beton Litteratur Referater* abstracts the cement literature of and for the Scandinavian countries. The *Journal of the American Concrete Institute* includes Current Reviews with cement and concrete abstracts.

Symposiums and Yearbooks. All the international symposia on the chemistry of cement have contained important summary papers. The "Fourth International Symposium" included sessions on the chemistry of clinker, the hydration of cement compounds, the hydration of portland cement, properties of cement paste and concrete, destructive processes in concrete, chemical additions and admixtures, and special cements. The principal papers are by leading scientists in each speciality. The papers included the authors' recent research work and a review of the developments since the last symposium. Each principal paper offers a comprehensive bibliography of related articles. The yearbooks of foreign cement societies contain significant papers as Deutscher Beton-Verein—Vorträge Betontag," Verein Deutscher Zementwerke—"Zement Taschenbuch," Verein Schweizerischer Zement-, Kalk- und Gips-Fabrikanten—"Jahresbericht" and the Japan Cement Engineering Association's Proceedings.

"Reports of Symposium on the Chemistry of Cements," 1956, edited by Budnikov, and sponsored by the Russian Scientific Research Society of the Structural Materials Industry, have been translated. Photocopies of 31 papers may be purchased from the Special Libraries Association Translation Center, John Crerar Library, Chicago.

The 1961 Russian "Conference on the Chemistry of Technology of Cement" was sponsored by the All State D. I. Mendeleev Chemical Society. These papers have been abstracted in *Chemical Abstracts* in Section 22 of May 13 and 27, and June 10, 1963. *Building Science Abstracts*, May 1963, also abstracts these important papers and gives this summary: "The papers presented deal with methods designed to improve the quality, yield, and production cycles in cement manufacture. Raw materials, hydration, testing, firing, and behavior of cements under various circumstances are given special attention. The properties and preparation of special types of cement (pozzolanic, borehole, slag, etc.) are included."

Periodicals. *Rock Products* "Annual Cement Issue," which is usually the May issue, reviews the trends and technology in the rapidly changing industry. The May 1964 issue covered white cement production, specific plant expansion, cement imports, x-ray analysis for sounder quality control.

Pit & Quarry, January issue, is a Review and Forecast Section. The January 1964 issue contained "Cement: Production and Shipments." *Pit & Quarry's* July issue is called the "Annual Cement Mill Issue.".

Cement and Lime Manufacture includes brief articles and worldwide news about cement plant developments.

An exhaustive bibliography of single papers on the chemistry of cement would be needed to give credit to the many distinguished scientists who have worked or are working in cement chemistry. Many important scientists not

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch008

mentioned individually are cited in bibliographies which are part of the references in this paper.

The British *Magazine of Concrete Research* and the *Journal of the PCA Laboratories* are important scientific research publications of trade associations.

Directories. The "American Cement Directory" is a source of useful information about the location of cement plants in U.S., Canada, and South America. Cembureau of Paris publishes a world directory of cement plants, giving locations, types of kilns and capacity, wet or dry process, production of clinker and cement, types of cement, brand names, number of employees, and helpful maps.

Cement Standards. Besides the ASTM Specifications, which have been mentioned, there are U.S. Federal Specifications. USA Standards Institute has adopted some of the ASTM methods of tests for cements. The USASI is represented when the Committee of Cement Standards of the International Standards Association (ISA) meets with European cement producers. Cembureau in Paris issues a world set of standards by country for both portland cements and other cements.

Cement Uses—Concrete. The volume of literature about plain, reinforced, precast, and prestressed concrete is enormous and only a few examples will be mentioned and listed in the bibliography. The article on concrete in the 1963 "Encyclopedia Britannica" (5) offers general information about plain concrete, structural concrete, and concrete products. The "Cement and Concrete Reference Book" is also a source of general information about the uses of portland cement and concrete.

"Design and Control of Concrete Mixtures" summarizes fundamental facts about concrete, materials for concrete, design of concrete mixtures, mixing concrete, placing concrete, joints, curing and protection, and finishing concrete.

The "American Concrete Institute 55-year Index, 1905-1959" for the *Journal,* along with their new Monograph and Bibliography series are indispensable in using the enormous collection of engineering data published by ACI during 60 years.

There are many excellent books on concrete. Troxell and Davis have written about plain concrete as a material. Sutherland and Reese's book and Ferguson's book are standard texts on reinforced concrete. The new edition of Urquhart's book is a fundamental design text, and Lin has written a new edition on prestressed concrete design. LaLonde and Janes' handbook covers many concrete construction details. Chapters on the design and construction of concrete pavements are included in Wood's highway handbook.

Lime

History and Literature. Spackman gives a good summary of ancient lime literature. Perhaps a dozen books written in the 18th, 19th and early 20th century on the production of lime are now of value principally for their histori-

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cal background. Eckel is an excellent source of information for the period up to 1922.

Bowles quotes the lime literature and gives a general picture of the industry. Nathan Rockwood, in the 2nd edition of "Industrial Minerals and Rocks," mentions the impossibility of giving an adequate bibliography on lime because it enters into so many specialized fields, such as the iron and steel industry. He suggests the need to search the literature of that field as well as the lime literature for a complete bibliography. C. Meade Patterson's chapter for many years in "Minerals Yearbook" is packed with authoritative information and statistics.

The ASTM "Symposium on Lime" in 1940 includes a dozen papers on the use of lime in the glass industry, for water treatment, and in agriculture, and papers on the properties of lime putties and lime characteristics.

The ACS Symposium on Lime in 1927 with Withrow as chairman (*27*) generated 23 papers.

In 1964 the British Chalk Lime and Allied Industries combined with the Whiting and Industrial Powders Research Council (WIPRC). The former comprehensive abstract card service offered CLAIRA members and subscribers is now issued by the Welwyn Hall Research Association as the Welwyn Hall abstracts. The new abstract classes include: lime manufacture; industrial and agricultural uses of lime; calcium silicate products; ready-mixed mortar manufacture; building technology; powder technology; etc. Patent coverage is included.

The National Lime Association's publications include a bulletin by Riehl on water supply and treatment which is used as a text by sanitary engineering classes.

Chemical Abstracts and *Ceramic Abstracts* are secondary sources of information on lime appearing in foreign and obscure journals. *Rock Products* and *Pit & Quarry* feature lime plants and production and along with *Minerals Processing* provide the best source of U. S. information about new types of kilns and equipment. In the foreign literature *Gypsum & Lime* (Japan), *Cement and Lime* and *Cement, Lime and Gravel* (England), *Zement-Kalk-Gips* (Germany), *Cement-Wapno-Gips* (Poland) are consistently useful journals.

Manufacture. Emley of the National Bureau of Standards in his bulletin and Boynton and Jander of the National Lime Association in Kirk-Othmer's Encyclopedia discuss lime manufacture in detail, as do Boynton and Gutschick in "Industrial Minerals and Rocks."

Azbe published a book (*2*) consisting of 166 articles from trade journals written between 1923 and 1946. At the ASTM Symposium on Lime in 1939 in his article on the fundamentals of calcination and hydration of lime, Azbe gave a hypothetical description of how CO_2 escapes the limestone crystal leaving a passageway in the porous lime structure for the entry of water for hydration. More than twenty years later Rune Hedin of Stockholm received the Azbe Lime Award for a paper (*10*) which clearly shows research on lime burning continues.

The fluidization principle has been used to calcine finely ground limestone suspended in gas, and currently fluidization is a dominant trend in the European lime industry (*11*).

Masonry Mortars and Masonry Cements. A National Lime Association's Bulletin, "Masonry Mortar," offers information on masonry mortars. Masonry mortar types M, S, N, O, and K are defined by ASTM Specification C-270-61T as containing varying proportions of aggregate, portland cement, masonry cement, and lime.

The National Bureau of Standards has conducted extensive research on masonry mortars and cements. Wells, Bishop, and Watstein (*25*) report on differences in limes and their effects in masonry mortars. Blaine (*3*) investigated commercial masonry cements over a ten-year period. Mortars for stone masonry were studied by Kessler and Anderson in their report. Levin, Clarke, and Wells (*17*) reported on the plasticity and water retentivity of hydrated limes. Fishburn (*7*) compared the physical properties of mortars, the bond strength of the mortars to masonry units, and the structural strength of concrete masonry and composite masonry walls containing the mortars.

The ASTM "Symposium on Masonry Testing" included papers on the effect of aggregate grading on properties of masonry mortar and factors affecting bond of mortar to brick.

The Building Research Institute held a 1963 Fall Conference on Problems and Practices in the Use of Masonry Mortars with papers on specifying mortars, field experience with an organic modified mortar, bond strength and other properties of cement mortars (*21*).

Gypsum

History and Literature References. Wilder (*26*) has briefly traced the history of gypsum, and Hammond's Historical Review in Kirk-Othmer's Encyclopedia also refers to Le Chatelier's work on the identification of plaster of Paris as the hemihydrate.

Most notable among geographical and geological studies is Wilder's classic "Iowa Geological Survey Report." Cole and Collings describe Canadian gypsum deposits in their bulletins. Newland has reported on the gypsum industry in New York state and Ver Planck on gypsum in California. Current data on deposits are annually given in Vol. III, "Minerals Yearbook."

The selected bibliography prepared by the Department of the Interior for the Committee on Interior and Insular Affairs of Congress in 1952 emphasizes sources of gypsum and its use as a building material.

Rock Products and *Pit & Quarry* regularly publish descriptive articles about new plant developments. Several foreign national gypsum associations publish reports of scientific, technological, and commercial developments. *Zement-Kalk-Gips* cosponsored by the Deutscher Gipsverein reports progress in manufacture and research. The Japanese *Sekko to Sekkai* (Gypsum & Lime), the Polish *Cement-Wapno-Gips,* and the "Jahresbericht" of the Verein Schweizerischer

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch008

Zement-, Kalk- und Gips-Fabrikanten publish valuable information about gypsum.

Collings in his bulletin outlines the mining, milling, and processing of gypsum and presents a typical flow sheet from quarry to finished product. Moyer also offers processing details. Havard in the 3rd edition of "Industrial Minerals and Rocks" describes the manufacture of gypsum board. Production statistics, and new mine and plant developments are reviewed annually in "Minerals Yearbook." Lerch (*16*) discusses the function of gypsum in regulating the reactions of hydration and hardening of portland cement. Steinour's bulletin reviews the literature on the role of gypsum in the setting of portland cement. Goudge described the use of gypsum and anydrite as industrial raw materials at the Conference on Industrial Minerals in Nova Scotia, and Edwards (*6*) discussed the use of processed anhydrite in the cement, paint, and rubber industries. Excellent trade literature on gypsum products is available from the manufacturers.

Building Plasters and Stucco. The Gypsum Association's 1964 "Manual of Gypsum Lathing and Plastering" gives general background material on gypsum and plasters. The National Bureau for Lathing and Plastering, Inc., issued a manual written by John Diehl. "Specifications for Lathing, Furring and Plastering" is issued by the Contracting Plasterers' and Lathers' International Association. The well-illustrated "Plasterer's Manual" distributed by the Portland Cement Association describes materials, methods, and the results achievable. The American Concrete Institute published a "Guide to Portland Cement Plastering" (*8*).

A bibliography on "Lath, Plaster and Trim" in the "Building Products Register" of the American Institute of Architects (*15*) gives brief annotations on federal and military specifications, ASA & ASTM specifications, the U. S. Dept. of Commerce's simplified practice recommendations, summaries of association literature, and reference materials.

Among the older publications are the work of Andrews (*1*) on "Gypsum and Anhydrite Plasters" done at the British Building Research Station, and McVay (*19*) on hard finish gypsum plasters done at the University of Illinois. Verrall's book "Solid and Fibrous Plastering" is dated 1941.

More recent research on gypsum plasters has been carried out at the Australian Division of Building Research by Ridge (*24*) and others. W. C. Hansen's 1963 article (*9*) explains theoretical aspects of the setting of gypsum plasters.

The trade journals *Gypsum Drywall Industry Newsmagazine, The California Plasterer* and *Plastering Industries* regularly present brief articles about current practices and new developments.

Sweet's "Architectural Catalog File" in Section 12—Lath, Plaster, Wallboard, and Trim, contains useful manufacturers' catalogs with specific data on plasters.

Gypsum Specifications. ASTM issues specifications for gypsum and for gypsum concrete, plasters, and molding plaster.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch008

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch008

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Patents

	Class: subclass numbers
Gypsum	263:53
	23:122
	106:109, 77
Lime	263:53
	23:186
	106:118
Plaster	106:77
	110:263
	263:53
Portland Cement	106:89, 76, 64, 100
	263:53
Other hydraulic cements	106:85, 64, 106, 100
	263:53
Kilns and Related Manufacturing Equipment	263
Grinding: design	D37, 241

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9

The Literature of Photographic Chemistry

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Since photographic chemistry includes subject areas from many of the specialized branches of organic and inorganic chemistry, the scattering, language, and format are problems for those using the photographic literature. Several good encyclopedias of photography exist, as well as foreign-language dictionaries covering photographic terminology. Textbooks are available, both on photography and its chemistry and on special topics in chemistry important to photography. The general abstract services are useful, but several abstract journals devoted specifically to photography are available. House organs, proceedings of congresses and annuals should not be overlooked in checking the periodical literature. Standards, patents, and government reports are other useful sources.

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The realm of photographic chemistry includes the chemistry of radiation-sensitive systems in general, all agents used to develop or "amplify" the image, the chemistry involved in the production of special photographic papers and film-base materials, the chemistry of gelatin, and much of the very broad field of dye chemistry. Because these broader subject areas embrace an extremely wide variety of chemical specialties, it will be impossible to treat each in detail. Rather, some of the more useful portions of the literature will be discussed, which will, in turn, lead interested investigators into the more specialized areas.

As in every literature of modern chemistry, the language barrier confronts all who investigate the photographic literature. In addition to German, French, and Italian literature, there is a flourishing photographic literature in Japanese. Fortunately, in most instances, there are English abstracts available for Japanese journals of interest. Russian still presents a formidable translation problem, and a knowledge of research results at various USSR institutes is increasingly important. Unfortunately, there are very few translations of the Russian publications that are needed.

Dictionaries and encyclopedias are basic tools, but they contain only general background information designed primarily for the casual questioner.

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Such books are naturally good starting points for newcomers to a particular subject. The only true encyclopedia devoted to photography is the "Encyclopedia of Photography." Its 15 volumes, the first eight of which were issued in 1963, cover all phases of photography, each topic written by an authority in the field. A useful single volume that attempts to be encyclopedic in its coverage is the "Focal Encyclopedia of Photography," either in its original edition of 1956, or in the somewhat abbreviated desk edition of 1960. It includes a survey of many technical topics with references for further consultation. Another useful quick reference similar in scope to the Focal volume is Sowerby's "Dictionary of Photography." First published in 1889, it is now in its 19th edition. The most useful and practical for a dictionary-like definition is the "Military Standardization Handbook: A Glossary of Photographic Terms."

Two outstanding foreign-language dictionaries that cover pertinent photographic terminology are "Dictionary of Photography and Cinematography in German, English, French, and Russian," and Sakharov's "English-Russian Dictionary of Photography and Cinematography," which contains nearly 10,000 terms and has a Russian index.

First among the photographic textbooks is Dr. C. E. K. Mees' "Theory of the Photographic Process," of which a new edition is in process. Detailed chapters were written by authorities from Eastman Kodak Co., and each chapter has an excellent bibliography. The same subjects are covered more briefly in "Fundamentals of Photographic Theory," by James and Higgins. "Photo Chemistry in Black-and-White and Color Photography" by Eaton limits itself to the chemistry of the photographic process and does not have the detailed information on sensitometry, tone reproduction, etc., which makes up a large portion of most photographic texts. Clerc's "Photography, Theory and Practice" is a thorough, comprehensive treatment of all phases of photography. Another translation from the French, Glafkides' "Photographic Chemistry" is very detailed in its two volumes but must be used cautiously as errors have been made in translating. Neblette's "Photography, Its Materials and Processes" is another general coverage of all aspects of photographic science in which experts have presented well-documented material.

Russian texts which might be of interest are Zelikman and Levi's "Fundamentals of the Formation and Deposition of Photographic Emulsions," and Chibisov's monograph, "Fundamental Problems of Chemistry of Photographic Emulsions." This latter was issued originally in Russian but is now available in German as the fifth supplement to the German periodical, *Photographische Korrespondenz.* A Russian book, translated into English, that is the only monograph on electrophotography which has appeared in any language, is Fridkin's "Photoelectrets and the Photographic Process."

In the field of photochemistry, useful volumes are "Chemical Aspects of Light" by Bowen and "Photochemische Versuchstechnik" by Plotnikow. A more recent publication is "Photochemistry in the Liquid and Solid States," based on papers presented at a 1957 symposium.

Dyes play many important roles in photographic systems. A useful compilation for studying dyes is the "Colour Index" and its recently issued

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supplement. For texts, there is Venkataraman's two-volume "Chemistry of Synthetic Dyes" and "Recent Progress in the Chemistry of Natural and Synthetic Colouring Matters," edited by Gore. Two symposia volumes which are useful are the "Perkin Centenary, London" and the "Proceedings of the Symposium on Colour Chemistry, 1960." The latter was published as a part of Vol. 15 of the periodical, *Chimia*. A Russian text which discusses photochemistry in relation to dyes is Terenin's "Photochemistry of Dyes and Related Organic Compounds." The 1947 edition is available in a translation from the Special Libraries Association Translation Center, John Crerar Library, 86 Randolph St. Chicago, Ill. 60601. A new German volume by Meier which has just appeared and should prove valuable is "Die Photochemie der Organischen Farbstoffe."

Another subject of interest to photographic chemists is surface chemistry. Several helpful books are Moilliet's "Surface Activity," Osipow's "Surface Chemistry, Theory and Industrial Applications," and Deryagin's "Research in Surface Forces," translated from the Russian.

For historical background, several sources are available. The classic is Epstean's translation of Eder's "Geschichte der Photographie," covering all aspects up to about 1930. Gernsheim's "The History of Photography" carries the history to the start of the First World War, with excellent documentation and a good index.

Abstracting and indexing services are important tools in gaining access to the literature. *Chemical Abstracts* should be searched in the following sections where articles and patents of chemical interest will be found: Section 5—Photography (before 1962); Section 11—Radiation Chemistry and Photochemistry (1962-1966); Section 74—Radiation Chemistry, Photochemistry, and Photographic Process (1967 on). Others such as *Applied Science and Technology Index* or *British Technology Index* are valuable because new items appear quickly although the coverage of photographic journals is limited. Specialized indexing services are frequently useful. For example, *Polymer Reports* from Japan has lengthy abstracts from Japanese journals and patents. The monthly *Journal of the Society of Dyers and Colourists* from England contains abstracts and has author and subject indexes.

Fortunately, there are several abstract journals devoted specifically to photography. The *Monthly Abstract Bulletin* (1915-1961), published by Eastman Kodak Co., is no longer in existence but is still available in libraries. It covered all aspects of the scientific and technical photographic literature, and the December issue contained an annual author index. In spite of the difficulties caused by the lack of an annual subject index, the *Monthly Abstract Bulletin* is probably the most comprehensive tool available. *ANSCO Abstracts* (1941-1961) was similar in scope and poses a similar searching problem because of the lack of annual subject indexes. Both publications ceased at the end of 1961. *Abstracts of Photographic Science and Engineering Literature* began in 1962 and is attempting to incorporate the scope of the two just mentioned. It provides access to the literature by subject through the use of descriptors, an author index in each issue, and annual subject and author indexes.

The Royal Photographic Society (London) has issued *Photographic Abstracts* since 1921 which are indexed annually both by author and subject.

Access to East European, Russian, and Asiatic literature is provided by *Referativnyi Zhurnal, Fotokinotekhnika,* and, although in Russian, it includes abstracts from very unusual sources.

The important photographic societies throughout the world all issue scientific journals that are important to the photographic scientist. These should be consulted for current developments: *Journal of the Society of Scientific Photography of Japan; Electrophotography,* by the Society of Electrophotography of Japan; *Journal of Photographic Science,* by the Royal Photographic Society; *Journal of the Society of Motion Picture and Television Engineers;* and *Photographic Science and Engineering,* by the Society of Photographic Scientists and Engineers. Others which should not be overlooked, although they are mostly published in foreign languages are: *Fotokemijska Industrija,* which is a section of the Yugoslav periodical, *Kemija u Industrija* (contains abstracts in English or German); *Kep-es-Hangtecknika* from Budapest; *Photographische Korrespondenz; Science et Industries Photographiques* (with an extensive abstract section); *Zeitschrift fuer Wissenschaftliche Photographie;* and *Zhurnal Nauchnoi i Prikladnoi Fotografii i Kinematografii. Perspective,* a British quarterly which continues a less-frequent publication called *Progress in Photography* is valuable for its review articles. The Russian publication, *Uspekhi Nauchnoi Fotografii,* appears irregularly and contains highly informative material such as symposia proceedings.

Several large photographic firms issue periodicals which frequently stress the research activities of the organization. *Abridged Scientific Publications* from Eastman Kodak (now superseded by *Scientific Publications*); *Mitteilungen* from the Development Laboratories of Agfa-Leverkusen; *Veröffentlichungen* from the Agfa-Photo Laboratories in Leipzig; *Ferrania, A Magazine of Photography and Cinematography,* which is more practical than scientific; and *Scientific Publications of the Fuji Photo Film* are some examples.

Proceedings of international congresses can be invaluable for providing state-of-the-art information. Important are "International Congress of Scientific Photography," "Symposia on Photographic Sensitivity," the "International Colloquium of Nuclear Photography," and "International Congress on High Speed Photography."

Annuals abound in the field of photography, but since the majority are devoted to collections of photographs, they are of little more than aesthetic value to the photographic chemist. However, the *British Journal Photographic Annual,* which has appeared regularly for nearly 100 years, carries much information not only on equipment, but also on processing chemistry.

Various photographic trade magazines, either for the amateur or the professional, occasionally carry discussions of a new process or valuable review articles. The *British Journal of Photography, Industrial Photography,* and *Photo-Technik und-Wirtschaft* are examples of publications of this type.

Some peripheral periodicals which are considered valuable are: *Journal of the Society of Dyers and Colourists; Photochemistry and Photobiology,* new in 1962, which covers pertinent fundamental research on photochemistry; *Journal of Polymer Science; Journal of Applied Polymer Science;* and *Polymer Science*

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USSR which covers the fundamental chemistry in the field of polymers. Frequently the coverage of physical aspects, dye chemistry, etc., is good in *Collection of Czechoslovak Chemical Communications, Ukrainskii Khimicheskii Zhurnal,* and *Doklady* from the Academy of Science of the USSR. Pertinent papers frequently are found in *Journal of the Chemical Society of Japan,* both in the Pure Chemistry section and in the Industrial Chemistry section. Excellent English abstracts indicate whether or not to obtain a translation. Various journals from the American Chemical Society and from the American Institute of Physics are of interest.

Standards are important for the photographic industry, not solely for equipment but also because of specifications for chemicals. American Standards Association (ASA) lists standards in the annual catalog in the section appropriately designated "PH" and in a separate index which is more detailed than the annual catalog. New proposals and standards can be followed through the monthly *Magazine of Standards.* Here also is reference to foreign photographic standards. Standards from Russia, identified as GOST in the Russian literature, can be obtained and are abstracted in certain Referativnyi, but in Russian. Occasionally a photographic International Standards Organization (ISO) recommendation appears. It is frequently identical with its equivalent ASA standard but should not be ignored.

Patents are abstracted in *Chemical Abstracts, Abstracts of Photographic Science and Engineering Literature,* and *Photographic Abstracts.* Coverage is not limited to U. S. or British patents and there will be some repetition. A specialized service, *Uniterm Index to Chemical Patents,* permits searching the U. S. patent literature. Patents of interest to photographic chemists should be covered, although the Uniterms require some ingenuity to use successfully.

There are several services which make it fairly easy to follow patents issued in foreign countries, particularly England, Belgium, France, and Germany. Derwent Information Service in England publishes several. *Fine Chemicals Patents Journal* has abstracts of British, German, French, South African, and Indian patents in weekly issues. A more specialized semimonthly publication covering patents for the same countries is the *Graphic Arts Patents Bulletin.* Soviet patents can be followed in *Derwent Russian Patents Report,* which includes Class 57-Photography. The same abstract service is provided in the *Derwent Japanese Patents Report,* which includes Class 103-Photography and Cinematography. This same patent class is included in the Interpas publication, *Japan Patent News, Edition VI,* but without the abstract which is, however, available in English for a fee. Belgian patents, because of speedy publication, have valuable information. Such chemical patents appear four weeks after issue in the biweekly *Derwent Belgian Patents Report.*

The disadvantage of these services covering foreign patents lies in the difficulties encountered in retrospective searching. No cumulative index by subject, company, or inventor is supplied, and therefore the publications must be scanned issue by issue. Again *Chemical Abstracts* provides the best source for preliminary searching.

A final class of material, which frequently contains invaluable data not published in any other form, is the technical report on research sponsored by

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the U. S. Government. Much government-sponsored photographic research is being conducted, and access to this class of material can be gained through *U. S. Government Research and Development Reports*, *Nuclear Science Abstracts*, and *Scientific and Technical Aerospace Reports*. These publications are the most useful, both for current awareness and for searching. Occasionally the material located will be hard to obtain since much of the information generated in the photographic industry is proprietary. However, the Defense Documentation Center can often supply copies of such reports. (Defense Documentation Center, Cameron Station, 5010 Duke St., Alexandria, Va.)

Trying to follow current developments in photographic chemistry is one of the most challenging and often frustrating assignments in the use of the literature. There is no single indexing service that covers the broad range of subject matter of interest to the photographic scientist. The Eastman Kodak Co. has established one of the largest photographic collections in the world and the remarks made here about the literature of photographic chemistry have been based on this collection and its use. Similar collections, with the scope and diversity required for photographic scientists, can be found only in the possession of the larger photographic manufacturers. However, other large collections can often be found in large public libraries, the George Eastman House Library in Rochester, and the American Museum of Photography in Philadelphia.

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Patents

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Class 96: Photographic Chemistry, Processes, and Materials

Subclass:

1.6	Dye sensitizer for electric photography
1.8	Zinc oxide for electric photography
2-26	Natural color techniques
28-47	Processes including exposure or use of image record
48-66.5	Developing and ancillary operations and compositions thereof
67-87	Light-sensitive elements
88-115	Light-sensitive compositions

RECEIVED September 9, 1963. Presented on the symposium, "Searching the Literature of a Number of Specialized Fields," sponsored by the Division of Chemical Literature at the 145th Meeting of the American Chemical Society at New York, N. Y., Sept. 9-13, 1963. Updated 1968.

10

The Literature of Pharmaceutical and Medicinal Chemistry

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Medicinal chemistry has benefited from many applications of computers to information problems during the past decade. New services offered by Chemical Abstracts Service include Chemical Titles, Chemical-Biological Activities, *and* CA *on microfilm. Through MEDLARS, the National Library of Medicine offers* Index Medicus, *"Medical Subject Headings," and* Bibliography of Medical Reviews. *Institute for Scientific Information introduced* Index Chemicus, Science Citation Index, *and Automated Subject Citation Alert. Science Information Exchange is custodian of a national registry of research in progress. Thesauri, chemical typewriters, and drug information services appeared during the decade. A national catalog of chemical patents was published, and the U.S. Patent Office applied mechanical searching to several classes of organic compounds. A list of periodicals and a classified list of books is included.*

The expansion of literature and information services of the past decade has been particularly apparent in medical fields. Medicinal chemistry has benefited from the many developments in chemical information services. Probably the single most striking development of the decade has been the application of computers to information problems.

Computer-based Services

Chemical Abstracts Service made its first move toward a computer-based operation when it started *Chemical Titles* (*CT*) in 1961. This is a biweekly computer-produced index to 725 journals. It features a keyword-in-context (KWIK) index of permuted titles, a technique developed by IBM. *BASIC* is a similar publication by *Biological Abstracts.*

Chemical-Biological Activities (*CBAC*), another CAS product, is a biweekly, current literature KWIK index to the biological activity of organic

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

compounds. Its digest section summarizes the message of each paper and lists the compounds it reports, each with its compound registry number for identification in the CAS computer system. Structural formulas may also be given.

Chemical Abstracts (*CA*) is now available on microfilm from volume 1 to date, together with an automated reader. Chemical Abstracts Service is in transition from a strictly abstracting-indexing-publication operation to a comprehensive computer-based information service. By 1970 this will provide the data base for producing *CA*, indexes, and searching services—all by computer (*1*, *8*). *CT* and *CBAC* are already available in tape editions.

During the past decade the Armed Forces Medical Library became the National Library of Medicine and occupied a new building on the grounds of the National Institutes of Health, Bethesda, Md. Its holdings exceed 1.2 million pieces, including books, journals, theses, pamphlets, prints, and microfilms. The library is open to the public, and remote access is through interlibrary loan; NLM will provide other libraries with photocopies of journal articles at no charge.

NLM provides a number of services through its Medical Literature Analysis and Retrieval System (MEDLARS), which is a computer-based system for producing *Index Medicus*, a monthly index to articles from periodicals and monographs. *IM* is an alerting and awareness tool, just as is *CT;* neither carry abstracts.

By-products of MEDLARS include annual printings of "Medical Subject Headings" (MESH), which is the basis of classification in *IM*, the annual "List of Journals Indexed," and the monthly *Bibliography of Medical Reviews*. This latter was published as annual compilations in *IM* from 1955 through 1966; Volume 6 (1961) was a separately published cumulation of review listings covering the period 1955-60 (*7*), and in 1967 the listings were published in *Cumulated Index Medicus*. *BMR* was resumed as a monthly publication in 1968. *CIM* is an annual produced from *IM* tapes; it was published originally by the American Medical Association, now by the Superintendent of Documents, Government Printing Office.

MEDLARS will also produce special bibliographies on request, subject to limitations on scope and available time. Some of these are made available for general distribution; they are announced in *Journal of the American Medical Association*.

The Institute for Scientific Information, Philadelphia, has developed a number of services, starting with *Current Contents* in the early 1950's and which now has an edition in the chemical, pharmaco-medical, and life sciences and another in the space, electronic, and physical sciences. *Index Chemicus* is a computer-based, weekly publication of ISI reporting new chemical compounds. An associated service is the Index Chemicus Registry System, which provides a comprehensive file of all compounds covered in *IC*, encoded in Wiswesser Line Notation.

A bibliographic tool of special utility in tracing the popularity of a given article is *Science Citation Index*, published by ISI. It lists where and by whom a specific paper has been cited since publication. *SCI* is published quarterly and cumulated annually; cumulations are available for 1961 and annually since

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1964. Added to *SCI* in 1966 was the Permuterm Subject Index, listing permuted pairs of terms from article titles.

ISI also has a selective dissemination of information service that it calls ASCA (Automated Subject Citation Alert); it is based on interest profiles that are matched weekly against current journal items.

Science Information Exchange (SIE) is a national registry of research in progress that is supported by the National Science Foundation and operated by the Smithsonian Institution, Washington, D.C. SIE registers research proposals and projects, stores information on tape, and answers inquiries on who is working on what projects, when, and where; this inquiry service is available at no charge to granting agencies and to recognized research institutions and their investigators. The bulk of the information is in the medical and life sciences because SIE was oriented in this direction when it was founded in 1949 as the Medical Sciences Information Exchange; the physical sciences division was started in 1962 and is growing rapidly, however. Most of the projects listed are being performed by or supported by agencies of the Federal Government, but a substantial amount of data on private research projects is included.

Impact of Computers

The advent of computers in information handling has forced a certain standardization of terms. The Engineers Joint Council mounted a large program to develop roles in indexing and their inclusion as key-word index terms with scientific papers as they are published. This effort, spearheaded by the Du Pont Co., was implemented by the American Institute of Chemical Engineers, whose "Chemical Engineering Thesaurus" was published in 1961. The broader EJC "Thesaurus of Engineering and Scientific Terms" (*3*), published in 1967, is a joint product of EJC and the Department of Defense Project LEX.

Thesauri and other indexing techniques are described in "Automatic Indexing: A State-of-the-Art Report" (*6*), by Mary Elizabeth Stevens of the Research Information Center and Advisory Service on Information Processing, which is jointly sponsored by the National Bureau of Standards and the National Science Foundation.

Computers have opened the possibility of storing and retrieving graphic representations of chemical structure by various techniques. The "chemical typewriter" invented at American Cyanamid's Stamford Research Laboratories and developed under Army sponsorship, is in use as an input/output device for this purpose. Among more sophisticated hardware being investigated at CAS are the light-pen and character recognition devices.

Chemical notations are being used in a growing number of installations for storing, manipulating, and retrieving structure information by techniques and programming adapted for both manual use and computer processing.

Several services are available that are directed specifically toward drug information. Beginning about 1960 a group of pharmaceutical companies began a voluntary cooperative exchange of information gleaned from the literature during their regular operations. The information included the chemical structure, activity reported, company code numbers, generic names, trademarks, molecular formula, and so on. As a direct outgrowth of this effort, Paul de Haen of New York offered a service called "Drugs in Prospect" beginning in 1963, which provides chemical and pharmacological data on file cards from the first published reports on new compounds. Three related services have since been added, "Drugs in Research," "Drugs in Use," and "Drugs in Combination."

"Ringdoc," by Derwent, London, England, represents another commercial outgrowth of a voluntary, cooperative program begun by a number of European and one U. S. pharmaceutical firms. It began operation in 1964 and represents a service which supplies abstracts of articles appearing in approximately 300 journals. About 40,000 abstracts are published annually. Also provided are indexes of two types, one in the form of direct coded punched cards and the other a manual searching capability based on key words under which bibliographic references are listed.

Chemotherapy Research Bulletin is a monthly magazine by Chemotherapy Research Institute, Philadelphia, that prints perforated index cards on new products, three to a page; the entire contents of the magazine convert to a card file.

One of the results of the thalidomide episode was an intensified interest in adverse reactions; this led to the introduction of information services specifically directed to this aspect of the literature of drugs. Among these services are:

FDA Clinical Experience Abstracts, published by the Food & Drug Administration, beginning in 1963 (originally under a different title).

Adverse Reaction Titles, published by the Excerpta Medica Foundation beginning in 1966.

Patent Literature

U. S. patents on medicines are in Class 167, but patents on products with medicinal uses may be found under Class 252, Compositions, and Class 260, Chemistry, Carbon Compounds.

"The National Catalog of Patents—Chemical," by Rowman and Littlefield, New York, lists all U. S. patents issued in 1961 and 1962 by major drawing and major claim, reprinted from the *Official Gazette of the U. S. Patent Office.* These group the patents by class and subclass from Classes 8 through 266 and are in five volumes; indexes include cross references to related patents, manual of classification for chemical classes, and subjects.

Patents from 1790 through 1960 are listed by number only in "The International Index of Patents—Chemical and Allied Arts—U. S.," a companion set by the Interdex Corp., subsidiary of Rowman and Littlefield. These are also grouped by class and subclass and include under each the numbers of patents cross referenced from other classes.

Patent information services are available from several firms. Information for Industry, Inc., Washington, D.C., offers its Uniterm Indexes to U. S. chemical patents since 1950 in book form, microfilm, and magnetic tape and provides patent searches on a service basis. Its indexes are very deep, not limited to titles, and are intended to be used for coordinate searching.

Derwent also offers "Farmdoc," a service on pharmaceutical patents from a number of countries in the form of punched cards and magnetic tape.

The U. S. Patent Office itself has been active in the study of mechanical aids to its search problems. Out of its efforts have come direct coded punched card indexes to steroids, phosphorus compounds, and certain organometallics. These indexes are available to the public on a subscription basis at nominal cost.

Books

The literature of pharmaceutical and medicinal chemistry was reviewed quite thoroughly in two symposia sponsored by the ACS Divisions of Chemical Literature and Medicinal Chemistry in 1953-1954. The 25 papers from these symposia were published as "A Key to Pharmaceutical and Medicinal Chemical Literature," ADVANCES IN CHEMISTRY SERIES No. 16 (1956). The chapter on market and economic information from this book has been updated and published recently (5). Many of the other papers from the book are still valid for specialized aspects of the subject and for the earlier literature.

A broad survey of drug literature was prepared by Winifred Sewell of the National Library of Medicine in 1963. This report, published as a Senate Committee Print by the Government Printing Office (*4*), carries several bibliographic appendices, one of which, "Selected List of Monographs in Pharmacy," is the basis for the book list presented here. The list in "Drug Literature" was compiled by Martha Jane Kay Zachart and C. Larry Thomasson, both then at Mercer University, Atlanta, and published in *American Journal of Pharmaceutical Education,* summer 1963, as "Bibliography of Books and Reference Works Relating to the Professional Courses in the Pharmaceutical Curriculum." This list, only part of which was printed in "Drug Literature," was supplemented to 1963-1964 by Elizabeth Jackson of Mercer University.

The list starting on page 157 does not include all of the topics from the source lists because some classes are too far removed from the primary emphasis of this article. Omitted were introduction to pharmacy, pharmacy principles and techniques, hospital pharmacy, manufacturing pharmacy, cosmetics, and dermatologic pharmacy. Only a few titles were selected on veterinary pharmacy, and pharmacognosy is almost entirely omitted except for books on chemical classes of active constituents and on plant chemistry. Also omitted are titles on plant physiology, plant taxonomy, anatomy, histology, and morphology of plants, pesticides, herbicides, and plant diseases.

To this basic list have been added a number of titles from the Searle library and recent titles through 1966 from publishers lists. The final list has been rearranged under fewer headings, and most of the out-of-print titles and those prior to 1955 have been omitted.

Periodicals

Two appendices in "Drug Literature" are devoted to periodicals. One is a world list of pharmacy periodicals; it lists 911 journals and is reprinted from the *American Journal of Hospital Pharmacy.* The other is a combined list of 717 journal titles of pharmaceutical interest assembled from three sources.

The list of periodicals that starts on page 184 is a composite of only those journals on which all three of the following services agree, as of mid-1968: *Current Contents,* Life Sciences (887 titles), CBAC (591 titles), and de Haen

(403 titles). With only 217 titles, this is a list of periodicals basic to this field. For more specialized and additional foreign titles, refer to these source lists and to those in "Drug Literature."

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Journal of Clinical Endocrinology and Metabolism, Official Journal of the Endocrine Society, Thomas, monthly.

Journal of Clinical Investigation, 333 Cedar St., New Haven, Conn. 06511, monthly.

Journal of Clinical Pathology, British Medical Association, bimonthly.

Journal of Clinical Pharmacology and Journal of New Drugs, Fort Orange Press, 883 Broadway, Albany, N. Y., bimonthly.

Journal of Comparative Pathology and Therapeutics, University Press of Liverpool, 123 Grove St., Liverpool 7, England, quarterly.

Journal of Endocrinology, Official Journal of the Society for Endocrinology, Cambridge, normally quarterly.

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Journal of Infectious Diseases, University of Chicago Press, bimonthly.

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Journal of Laboratory and Clinical Medicine, Official Publication of the Central Society for Clinical Research, Mosby, monthly.

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Journal of Tropical Medicine and Hygiene, Staples Press, Ltd., 3 Mandeville Place, London, England, monthly.

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Pharmacologist, American Society for Pharmacology & Experimental Therapeutics, Inc., 9650 Rockville Pike, Bethesda, Md. 20014, semiannually.
Pharmazie, Zeitschrift fuer Wissenschaftiliche und Practische, Berufliche und Wirtschaftliche Fragen der Pharmazie und Pharmakologie sowie Angreuzende Probleme in der Lebensmittelchemie und Ernaehrungsphysiologie Einschliesslich Arzneipflanzen-Um-Arzneibuch-Kommission, VEB Verlag Volk und Gesundheit, Neue Gruenstr. 18, Berlin C2, Germany, monthly.
Practitioner, 5 Bentinck St., London W1, England, monthly.
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Proceedings of the National Academy of Sciences of the United States of America, 2101 Constitution Ave., Washington, D.C. 20418, monthly.
Proceedings of the Royal Society; Series B: Biological Sciences, Royal Society, Burlington House, Piccadilly, London W1, England, quarterly.
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Proceedings of the Society for Experimental Biology and Medicine, 104 S. Liberty St., Utica, N. Y. 13500, monthly.
Psychopharmacologia, Springer, Berlin, irregular (about monthly).
Radiation Research, Academic, monthly.
Recueil des Travaux Chimiques des Pays-Bas, Nederlandee Chemische Vereniging, Bureau, Lange Voorhoul 5, The Hague, Netherlands, monthly.
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Scandinavian Journal of Clinical & Laboratory Investigations, edited for the Scandinavian Society for Clinical Chemistry and Clinical Physiology, Munksgaard, quarterly.
Schweizerische Medizinische Wochenschrift, Journal Swisse de Medecine, Benno Schwabe & Co., Postcheckkonto V265, Basel 10, Switzerland, weekly.
Science, American Association for the Advancement of Science, 1515 Massachusetts Ave., Washington, D.C. 20005, weekly.
Southern Medical Journal, Journal of the Southern Medical Association, Robert F. Butts, 2601 Highland Ave., Birmingham, Ala. 35205, monthly.
Steroids, an international journal, Holden-Day Co., 728 Montgomery St., San Francisco, Calif., monthly.
Surgery, Gynocology, and Obstetrics with International Abstracts of Surgery, The Franklin H. Martin Memorial Foundation, 54 E. Erie St., Chicago, Ill. 60611, monthly.
Tetrahedron, The International Journal of Organic Chemistry, Pergamon, about monthly.
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Texas Reports on Biology and Medicine, Library, Medical Branch, University of Texas, Galveston, Tex. 77550, quarterly.

Therapie der Gegenwart, Urban & Schwarzenberg, Pettenkoferstr. 18, Munich 15, Germany, monthly.
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For more information on these periodicals, *see Chemical Abstracts List of Periodicals* (1961) and annual supplements.

Chemical Abstracts Sections

	1915-1961	*1962*	*1963-1966*	*1967*
Biochemistry	11	56–74	54–73	1–20
Organic Chemistry	10	31–44	26–44	21–34
Pharmaceuticals	17	30	39	63
Pharmaceutical Analysis				64
Organic Analysis				80

U.S. Patents

Class 167, Medicines, Poisons, and Cosmetics

Subclass		*Subclass*	
50	Medicines	67	Alkaloids
51	Radioactive	68	Metallo compounds
51.5	Sulfa compound containing	69	Arsenic
52	Anesthetic and hypnotic	71	Mercury
53	Veterinary	72	Inorganic
53.1	Fowl	73	Ferments
53.2	Topical	74	Animal extracts
54	Inhalents	74.5	Urine
55	Internal	74.6	Liver or kidney
56	Laxative	75	Pancreas
57	Effervescent	76	Thyroid
58	Topical	77	Suprarenal
59	Eye	78	Antigens and sera
60	Dental	79	Tuberculosis
61	Corn	80	Hog cholera
62	Liniments	81	Vitamins
63	Ointments	82	Vehicles
64	Suppositories	83	Capsules
86	Medicinal bath	84	Medicated papers and fabrics
70	Iodine	84.5	Diagnostic
65	Organic	95	X-Ray contrast compositions
66	Oils and fats		

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11

Literature Resources for the Cosmetics Industry

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The literature of cosmetics is tied in with that of various disciplines in the physical and biological sciences. To interpret and utilize this information, the cosmetic scientist must have a broad background in subjects ranging from chemistry and physics to physiology and pharmacology, even to production techniques. The library servicing the cosmetic industry must organize a strong core collection of reference tools and current publications and should have prompt access to other necessary and useful sources.

The formulation and manufacture of cosmetics have evolved from an art to a science. The complex technological developments and the emergence of an array of new compounds and new processes have increased the opportunity and need for creativity in applying the findings of basic research to practical problems of product development.

The modern cosmetic chemist must span diversified fields in science and technology. His literature is tied in with that of various disciplines in the physical and biological sciences. To interpret and utilize this information, he must have a broad background in subjects ranging from chemistry, physics, physiology, pharmacology, and microbiology to production techniques and in addition maintain a reasonable awareness of recent developments in all areas which influence his sphere of interest.

In the field of cosmetics investigation, as in all scientific endeavor, the library serves as an integral segment of the research foundation. While the library serving the cosmetics industry can have on hand only a small part of its potential requirements, it should organize a strong core collection of reference tools and current publications in pertinent areas, and it should have prompt access to other necessary and useful resources.

The interrelationships between the various disciplines, and the dependence of an investigator in one field upon the achievements of others in allied fields apply to the same extent to cosmetics science.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

General Literature

The literature explosion which has characterized all scientific fields recently has also affected cosmetics publications. The annual output of information is vast and continually growing in scope. On the other hand, the formulation of cosmetics based on scientific concepts is relatively new, and consequently, the early literature is chiefly of interest from an historical viewpoint.

Sagarin traced the historical background of perfume literature (*64*). The early written record of perfumery consisted of brief remarks in works relating to botany, medicine, pharmacy, and other sciences. A large part of these early writings originated in Italy. The first English language books on perfumery were the pharmacopoeias and popular cosmetics works addressed to women, containing instructions for preparing perfumes and beauty products at home. Many old cookbooks contained sections on perfumes. Early writings on essential oils were associated with the literature of distillation and thus were tied in with the literature of alcohol and the liquor industry.

In another article Sagarin reviewed popular and semi-popular "Books that Tell of Perfume and Fragrance" (*65*). Florence Wall presented an extensive bibliography dealing with the historical background of cosmetics (*76*). An impressive compilation of books concerning the development of cosmetics in America was given in Vail's bibliography (*75*).

Naves expressed dissatisfaction with the current literature in the area of essential oils (*58*). In articles dealing with problems of fragrance, for example, according to Naves most of the authors "exhaust their vocabulary to conceal the emptiness of their thoughts."

In tracing the long history of the essential oil literature, Leidy observed that "it has tended to develop along two fairly distinct lines, one dealing with the preparation and application of the oils, the other with the identification, structure, and synthesis of their components" (*49*). World-wide study of this subject has resulted in a literature which is notable for its polyglot nature and its nomenclature problems. Leidy's bibliography, intended to serve as a general guide, includes books on botany, cultivation of oils, methods of production, general texts, isolates and synthetics, and methods of analysis. In addition, he furnishes periodical titles, sources for specifications, and abstract journals devoted exclusively to essential oils.

Gertrude Schutze summarized the outstanding technical books, periodicals, house organs, publications of professional societies and associations, trade catalogs, technical reports, manufacturers' specifications on specific ingredients used in cosmetics, patents, and Government publications, which were available to the industry in 1951 (*68*). These sources today are still fertile avenues of approach to the literature in conjunction with newer ones which continue to appear.

Periodicals. Except for a few standard cosmetic reference books, most of the published technical information in this field is to be found in the form of journal or periodical articles. Pertinent publications of general interest in the field are listed in the Bibliography.

Abstracting and Indexing Services. There is no single abstracting and indexing service devoted exclusively to cosmetics and perfumes. Abstracts are included, however, in *Chemical Abstracts* and in *Chemisches Zentralblatt.* Excellent abstract coverage of cosmetic literature is provided by *Parfümerie und Kosmetik* in the Referate and Patente sections. About 1000 abstracts per year appear, taken from the world literature and patent journals. *Rivista Italiana Essenze-Profumi, Piante Officinali, Aromi-Saponi, Cosmetici-Aerosol* furnishes approximately 300 references a year to English-language and European journals in the form of tables of contents listings on perfumes, soaps, oils, cosmetics, and drugs. *Seifen, Öle, Fette, Wachse* (Neue Literatur) contains about 150 abstracts of European and English-language books per year on soaps, oils, fats, waxes, and cosmetics. *Drug and Cosmetic Industry* (Perfumers Shelf, Cosmetic Compounding, Advancing Therapy, Skin Research sections) offers approximately 200 abstracts a year on cosmetics and drugs (*57*). *Perfumery and Essential Oil Record,* in the section Technical Journals, offers brief abstracts of papers in other journals covering all facets of the industry. Finally, the Toilet Goods Association publishes the periodic *Literature Reference Bulletin* for its members, listing articles of possible interest. Abstracts on perfumes can be found in *The American Perfumer and Cosmetics* in the section: Technical Abstracts.

Reviews. Valuable, comprehensive reviews of research in perfumery are offered annually by Paul Z. Bedoukian in *American Perfumer and Cosmetics* (*5, 6*). The scientific literature covering research activities in essential oils and synthetic aromatics is also reported. The author's 20th annual article in 1963 covered such topics as research in odor and its perception, perfumery and its problems, advances in flower oil extraction techniques, analytical procedures, new and interesting aromatics, reports on perfumery synthetics and essential oils, and a bibliography of books and other review articles (*5, 6*).

Important reviews by Paul G. I. Lauffer (*47, 48*) have appeared in the *Proceedings of the Scientific Section of the Toilet Goods Association.* The 1963 review contained 290 references; 1964, 331 references.

An annual review of the literature of fats, oils, and detergents appears in the *Journal of the American Oil Chemists' Society* (*52*). The reviews are compiled by V. Mahadevan from current, original publications and from abstracts of publications which are not available in the original. Among the subjects covered are the manufacture and analysis of soaps, surfactants and detergents; pharmaceutical and cosmetic fat products, emulsifiers, waxes, resins, and plasticizers; deterioration of fatty materials; nutrition; physiology (digestion, intestinal absorption and excretion, lipid transport and body fats, lipid metabolism); biochemistry (analytical and methodology, lipid biosynthesis and biooxidation, steriods, lipoproteins); and new books of interest published during the year.

Patents. Patents offer a substantial contribution to the technical literature of the cosmetic industry. The various official national patent journals, the patent-alerting services, and pertinent indexing and abstracting publications may be utilized to advantage in insuring up-to-date knowledge of new inventions in cosmetics and related areas. In two articles Fleischer offers useful aids in locating U.S. patents and discusses the patent structure in several countries, including chemical classification and specific features of general interest (*29, 30*). His extensive bibliography, lists references on patent searching; special compilations of chemical patents; chemical patent abstracts, lists, and encyclopedias; articles, books, and journals furnishing chemical patent references; classification of patents; and information on U.S. and foreign patent laws. Sources of patent information are outlined in "A Guide to the Literature of Chemistry" (*12*). Information on European patents was presented by Lindenmeyer (*50*). The various patent services may supply lists, indexes, abstracts, and originals of patents in various forms. Documentation, Inc. offers a "Textape" indexing service, an index to chemical patents on magnetic tape. Complete coverage of all British, West German, and U.S.S.R. patent specifications is offered by the Derwent patent abstract service. Abstracts of specifications for patents of chemical and allied interest are available for Belgian, French, and Japanese patents. In addition, detailed abstracts in English are offered for all British, German, French, South Africa, and Indian patent specifications issued in selected technological fields. Of further interest is the "Uniterm Index to Chemical Patents." A selected list of official patent journals and pertinent U.S. patent classes and subclasses is included in the Bibliography.

House Organs and Trade Publications. Manufacturers' publications are often sources of technical information not published elsewhere. Catalogs, brochures, data sheets, and information bulletins frequently offer the most recent technical information on physical properties, reactions, uses, and toxicity of chemical compounds. A bibliography of house organs is available in "Printer's Ink Directory of House Organs" (*62*), and a selected list is included in an article by Baer and Skolnik (*4*).

Of interest to the cosmetic and perfume chemist is *The Fritzsche Library Bulletin,* a monthly check-list of current literature covering research on essential oils, aromatic chemicals, perfume and flavor raw materials and their industrial application, with a special section on organoleptic problems and procedures. The titles are taken from issues of technical and trade journals. *Dragoco Report,* a monthly information service for the perfume, cosmetics, and toilet goods industries is published by Dragoco, Inc., manufacturers of perfume concentrates. Editions are issued in German, French, Spanish, and Italian. It contains articles on composition and basic principles relating to cosmetics. A monthly leaflet, *Norda Schimmel Briefs,* contains similar information and has been published since 1935. *The Givaudanian,* issued monthly, contains articles dealing with perfumery.

Trade and Professional Associations and Societies. The services and publications of societies and trade associations are invaluable aids to the cosmetic and perfume industries.

THE TOILET GOODS ASSOCIATION. Founded in 1894, The Toilet Goods Association (T.G.A.), formerly known as the Manufacturing Perfumers Association, The American Manufacturers of Toilet Articles, and the Associated Manufacturers of Toilet Articles, has about 500 members in its Scientific Section engaged in research, control, and production. T.G.A. members are manufacturers and distributors of finished cosmetics and toilet preparations and suppliers of raw materials and services. Papers from the two annual meetings are published in the *Proceedings of the Scientific Section of the Toilet Goods Association,* beginning in 1944. The Scientific Advisory Committee has produced about 100 standards for cosmetic raw materials, most of which require a higher degree of purity than the "U. S. Pharmacopoeia." As part of a broadened program of research, a project covering allergy, sensitivity, and irritation, sponsored at Yale University, resulted in "The Handbook of Cosmetic Materials." T.G.A. publishes the "Trade Mark Record," a service listing all registered trademarks in perfumes, toilet preparations, and soaps as well as thousands of additional ones in use but not registered with the U. S. Patent Office. The Association's weekly bulletin service advises members of marks registered in the Patent Office and trademarks published in the *Official Gazette* for which registration is being sought. Among the various types of information furnished in the *T.G.A. Bulletin* are literature reference notes, legislative reports, and notices of judgment.

As a further service, the T.G.A. maintains an advertising copy review service, conducted by its Board of Standards. Members may submit advertising and labeling copy prior to publication, which the Board reviews and subsequently approves, suggests changes in, or rejects. A history of The Toilet Goods Association appeared in the *American Perfumer* (*46*).

THE SOCIETY OF COSMETIC CHEMISTS. An association of 1285 professional cosmetic and perfume chemists, the Society was founded in 1945. Papers from the semiannual meetings are published regularly. The *Journal of the Society of Cosmetic Chemists,* a joint venture of the U. S., British, and German Societies, is published monthly: five issues a year for the Society of Cosmetic Chemists of Great Britain, six issues by the Society of Cosmetic Chemists in the U. S., and two issues by the Gesellschaft Deutscher Kosmetik-Chemiker. In addition to original papers, the Society also publishes an occasional review paper as well as preliminary notices, covering experimental findings of scientists which are too brief for full papers or are of a preliminary nature. A 12-year cumulative index to the Journal, covering the years 1947-59, has been published by the Society Suisse des Chimistes-Cosmeticiens.

A special collection of books and periodicals embracing cosmetics and allied subjects has been assembled by the Society and is now housed in the library of the Chemists' Club in New York City. Copies of all papers which have received awards are kept for reference. The special collection consists of about 250 volumes on flavors and perfumes, cosmetic formulation, cosmetic analysis, essential oils, hair treatment, biology of hair growth, hair dyes, soap manufacture, detergents, dyes, waxes, aerosols, physiology and biology of the skin, marketing of drugs and cosmetics, and the history of cosmetics and perfumes. The books may be borrowed by members of the Society.

THE ESSENTIAL OIL ASSOCIATION OF THE U.S.A. The Association consists of about 60 companies which produce or sell essential oils, aromatic chemicals, perfume, or flavor compounds in the United States and its posses-

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sions. One of the services of its Scientific Section is the acceptance of quality standards and specifications of various commercial grades of essential oils and aromatics. As of 1964, over 225 specifications were established with test methods to aid in their determination. The suggested tests, universally recognized as standards for essential oils, aromatic chemicals, and isolates, have been incorporated in the booklet, "E.O.A. Standards and Specifications." The Instrumental Analysis Committee evaluates new spectroscopic developments in analytical techniques for perfume and flavor materials. The Trade Names Committee publishes "Coined Names and Trade Mark Catalog" and establishes rules and principles to guide members in selecting names for new products. The list includes names that have already been registered and those in the coined-name category.

Chemical Specialties Manufacturers Association. The published proceedings of the C.S.M.A. provide the cosmetic chemist with technical information on various topics. Other publications of interest include "C.S.M.A. Aerosol Guide," "Agencies and Regulations of Interest to the Aerosol Industry," "Compilation of Labeling Laws and Regulations for Hazardous Substances," "Vendors to the Trade," and "Test Methods." The Association also compiles local, state, and federal laws concerning the chemical specialties industry.

The Toilet Preparations Federation. With a membership of 157, the Federation publishes specification standards for raw materials and maintains an unofficial register of shade names, brand names, and trade names. Calls may be made to the Secretariat to ensure non-confliction of names.

American Medical Association. The AMA Committee on Cosmetics, staffed at A.M.A. headquarters under the Department of Drugs, was established to meet the growing demand for authoritative information on the increasing number of cosmetic preparations. The committee members (dermatologists, biochemists, pharmacists, and pharmacologists) investigate each product, present the results to the public, and inform physicians about their effects. Over 100 journals are checked for new data. In addition, a file of formula information is maintained for staff use only, through the cooperation of cosmetic manufacturers. Articles, reports, and editorials are published in the *Journal of the American Medical Association* and in *Today's Health*. Additional material is distributed in pamphlet form. Lectures and discussion groups are arranged by the Committee at medical and scientific meetings, covering a wide range of cosmetic topics.

International Federations. Several important international organizations have contributed to the growth and development of the cosmetic industry. Recent progress in the science of cosmetics and allied fields is reported throughout the world through these organizations.

International Federation of Societies of Cosmetic Chemists. Founded in September 1959 in Brussels, the membership consists of cosmetic societies in 14 countries. Congresses were held in London in 1962 and in New York in 1964. The Federation seeks to advance cosmetic science; encourage research and coordinate the work of the national societies; help research workers obtain information; develop standardized procedures for

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch011

analyzing raw materials and finished products and to estimate efficiency of products; hold international congresses; sponsor awards for achievements in research.

INTERNATIONAL CONGRESS OF AESTHETICS AND COSMETOLOGY (COMITÉ INTERNATIONAL D'ESTHETIQUE ET DE COSMÉTOLOGIE (CIDESCO)). The Federation was founded in December 1946 in Brussels. Its members are national associations in 19 countries. As of 1965, 19 international congresses have been held. The Federation aims to establish liaison between national groups and federations of beauty specialists, manufacturers of cosmetics, dermatologists, and plastic surgeons; to diffuse information on new techniques and processes; to establish standards for professional training.

INTERNATIONAL ASSOCIATION OF THE SOAP AND DETERGENT INDUSTRY. Founded in October 1952, the Association consists of employers' associations in 10 countries. By 1964, 16 congresses were held. The Association aims to advance the interests of industries concerned with soap-making, detergents, and allied products.

INTERNATIONAL AEROSOL ASSOCIATION. Founded in 1957 in Zürich, the membership consists of 150 companies in 20 countries. National associations are grouped within the Federation of European Aerosol Associations, which shares the IAA office and secretariat. Up to 1963, four congresses were held. The association seeks to further and protect the interests of all members of the aerosol industry in all countries of the world; act as a clearinghouse for settling common problems; represent the industry *vis-a-vis* public and government agencies. Its *Aerosol Bulletin* is published six times a year in English, French, and German.

Literature of Cosmetics as Related to Various Disciplines

Medicine. The significance of cosmetics in medical practice was recognized by the American Medical Association when it established its Committee on Cosmetics in 1948. This Committee was set up to promote better understanding of the function, care, and significance of the skin, with special emphasis on cosmetics and allied preparations; to emphasize the serious psychological implications of temporary or permanent skin disfigurements; to inform the public so that it can wisely select and intelligently use cosmetics; to stimulate increased cooperation between the health professions and the toilet goods industry in providing safe and effective products promoted with reasonable and informative claims; to supply available data from the Committee files to authorized persons in the mass media, and to direct those who must evaluate cosmetics to sources of information (*41*).

In creating effective and beneficial products, the cosmetic chemist must be well informed as to the physiological characteristics of normal skin, hair, and nails and the effects which the proposed products will have upon them. The cosmetic industry is drawing increasingly upon the published research results of dermatologists in the areas of aging skin, healing processes, percutaneous absorption, skin respiration, allergic sensitization, and cutaneous irritancy. These findings guide cosmetic investigators with such problems as wrinkles, acne, excessively dry or oily skin, and facial blemishes. In addition, the formulator of hair products must understand thoroughly the structure, physical properties, and physiology of the hair.

As a guide to a basic reference collection in dermatology, the cosmetic librarian may turn to bibliographies such as those of Fleming (*31*) and Doe and Marshall (*19*). Especially to be recommended are the texts listed under the section Cosmetics and Medicine in the Bibliography.

A section of the cosmetics library should be devoted to the biological sciences. A guide to the literature sources in this area was prepared by Kerker and Schlundt (*43*).

Pharmacy. A close kinship between pharmacy and cosmetics can be traced through the years. Faust has described the contribution and role of the pharmaceutical chemist in the cosmetic industry (*23*). With the increasing incidence of cosmetics which contain pharmacologically active agents, cooperation and common interest have expanded. The current literature indicates a positive trend towards incorporating medicinal agents in cosmetic products (*24, 45*). Vitamins, hormones, steroids, antibiotics, enzymes, proteins, antihistamines, botanicals, antimicrobial and antifungal agents, and substances affecting skin pigmentation have found their way into cosmetic formulations.

Many products may be classified as both drugs and cosmetics—e.g., antiperspirants, acne preparations, sunburn remedies, and antidandruff preparations. "The U.S. Pharmacopoeia" and the "National Formulary" contain many official drugs commonly used in cosmetic creams and lotions.

Several excellent guides to the pharmaceutical literature are available to assist the cosmetic librarian. In August 1963 a factual survey on the nature and magnitude of drug literature was prepared by the National Library of Medicine for studying interagency coordination in drug research and regulation, by the Subcommittee on Reorganization and International Organizations of the Senate Committee on Government Operations (*74*). The activities of organized groups concerned with drug literature, such as the Pharmaceutical Manufacturers Association, American Association of Colleges of Pharmacy, Special Libraries Association, Medical Library Association, International Pharmaceutical Federation, and other groups, were outlined. "Appendix B" consists of a classified bibliography of books on pharmacy and reference works in the following categories: directories, drug compendia, introduction to pharmacy, pharmacy principles and techniques, hospital pharmacy, manufacturing pharmacy, cosmetics and dermatologic pharmacy, and veterinary pharmacy. "Appendix C, World List of Pharmacy Periodicals," was initiated as a project of the Medical Library Association, Pharmacy Libraries Group. "Appendix E, Drug Information Sources: A World List," compiled by a Committee of the Pharmaceutical Section, Science-Technology Division, Special Libraries Association, is a revision of a bibliography which first appeared in 1957.

An additional guide of value is "A Key to Pharmaceutical and Medicinal Chemistry Literature" (*2*). Oatfield and Emilio have analyzed the state of indexing and abstracting of pharmaceutical literature and have included a list of publications and sources helpful in pharmaceutical literature searching

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch011

(*61*). A list of pharmaceutical journals, their abbreviations, and history, can be found in "Orientation to Pharmacy" by Burlage (*9*). The holdings of 25 pharmaceutical libraries in the United States and Canada appeared in the "Union List of Periodicals in Pharmaceutical Libraries" (*70*). An annual review surveying the literature pertaining to pharmaceutical sciences appears in the *Journal of Pharmaceutical Sciences* (*51*). The basic cosmetic collection may be enriched by including selections from those listed in the Bibliography under Cosmetics and Pharmacy.

Pharmacology. Testing and interpreting the safety of cosmetic ingredients rests in the hands of the pharmacologist and the dermatologist. Since cosmetics are used by persons of different ages, for indefinite periods of time, and by individuals with varying skin types and sensitivities, a responsible industry must always be alert to protect the consumer from irritation, sensitization, carcinogenesis, or other toxicity. Although the real probability of any adverse physiological reaction to a proposed product may be nonexistent, the manufacturer must nevertheless take every possible step to investigate this question before bringing a new product to the market. The raw materials used in manufacturing the products as well as the finished composition, must be carefully screened for possible consumer reactions. Every ingredient in the formula, the manufacturing process involved, and the finished product must meet carefully designed specifications. As more new compounds are discovered, many find their way into cosmetic formulations. Continual research on their toxicity is the concern and responsibility of the pharmacologist.

Gaddum has compiled a bibliography of pharmacological literature in which he lists textbooks in pharmacology, treatises on experimental methods, books on the chemistry of drugs as well as works by industrial and governmental committees (*33*). A more recent bibliography of pharmacological literature appears in "Drug Literature," prepared for the Senate Committee on Government Operations (*73*). The Bibliography lists selections which should be valuable in this area.

Toxicology. In a review, De Navarre notes that safety is a relative matter and that nothing is absolutely safe under all conditions of use (*13*). "From a cosmetic viewpoint, safety of a product involves properties of the substance, use by children or adults, male or female, how it is to be used, how much is to be used at a time, how much body area is involved, frequency and duration of use, skin condition at the time of use, and racial differences. Before considering the safety of a finished product, the materials from which it has been made must first be examined for hazardous or deleterious properties." Helpful information regarding the toxicology of cosmetic materials may be found in the "Handbook of Cosmetic Materials" (*37*), which reports on the toxicity or allergenic qualities as well as the properties of the more commonly used cosmetic materials. Compounds are listed alphabetically, and pertinent literature citations are given. Similarly, Harry in "Cosmetic Materials, their Origin, Characteristics, Uses and Dermatological Action," offers valuable toxicological information (*39*).

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch011

Wiswesser, in a paper on sources of mammalian toxicity data in the literature, tabulated a list of journals which are current sources of such data (*79*).

Considering the finished cosmetic product, Draize and Alvarez planned a series of experiments for appraising cosmetic safety (*20*), and in a later publication, Draize and Kelley outlined pharmacological and toxicological considerations in evaluating the safety of cosmetics (*21*). A further contribution was offered by the Division of Pharmacology of the Food and Drug Administration, with the publication of "Appraisal of the Safety of Chemicals in Foods, Drugs and Cosmetics" (*72*).

Of special interest to the cosmetic chemist is the bimonthly, *Food and Cosmetics Toxicology,* published on behalf of the British Industrial Biological Research Association. This association was established to undertake the research necessary to assure manufacturers and the public that chemical substances used in food, beverages, confections, packaging and cosmetics were not harmful. The journal provides an extensive service of abstracts and general articles, as well as coverage of changes in legislation relating to additives. It also publishes reviews and original papers relating to fields of interest of the association. Another of their publications, the *Information Bulletin B.I.B.R.A.* contains current developments in food additive legislation and toxicology.

If toxicological information is not available from expected sources, specialized associations may be consulted, such as the U. S. Public Health Service, The National Safety Council, The Industrial Hygiene Foundation, the Chemical-Biological Coordination Center of the National Research Council, and the Manufacturing Chemists Association.

The Food and Drug Administration Information Center on Adverse Reactions and Hazards, a function of the Division of Research and Reference in the Bureau of Medicine, is concerned with adverse reactions to drugs and therapeutic devices; the hazards of chemicals used in the house, and of cosmetics, pesticides and food additives; and the accidental ingestion of drugs. The Center has over 45 sources of information relating to its areas of interest, including the Hospital Reporting Program on Adverse Reactions to Drugs. Over 600 hospitals participate in the latter program. The center collects, screens, evaluates, stores, retrieves, re-evaluates and disseminates information on adverse reactions and hazards. Information is disseminated by monthly reports, issued by the Adverse Reaction Reporting Branch and the Hazardous Substances Evaluation Branch, and by a weekly literature abstract journal released by the Medical Reference Library.

Since 1953, poison control centers have been available for ingredient and toxicity information on a broad range of toxic or potentially toxic products. As of July 1961, there were approximately 460 poison control centers in the United States (*73*).

The Bibliography lists some noteworthy texts and periodicals in the field of toxicology for the cosmetic chemist.

Law. With the enactment of the Federal Food, Drug and Cosmetic Act of 1938, cosmetics were brought under Federal control for the first time. The movement of adulterated or misbranded cosmetics in interstate commerce was subjected to federal regulation (*25*). The act set forth the circumstances under which cosmetics would be deemed adulterated or misbranded. The amended text and general regulations for administering this act are available in "Federal Food, Drug, and Cosmetic Act as Amended and General Regulations for its Enforcement," Title 21, Part I (Act revised October 1962; Regulations revised January 1964) (*26*).

The new Food Additives Amendment of 1958 (Section 409) requires that new food additives be tested for safety before use and that governmental approval for use is necessary. The text of the regulations are available under "Food Additives Regulations Under the Federal Food, Drug, and Cosmetic Act, Part 121, Chapter I, Title 21, Code of Federal Regulations" (*32*).

The Color Additive Amendment was enacted in July 1960 (*11*), stating that foods, drugs, and cosmetics are adulterated if they contain color additives which have not been proved safe to the satisfaction of the FDA for a particular use. This amendment authorized the FDA to set safe limits, or tolerances, on the amount of color permitted in foods, drugs, and cosmetics. It brought all colors for these uses under premarketing safety clearance provisions. In addition, it authorized the FDA to require that previously authorized colors be retested for safety, using new techniques and procedures, where any question as to safety may have arisen since the original testing and government's listing of the color as safe. Finally, it authorized the FDA to require proof of safety for products used to color the human body.

New regulations published in the Federal Register in 1963 (*28*) implemented the Color Additive Amendment as a further step for assuring the safety of color additives used in foods, drugs, and cosmetics. Additional safety precautions were provided for lipsticks, rouge, eyebrow and lash color, and other substances which apply color to the human body. Under the new regulations, FDA requires that an entire product, not just the color ingredient, be shown by the manufacturer to be safe before it is released for sale. Previously only coloring from coal tar type ingredients was subject to this requirement.

The text of the color additives regulations are available under the title, "Color Additives Regulations Under the Federal Food, Drug, and Cosmetic Act," Part 8, Title 21, Code of Federal Regulations (*11*). Part 8 contains general color regulations, procedures for petitions proposing regulations for color additives, and provisional listings to be used on an interim basis until the basic provisions of the Color Additive Amendments become fully effective. Part 9, "Color Certification," contains specifications for the identity and purity to which colors must conform to be certified and regulations for certification procedures.

The Kefauver-Harris Drug Amendments of 1962 further tightened the control exercised over drugs. They provided new means for assuring the safety and effectiveness of drugs and required that the manufacturer's claims made in regard to their effectiveness be supported by medical data.

In 1964, the FDA published (*27*) its new regulations requiring an industry-wide review of the safety and effectiveness of drugs. The regulations require firms marketing drugs approved since 1938 to examine both their

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch011

promotional material and their clinical records to be sure that all their claims were justified by experience and that the promotional material include all necessary warnings, contraindications, side effects, and untoward reactions which may have appeared after the drugs were originally marketed.

A report on the Federal Food, Drug, and Cosmetic Act and regulation of cosmetics appears in "The Chemistry and Manufacture of Cosmetics" (*16*).

Several directories, alerting services, and other publications are valuable in reference to cosmetic legislation:

Federal Register—publishes the official regulatory actions of the FDA. The Administrative Procedures Act in 1946 required that law interpretations must be formalized and published in this medium.

Food, Drug, Cosmetic Law Reports—issues weekly reports on federal and state controls of purity, packaging and labeling. New and amendatory laws and regulations, as well as court decisions, rulings, releases, comments, etc. are published for each major topic. Detailed information on current petitions for the qualification of food and color additives is published. A special feature is the "Index to Substances," alphabetically arranged entries for each of the chemical and other substances detailed by name or formula in the federal laws, regulations, and food and color additive petitions.

Compilation of Laws Affecting Proprietary Drug and Allied Industries—sets forth federal laws and excerpts from such laws which may be of immediate interest to the industry. Regulations promulgated pursuant to such laws are also included. The text of state food and drug laws are offered, and loose-leaf inserts are given at the end of each legislative year.

Food, Drug Cosmetic Law Journal—records the progress of law in these fields and provides a constructive discussion of the laws.

Bulletin of the Toilet Goods Association—offers legislative reports and notices of judgment in regard to cosmetics.

Food and Cosmetics Toxicology—covers changes in legislation relating to additives. Reports are given on both legislation in the United States and other countries.

Microbiology. Preserving cosmetics to assure their stability under repeated contamination by the consumer requires the use of antibacterial and antifungal agents. These are also used in products designed to control dandruff, perspiration odor, acne, athlete's foot, and mouth odor (*36*). A selective guide to the literature of microbiology can be found in Grainger's "Guide to the History of Bacteriology" (*37*) and in Fleming's "Guide to the Literature of the Medical Sciences" (*31*). Gay published a general review of sterilization, disinfection, preservation, and terminology (*35*) while Nogueira gave a detailed review of preservatives in pharmacy (*60*). In "Advances in Pharmaceutical Sciences" vol. I, edited by Bean *et al.*, a section on preserving emulsions against microbial attack was given by Wedderburn as well as a section on "Contemporary Trends in Heat Sterilization" by Wilkinson and Baker. The other texts listed in the Bibliography are valuable for a library serving the cosmetic research laboratory.

Chemistry. By far the largest section of the cosmetics library is the chemistry collection. Organic chemistry, particularly polymer and dye chemistry, analytical, physical, pharmaceutical, and biochemistry, are of major importance. Selections should include encyclopedic works, dictionaries, handbooks, monographs, books of constants, formularies, treatises, laboratory

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch011

manuals, journals, trade publications, and catalogs. Basic texts should cover fats, oils, waxes, detergents, gums, resins, plastics, paints, lacquers, inks, dyes, textiles, solvents, etc. Some excellent guides to the chemical literature are "Guide to the Literature of Chemistry" (*12*), "Chemical Publications" (*56*), and "Searching the Chemical Literature" (*3*). Reviews of recent publications encompassing the entire chemical field appear in the *Journal of Chemical Education, Chemical and Engineering News,* and *Journal of the American Chemical Society*. For general reference, "Kirk-Othmer Encyclopedia of Chemical Technology" is valuable (*44*). This is a standard work on the American chemical industry, its methods, processes, equipment, and materials.

Books which describe test methods are needed to identify substances properly, to ascertain their purity, to establish specifications, to evaluate products, and to help investigate consumer complaints. Among the sources recommended are "A Manual of Cosmetic Analysis," "Official Methods of Analysis, A.O.A.C.," *Journal of the Association of Official Analytical Chemists,* "ASTM Standards," U.S. Pharmacopeia," the "National Formulary," and the raw materials standards of the Toilet Goods Association.

Biochemistry. In formulating a new product, the cosmetic chemist must be aware of its effect on the body. He cannot always predict the biological properties of the ever increasing number of new substances which are available for his investigation.

A basic biochemical text which is also a laboratory handbook is "Practical Physiological Chemistry" by Hawk and Oser. Others which are especially recommended are "Comprehensive Biochemistry," "Biochemistry of Skin in Health and Disease," "Annual Review of Biochemistry," and "Progress in Biochemistry: A Report on Biochemical Problems and on Biochemical Research Since 1949." Other references are given in the Bibliography; for the most part; they are general biochemical texts.

Lipids. By means of their lubricating action, and their role in keeping the proper degree of hydration of the stratum corneum the lipids of the skin help maintain a smooth and soft-textured skin. Nicolaides (*59*) presented a study of the human skin lipids, their origin, composition, and possible functions. Other references to the lipids are listed in the Bibliography.

Enzymes. De Navarre has reviewed the use of enzymes in cosmetic practice (*13*). There are several enzymes of cosmetic significance: pigmentation of the skin is governed by tyrosinase while combinations of tyrosinase and other substances have been patented as hair dyes. Among enzymes which have been effective in dermatological cosmetics are papain, hyaluronidase, ribonuclease, catalase, pepsin, and urease. Investigations have been undertaken to determine the effectiveness of enzymes as depilatories. Their importance as cosmetic additives as of now is debatable. The references on enzymes listed in the Bibliography will enable one to acquire a broader understanding of their physiological functions.

Proteins and Amino Acids. Recent studies have led to the claim of beneficial results from using proteinaceous material in cosmetics. According to Burnett, there is evidence that one of the benefits derived from protein hydrolyzates in cosmetics is their participation in the metabolism of the epidermis (*10*). A review of the literature of protein hydrolyzates and amino acids in cosmetics was presented recently by De Navarre (*15*). The hydrolyzates have been incorporated in creams, lotions, ointments, shampoos, hair treatments, and permanent waving solutions with reported effective results. A study of human epidermal proteins was conducted by Matoltsy (*55*), and Rudall (*63*) investigated the fibrous proteins which form the greater part of the epidermal cells.

The references listed in the Bibliography are important for understanding the properties of proteins in relation to cosmetic formulation and their functions in human tissues.

Fatty Acids. Myristic, palmitic, and stearic acids are used extensively in cosmetics. The effectiveness of unsaturated fatty acids and their esters for dry skin, eczema, and other skin and scalp ailments has been confirmed by investigators. De Navarre reviewed the use of fatty acids in cosmetics in his recent book (*14*). Other texts are listed in the Bibliography.

Physical Chemistry. The formulator of cosmetics must be familiar with the principles of emulsions, rheology, and particle size measurement in order to prepare products with the proper physical characteristics. The viscosity and rheological behavior of cosmetic pastes, suspensions, and emulsions are recognized as fundamental properties.

The cosmetic scientist is concerned with two aspects of flow properties: the behavior of the product in the container and when applied to the body of the consumer. Various problems associated with flow and viscosity patterns must be recognized. Emulsions must be stable on storage while at the same time (according to the opinion of many experts) they should possess the correct degree of instability when applied to the skin to cause the emulsion to break. A lotion should pour or squeeze from a tube easily, spread readily, and feel smooth when rubbed on the skin. No matter how efficient a product is, it will not be accepted by the consumer if it is too stiff or too fluid when applied.

Rheology fundamentals and applications in cosmetics have been the subject of a paper by Joe Lin Tong (*71*). Other authors have discussed the usefulness of rheology in cosmetics (*40*) and the rheology of pastes, suspensions, and emulsions (*69*). Scarbrough presented a rheological review for cosmetic chemists (*67*); Wood discussed the prediction of rheologic aging of cosmetic lotions (*80*); Adler gave suggestions on evaluating products from a rheological viewpoint (*1*); Marriott discussed rheological measurements in the cosmetic industry (*54*); De Waele gave an introduction to the rheology of disperse systems (*18*). Many texts on theoretical and applied rheology are available. Among those are the ones listed in the Bibliography.

Statistics. In a paper given in 1964 Frey (*33*) acknowledged that cosmetic formulators generally have been able to prepare fine products without the aid of statistics, simply by exercising sound judgment. He noted, however, that such judgment can be augmented and sharpened by this research tool.

In any laboratory engaged in industrial research, particularly in areas such as cosmetics where experiments are influenced by many unidentified factors, the old-fashioned method of one-variable experimentation has some serious disadvantages. Among these are: (1) the possibility of being misled with regard to an optimum combination of experimental conditions to achieve a desired result; (2) lack of control of or compensation for extraneous variables; (3) inability to evaluate interactions; (4) generally lowered efficiency with regard to information gained per unit of experimental work input. These disadvantages may usually be eliminated if properly designed multivariable experimentation is used, coupled with adequate statistical analysis of the results. The statistical approach is at its greatest advantage when the formulator designs his own experiments. The cosmetic chemist should be familiar with the information sources in statistics so that they may serve him in his every day work. Oatfield and Emilio compiled a bibliography of statistical methodology sources which may be consulted (*61*). Bibliographies of basic texts and monographs on statistical methods and sources have been compiled by Buckland (*8*), Kendall (*42*), and Wasserman (*77*). Savage has prepared a bibliography of nonparametric statistics (*66*).

Particularly worthwhile are the texts and periodicals listed in the Bibliography. Most of the references in this area are concerned with technologies not necessarily directly related to cosmetics and pertinent allied fields. The subject of experimental design and analysis, however, which is the basic meaning of the term statistics, as used here, is common to all technologies in which it is applicable. The orientation of various texts to specific technologies, in general, refers only to their exemplary materials. The basic experimental design and analysis texts have not been written with examples in the medical or biological fields, but usually in chemistry or agriculture. However, there are exceptions, and such examples are listed in the Bibliography under Statistics as Related to Medical Sciences.

Modern Standards of Clinical Investigation. The incidence of untoward reactions from cosmetics has been remarkably low. Most of the companies which produce cosmetics perform the necessary pharmacological and clinical investigations with programs designed to determine safety and effectiveness of products without bias. Wilkinson has discussed the reliability of methods of testing new products designed for the skin (*78*). For the maximum protection to the consumer, there must be close cooperation between the cosmetic industry and clinical investigators. Properly designed tests for toxicity, sensitization, and clinical effect must be designed. It is important to plan the tests with the help of a statistician in order to determine what questions are to be answered and within what limits the answers apply. Several texts have been published with regard to clinical trials and are listed in the Bibliography.

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P	= Pharmacy	Li	= Lipids
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Journal of the American Pharmaceutical Association (formerly *Journal of the American Pharmaceutical Association, Practical Pharmacy Edition*), American Pharmaceutical Association, 2215 Constitution Ave., N. W., Washington, D. C. 20037, monthly, P.

The Journal of Applied Bacteriology, (formerly *Proceedings of the Society for Applied Bacteriology*), Academic Press Inc. (London), Berkeley Sq., London W1, England, 3 issues per year, Mi.

Journal of Bacteriology, official organ of the American Society for Microbiology, Williams & Wilkins Co., Baltimore, Md. 21202 monthly, Mi.

The Journal of Biochemistry (Tokyo), The Japanese Biochemical Society, c/o Department of Biochemistry, Faculty of Medicine, Tokyo University, Bunkyo-ku, Tokyo, Japan, monthly, B.

The Journal of Biological Chemistry, American Society of Biological Chemists, Inc., Mount Royal and Guilford Aves., Baltimore, Md., 21202, semimonthly, B.

Journal of Colloid and Interface Science, Academic Press, 111 Fifth Ave., N.Y., N.Y. 10003, monthly, C.

The Journal of General Microbiology, Cambridge University Press, Bentley House, 200 Euston Rd., London NW1, England, 4 vols. per year, Mi.

Journal of Investigative Dermatology, Williams & Wilkins Co., Baltimore, Md. 21202, monthly, M.

Journal of Lipid Research, E. H. Ahrens, Jr., ed., Rockefeller Institute, New York, N. Y. 10021, bimonthly, Li.

Journal of Medicinal Chemistry (formerly *Journal of Medicinal and Pharmaceutical Chemistry*), American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036, bimonthly, M, P.

Journal of Clinical Pharmacology and the *Journal of New Drugs*, 1300 York Ave., New York, N. Y. 10021, bimonthly, Ph.

Journal of Pharmaceutical Sciences (formerly *Journal of the American Pharmaceutical Association, Scientific Edition*) (Absorbed *Drug Standards*), American Pharmaceutical Association, 2215 Constitution Ave., N. W., Washington, D. C. 20037, monthly, P.

The Journal of Pharmacology and Experimental Therapeutics, Williams & Wilkins Co., Baltimore, Md. 21202, monthly, Pl.

Journal of Pharmacy and Pharmacology (formerly *Quarterly Journal of Pharmacy and Pharmacology*), The Pharmaceutical Society of Great Britain, 17 Bloomsbury Square, London WC1, England, monthly, P, Pl.

Kolloid-Zeitschrift und Zeitschrift für Polymere (formerly *Kolloid Zeitschrift*), Dr. Dietrich Steinkopff Verlagsbuchhandlung, Saalbaustrasse 12, 6100 Darmstadt, Germany, monthly, C.

The Medical Letter, Drug and Therapeutic Information, Inc., 305 East 45th St., New York, N. Y. 10017, fortnightly, P, Pl.

Microbiology (USSR) (English translation of *Mikrobiologiya*), Consultants Bureau, 227 W. 17th St., New York, N. Y. 10011, bimonthly, Mi.

Minerva Dermatologica (formerly *Il Dermosifilografo*), Libreria Minerva della S.p.A. Edizioni Minerva Medica, Corso Braumante 83-85, Casella Postale 491, Torino, Italy, monthly, M.

National Pharmaceutical Association Journal, National Pharmaceutical Association, Inc., Howard University College of Pharmacy, Washington, D. C. 20001, quarterly, P.

Oil, Paint, and Drug Reporter, Schnell Publishing Co., Inc., 100 Church St., New York, N. Y. 10007, weekly, P.

Pharmaceutical Journal, Pharmaceutical Society of Great Britain, 17 Bloomsbury Square, London WC1, weekly, P.

Pharmacological Reviews, Williams & Wilkins Co., Baltimore, Md. 21202, quarterly, Pl.

Pharmacology and Toxicology (USSR) (English translation of *Farmakologiya i Toksikologiya*), Consultants Bureau, bimonthly, Pl, T.

Pharmazeutische Zeitung, Vereinigt mit Apotheker-Zeitung (formerly *Pharmazeutische Zeitung-Nachrichten*), Govi-Verlag GmbH, Postfach 7708, Frankfurt am Main, Germany, weekly, P.

Rheologica Acta, Dr. Dietrich Steinkopff Verlag, Saalbaustrasse 12, 6100 Darmstadt, Germany, irregular, PC.

Rheologie, Brazil Instituto Nacional de Technologia, PC.

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Rheology Bulletin (Society of Rheology), American Institute of Physics, 335 East 45th St., New York, N. Y. 10017, irregular, PC.

The Schoch Letter, Current News in Dermatology, The Schoch Letter, 1310 Medical Arts Building, Dallas, Tex., monthly, M.

Skin, A Journal of Dermatology, Western Medical Publications, 1721 West Olympic Blvd., Los Angeles, Calif. 90015, monthly, M.

Technometrics; a journal of statistics for the physical, chemical, and engineering sciences, American Statistical Association, 810 18th St., N.W., Washington, D. C. 20036, quarterly, S.

Toxicology and Applied Pharmacology, Academic Press, 111 Fifth Ave., New York, N. Y. 10003, bimonthly, Pl, T.

Transactions of the St. John's Hospital Dermatological Society, C. D. Calnan, ed., Wilding & Son, Ltd., 33 Castle St., Shrewsbury, England, semiannual, M.

Zentralblatt für Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene, Abteilung II: VEB Gustav Fischer Verlag, Villengang 2, 69 Jena, Germany, monthly, Mi.

Zeitschrift für Haut- und Geschlechtskrankheiten, Grosse Verlag GmbH Baselerstrasse 67, 1 Berlin, Germany, semimonthly, M.

Zeitschrift für Physiologische Chemie, Walter de Gruyter & Co., Woyrschstrasse 13, 45 Berlin W35, Germany, irregular, B.

Patent Classes and Subclasses

Most all patents relating to cosmetics and toilet goods will be found in Class 167, Medicines, Poisons, and Cosmetics, and Class 132, Toilet. The following list is a subject guide to this source.

	Class	*Subclass*
Antiperspirants	167	90+
Bath Oils	167	90
Bath Salts	167	86
Combs	132	11+
Compacts	132	82, 83
Cosmetic Applicators	132	88.7
Cosmetic Preparations	167	85+
Creams	167	91
Dentifrices	167	93
Deodorants	167	90+
Depilatories	167	89
Detergent Compositions	252	89+
Essential Oils	260	236.6
Eye Make-up	167	85
Face Cosmetics	167	90+
Hair Conditioners	167	87
Hair Curlers	132	31
Hair Dressing Compositions	167	87
Hair Dyes and Dyeing; Hair Coloring	167	88
	8	10+
Hair Nets	132	49
Hairpins	132	50
Hair Spray (Aerosol)	167	87.1
Hair Waving; Permanent Waves	167	87.1
	132	7
Hair Wigs	132	53+
Lipstick Compositions	167	85
Lipstick Container	206	56
Lipstick Shaped Applier	132	88.7
Lotions	167	91
Make-up Base	167	85
Make-up Boxes	132	79+
Manicure Nippers	30	28
Manicure Shears	30	29

Manicuring Devices	132	73+
Mascara	167	85
Mouth Wash	167	93
Nail Enamel	167	85
Nail Enamel Remover	252	162+
	167	85
Nail Brush	15	167
Nail Buffer and File	132	76.4; 76.5
Nails, Artificial	132	73
Ointments	167	63
Perfume	167	94
Perfume Atomizer	239	355+
Powder	167	92
Powder Box and Applicator	132	82; 83
Powder Compacts	132	82; 83
Powder Puffs	15	564
Rouge	167	85
Shampoo	252	89+
Shampoo, Therapeutic	167	87
Shave Cream or Lotion	167	85
Shave Lather	252	90
Shave Soap	252	108+
Shaving Toilet Kits	132	80; 81
Skin Bleach	167	91
Skin Cosmetics and Toilet Preparations	167	90
Soap Bar	252	174
Soap Making	252	367+
Sunscreens, Sunburn Protecting Compositions	167	90
Talcum Powder	167	92
Toilet Kits	132	79+
Toilet Preparations	167	85
Tweezers	128	353

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12

Literature of Soaps and Synthetic Detergents

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Written late in 1966, this paper records the literature on soaps, surfactants, and synthetic detergents up to that time. Some discussion of specific publications precedes a bibliography of 300 items. The literature listed, and to some degree discussed, includes books, periodicals, abstracts, indexes, information services, patent publications, association publications, conference proceedings, and a few selected articles.

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Soap has been used as a cleansing agent since the second century A.D. We were well into the present century before much attention was directed to the cleansing properties of the surfactants and the detergent combinations prepared from them. Once launched, however, the new cleaning preparations gained rapidly in favor. By 1953 annual detergent sales in the United States had surpassed those of soap.

Since the principal use of both soaps and synthetic detergents is for cleansing, these materials, though dissimilar in composition, are usually discussed together. Early sources of information on cleansing agents, of course, deal primarily with soaps. Current sources generally serve for soap as well as detergents.

The literature treated here will include books, periodicals, abstracts, indexes, information services, patent publications, association publications, proceedings of international conferences, and a few selected articles from periodicals. Some discussion of particular publications in most of these categories precedes the more comprehensive listings in the bibliography at the end of this discussion.

Books

The book section of the bibliography is far from complete. It is intended, however, to include the titles most commonly or most usefully consulted in the field. Many of the works selected are out of print, but they can be found in large libraries.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Good, modern books on soap are scarce. In the early literature, however, there are books, such as those by Lewkowitsch, Lamborn, and Ellis, which may be considered classics today. These are listed under History and Background and are usually consulted currently only when a date must be established for an early process or when an illustration of an old piece of equipment is wanted. Under the same heading the treatises by Merklen and by Lawrence merit special notice as background publications.

Later soap books of perhaps special value are those by Hefter-Schönfeld, Ubbelohde-Heller, Thomssen and McCutcheon, and Davidsohn. Moreover, a number of books on colloids and surface chemistry, such as those by McBain, Alexander, and Osipow, are of great interest to soap chemists. Some of the best modern information on soap is found in the Kirk-Othmer Encyclopedia, in Encyclopaedia Britannica, and in appropriate sections of the books by Bailey, Dixon and Fisher, and Shreve. Both Elliott and Braun contain good reviews on metallic soaps.

Useful books concerned with synthetic detergents are those by Stüpel, Schwartz *et al.*, Lindner, McCutcheon, Shinoda, Moilliet *et al.*, Schönfeldt, and Gawalek. Good accounts also appear in the Kirk-Othmer Encyclopedia.

Finally the book list records a group of titles on related topics, such as raw materials, by-products, and other miscellaneous matter of interest to soap and detergent chemists. The works by Gilbert, Topchiev, Van Wazer, and Miner and Dalton are possibly of special interest. Also included are books on sequestering agents. Such compounds are important in the study of detergent builders.

Dictionaries, Glossaries, Handbooks

Attention is drawn to the *Detergents and Emulsifiers Annual,* listing detergents by tradenames with information on each. McCutcheon's card service, "Synthetic Detergents File," supplies similar information at shorter intervals. The volumes by Zimmerman and Lavine, the dictionary by Rose and Rose, and the Technical Manuals of the AATCC also are means of locating surfactants and detergents by tradename. The works by Römpp and by Sisley are especially helpful for finding foreign products by tradename.

Analysis, Testing, and Standards

For the analytical chemist working with soaps and detergents useful guides are the annually revised loose-leaf collection of the American Oil Chemists' Society, the ASTM Standards, the English translation of Hummel, and the volume by Rosen and Goldsmith.

Kirk and Stüpel report studies on the action of soaps and detergents on the skin (listed in the book section).

The U.S. General Services Administration and the U.S. Department of Defense are sources of most of the specifications formulated for soaps and detergents.

Periodicals

The listing of periodicals in the bibliography has, with few exceptions, been limited to those dealing specifically with the subject under consideration. Many other periodicals in the fields of the various branches of chemistry, as well as in the fields of bacteriology, biology, chemical engineering, home economics, laundering, medicine (especially dermatology and toxicology), packaging, and water pollution, are also of continuing interest to the chemist working with soaps and detergents. Such publications are just too numerous to list.

Chemical and Engineering News, Industrial and Engineering Chemistry, and *Oil, Paint and Drug Reporter* have been included because of their importance in supplying general, industrial, and price information, respectively. In addition to those periodicals obviously pertinent by title, as *Detergent Age* and *Soap and Chemical Specialties,* a few periodicals giving good coverage should be noted. These are *Fette, Seifen, Anstrichmittel, Journal of the American Oil Chemists' Society,* and *Tenside.* One journal with an especially pertinent title has been omitted in the listing. It is the *Journal of Detergents,* published briefly and irregularly in the past by L. and J. Zakarias in Bristol, England. Copies have been difficult to obtain.

Abstracts, Indexes, and Information Services

Most of the major abstracting and indexing publications in science, technology, and business are useful at one time or another in searching for information on soaps and detergents. For this reason the listing of these publications in the bibliography has been generous. Even so, additional titles could well have been included.

The Clearinghouse for Federal Scientific and Technical Information (U.S. Department of Commerce) is the supplier of numerous PB, AD, and other reports with applications in the soap and detergent field. Lists of these reports are available from this agency. Abstracts of the reports appear in *U.S. Government Research and Development Reports.* The Clearinghouse's *Government-Wide Index* also provides means for locating pertinent reports.

Another Clearinghouse publication worthy of special mention is *Technical Translations.* Originated by the Special Libraries Association, it was a semimonthly record of translations, contributed by workers in science and industry. In 1967 it ceased publication and was superseded by *Translations Register-Index.*

As a general listing of publications, the *Monthly Catalog of U.S. Government Documents* is occasionally fruitful in producing titles of documents relevant to soaps and detergents. In addition, useful bulletins on laundering and cleaning can be requested from the U.S. Department of Agriculture, Office of Information, and from some of the related State Experiment Stations.

Special attention should be directed to *Chemical Abstracts,* section 46 (Surface-Active Agents and Detergents) since 1967. From 1963-66 such abstracts appeared in section 53, in 1962 in section 42, and earlier in section 27.

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Also worthy of note is the *Annual Review of the Literature on Fats, Oils, and Detergents,* appearing each year in the *Journal of the American Oil Chemists' Society,* as well as the monthly abstract section in that journal.

The *Reports on the Progress of Applied Chemistry* include good annual reviews on soaps and detergents.

For quick location of quite current information, *Chemical Titles, Applied Science and Technology Index, Business Periodicals Index,* and *Readers' Guide to Periodical Literature* are useful.

Patent Publications

The patent literature of soaps, surfactants, and detergents is extensive. The official patent journals of various countries are the basic sources of information on patents. Since titles and publishers of these official publications are recorded in the front section of the 1961 "List of Periodicals" abstracted by *Chemical Abstracts,* the journals were not entered in the listing of patent publications here. The one exception is the *Official Gazette of the U.S. Patent Office,* which deserves special mention.

Descriptions of patents on soaps, detergents, and related topics in the *Official Gazette* fall largely in various subclasses of Class 252 (Compositions), Class 260 (Chemistry, Carbon Compounds), and Class 8 (Bleaching and Dyeing, etc.). It should be noted, however, that patents on these subjects may also be found in other classifications, depending on subject emphasis.

In addition to the official journals, there are a number of secondary sources of patent information available. For instance, some of the usual abstracting and indexing publications already mentioned include patents in the fields they cover. Other special compilations and services are described below.

The *Uniterm Index to Chemical Patents* is useful for its modern-type subject index to U.S. patents in the field of chemistry. Publication has been continuous since 1950, and the years 1946–1949 are covered by an expanded title index.

The lengthy titles of the large compilations by Interdex Corp., and by Rowman and Littlefield are sufficiently descriptive of their usefulness to the patent searcher.

For certain foreign patents the Derwent services provide helpful current-awareness tools and search aids.

Moser-Verlag, of Garmisch-Partenkirchen in West Germany, has issued a number of reviews of patents on subjects relating to soaps and detergents. Examples of these are the compilations by Manneck.

Finally the books by Möllering *et al.* and Müller *et al.* are well-indexed sources of abstracts of earlier U.S. and foreign patents. The treatises by Weber and Martina and by Ühlein, listed under Books, should also be noted here as sources of patent abstracts.

Economics and Statistics

Useful information on soaps and detergents is found in publications issued by various governments and states. The Bureau of the Census of the U.S.

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Department of Commerce, the U.S. Department of Agriculture, and the U.S. Tariff Commission supply much of the statistical information on these products and their raw materials. A report series of interest from a foreign government is that issued periodically by the British Ministry of Housing and Local Government on the problem of detergents in water pollution.

Association Publications

Domestic associations concerned in part or entirely with the field of soap and detergents are, in alphabetical order, the American Association of Textile Chemists and Colorists (AATCC), the American Chemical Society (ACS), the American Institute of Chemical Engineers (AIChE), the American Oil Chemists' Society (AOCS), the American Society for Testing and Materials (ASTM), the American Standards Association (ASA), the Association of Official Analytical Chemists (AOAC), the Chemical Specialties Manufacturers Association (CSMA), the Manufacturing Chemists' Association (MCA), and the Soap and Detergent Association (SDA). Appropriate publications of these organizations are listed in the bibliography by their titles under suitable headings.

The annual Technical Manuals of AATCC were mentioned previously for their useful alphabetical lists of tradenames of surfactants with accompanying names of manufacturers. In addition, the manuals contain other helpful information, such as description of methods of evaluating wetting agents and description of washing tests.

The many journals and other publications of the ACS carry much information for workers in soaps and detergents. Attention here is called only to the annual "Facts and Figures" issue of *Chemical and Engineering News,* which includes statistics of the soap and detergent industry.

Among numerous useful publications of the AIChE, the monograph by Marshall on spray drying is of particular interest (listed under Books).

All AOCS publications are excellent sources of information on soaps and detergents, particularly the "Official and Tentative Methods," the *Annual Review of the Literature of Fats, Oils, and Detergents,* and the *Journal.* To these must be added the annual *Lectures of the Short Course,* usually published in the *Journal of AOCS,* as well as in reprint form. The lectures are reviews of particular areas of oil, fat, soap, and detergent chemistry.

Both ASTM and ASA supply standards on soaps. In Part 22 of the annual *Standards,* ASTM also publishes methods for testing soaps and detergents and provides a good set of current definitions of terms used in the soap and detergent industry.

In both its *Journal* and its book on "Official Methods of Analysis," the AOAC contributes considerably to the analytical chemistry of oils and fats.

The published proceedings of the mid-year and annual meetings of the CSMA include many articles of interest to soap and detergent chemists. Papers in the Detergent and Cleaning Compounds Division are particularly important. CSMA also provides its members with occasional booklets and bulletins.

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The "Chemical Safety Data Sheets" of MCA discuss hazards and proper methods of handling of some of the raw materials used in the manufacture of soaps and detergents.

SDA compiles statistics of the industry, releases papers delivered at annual meetings, and supplies members with miscellaneous literature. Especially useful as current-awareness tools are the *Periodical and Literature Digest for Soap and Detergent Executives* and the alternately appearing *Technical and Materials News Supplement.* These bulletins summarize current literature of interest to the particular readers served.

Selected Articles

The scope of this paper could have been profitably enlarged to include references to many important individual articles in the periodical literature. Time and space do not permit the addition of more than a few examples of such articles. Those recorded in the Bibliography may be regarded as landmarks in the progress of the soap and detergent field.

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Patents

Class 252	*Compositions*
89	Detergents (for use on solid materials)
90	Packages or heterogeneous arrangements
91	Impregnated or coated with detergents
92	Separate soap containing and non-soap zones
93	Wrapped or encased soaps
94	With chemical bleachant, oxidant, or reductant
95	Oxidant containing
96	Soap (water-soluble fatty acid or rosin) containing
97	Water-soluble inorganic B, Si, or P compound containing
98	NH_3, amine, or nitrogen base compound containing (except proteins)
99	Water-soluble inorganic B, Si, or P compound containing
100	Acidic
101	HNO_3 or aqua regia containing
102	NH_3, amine, or nitrogen base compound containing (except proteins)
103	Alkaline
104	Solvent (physical or chemical) containing
105	Reductant containing
106	Antiseptic, insecticide, or biocide containing
107	Soap (water soluble fatty acid or rosin) containing
108	Soap (water-soluble fatty acid or rosin) containing
109	Water-soluble inorganic B, Si, or P compound containing
110	NH_3, amine, or nitrogen base compound containing (except proteins)
111	Physical non-water solvent containing
112	Water insoluble abradant, wax or filler containing
113	Water-insoluble abradant, wax or filler containing
114	Physical non-water solvent containing
115	Water-insoluble abradant, wax or filler containing
116	Water-insoluble abradant, wax or filler containing
117	NH_3, amine, or nitrogen base compound containing (except proteins)
118	Physical non-water solvent containing
119	Water-insoluble abradant, wax or filler containing
120	Water-insoluble abradant, wax or filler containing
121	Organic sulpho-compound containing
122	Physical non-water solvent containing
123	Water-insoluble abradant, wax or filler containing
124	Organic and inorganic type
125	Organic type
126	Hydrocarbon or halohydrocarbon containing
127	Non-hydrocarbon non-soap organic compound containing
128	Water-insoluble abradant, wax or filler containing
129	Organic and inorganic type
130	Organic type
131	Inorganic type
132	With other organic, plant, or animal matter or compound
133	With inorganic compound or element (except alkali-metal hydroxides and carbonates and water)
134	Shapes or structures
135	Water-soluble inorganic B, Si or P compound containing
136	Acidic
137	NH_3, amine or nitrogen base compound containing (except proteins)
138	Organic sulpho-compound containing
139	Physical non-water solvent containing
140	Water-insoluble abradant, wax or filler containing
141	Water-soluble cyanides or cyanates containing
142	Acidic
143	Physical non-water solvent containing
144	Water-insoluble abradant, wax or filler containing
145	Water-insoluble abradant, wax or filler containing
146	With corrosion inhibitants
147	Compounds of elements other than C, H, O, N, S, Cl, Na, and K containing

148 Organic nitrogen compound containing
149 Thio organic compound containing
150 Thiazole nucleus containing
151 Organic sulphur compound containing
152 NH_3, amine or nitrogen base compound containing (except proteins)
153 Physical non-water solvent containing
154 Water-insoluble abradant, wax or filler containing
155 Water-insoluble abradant, wax or filler containing
156 Alkaline
157 Gas-generative
158 Physical non-water solvent containing
159 Water-insoluble abradant, wax or filler containing
160 Water-insoluble abradant, wax or filler containing
161 Organic sulpho-compound containing
162 Physical or chemical non-water solvent containing
163 Abradant, wax, cellulose ester, inorganic solid or filler containing
164 With oxygen organic compounds
165 With organic compounds of other than C, H, and O
166 With hydrocarbon solvents
167 With hydrocarbon solvents
168 Wax or cellulose-ester and abradant, inorganic solid or other filler containing
169 Wax or cellulose-ester containing
170 Oxygen organic compound containing
171 Organic compounds of other than C, H, and O containing
172 Non-hydrocarbon substances containing
173 Aqueous
174 Shapes or structures
175 Water-Softening or Purifying or Scale-Inhibiting Agents
176 Packages or heterogeneous arrangements
177 Antiseptic, germicide or biocide containing
Colloids
351 Wetting, emulsifying, dispersing or stabilizing agents
352 Organic and inorganic agents containing (except water)
353 Organic sulphoxy compound containing
354 Protein or carboxylic compound containing
355 Organic amine, amide or N-base containing
356 Protein or carboxylic compound containing
357 Organic amine, amide, or N-base containing
367 Soaps (Alkali-Metal Salts of Water-Insoluble Fatty or Rosin Acids)
368 Products
369 Including saponification
370 With subsequent operations
371 Apparatus only

Patents of interest may also appear in Class 260, Chemistry, Carbon Compounds (subclasses 105, 413, 503+, 606.5, 686), in Class 8, Bleaching and Dyeing, and elsewhere.

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13

Literature of Waxes and Polishes

E. H. McMULLEN

S. C. Johnson & Son, Inc., Racine, Wis.

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Although waxes are abundant in nature and have been used by man from early times, there is no clear-cut literature of this field. Except for two books on waxes in general and a few on specific waxes, the major access to this literature is through Chemical Abstracts. *A broad spectrum of books and periodicals is encountered in scanning* Chemical Abstracts *for references on wax. Sources of basic formulas for various types of polishes are given. The use of emulsion polymers in the newer self-polishing floor waxes has brought a new group of periodicals into the wax chemist's library. A bibliography of books and periodicals useful to this field is included.*

Wax is as old as man. The Egyptians in 4200 B.C. found numerous and varied uses for beeswax. For example, they used it to preserve mummies: the wrappings which encased the corpse were first dipped in a wax solution, and wax was used in sealing the coffin. The sculptured portrait of the deceased, which decorated the cover of the coffin, was often modeled in wax and painted with pigmented beeswax. This process of mixing pigments with beeswax and applying it with a heated spatula was later called "encaustic." The Egyptians are also known to have made square wax writing tablets that could be rubbed down and reused. Several tablets were often fastened together with fiber; these wax tablets were the forerunners of modern books.

Wax is the term originally applied to the material now known as beeswax. Chemically, it is defined as an ester of a long chain fatty acid and a long chain alcohol. In actual use, however, it has taken on a broader significance and is used to include materials which have waxy physical characteristics even though they may not be waxes from the chemical standpoint.

This discussion is limited to non-petroleum waxes of natural origin. Even so, the technical literature is abundant but scattered through a broad spectrum of books and periodicals. The bibliography will list the more important of these.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Books

The best book on the general subject of waxes and polishes is "The Chemistry and Technology of Waxes" by A. H. Warth. In the author's words "this book was prepared to provide a ready reference work for chemists and industrialists who require a knowledge of waxes in their line of endeavor, and for those students and technicians who may wish to extend their background in a field with which they are not familiar." Most of the waxes which have been described in the literature are included in this book. Also included are applications and uses of the waxes in various industrial applications.

Bennett's "Industrial Waxes" presents a comprehensive survey of all the types of waxes found in industry. He discusses sources, preparation, properties and uses. Earlier works by Bennett are listed but are not as highly regarded as "Industrial Waxes." His "Chemical Formulary Series" lists many formulas for polishes and other wax-containing products. Most of these should be considered as a guide to a chemist rather than the formula of an ideal product.

Davidsohn's "Polishes and Cleaning Materials" is a guide to the understanding of principles essential to the manufacturer and the chemist active in the field of polishes and cleaning materials. It discusses the theory of emulsions and polishes as well as their manufacture. Another publication of interest, although not strictly a book, will be described briefly. "Vom Wachs" was issued to the trade in several parts by Farbwerke Hoechst AG. It is a beautifully illustrated, including many pictures in color, history of wax and the use of wax in the arts as well as industry in general.

"The Encyclopedia of Chemical Technology" edited by Kirk and Othmer contains informative articles on waxes and polishes. Wool wax is more completely covered in Truter's "Wool Wax" than any other type of wax in a single book, although Root's "Beeswax" and Carvalho's "Ensaios sobre a Carnaubeira" do a fair job for beeswax and carnauba wax respectively. The latter's chief fault is that much work on the composition of carnauba wax has been carried out since its publication, and this portion of the book is out-of-date. Some of this later work is still unpublished.

Ivanovszky's "Wachs-Enzyklopädie" and Ludecke's "Taschenbuch für die Wachsindustrie" round out the books of value. Most others are only of historical interest. Two of these deserve mention here, however, although their primary value is in the related field of oils and fats. They are "Chemical Technology of Oils, Fats and Waxes" by Lewkowitsch and Hilditch's "Industrial Chemistry of the Fats and Waxes."

Scientific Journals

There is no publication devoted exclusively to the field of waxes, and through the years papers on this subject can be found in a wide variety of journals. A cursory glance at the bibliographies in Warth's book and Bennett's "Industrial Waxes" shows references in familiar journals throughout the world. Included are *Journal of the American Chemical Society, Industrial and Engineering Chemistry, Journal of the Chemical Society, Journal of Science of Food and Agriculture (Abstract Section), Australian Journal of Chemistry, Berichte,* *Annalen, Recueil des Travaux Chimiques, Helvetica Chimica Acta, Gazzetta Chimica Italiana, Journal of the Agricultural Chemical Society of Japan,* and *Journal of the Russian Physical Chemistry Society.*

In the U.S. in recent years most articles on the chemistry of waxes may be found in the *Journal of the American Oil Chemists' Society,* and those on the application or use of waxes and polishes in *Soap and Chemical Specialties.* Many of these papers and some not printed elsewhere may also be found in the *Proceedings of the Chemical Specialties Manufacturers' Association. Aerosol Age* should be examined for technical information on pressurized polishes. Foreign journals which frequently carry articles on waxes include *Fette Seifen Anstrichmittel* and *Seifen-Ole-Fette-Wachse. Oil, Paint and Drug Reporter* has current market information on waxes.

At the current time, polymers are being used extensively in the manufacture of polishes. Thus many of the journals on emulsions and polymers are useful. These include the *Journal of Polymer Science, Journal of Colloid Science, Journal of Physical Chemistry, Kolloid Zeitschrift, Journal of Russian Polymer Science,* and others of this nature. It hardly needs to be pointed out that these journals do not give information on polishes as such but are extremely valuable in helping the chemist develop intermediates for use in these systems.

Patents

The world's patent literature has many patents on refining, purification and uses of waxes. The best access to this area is *Chemical Abstracts.* U.S. patents can be found in the classes and sub-classes listed in the bibliography.

In summary, information pertaining to waxes and polishes is abundant but scattered throughout the literature. The most important single source, not only for the information it contains but also for its bibliography, is Warth's "The Chemistry and Technology of Waxes."

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Chemical Abstracts Sections

Year	*Section*
1912	27. Fats, Fatty Oils, & Soaps
1961	27. Fats, Fatty Oils, Waxes, & Detergents
1962	41. Fats & Waxes
1963	54. Fats & Waxes
1967	45. Fats & Waxes

Patents

Title	*Class*	*Sub-Classes*
Coating or Plastic Compositions	106	10, 31, 38.25, 38.8, 83, 134, 145, 152, 156, 160, 201, 207, 212, 216, 229, 230, 231, 245, 268, 270, 271, 272
Coating: Processes and miscellaneous Products	117	158, 168
Chemistry, Carbon Compounds	260	28, 398 through 428.5

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14

The Literature of Synthetic Dyes

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In more than 100 years the synthetic dye industry has developed an extensive and valuable literature. A measure of the more important periods can be correlated with the dates of discovery for 3300 commercial dyes. The searcher must know the searchable quantities and the inherent difficulties in the commercial, trivial, and systematic nomenclature as well as the main classification systems. Sources such as special indexes, PB reports, reference works, abstracts, and patents are particularly important. Through Chemical Titles *the leading journals can be determined. A compilation of recent books and pertinent journals is given in the accompanying bibliography.*

We know that the dye industry is over a century old, but how old is its literature? Perhaps an answer may be gleaned by examining the most important dyes that have been or are now manufactured. About 2300 of the 3300 dyes of known structure covered in the second edition of the "Colour Index" have their dates of discovery listed. More dyes were discovered between 1890 and 1899 than in any other decade, and before the turn of the century almost one-half of the dyes in the index were known. Furthermore, since the 1930's and up to about the middle of the 1950's only a little more than 10% of these dyes were developed. With the increased competition in recent years and with the development of specialized dyes for new fibers, there has probably been an appreciable upturn in dye discoveries, though much smaller than in the fabulous 1890's. The most important contemporary dyes are, for the most part, of ancient vintage. We may logically conclude that the dye industry and probably its original literature is old and has been published in German. Basic sources, then, will have to include much in the old German journals, patents, and books. It is also likely that dye intermediates followed a similar historical development.

In discussing the sources which best serve the purposes of information retrieval in the field of dyes, we are limited to material related to the chemistry of dyes and less to their application. Several authors (3, 9) and "The Chemistry

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

of Synthetic Dyes and Pigments," edited by H. A. Lubs, have published valuable and comprehensive bibliographies of the chemistry and application of dyes and related materials. Therefore, this discussion concentrates on the qualitative aspects of some important examples drawn from the large mass of older sources as well as the more recently available information.

Searchable Quantities

The first step in retrieving information is to designate searchable quantities. For dye intermediates a wide variety of aromatic organic compounds running the range of types such as benzene, naphthalene, anthracene, and higher polycyclic derivatives as well as a host of heterocyclic materials are included. Obviously the nomenclature will vary accordingly, and to this must be added the further complication of many common names, trivial names, and foreign designations.

Fortunately there are ways of "decoding" these products. Thus, these trivial names are nicely related to chemical names in Chapter 13 of "The Chemistry of Synthetic Dyes and Pigments." A bibliography of other dictionaries of trivial names is also included. In Volume 3 of the "Colour Index" there are an empirical formula index, through which a *Chemical Abstracts (CA)* name and alternate systematic and trivial names may be found, and a valuable intermediate index, where the *CA* names of most dye intermediates are listed with their structures, molecular weights, and melting points. Many trivial and systematic names are cross-indexed. The indexes of *CA* are also extensively cross-indexed.

The dyes themselves are often much more complicated than the intermediates from which they are derived. Some dyes are mixtures while others, such as aniline and sulfur colors, are still of unknown structure. Almost all of them have a multiplicity of trade names, since many dye manufacturers make and market the same dyes. Classical, trivial, systematic, former I.G. Farbenindustrie and "Colour Index" names and numbers are known. Some *CA* names are useful but these are often unwieldy because of the complicated structures involved.

Searchable quantities in these cases may be any or all of these names, and it is important to determine all the synonymous designations. This can be done by inspecting *CA*, Patterson's "Ring Index," and the "Glossary of Trade Names" used by the I.G. (*8*). A lexicon of trivial names of organic compounds to be published by the Synthetic Organic Chemicals Manufacturing Association (SOCMA) and *CA* may shed more light on this situation. Fortunately, correlation of all trade names with structure (when known) and an application name and number are possible through the "Colour Index." Starting with the indexes of *CA* Vol. 56 all dyes were indexed by both chemical and "Colour Index" names.

Searching is often done according to the classification of dyes on an application or chemical basis. Many methods of classification have been proposed, and though they all suffer from certain defects and overlap to a great extent,

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the systems employed in the "Colour Index" are perhaps the most popular. The classes set up there are well defined, and each is preceded by a comprehensive explanation.

Indexes

Published jointly by the American Association of Textile Chemists and Colorists and the Society of Dyers and Colourists (England) the "Colour Index" is probably the most important reference work for the majority of chemists in the dye field. In its four volumes and 4856 pages the structures of about 3290 dyes and a great many intermediates are given. For each dye this work provides information on all trade names; a special "Colour Index" (CI) name related to its application; a CI number to identify its structure as well as syntheses or methods of manufacture; literature references; cross references to older dye indexes such as the "Colour Index," 1st edition, or Schultz's "Farbstofftabellen;" application and chemical properties; uses, and tests.

The "Colour Index" also include articles on the history, development, and uniqueness of each class of dyes as well as extensive bibliographies. The designations utilized find wide application, as evidenced by their use in both *Chemical Abstracts* and the U. S. Tariff Report. Small supplements have been published at quarterly intervals, and a 1124-page supplement was issued in 1963.

The annual "Technical Manual and Yearbook" of the American Association of Textile Chemists and Colorists is a useful supplement to the "Colour Index." It gives the trade names of American dyes and their CI names and numbers. In addition, latest test methods are reported, and a valuable bibliography of current periodical and book literature indexed by subject and author is included.

PB Reports

Many reports and documents were obtained from Germany after World War II which were later published by the Publication Board (PB) of the Office of Technical Services whose name has since been changed to Clearinghouse for Federal Scientific and Technical Information. These reports are composed of over one-quarter million documents, a large portion of which are related to chemistry. Many of these were obtained by the American FIAT (Field Information Agency Technical) and British BIOS (British Intelligence Objectives Subcommittee) groups.

The voluminous reports from the dye industry, captured between 1945 and 1947, contain valuable data on industrial processes of dyes and intermediates including engineering and research and development information. Because these reports were taken from the whole I.G. Farbenindustrie complex and covered many years of German preeminence in the field, they may be considered primary, comprehensive sources.

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Unfortunately their wealth of information is inadequately indexed and difficult to search. However, correlation indexes for the PB numbers of all BIOS and FIAT reports are available, as are page-by-page indexes for which broad subject classifications are given. A good list of the important PB reports on dyes and intermediates can be found in Chapter 14 of "The Chemistry of Synthetic Dyes and Pigments." The "Bibliography of Indexes to German Chemical Products" including the I.G. Farbenindustrie Index Cards (*1*) may prove valuable. Most of the names used are the I.G. names and may be found in the "Colour Index." Many books and reference works such as the "Colour Index," "Encyclopedia of Chemical Technology," and "The Chemistry of Synthetic Dyes and Pigments," as well as patents and journal articles, give citations to the PB reports. Frequently dye manufacturers' libraries where this information is constantly searched have developed their own extensive formula and subject indexes.

Reference Works

The best known reference work in organic chemistry is, of course, "Beilstein's Handbuch der Organischen Chemie." It is also one of the most important sources for information on the chemistry and properties of dyes and intermediates. However, its 35-year time lag limits its usefulness, especially for the small number of dyes and intermediates which have been described in the interim. Thus, the original fourth edition covered all organic compounds up to 1910, its first supplement extended this to 1919, and the second supplement increased the coverage through 1929. A third supplement will cover the literature through 1949, but as yet no books on aromatic compounds have been issued.

Besides gleaning its information from the world's literature, Beilstein gives many references to the original German patents along with their volume and page locations in Friedländer (*6*). Though this work is elaborately indexed and not readily handled (up to 4877 possible classes), the subject and formula indexes are complete. Even complicated dyes may be found readily either by using the formula index or by searching under their I.G. Farbenindustrie trade names in the subject index.

Another reference work of value is "Elsevier's Encyclopaedia of Organic Chemistry." This work offers the searcher the advantages of an English text and literature coverage through 1940. On the other hand, it is much less extensive than Beilstein and covers only a few parts of the field of organic chemistry. In Volume 12 there are 5700 pages on bicyclic compounds including many naphthalene intermediates as well as azo dyes derived from them. The patent coverage, however, is not thorough, especially for volumes published before 1951. Volume 13 covers much of the information from the journals on tricyclic condensed ring compounds, including many important anthraquinone dyes and intermediates. Volume 14, for which there are four supplements, covers tetracyclic and greater ring compounds and includes some patent references to carboxylic vat dyes and intermediates.

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Abstracts

Abstracts are among the important sources in searching the dye literature, the foremost being *Chemical Abstracts (CA).* Up to 1962 Section 25 contained the specific information on dyes and textiles, but these categories have now been separated. Thus, in 1962 dyes were covered in section 44 and textiles in section 48. In 1963 these sections were redesignated as 46 and 47, respectively.

CA's remarkable indexes list dyes in various ways, including classical names, systematic names, "Colour Index" names, and I.G. Farbenindustrie names such as Indanthrene Red FBB or Celliton Fast Pink 4BN. In the 1962 index of *CA*, Vol. 56, the "Colour Index" names are a regular entry. Cross-indexing is extensive, and the formula index is complete.

The German *Chemisches Zentralblatt* is probably a much better source of literature and patents than *CA* for the earlier years, especially before *CA* was started in 1907. Subject indexing began in 1889 on a semiannual basis while annual formula indexing began in 1925. Other standard abstracts sources in English, German, and French are also useful. The literature of organic chemistry has been continuously abstracted since 1875. There are many fine discussions on using abstracts such as those in Crane, Patterson, and Marr's book (*2*).

Special abstracts are produced by some of the larger European companies in the dye industry. Thus, there are companies whose extensive information departments regularly publish abstracts of patents and/or journals relating to their special interests. A fine example of such a publication is Farbenfabriken Bayer's, *Fortschrittesbericht uber neue Veröffentlichungen auf dem Gebiete der reine und angewandten Chemie* (*4*). The section of particular value is Gruppe E, Organische Farbstoffe, as well as Gruppe C.

Other sources of special abstracts are some of the dye and dye application journals. The abstracts of both papers and patents under the heading, "IV. Raw Materials; Intermediates; Colouring Matters," in the monthly *Journal of the Society of Dyers and Colourists* are especially valuable. Those appearing in the *American Dyestuff Reporter* patent abstracts are usually related to dye application and textiles.

Patents

According to Crane, Patterson, and Marr (*2*), "patents are the major sources of information regarding technological advances in chemistry." This is especially true for the dye field. Indeed, Venkataraman states in his book that "the literature of dyestuffs is largely in patents." Despite the academician's merited contempt for the unscientific aspects of patented information, they nevertheless represent a primary source of information on new and useful work. In searching the literature of dyes, patents frequently become the only available sources.

First in this field are the old German patents. For this reason the collection of German patents begun by Paul Friedländer, entitled the "Fortschritte der Teerfarbenfabrikation und Verwandte Industriezweige" (*6*), which covers the years between 1877 and 1938 in 26 volumes, is the single most valuable source. The first year it covers coincides with the advent of the German patent system. Few if any prior patents by German companies would exist before this date. The collection carries the full text of each patent and contains subject, patent, and numerical indexes for each volume. Subject indexes are organized by classes of dyes in each volume, and a small review of the advances during the period covered by that volume is given. However, the indexes in each volume are sketchy and limited to such an extent that one patent expert has described Friedländer as "a monumental example of inadequate indexing." The saving grace is its accurate numerical patent index as well as the citation of corresponding foreign patents.

Throughout its long history of publication, its content has changed with the shift of emphasis from dyes to other synthetic organic materials. More recent coverage of German patents is found for the war years, 1939-1945, and 1950-1 in Bayer and Stoetzer's "Deutsche Reichspatents aus dem Gebiete der Organischen Chemie."

Most industrialized countries have some sort of patent laws, and for more recent work the more important patent systems must be consulted. Table I lists the classes under which dyes may be found. Several countries utilize the German patent system, and the Russians do indeed issue patents. In general Belgian patents are good starting points for a patent search since they are issued quickly (as photostats) without prior consideration of novelty. The quality of the classification system varies considerably, with the French being considered at the low end of the scale and the Swiss and German at the top. Reference to the patent literature may be obtained from the sources already discussed as well as from journals and other patents. Recently, the international patent classification number, I.P.C. C 09 b, was assigned to dyes and intermediates.

The classification system given in Table II for U.S. dye patents shows that 78% fall into Class 260—the chemistry of carbon compounds—but only 20% of these are found in readily observable subclasses while the remaining 58% are scattered among many different subclasses. About 17% of the patents are in Class 8, and the only prominent subclass here is 55, accounting for only 6% of the dye patents. These statistics (based on patents issued during the first 25 weeks of 1962) illustrate some of the problems arising from the complicated U.S. classification system. Thus, a strict chemical type may be readily searched, but the dye usage is usually not apparent. Since 1947 the references submitted in filing each U.S. patent have been included at the end of the published patent.

Journals

The only remaining primary source is the journal literature in which format most scientists prefer to find their information. Citations to this literature are, of course, found in abstracts, patents, reference books, and in the journals themselves. A relatively new source is the keyword in context, *Chem-*

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Table I. Foreign Patent Classifications for Dyes (5)

Patent System	*Classification*
British	Group IV
French	Class XIV-2
German	Class 22
Austrian	Class 22
Danish	Class 22
Dutch	Class 22
Norwegian	Class 22
Swedish	Class 22
Russian	Classes 8 and 22
Swiss	Class G-37

ical Titles, which was begun in 1961. Here articles of potential interest may be quickly located in the period of time between publication of the original article and its abstracts.

To determine and rank these contemporary journals which are important sources of articles on dyes all the issues from 6 months of *Chemical Titles* during 1962 were examined for the key words, dye, dyes, dyeing, dyed, and dyestuffs. A total of 166 papers of interest to workers in the synthesis of dyes were found. Obviously there are many other articles of interest which do not have these keywords in their titles, but the tables of contents of many of these journals show that a majority of the important articles were covered.

The countries with the greater numbers of leading journals are in the order: Russia > Japan > Germany > England > India > Czechoslovakia = Poland = Switzerland. American journals are conspicuously absent, but some mention should at least be made of the *American Dyestuff Reporter*.

Older lists of journals have been compiled by Mellon (*7*) and also by Crane, Patterson, and Marr (*2*), although these are based on the old *CA* Section 25 classification which includes textiles as well. Neither list is as comprehensive as the one provided in the bibliography.

Table II. U. S. Patent Classes and Subclasses for Dyes

		% of Dyes[a]
Class 260	Chemistry, Carbon Compounds (78% of total)	
Subclass		
314.5	Phthalocyanine	9
145	Heavy metal or Al containing azo compounds	6
279	Heterocyclic 6 membered compounds with one *N* atom-acridines	5
Class 8	Bleaching and Dyeing; Fluid Treatment and Chemical Modification of Textiles and Fibers (17% of total)	
Subclass		
55	Bleaching and dyeing artificial fibers	6

[a] Based on patents issued during first 25 weeks of 1962.

Books

Books are always welcome sources because their authors have already searched certain areas of the literature for us. Unfortunately, they contain little primary or original material and are quickly outdated. The list of books in the bibliography was developed to update the comprehensive list in Crosland and Cady (3). Therefore, it is limited mainly to works on the chemistry of dyes appearing after 1952. Sources were the reviews in the *Journal of the Society of Dyers and Colourists, Chemical Abstracts* (Section 25), and Library of Congress cards.

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Angewandte Chemie (Formerly *Zeitschrift fuer Angewandte Chemie*), Verlag Chemie, GmbH, Pappelallee 3, Weinheim/Bergstr., Germany, bimonthly.

Canadian Textile Journal, Canadian Textile Journal Publishing Co., Ltd., 4795 St. Catherine St., W., Montreal 6, Quebec, Canada, fortnightly.

Chemical Abstracts, American Chemical Society, 1155 Sixteenth St., Washington, D. C. 20036, weekly:

Year	*Section*
1912	25. Dyes & Textile Chemistry
1961	25. Dyes & Textiles
1962	44. Dyes
1963	46. Dyes, Fluorescent Brightening Agents, & Photosensitizers
1967	40. Dyes, Fluorescent Brightening Agents, & Photosensitizers

Chemicky Prumysl (*Chemical Industry*) (Formerly *Chemicky Obzor*) (Printed in Czech with Eng. and Russ. summ.), Statni Nakladatelstvi Technicke Literatury, 51 Spalena, Prague 1, Czech., monthly.

Chemisches Zentralblatt, Akademie-Verlag, GmbH, Leipziger Str. 3-4,, Berlin W8, Germany, weekly.

Colourage, 126-A Dhruvadi, Off Dr. Nariman Rd., Bombay 28, India, monthly.

Dyes and Chemicals Technical Bulletin (Du Pont) (Formerly *Technical Bulletin*), E. I. du Pont de Nemours & Co., Inc., Organic Chemical Dept., Dyes and Chemicals Division, Wilmington, Del. 19898, irregular.

Dyestuffs, National Aniline Division, Allied Chemical & Dye Corp., 40 Rector St., New York, N. Y. 10006, quarterly.

Helvetica Chimica Acta (Printed in Fr. and Ger.), Verlag Helvetica Chimica Acta, Basel 7, Switzerland, about 7 nos. a yr.

International Dyer, Heywood & Co., Ltd., Russell St., Drury Lane, London WC2, England, biweekly.

Journal of the Indian Chemical Society, 92 Acharya Prafulla Chandra Road, Calcutta 9, India, monthly.

Journal of the Society of Dyers and Colourists, Dean House, 19 Piccadilly, Bradford 1, Yorkshire, England, monthly.

Kogyo Kagaku Zasshi (*Journal of the Chemical Society of Japan, Industrial Chemistry Section*) (Printed in Japan, with Eng. sum.), Secy., Chemical Society of Japan, No. 5, 1-Chome, Surugadai Kanda, Chiyoda-ku, Tokyo, Japan, monthly.

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Teintex, Revue generale des matieres colorantes, 60 rue de Richelieu, Paris 2^e, France, monthly.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch014

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Yuki Gosei Kagaku Kyokai Shi (*Journal of the Society of Organic Synthetic Chemistry, Japan*) (Printed in Japan. with Eng. sum.) The Society of Organic Synthetic Chemistry, Japan, Echiso-Bldg., 1-1 chome, Hongo, Bunkyo-ku, Tokyo, Japan, monthly.
Zeitschrift für Analytische Chemie, Fresenius', Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf (West) Germany, irregular.
Zhurnal Obshchei Khimii (*Journal of General Chemistry*) (Formerly *Chemical part of the Journal of the Russian Physical-Chemical Society and Series A of Khimicheskii Zhurnal*), Izdatel'stvo Akademii Nauk SSSR, Podsosenskii per., 21, Moscow B-62, USSR, monthly.
Zhurnal Prikladnoi Khimii (*Journal of Applied Chemistry*), same address as above, monthly. Translations of *Zhurnal Obshchei Khimii* and *Zhurnal Prikladnoi Khimii* available from The Consultants Bureau, 227 West 17th St., New York, N. Y. 10011.

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15

The Literature of Textile Chemistry

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Searchers in the literature of textile chemistry should be familiar with literature sources on fundamental research, applications, developments, testing methods, economics, and general news of both the fiber-making and the textile-finishing industries. This paper presents a bibliography of sources grouped according to their relation to these various aspects of the fiber industry.

The developments since 1952 in the literature of textile chemistry are based on an expansion of knowledge through chemical research into the nature of the textile materials and the changes which they undergo. In 1952 the world textile fiber market stood at 75% cotton (19 billion pounds), 10% wool (2.6 billion pounds), 14% rayon and acetate (3.5 billion pounds), and about 1% noncellulosic synthetics (0.3 billion pounds). By 1964, although the wool portion of the market had remained nearly static at 9% (3.3 billion pounds), cotton had lost one-fifth of its market on a percentage basis and was down to 63% of the world fiber consumption (although its actual poundage increased to 25 billion pounds), while the artificial cellulosics had advanced to 19% (7.3 billion pounds) and the synthetic fibers had grown more than ten-fold to about 10% of the total market with an annual production of about 3.7 billion pounds (*12*). Such rapid growth represents a growth of the chemical industry, too, which is concerned with converting fiber into finished textile products. The largest U.S. chemical companies are also the large fiber producers. In fact, of the 16 largest fiber producers (almost all of them), only three produce fibers exclusively.

Literature Sources

The literature of textile chemistry reflects the great activity and vigorous growth of man-made fibers. Fourteen years ago at the symposium on the

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

literature of textile chemistry (*11*), some 210 references cited in four papers (*3, 4, 10, 14*) referred exclusively to man-made fibers. In the bibliography at the end of this paper, the natural fibers and the man-made fibers are about equally represented. The proportionately increasing reference to man-made fibers in the literature corresponds generally to the changing relative amounts of these fibers in the world markets.

There has been some increase in specificity of literature resources now available. This period has also seen the appearance of several entirely new services, some new and more specialized journals, and many new specialized books. As might be expected, some of the familiar earlier journals have either ceased publication or reflected new trends by changes in organization and name.

Most of the books listed in the bibliography are concerned with phases of textile chemistry that apply broadly to all classes of fibers. This approach corresponds closely to that of the textile fiber manufacturers (the chemical companies) as well. Technological attention is no longer confined to a single fiber by either company management or the research scientists, except possibly those of one-fiber trade organizations. Fiber blends are spun, woven, and finished as required for each end use. Dacron fiber is used in Dacron/wool blends; the nylons are used for the strength and toughness which they impart to formerly all-cellulosic constructions; rayon is experiencing an upsurge in the present markets partly because the new chemically modified high modulus rayons can better withstand the chemical stresses placed upon them during finishing with other fibers in blends. The fiber manufacturers have followed suit to meet the demands of their customers—of the 16 fiber producers previously referred to, only five devote their entire fiber manufacturing facilities to fibers of a single chemical class (*12*). Even so, it is safe to assume that the research departments of these five manufacturers do not share the same limitations.

Another development is the tremendous acceptance of wash-and-wear finishes and "sensitized" finishes which enable the fabric to accept "permanent" pressing. While there are many routes to these finishes, by far the largest requires chemical treatment of the cloth. Cross-linking agents from formaldehyde to bishydroxyethyl sulfone are consumed by the tens of millions of pounds. The chemical research behind these finishes falls properly to the purely chemical science journals as well as to those oriented toward technology. The over-all effect has been a decided integration of much textile literature into the more general journals. The reciprocal change in editorial content has also taken place among the technology-oriented periodicals.

Books

All of the books included in the bibliography are not written from the point of view of the chemist and do not cover all the available literature on man-made fibers; however, they contain information of immediate application in textile chemistry. Some of them on textile finishing are purely technological, but the presentation of time, temperature, and concentration relations for chemical treatments leads to their inclusion. Excellent reviews of most of the

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch015

books listed have appeared in the *Textile Research Journal,* the *Journal of the Textile Institute, The Textile Institute and Industry,* the *American Dyestuff Reporter,* and the *Journal of the Society of Dyers and Colourists.* These reviews may be consulted for an indication of the contents of each book. The following discussion is intended to provide only the broadest overview.

General. The importance of the encyclopedic publications generally has been understated by reviewers. Even the most experienced chemist can consult profitably the "Kirk-Othmer Encyclopedia of Chemical Technology" for a wealth of information on textile chemistry. Furthermore, this unrivaled library of information for the whole chemical industry is now being updated. Fourteen volumes of the second edition have already appeared. The companion, "Encyclopedia of Polymer Science and Technology," is equally rich in its scope of textile chemistry and more basically oriented.

Written from a somewhat more technological view, but of equally great value to the chemist, is Jack Press's magnificent single volume entitled "Man-Made Textile Encyclopedia." Limited as its title indicates, it is now 10 years old, but it wears its age exceptionally well.

The wealth of data contained in Harris' "Handbook of Textile Fibers," together with the complete references to the original sources, serves almost as a critical review of all the textile test methods and data published before 1955.

Von Bergen's excellent "Wool Handbook," the ageless "Matthews' Textile Fibers," by Mauersberger, and Ward's "Chemistry and Chemical Technology of Cotton" cover processing technology to perfection. Hamby's new third edition of "The American Cotton Handbook" is invaluable. Kaswell's latest revision of the "Handbook of Industrial Textiles" represents a complete rewriting of this standard text and strengthens its peerless position.

Dyeing and Finishing. The increased specialization in books on textile science and technology are exemplified by extended monographs on such rigidly limited subjects as "The Dyeing and Finishing of Half-Hose and Other Footwear" by Datyner and "Warp Sizing" by Seydel. "Surface-Active Agents and Detergents" by Schwartz et al. and Martin and Fulton's "Drycleaning Technology and Theory" are valuable books in this area. Much information may be gained from the booklets and pamphlets issued frequently by each major producer of fibers and textile finishing agents. While reference is usually made only to the issuing company's fibers or dyestuffs, the information given represents an especially valuable summary of current knowledge (and the results of costly research) in the technology of the processes described.

Properties and Test Methods. Committee D-13 of the American Society of Testing and Materials is occasionally overlooked as a composite author. Their annual "ASTM Standards on Textile Materials" is a bible of test methods. If a textile chemist is to apply his knowledge, the D-13 tests must be used; comparisons must be made with existing materials, and the ASTM Standards stand ready to give precise consultation and instructions on what tests to run and how to interpret the results.

The AATCC "Technical Manual" (*1*) contains a complete description of many textile test methods which are more applications-oriented than those of the ASTM. A bibliography of books on textile chemistry is included.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch015

Abstracts, Indexes, and Information Services

For the most part the earlier standard services, such as the *Journal of the Textile Institute: Abstracts; Engineering Index; Applied Science and Technology Index* (formerly *Industrial Arts Index*), which deals with processing; and *Business Periodicals Index,* which covers general topics; *Textile Technology Digest,* and *Chemical Abstracts,* remain as major general indexes and standard sources of abstracts.

U.S. Government Research and Deveopment Reports (formerly *Bibliography of Technical Reports*) lists unclassified reports of government-sponsored research and development released by the Department of Defense and other federal agencies. A keyword index is also issued to facilitate reference. Also important are *Scientific and Technical Aerospace Reports,* a semimonthly abstract journal with indexes from National Aeronautics and Space Administration, and *Technical Abstract Bulletin,* which announces the availability of research, development, test, and evaluation documents acquired by the Defense Documentation Center of the Department of Defense. These abstract services are the keys to U. S. Government research.

The specialized abstract service, *Natural and Synthetic Fibers,* published by Interscience since 1944, ceased publication at the end of 1962. The *Natural and Synthetic Fibers Abstracts Service,* operated by Information for Industry, Inc., provided monthly or yearly accumulations with indexes through 1966 when it, too, ceased. The *Textile Technology Digest,* an abstract journal issued monthly by the Institute of Textile Technology, Charlottesville, Va., has continued; it is supplemented now by a computerized retrieval system.

The American Association of Textile Chemists and Colorists (AATCC) provides information or refers requests to members or member organizations for reply. It maintains a card index of textile dyes and finishes.

Patents. Several important sources for current and retrospective searching of patents have become available within the past few years. A number of countries publish official bulletins to announce the issuance of patents or the laying open to public inspection of patent applications. Some of these contain a typical claim or patent abridgment. Others contain only titles, or announce the laying open for inspection only in the patent office (Belgium). Obviously, patent copies can be obtained quickly in some instances (U.S. and Canada), but in other countries, distance, foreign language, delayed publication, and other problems create barriers to prompt access to patent publications.

Starting in 1953, the Derwent Information Service has been offering a continuously expanding current awareness and translation service for patents. All of these are printed in English and are listed in the bibliography under Abstracting and Indexing and Information Services. *British Patents Abstracts* issues abstracts for all British patents; *German Patents Abstracts* are based on the full patent specification; *Soviet Inventions Illustrated* are translated claims of Russian patent specifications in three sections. Partial coverage is also given in *Russian Patents Report* (translations of specifications relating to chemicals and allied subjects); *French Patent Abstracts* (summaries from abridgments

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch015

appearing in the French *Official Bulletin,* issued three weeks after the *Official Bulletin;* alternate weekly issues also include abstracts of South African and Indian patents); *Japanese Patents Report* (includes abstracts of patents of particular interest to the chemical and textile fields as well as others); and *Belgian Patents Reports* (abstracts from applications available for public inspection; this service is particularly valuable since the abstracts are issued about four weeks after the patents are available to the public; for Belgium this is some three to six months after filing—a fact that makes Belgian patents well recognized as a source of early information on new inventions). Specialized patent services, such as abstract journals of foreign patents for specialized fields are also published by Derwent.

An important index to a portion of United States patents is the *Uniterm Index to Chemical Patents,* published since 1955. Coverage is restricted to chemical and related patents. The Index comprises both a "dual dictionary" look-up device and a separate book of copies of the *Official Gazette* claims for patents covered. The *Uniterm Index* now covers the period from January 1, 1950 to date. An index to expanded titles of U. S. chemical patents for the period 1946–1949 was introduced in 1962. Also, starting in 1963, a magnetic tape search edition of the 1950–1961 *Index* was introduced. This is designed specifically for searching on the IBM-1401 computer but is adaptable to other equipment. This magnetic tape file covers approximately 100,000 patents. It will be updated annually to include the patents of the preceding year as covered in the *Uniterm Index.*

Another important publication is the *National Catalog of Patents* covering U. S. patents from 1790 and continuing.

Periodicals

Publications reporting basic research have changed little in the past decade. The abstract services mentioned earlier, particularly *Chemical Abstracts,* usually will provide an adequate route to worldwide literature. The *Journal of Applied Polymer Science* first appeared in 1959 as a separate publication of the applications and technology portion of the *Journal of Polymer Science,* which now deals exclusively with basic and fundamental polymers studies. A new quarterly, *Polymer,* dealing with the chemistry, physics, and technology of high polymers, was introduced by Butterworth & Co. in 1960. In 1968 a new ACS journal, *Macromolecules,* commenced publications.

Textile Organon is the most valuable source of price, production, and consumption statistics (*12*). This periodical has published a valuable cumulative volume of textile statistics running through 1950. It also publishes an annual directory of man-made fiber producers, which describes fiber types from producers throughout the world and defines the trademarks for synthetic fiber types.

Several of the familiar earlier titles dealing with applied and general information have changed since 1952. The former *British Rayon & Silk Journal* is now *Man-Made Fibers. Reyon, Zellwolle, und Chemie-fasern* has become

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch015

Chemiefasern. Skinner's Silk & Rayon Record is now *Skinner's Record of the Man-Made Fibres Industry,* effective with the October 1962 issue. *Textile Age* has been discontinued.

The outstanding development in the periodical literature is the appearance of a great many publications from Eastern Europe, principally the Soviet Union. The Soviet textile industry is woefully inadequate, both in natural and man-made fibers but its research in the chemistry of textile fibers of all classes, plus the synthesis and examination of new polymers, is unsurpassed both in originality and in execution (*2, 9*). The highly developed Soviet scientific periodical system, as described by Hoseh (*7*), is comparable with that of the Western world and nearly as voluminous. Conveniently, those periodicals which are of greatest interest to textile chemists are available in English translation in their entirety as are selected portions of the Soviet abstract periodical *Referativnyi Zhurnal Khimia*. The titles of these journals (*see* the Periodicals list appended) indicate their scope, and their contents compare closely with the similarly titled U. S. publications.

Five Japanese journals of interest to the textile chemist are available in English (*8*). Many of these have been available for some time but have remained relatively unknown. One British and six new U. S. periodicals listed in the bibliography should not be overlooked.

Many thorough reviews have also appeared during the past decade. As pointed out by Friedman (*5*), in the *Bibliography of Reviews in Chemistry* during 1958–1961, there appeared 373 abstracts of review papers on dyes and textiles. This represents 9.8% of the 3803 abstracts of all papers appearing in the same section of *Chemical Abstracts* (*CA*) for the same four years. Among the 33 sections in the *CA* classification arrangement which prevailed during the survey period, dyes and textiles ranked sixth in percent of review articles. This ranking fits Friedman's generalization that applied areas of chemical literature tend to consist of a larger proportion of review articles than theoretical areas. The chemist who seeks information in textile chemistry should not overlook the many excellent reviews listed in the newly divided sections of the *Chemical Abstracts;* all appropriate sections are listed in the bibliography.

Periodic Reviews. The annual *Review of Textile Progress* continues, with the latest volumes appearing about 18 months following the end of the year covered. They are a highly useful source for both fundamental and applied phases of textile processing, chemistry, dyeing, and polymer chemistry of interest to the textile chemist. Generally, broad coverage of the world's technical literature, including patents, is provided by this source. These publications are highly useful for introducing the specialist into new fields and also serve as an excellent annual over-all view for those who find use for this approach.

Another annual review series by the same publisher, begun in 1961, is *Advances in Textile Processing.*

The annual reviews of the *Textile Research Journal,* to which, at one time, an entire month's issue was devoted, were discontinued with the 1954 edition.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch015

Summary

The literature of textile chemistry has not only greatly enlarged during the past decade, but it has been greatly enriched. The closer union of the textile and chemical industry has introduced considerable fusion of the viewpoints of the scientists involved, and this has been reflected in their publications, both as periodicals and books. The chemist and the technologist also have profited from this fusion in the past decade—they cannot do less in the future.

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch015

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1961	23. Cellulose, Lignin, Paper, and Other Wood Products
	25. Dyes and Textiles
	31. Synthetic Resins and Plastics
1962	44. Dyes
	47. Plastics
	48. Textiles
	49. Cellulose, Lignin, Paper, and Other Wood Products
1963-1966	45. Synthetic High Polymers
	47. Textiles
	48. Plastics Technology
	51. Cellulose, Lignin, Paper, and Other Wood Products
1967	35. Synthetic High Polymers
	36. Plastics Manufacture and Processing
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	39. Textiles
	43. Cellulose, Lignin, Paper, and Other Wood Products

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Patent Classes and Subclasses

Subject	*Class: Subclass*
Additive treatments	117: 138.5; 167: 37, 38.5-38.7, 84; 252: 8.1
Artificial fiber compositions	106: 164-169, 138-148; 260: 217-218
Bleaching	8: 101-111; 204: 133
Chemical modification	8: 115.5-132, 112
Cleaning and laundering	8: 137-142
Coating and laminating	260: 2+, 726+; 167: 84
Creaseproofing and softening	117: 139.4, 139.5
Dyeing	8: 1-94; 204: 134
Fiber spinning	264: 178-208; 161: 172-180
Synthetic resin compositions	260: 823-901, 46.5-94.9, 239.3, 465.9, 475, 485, 326

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16

The Literature of Textile Utilization and Evaluation

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This guide describes references in the areas of general abstract series; trends in textile utilization, including end use distribution and examples of surveys of possible changes in consumption if price or properties change in certain ways; evaluation of physical serviceability; and evaluations of comfort or of physical properties related to comfort and suitability for use as clothing.

Since the uses of textiles seldom depend directly on their chemical properties or involve their chemistry, most of the literature on uses and evaluation for use falls outside the chemical literature and outside the fields of *Chemical Abstracts*. Two abstract series useful for the nonchemical literature of textiles are *Textile Technology Digest* and the Abstracts section of *Journal of the Textile Institute*.

The governing factors in the uses of textiles are mechanical and structural properties, durability, requirements for care during use, cost and the decorative or fashion possibilities. In the industrial uses of textiles rather definite engineering requirements can be set. In the household or clothing realms, however, we are much more influenced by the aesthetic or historical aspects of use. In all fields we are in the midst of not only the normal changes of taste or fashion, and economic competition, but also a more deeply seated set of changes arising from the availability of new fibers and of new understanding of the basis for both traditional and new uses of fibers.

In surveying the literature of textile utilization and evaluation we shall first look at general trends: economic statistics and prices, and indicators of current trends; then at evaluation of physical serviceability, the classic field of textile testing and specifications. Then we shall look at the much less precise field of assessment of "comfort," and the more scientific measurement of performance of the man-clothing system in extremes of environment.

In Literature of Chemical Technology; Smith, J.;
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General Trends of Textile Utilization

The one best source of statistics on the production of different fibers, in different countries, and the utilization of fibers in various end uses, is the *Textile Organon*. This monthly publication in the course of the year makes a very complete survey and presents the current information in comparison with the trends shown in previous years.

The United States Government and United Nations statistical services covering wider fields but including various parts of the textile field are listed in the bibliography. Current information on fiber prices is available for man-made fibers in *Modern Textiles Magazine* and *Wool Record and Textile World.* Trade trends for wool are also covered in *World Wool Digest.*

Utilization of fibers in 101 relatively specific end use categories is reviewed annually in *Textile Organon*. Consumption of cotton, in relation to all fibers, in 110 end use categories, many of which are further subdivided, is published annually as "Cotton Counts Its Customers" by the Utilization Research Division of the National Cotton Council of America.

If one is concerned with the economic worth of a possible new development, for example, of a new finish, or the improvement of a fiber or type of yarn, it is valuable to form an idea of the possible market before deciding to undertake the expensive steps of commercial scale development and promotion. Surveys for this purpose must be tailored to particular situations, but published models which will repay study are the "Cotton Quality Studies," prepared by the staff members of the National Cotton Council of America and published in the *Textile Research Journal*. These studies attempt to pick out the particular end uses in which a change of characteristics is desired, and to estimate the effect of varied levels of increased cost.

Evaluation for Physical Serviceability

Test Methods. The physical description of fabric construction and the testing of physical properties, which are the foundations of estimates of serviceability, are kept up to date for this country by the annual compilation of "ASTM Standards on Textile Materials" and the "Technical Manual of AATCC." These compilations, plus the federal specification "Textile Test Methods," constitute the major sources of information on test methods approved by responsible large scale technical groups in the U. S. However, these methods do not give the background of their development and interpretation. The best source for that is active participation in the committees of the technical societies. Papers published in *American Dyestuff Reporter* for the American Association of Textile Chemists and Colorists (AATCC), or in *Materials Research and Standards* for the American Society for Testing and Materials (ASTM), or in *Textile Research Journal* are sometimes sources for the "why" behind methods. The tentative Textile Standards published from time to time in the *Journal of the Textile Institute* are usually accompanied by a critical article. Textile standards which have been reviewed and adopted are available from the British Standards Institution in "Methods of Test for Textiles." General discussions of textile testing are given by Skinkle's book and

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Garner's manual. Other countries also have national standards groups, and there is an International Standards Organization (ISO) for which the American Standards Association (ASA) is the U.S. representative.

Specifications and Levels of Performance. Textile test methods which are "American Standard" originate with the AATCC or ASTM, but the American Standards Association goes further in adopting levels of test performance as well as test methods. The ASA has published "American Standard Minimum Requirements for Textile Fabrics, L22," sponsored by the National Retail Merchants Association and "American Standard Minimum Performance Requirements for Institutional Textiles, L24," sponsored by the American Hotel Association. There are also "Proposed Voluntary End-Use Serviceability Standards," of the Textile Distributors Institute. These specifications cover fabrics for large blocks of end usage. Government specifications cover particular fabrics and particular end use items, in varying degrees of generality. Finding the government specification in a particular area requires searching both the general civilian purpose Federal Specifications and the military specifications. A useful start is through "U.S. Government Specifications Directory," published by the Small Business Administration. "Summary of Specification Requirements for Military Fabrics," Textile Series Report No. 102 is a concise and often sufficiently complete guide in the military fabric area.

Only a fraction of the textile goods bought or sold each year would meet the requirements of any of these specifications. The general problem of acceptability for consumer use is regulated by market forces of price, promotion, and consumer experience. At least two publications attempt to assess serviceability and value in the general market. In the U. S., *Consumer Reports,* and in England, *Which,* attempt to indicate quality levels. More valuable than the particular product recommendations, in many cases, are the discussions of the differences between classes of goods offered for the same use, which can guide selection on a basis of structure or function rather than price.

The analysis of fabric defects, as recognized in manufacturing, is partly covered in Goldberg's book, "Fabric Defects." The meeting programs and publications of the American Society for Quality Control and its textile and apparel section cover a very wide range, usually from the producer or large scale purchaser's point of view.

Other sources of comparative studies or guides to serviceability are contained in publications of the U. S. Department of Agriculture and Department of Commerce. Currently available titles under "Consumers" and "Textiles" are listed in "Home Economics," Price List 11, and "Commerce," Price List 62, available from the Government Printing Office. An annual compilation "Titles of Completed Theses in Home Economics . . ." is available from the Agricultural Research Service, U. S. Department of Agriculture. [For 1964 and 1965, the thesis compilation is available from the American Home Economics Association, 1600 Twentieth St., N.W., Washington, D. C. 20009.]

In the military field, two series of publications should be noted. One is the annual "Bibliography of Publications and Technical Papers" of the Quartermaster Research and Engineering Center at Natick, Mass. The other is the

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Textile Series Reports, of which the most recent is No. 125. The first 104 titles are listed in a bibliography available from the Clearinghouse for Federal Scientific and Technical Information. The latest number, however, is 125 and current information should be secured from the U. S. Army Laboratory, Natick, Mass. Two other bibliographies that cover related areas are "Textile Fabrics and Related Research" and "Textile Fibers," also available from the Clearinghouse. It is worth noting that the same material is in many cases available as journal articles or books, which can be located by search under the names of the authors.

In addition, various trade associations have standards and specification programs. One of general interest in the washability certification program of the American Laundry Association. A directory of trade associations is available in libraries as "Directory of National Associations of Business Men, 1961," compiled by the Business and Defense Services Administration, Department of Commerce.

Evaluation for Comfort

Definition of Comfort. One of the chief subjects of discussion about natural fibers and the fabrics made from them, and fabrics made from the newer fibers, is comfort. The outcome has been a realization that comfort is more difficult to define than might be thought, and one needs an improved understanding, if not of comfort itself, of how fibers work together to give the characteristics of the fabric as a whole.

Studies of heating and air conditioning, and of physiology, have combined to recognize comfort, in terms of room conditions, as a statistical concept, as summarized in the trade publication "Heating, Ventilating, Air-Conditioning Guide." Similarly in terms of measurements of the human body, such studies suggest as a base line the range of conditions in which heat balance is maintained by regulation of the circulation, without progressive cooling of the body and without increase of the body temperature or sweating. This is a rather narrow concept of comfort, directed mostly toward conditions of rest or light activity and does not take account of the wide capacity of the body to endure cold or hot conditions or adjust to the requirement of work. Because the ranges of comfort are difficult to define or measure, much of the comparative work on clothing has endeavored to measure the difference due to clothing under conditions of cold, heat, or exercise.

The leading work in comparing different types of fibers with comfort is that of Wetmore and co-workers (*1, 10*) and Galbraith and co-workers (*9, 17*). All agree on the difficulties of finding objective measurements of the thermal aspects of comfort in relation to fiber composition of fabrics.

A great deal of work has been done by physiologists on methods of measuring stress in man and on application of such measurements to the combined influence of extreme environments and various forms of clothing. A good foundation in this area is given in the book "Physiology of Heat Regulation." The continuation to the present can be traced in the bibliographies on Aviation Medicine or Aerospace Medicine from 1952 onward, edited by A. J. Jacobius of the Library of Congress. These annotated bibliographies have been issued through 1963 and continued with the "continuing" bibliography series starting in 1964. Current physiological studies on clothing can be found in the abstracts of current literature in *Aerospace Medicine* and in *Scientific and Technical Aerospace Reports.* [A more specialized listing of annotated references, "Aerospace Medicine and Biology," is published as NASA SP-7011. It has a continuing bibliography which includes clothing and protective clothing.] In addition to the relatively concentrated coverage of clothing studies in the monthly *Aerospace Medicine*, which is not limited to space suits, the *Index Medicus* is a guide to the whole area of medical and physiological literature in relation to clothing.

An effort to use subjective ratings of comfort to identify other factors than thermal effects has been reported by Mehrtens and McAlister (*13*).

Physical Studies Related to Fabric Comfort. In addition to whole man studies, isolated segments of the physical relations of fabric properties to comfort have been studied. Thermal transmission properties of fabrics are rather easily measured by various methods which have been reviewed by Morris (*15*), but are probably dwarfed in practical significance by questions of amount of air enclosed in garments, and the movement of this air with activity of the person, studied by Belding (*3*), or by the influence of wind which has been studied by Niven and others (*16*).

The surface character of fabrics, from the smoothness of filament fabrics to the hairiness of wool, and the degree of regularity of structure in the yarns, have been recognized by Hollies and others (*4, 5, 11*). The effect of fabric on moisture transfer and the combined flow of heat and water vapor through clothing are also factors in the physics of comfort (*8, 18, 19*).

One of the long-neglected areas related to comfort and to the "looks" or aesthetic acceptability of fabrics is the question of flexibility or stiffness, not only for bending, but also for drape and for shear within the plane of the fabric. Chu and others (*6*) have made advances in the study of drape, and Lindbergh, Behre, and others in Sweden (*2, 7, 12, 14*) have advanced our understanding of compression and shear within the plane of the fabric. It is likely that these more subtle properties of the fabric are the main components of our ideas of acceptability and comfort, rather than thermal relations.

Information Access and Retrieval

Since the preparation of this paper, two groups have been developing advanced information retrieval services, each based on a controlled vocabulary "thesaurus" and computerized information storage and retrieval. For the current state of development, inquire of: (1) Massachusetts Institute of Technology, Cambridge, Mass. 02139 (Prof. Stanley Backer); (2) Textile Information Center, Institute of Textile Technology, Charlottesville, Va. 22902 (Robert S. Merkel).

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U.S. Patent Classes and Subclasses

Apparel per se	2
Coating and printing	117
Coating and uniting	156
Coating and waterproofing	
compositions	106
rubber containing	260: 726+
synthetic resin containing	260: 2+
Fabric	
clothing: thermal and electric treatment	128: 379+
cloth: fireproof	117: 136+
coating processes: textiles chemical modification combined	8: 115.6
coating: textile operation combined	28: 74+
Making	28
Laminated	161
Medicated	167: 84
Preserving, disinfecting and sterilizing	
biocidal compositions	167: 38.5+
coating or impregnating	117: 138.5+
fireproofiing compositions	252: 8.1
Testing	73: 159
stress and strain of materials	73: 88+
Textiles	
testing	73: 159
woven	139: 383+
fiber preparation	19
fiber finishing	26
treating compositions	252
Woven	139: 383+
Waterproof	161

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17

The Literature of Cellulose, Pulp, and Paper

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The literature of cellulose, pulp, and paper includes articles relating to the various forms of cellulose (holocellulose, native fibers such as cotton, regenerated celluloses such as acetate and viscose rayons, dissolving-grade and paper pulps), chemical derivatives of cellulose, and wood, bast and bark components, such as hemicelluloses, pentosans, and lignins. These have been published in high-standard chemical or general science journals, applied science and industrial periodicals, major trade journals and institutional publications, as well as the better company magazines and house organs. Abstracting, indexing, and literature-survey services furnish condensed information. Other information can be found in books, bibliographies, and reviews.

In discussing the literature of cellulose, we have considered not only various forms of cellulose (holocellulose, native fibers such as cotton, regenerated celluloses such as acetate and viscose rayons, dissolving-grade and paper pulps) and chemical derivatives (esters, ethers) of cellulose, but also closely or distantly allied wood, bast, and bark components, notably hemicelluloses, pentosans, and lignins. Extraneous materials, such as mineral constituents, oils, fats, resins, tannins, and solvent-extractable plant components in general, have been disregarded as having no direct chemical connection with cellulose.

Journals

Journals devoted exclusively to articles on cellulose have appeared from time to time, but none has survived to now. *Cellulosechemie* was started in 1920 by Emil Heuser in Germany and ceased publication in 1944. Another German periodical, *Nitrocellulose*, containing mostly articles on cellulose nitrates, was published from 1930 to 1943 whereas the American journal, *Cellu-*

[1] Deceased.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

lose, lasted only for the year 1930. *Cellulose Industry,* the official journal of the Cellulose Institute in Tokyo, appeared monthly from 1925 until 1943, at which time it was followed by *Sen-i Gakkaishi (Journal of the Society of Fiber Science and Technology, Japan).*

Although several foreign journals carry the word cellulose or its equivalent in their title, such as the French *Papier, Carton et Cellulose,* the Italian *Cellulosa e Carta,* the Romanian *Celuloză si Hîrtie,* and the Czech *Papír a Celulosa,* the expressed connection of cellulose with paper suggests that it is better translated as pulp.

Because only one present journal is devoted exclusively to studies on cellulose and related materials, namely, *Cellulose Chemistry and Technology,* published by the Romanian Academy of Science (Vol. 1, 1967), authors have resorted to publishing such studies in high standard chemical or general science journals, such as the *Journal of the American Chemical Society, Chemische Berichte,* and *Nature,* or in reputable applied science and industrial periodicals, such as the *Journal of Applied Polymer Science, Chemistry & Industry (London),* and *Tappi.* In addition, major trade journals and institutional publications, such as *Pulp and Paper International and Paper Technology* (Journal of the Technical Section, British Paper and Board Makers' Association), as well as the better company magazines and house organs, may well be chosen for publishing research articles or new technical data on cellulose and cellulose derivatives. (The bibliography at the end of this article gives the most likely candidate journals for such articles.) In fact, technical information bulletins issued by various chemical companies, such as Dow, duPont, Eastman Kodak, and Hercules, are often excellent and sometimes the only sources of certain details on properties and applications of cellulose-based chemicals.

Hence, the choice of a periodical in which cellulose chemists and technologists may publish their findings depends on various factors—notably (a) the field in which the research was done (organic chemistry, biochemistry, physical chemistry, analytical chemistry), (b) the nature of the study (fundamental *vs.* applied, experimental *vs.* developmental), (c) the sponsoring organization or industry (paper, textile, wood, plastics, paint, graphic arts, or otherwise-oriented bodies), and (d) national, linguistic, local, and other customs and limitations. For these reasons, it is difficult to classify and analyze the many pertinent journals in the field. In the following discussion, we have arbitrarily adopted an industry-oriented classification and a geographic subdivision.

Cellulose in the form of pulp, paper, and paperboard has a literature all its own, although the high standard of many journals in this field attracts contributions from other cellulose-based industries as well. Thus, *Tappi,* which is probably the best known and most scientific paper journal published in the United States (prior to 1949 as the *Technical Association Papers*), carries not only articles on cellulose, hemicellulose, lignin, wood chemistry, pulp, and paper in its Advances in Science and Engineering Section, but also occasional contributions from the graphic arts, forest genetics, rayon, nonwoven textiles, and other fields. In addition, the Industry and Technology section of *Tappi* contains industry and personnel news, reports of meetings and committees, industrial

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standards and methods, and practical contributions on pulp and paper-mill operations.

Good American trade journals are *American Paper Industry, Paper Trade Journal, Pulp and Paper* (recently combined with *Paper Mill News*), and *Southern Pulp and Paper Manufacturer.*

In Canada, equivalent material is published in the *Pulp and Paper Magazine of Canada, Canadian Pulp and Paper Industry,* and *Technical Section Proceedings of the Canadian Pulp and Paper Association (CPPA).*

Journals analogous to *Tappi,* though far less comprehensive, exist in many countries—e.g., *ATCP* in Mexico, *ATIP Revue (Revue de l'Association Technique de l'Industrie Papetière)* in France, *Appita* in Australia-New Zealand, and in Japan the *Journal of the Japanese Technical Association of the Pulp and Paper Industry.* The *Bolletino della Sezione Italiana della TAPPI* (Italian Section of the European TAPPI) has been published since 1934 as part of the journal of *Industria della Carta.*

In Europe, the Scandinavian countries perform a large amount of work in the pulp, paper, and allied fields and, as a result, have several good journals. Of these, *Svensk Papperstidning* (Sweden), *Norsk Skogindustri* (formerly *Papir-Journalen,* Norway), and *Paperi ja Puu* (also known as *Papper och Trä* or *Paper and Timber,* Finland), deserve special mention, partly because all three carry original contributions in English or with good English summaries. *Finnish Paper and Timber* is an English language trade journal with statistical-economic information and descriptions of new or modernized paper mills. In addition, *Acta Chemica Scandinavica* contains frequent chemical studies, all in English, on cellulose, related saccharides, and other wood components.

Several foreign journals equivalent to *Tappi* and those having cellulose in their titles have been mentioned. Of these, *ATCP* contains English summaries of Spanish articles, and *Papier, Carton, et Cellulose* deserves special mention for its extensive English, German, and Spanish summaries. Other major overseas pulp and paper journals in which information on cellulose appears fairly regularly include the *Paper-Maker and British Paper Trade Journal* and the *World's Paper Trade Review* (both British); *Indian Pulp and Paper* (concerned mostly with indigenous cellulosic fiber sources); the West German *Das Papier* (with English and French summaries), *Der Papiermacher, Wochenblatt für Papierfabrikation,* and *Allgemeine Papier-Rundschau;* the East German *Zellstoff und Papier;* the French journals *La Papeterie* and *Techniques et Recherches Papetieres,* in addition to the aforementioned *ATIP Revue;* the Dutch *Papierwereld* (usually only one technical article per month); the Polish *Przeglad Papierniczy* (with English and Russian summaries); the Hungarian *Papíripar* (with German and Russian summaries); and the *Osterreichische Papier-Zeitung* and *Das Osterreichische Papier,* both Austrian.

Although *Bumazhnaya Promyshlennost (Paper Industry)* is the only Russian journal specifically devoted to paper, most fundamental and applied studies on cellulose in Russia appear in academic and institutional publications, depending on the discipline involved, as well as on regional raw materials. Some Russian journals containing several articles per year on cellulose and lignin include *Zhurnal Obshcheĭ Khimiĭ (Journal of General Chemistry), Zhurnal Prikladnoĭ Khimiĭ (Journal of Applied Chemistry), Kolloidnyi Zhurnal (Colloid Journal), Khimicheskie Volokna (Chemical Fibers), Vysokomolekulyarnie Soedineniya (High-Molecular Compounds),* and *Gidroliznaya i Lesokhimicheskaya Promyshlennost (Hydrolysis and Wood-Chemical Industry).*

Articles on cellulose oriented toward the textile industry appear in many good journals, notably the American *Textile Research Journal* and the *Journal of the Textile Institute* (Manchester, England). The *Bulletin de l'Institut Textile de France, Melliand Textilberichte* (West Germany), *Faserforschung und Textiltechnik* (East Germany), the *Bulletin of the Textile Research Institute of Japanese Government,* and *Sen-i Gakkaishi* (mentioned before), all carry English summaries. *Textil-Rundschau,* published in Switzerland, often contains pulp and papermaking articles as well.

Wood as a raw material for cellulose has its own characteristic literature. In North America, the *Forest Products Journal* (formerly *Journal of the Forest Products Research Society*), *Wood Science,* and the publications series of the U. S. Forest Service (including the Forest Products Research Laboratory in Madison, Wis.) and of the Canadian Department of Forestry are the most noteworthy, in addition to various journals devoted to forestry and forest operations.

Among foreign journals in this field, the following all carry English summaries: *Holzforschung* and *Holz als Roh- und Werkstoff* (both West German), *Holztechnologie* (East German), *Holzforschung und Holzverwertung* (Austrian), *Drevárský Výskum* (Czechoslovakian), the *Journal of the Japan Wood Research Society* (Mokuzai Gakkaishi), *Wood Research* (Bulletin of the Wood Research Institute, Kyoto University), the *Journal of the Hokkaido Forest Products Research Institute,* and the Norwegian *Norsk Skogindustri* mentioned earlier. Additional mention might be made of the British *Journal of the Institute of Wood Science* (irregular).

Although the number of general or special chemical periodicals in which information on cellulose and lignin can be found is too great to be listed even by name alone, those most likely to contain such articles are the *Journal of the American Chemical Society,* the *Journal of the Chemical Society* (London), the *Journal of Polymer Science, Helvetica Chimica Acta, Acta Chemica Scandinavica, Makromolekulare Chemie,* and, of course, the *Journal of Organic Chemistry.* The Austrian *Monatshefte für Chemie* is noteworthy for its occasional articles on lignin.

The literature searcher should not, of course, overlook news journals, such as *Chemical and Engineering News* and *Chemical Week,* as possible sources of preliminary and statistical-economic information on cellulose. The Bibliography lists journals which publish cellulose, pulp, and paper articles.

Abstracting and Indexing Services

Abstracting, indexing, and similar literature survey services which furnish condensed information on cellulose and allied materials can be divided into three groups:

(1) Journals devoted exclusively to one or more special fields in which

cellulose is dominant, notably the wood, paper, textile, plastics, packaging, and graphic arts industries.

(2) Periodicals covering all branches of chemistry and/or chemical technology, which regularly contain sections on cellulosic materials.

(3) Publications dealing with science and technology in general, including chemistry, in which information on cellulose appears sporadically or irregularly.

In addition to true abstract journals, which publish summaries, extracts, or annotated literature citations exclusively or as a major service, several related literature services, such as those forming part of a larger journal, will be included here. However, the minor literature survey sections of nearly all applied science and trade journals will not be discussed since they are usually neither indexed nor sufficiently organized to permit retroactive searches. Some of these are included in the bibliography.

Group I. The most comprehensive domestic abstract service devoted to wood, paper, and allied materials is the *Abstract Bulletin of The Institute of Paper Chemistry (A.B.I.P.C.).* This monthly bulletin was started in 1930 by The Institute of Paper Chemistry in Appleton, Wisc. It contains 10,000–12,000 abstracts of journal articles and patents per year, as well as reviews of books, pamphlets, and dissertations, covering the literature of cellulose, lignin, and related substances and all phases and problems of pulp and paper technology. It surveys close to 1000 journals directly and several hundred additional titles by using various checklists, other abstract publications, and loan or photocopying services. Author, subject, and numerical patent indexes are issued monthly and annually. Cumulative decennial indexes are available for Volumes 1–10 (1930–39) and 11–20 (1940–49). *A.B.I.P.C.* is distributed in Great Britain under a different cover design by PIRA, The Research Association for the Paper and Board, Printing and Packaging Industries, Leatherhead, Surrey. In addition, *A.B.I.P.C.* serves as a base of reference for other I.P.C. services, notably bibliographies, photocopies, and translations. Monthly and semiannual "Keyword Supplements" published since July 1966, serve as a basis for mechanized information retrieval.

Among other domestic abstract journals covering some aspects of cellulose, paper, and related technologies are *Abstract Review, National Paint, Varnish and Lacquer Association, Abstracts of Photographic Science and Engineering Literature, Graphic Arts Abstracts* (formerly *Lithographic Abstracts*), and *Textile Technology Digest.*

Although no foreign abstract service, to our knowledge, is comparable in scope and coverage to *A.B.I.P.C.*, several of them come close. One of these is *Auszüge aus der Literatur der Zellstoff- und Papiererzeugung und Celluloseverarbeitung,* published annually by the Verein Zellcheming (German Association of Pulp and Paper Chemists and Engineers), although it is actually a compilation of the 12 monthly abstracts sections from *Das Papier.* The French service *Feuillets Bibliographiques,* issued monthly by ATIP, gives only lists of references without annotations, whereas the Italian *Indicatore Cartotecnica* provides short abstracts, as does its sister service, *Indicatore Grafico,* both sponsored by the Ente Nazionale per la Cellulosa e per la Carta. The Russian *Ekspress-Informatsiya Tsellyulozne-Bumazhnaya Promyshlennost'* is one of several industry-oriented "express-information" services which gives condensed Russian versions of selected Western language paper technology articles rather than true abstracts. The former *Kenley Abstracts* (England) is now published by PIRA as *Paper and Board Abstracts.*

There are several foreign abstract journals in related fields, such as the two PATRA services, *Packaging Abstracts* and *Printing Abstracts;* the *Survey of Literature* of the British Metal Box Co. Ltd.; *Photographic Abstracts;* the British *Plastics Abstracts* (RAPRA); and the *Review of Current Literature on the Paint and Allied Industries.*

The French *Emballage Digest,* the British *Packaging News* and *Packaging Digest,* and similar service journals are coupon-type information request services, rather than true abstract publications.

Four services in Europe are published on filing cards—namely, the West German *FOGRA Literaturdienst,* the similar East German *Grafische Technik Literaturdienst,* the French *Cahiers de Documentation de la Recherche Graphique,* and the Czech *Přehled Literatury pro Poligrafický Průmysl.*

The *Shirley Institute Summary of Current Literature* is devoted to all phases of fiber and fabric technology, including cellulosics. It used to appear also, with certain modifications, as part of the *Journal of the Textile Institute* (Manchester), at first together with the *Proceedings,* later separately. Since the beginning of 1964, however, the *Shirley Institute Summary* is taken over without changes (in the interest of avoiding duplication of effort) as Section I of the Textile Institute's *Abstracts;* until the end of 1951, the *Abstracts* also appeared as part of the *Textile Research Journal.*

Among other elaborate abstracts sections appearing within recognized journals are the previously mentioned patent and journal-article abstracts in *Das Papier,* the excellent condensed translations of foreign articles in *Paper Technology,* the classified abstracts on textile and papermaking fibers in the *Journal of the Society of Dyers and Colourists,* and the *Documentation* section which appears in addition to the *Recherche* section in *Bulletin de l'Institut Textile de France.* Also worth mentioning is the *Graphic Arts Index,* a classified list without annotations of articles in the printing field, published as part of *Graphic Arts Progress* by the Rochester Institute of Technology's Graphic Arts Department.

Group II. Among general abstract journals covering all branches of pure and applied chemistry, *Chemical Abstracts (CA)* is undoubtedly of greatest importance to the cellulose and paper chemist. It covers over 10,000 journals in addition to domestic and foreign chemical patents and books and publishes now over 200,000 abstracts a year. The extensive annual and cumulative indexes (decennial up to 1962, pentennial thereafter) to authors, subjects, patent numbers, and chemical formulas make *CA* an indispensible tool for the literature searcher. Sections of particular interest to the cellulose chemist are given in the bibliography. Cross-references to abstracts in other sections and thorough indexing make it unlikely that any item of interest to the cellulose field is missed.

Although *British Abstracts* ceased publication in 1953, abstracts of applied chemical interest are now carried as a separate section in the *Journal of*

Applied Chemistry. In many industrial countries, the Documentation sections of several journals must be consulted for complete coverage of the chemical literature. Thus, at least three sources of chemical abstracts exist in France—namely, the *Bulletin de la Société Chimique de France* (pure chemistry), *Chimie et Industrie* (applied chemistry), and *Bulletin Analytique* (general chemistry and related sciences). Other countries have a centralized or nearly centralized service. Of these, *Chemisches Zentralblatt* is the oldest. It is still a good and reliable source of chemical information and a valuable tool for searching the early literature, especially of European origin, despite lagging indexes and economic restrictions. The chemist who can read Russian is, however, better off consulting the *Referativnyi Zhurnal Khimiya*, which started in 1953 and claims an impressive coverage equivalent to or exceeding that of *CA*. [Although figures of 700,000 abstracts from 16,000 journals have been quoted, these encompass some 2 dozen "Referativnyi Zhurnals" covering as many fields of science and technology, all published by the centralized Soviet Institute of Scientific Information, of which *Referativnyi Zhurnal Khimiya* is only one. The present authors estimate the combined coverage of this abstract journal and of *Referativnyi Zhurnal Biokhimicheskaya Khimiya* to be more like 130,000 abstracts per year from a little over 10,000 journals.]

Concerning the availability of Soviet literature in English and other western tongues, the formerly critical dearth of adequate translations has been greatly relieved. Scientists working in the field of cellulose and related materials need no longer worry about this problem since both the *Abstract Bulletin of The Institute of Paper Chemistry* and *Chemical Abstracts* carefully check *Referativnyi Zhurnal Khimiya* for articles possibly missed in their own coverage. Even though the original articles may not be available in this country, at least English versions of corresponding abstracts are provided.

On the other hand, ascertaining the existence and location of available translations is still a problem, even though the task now falls to the librarian or information specialist rather than the scientist. Some help along these lines is provided by the *Consolidated Translations Survey* (Central Intelligence Agency) and *Translations Register-Index* (Special Libraries Association). A list of translations available in the pulp and paper field can be obtained free from The Institute of Paper Chemistry's library.

Group III. Among abstract services covering the sciences and technology in general or in an interdisciplinary manner, *Physics Abstracts*, the *Engineering Index*, *Applied Science and Technology Index*, *Nuclear Science Abstracts*, *Analytical Abstracts*, the *Battelle Technical Review*, and many more are sufficiently known to dispense with detailed descriptions.

The *Australian Science Index* is one of the better known nationally oriented general science surveys in various countries. Many others can be found in the bibliography.

Biological Abstracts, in which some subsections deal with forestry and with cellulose-destroying organisms, is valuable to the cellulose researcher. Certain aspects of packaging and sanitation in the medical and biological literature are covered—e.g., by *Review of Applied Mycology* and *Index Medicus*. *Forestry Abstracts* is certainly pertinent to the genetic, physiological,

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and silvicultural aspects of cellulose, lignin, and hemicellulose biosynthesis. Similar material is also available on individual filing cards as *Centralized Title Service* (Commonwealth Forestry Bureaux, Oxford).

Some special technical and legal interests of various industries processing cellulose and related materials are reflected in such journals as *Corrosion Abstracts, Building Science Abstracts, Water Pollution Abstracts, APCA Abstracts* (Air Pollution Control Association), and *Nalco Abstracts of Current Articles on Water Treatment,* while the *Business Periodicals Index, Marketing Information Guide,* the U. S. *Index of Federal Specifications, Standards and Handbooks,* and the equivalent Canadian *Index of Specifications* are valuable to industrial executives seeking economic-statistical and merchandising information.

A significant number of bibliographic reference services cover special types of publications, notably patents, dissertations, books and pamphlets, government reports, and miscellaneous sources of information. This discussion would not be complete without mentioning some of these.

Among the various patent gazettes of industrial countries, the *Official Gazette* of the U. S. Patent Office, the *Canadian Patent Office Record,* the *Abridgments of Specifications [of British] Patents for Inventions* (supplementing the British *Official Journal of Patents*), the *Abrégés Descriptifs des Brevets d'Invention* (Bulletin Official de la Propriete Industrielle de France), and the Russian *Izobreteniya, Promyshlennye Obrazit, Tovarnye Znaki* publish either abstracts, summaries, or representative patent claims. The gazettes of many other countries, such as the German *Patentblatt,* however, publish only lists of patents granted and/or applied for, without abstracts or claims.

Complete specifications of all U. S. papermaking and related patents (*ca.* 2500 per year) are available on microcards from The Institute of Paper Chemistry. U. S., Canadian, British, German, French, and Russian patents on cellulose, lignin, etc., are covered completely in *A.B.I.P.C.,* and patents of other countries as far as they are discovered by perusing other abstract journals. *Chemical Abstracts,* of course, provides good coverage for chemical patents of all countries.

The special problem of obtaining information on new technical books is probably solved best by scanning appropriate checklists, such as the *Cumulative Book Index, New Technical Books* (a bimonthly list of additions to the New York Public Library), *Stechert-Hafner Book News, Pergamon Progress, Scholarly Books in America* (a quarterly bibliography of University Press publications), and the *Monthly List of European Books in Science and Technology* (Dekker en Nordemann, Amsterdam, Holland).

Summaries of U. S. doctoral theses are provided in *Dissertation Abstracts* (formerly *Microfilm Abstracts*), while *Masters Abstracts* covers M.S. and M.A. theses. Lists of doctoral dissertations can also be found in various technical-scientific journals. The Wilson Co. also compiles a yearly list, named *Doctoral Dissertations Accepted by American Universities,* on behalf of the Association of Research Libraries.

U. S. Government Research & Development Reports cover unrestricted project reports sponsored by the U. S. government, whereas special clearance is necessary to obtain classified reports indexed by Defense Documentation Cen-

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ter. Of similar value are the *Monthly Catalog of Canadian Government Publications* and the *Monthly Checklist of State Publications* (Library of Congress).

Information on scientific conferences and symposia sufficient for ordering their proceedings can be found in *World Meetings United States and Canada (TMIS),* the *World List of Future International Meetings* (Library of Congress) and in *Scientific Meetings* (Special Libraries Association). *Chemical and Engineering News* and other professional society journals also publish meeting calendars of current interest.

A fairly recent method of providing current-awareness services is the publication of KWIC (keyword in context) and KWOC (keyword out of context) indexes. The best known and well-established ones are those published biweekly by *Chemical Abstracts* as *Chemical Titles* and by *Biological Abstracts* as *B.A.S.I.C. Biological Abstracts* has gone so far as to substitute a cumulative version of *B.A.S.I.C.* for its conventional annual subject indexes. More orthodox current-awareness listings are provided by the British *Current Chemical Papers* and by the *East European Accessions List* and *Monthly List of Russian Accessions* of the Library of Congress.

Also among recent innovations in literature-survey services are *Contents in Advance,* an optically reduced collection of Tables of Contents of various journals in a given field, which appears before the publication date of the journals themselves, and the *Science Citation Index,* a guide to literature references cited by various authors in current journals. Both of these innovations were pioneered by the Institute for Scientific Information in Philadelphia. The Uniterm method of indexing, a specific form of coordinate indexing which is eminently suited to automated document retrieval, is the basis of the *Uniterm Index to Chemical Patents* published by Information for Industry, Inc. The bibliography lists abstracting and indexing services of interest to the cellulose chemist.

Books

The definitive or book literature of cellulose began around the turn of the century and developed slowly. Nonetheless, the number of pertinent books acquired since 1930 by the special library of The Institute of Paper Chemistry is estimated at between 10,000 and 15,000 (exclusive of bound periodicals). Not all of these titles deal with cellulose, but a significant part of this collection is devoted to pulp and paper and related areas. Hence, the list of books and monographs in the bibliography should be considered only as a central core of the definitive literature but makes no claim of complete coverage.

Outstanding among the early book literature are Cross and Bevan's, Hägglund's, and Schwalbe's contributions; slightly later classics include works by Faust, Freudenberg, and Heuser, to name only a few. Some of the early information on cellulose appeared in works on plant biochemistry and physiology, of which Czapek's "Biochemie der Pflanzen" is a good example. Similarly, cellulose is often included in books dealing with broader topics, such as wood chemistry, polysaccharides, carbohydrates, and polymers, or with special phases of chemistry, notably colloid science, plant analysis, and rheology.

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The most recent book on lignin is "The Chemistry of Lignin" by I. A. Pearl, published in 1967. B. L. Browning's "Methods of Wood Chemistry" in 2 volumes has just been published. The same author's "The Chemistry of Wood" appeared in 1963.

Apart from the standard commercial publishing houses, many professional and trade associations, as well as academic institutions and other organizations, publish monographs, special brochures, and the like, some of which deal with cellulose, wood, and related materials. Examples are various TAPPI monographs, U. S. Department of Agriculture handbooks, studies sponsored by the Food and Agriculture Organization of the United Nations, and some doctoral theses (notably European) published as books or pamphlets. Some special publications may have serial titles, such as the *Yale University School of Forestry Bulletin.* In addition, the proceedings of various special symposia, such as those sponsored by EUCEPA, TAPPI, CPPA, and other international and national societies and science academies, are often published in book form and may be considered as part of the definitive literature. A typical recent example is the Symposium on Topical Questions on the Chemistry and Technology of Cellulose, held in Jassy, Romania, September, 1961, which was published largely in German, as a book, by the Romanian Academy of Science.

Bibliographies and Reviews

Bibliographies on the chemistry of cellulose and its derivatives are found mostly in books, periodicals, and reviews in the form of literature cited or bibliographic footnotes (mostly unannotated). Examples of comprehensive reviews of the literature on cellulose and cellulose derivatives are given in the bibliography. These references contain unannotated bibliographies as footnotes or literature cited.

The number of annotated bibliographies which have been prepared in the pulp and paper field far exceeds the total in the field of cellulose and its derivatives. A selected number of bibliographies and review articles in this broader category has been included in the bibliography.

The most important bibliographic publication on papermaking is the "Bibliography of Papermaking and U. S. Patents" initiated by C. J. West and continued by Jack Weiner at The Institute of Paper Chemistry under the sponsorship of TAPPI. This annual bibliography cites for each periodical reference, the author, title, journal with volume and page numbers, and year. Most references also contain at least one abstract journal citation. The papers cited are classified according to subject matter. The patent section is classified according to the classification of the U. S. Patent Office. Author, subject, and patent indexes are included. Beginning with the 1966 issue, foreign patents have been included.

The Institute of Paper Chemistry also publishes its own "Bibliographic Series" (now numbering well over 200 separate bibliographies). A price list of those available can be obtained upon request from the Institute Editor.

Up to March, 1964, *Tappi* had published a bibliographic list of U. S. patents dealing with pulp and paper on a quarterly basis. This annotated list is no longer published. The Institute also prepares a yearly review "Progress in Alkaline Pulping" for publication in *Tappi.*

The *Reports on the Progress of Applied Chemistry,* issued annually by the Society of Chemical Industry, contain chapters (reviews) on pulp and paper. Similar annual review serials in which advances in cellulose chemistry or related disciplines appear include *Advances in Carbohydrate Chemistry, Advances in Textile Processing, Review of Textile Progress,* and *Annual Reports on the Progress of Chemistry.* Some TAPPI Monographs contain reviews of the literature. In its annual "Reviews of Unit Operations," *Industrial and Engineering Chemistry* surveys the literature of those operations that are of interest to celluose industries. The bibliographies and reviews given in the bibliography are as complete as possible.

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Year	*Section*
1912-1961	22. Petroleum, Asphalt, Coal Tar, and Wood Products 23. Cellulose and Paper
1961	23. Cellulose, Lignin, Paper, and Other Wood Products
1962-1965	49. Cellulose, Lignin, Paper, and Other Wood Products
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Patents

Many patent classes must be searched in the cellulose, pulp, and paper fields to obtain pertinent literature. The main classes and subclasses of the U. S. Patent Classification which should be used in searching are:

Class 8, Bleaching and Dyeing: Fluid treatment and chemical modification of textiles and fibers
- 115.5: Chemical modification of textiles and fibers
- 116: Cellulose fibers

Class, 53, Package Making
- 48: Multiple bottle or can carrier type package
- 52: Automatic or triggered control
- 177: Progressively seamed cover webs or web folds
- 203: Wrapping machines
- 285: Closing packages and filled receptacles

Class 93, Paper Manufactures
- 8-35: Bag machines
- 36-60: Box machines
- 61-76: Envelope machines
- 77-83: Tube machines
- 87-92: Tag machines
- 84-86: Folding

Class 101, Printing
- 35: Special-article machines
- 460: Including paper or cellulosis support having printing or nonprinting surface

Class 106, Compositions, coating or plastic
- 124: Protein or derivative containing
- 162: Carbohydrate or derivative containing

Class 117, Coating: processes and miscellaneous products
- 36.1: Reusable transfer sheet making
- 36.7: Recording or copy sheet making with latent color component

36.8: Reactive components
37: Non-uniform coating
38: Printing, masking or stenciling
62: With treatment of the coating
121: Particular base or coating
140: Felted or loose fibrous material base
143: Cellulose or derivative base

Class 118, Coating apparatus
200: Solid applicator contacting work
300: Projection or spray type

Class 129, Paper files and binders
21: Pins
24: Hinged
41: Transverse cords

Class 144, Woodworking
309: Processes
311: Bark removing

Class 156, Adhesive bonding and miscellaneous chemical manufacture
1: Methods
349: Surface bonding means and/or assembly means therefor

Class 161, Stock material and miscellaneous articles
46: Structurally defined web or sheet

Class 162, Paper making and fiber liberation
1: Processes of chemical liberation, recovery or purification of natural celluose or fibrous material
100: Processes and products
232: Apparatus

Class 206, Special receptacles and packages
1: Receptacles
46: Packages

Class 229, Paper receptacles
6: Boxes
16: Folded blank boxes
68: Envelopes
87: Wrappers

Class 260, Chemistry, carbon compounds
2: Synthetic resins
124: Lignins and reaction products thereof
209: Carbohydrates and derivatives

Class 270, Sheet-material associating or folding
52: Associating or disassociating
61: Folders

Class 271, Sheet feeding or delivering
8: Feeding
63: Delivering

Additional classes which may contain subject matter of interest are:

Class 18, Plastics
Class 83, Cutting
Class 96, Photographic chemistry, processes and materials
Class 99, Foods and beverages
Class 100, Presses
Class 128, Surgery
Class 131, Tobacco
Class 136, Batteries
Class 167, Medicines, poisons and cosmetics
Class 177, Weighing scales
Class 181, Acoustics
Class 198, Conveyors, power-driven
Class 209, Classifying, separating and assorting solids
Class 220, Metallic receptacles
Class 221, Article dispensing
Class 222, Dispensing
Class 223, Apparel apparatus
Class 225, Severing by tearing or breaking
Class 226, Advancing material of indeterminate length
Class 241, Solid material comminution or disintegration
Class 242, Winding and reeling
Class 248, Supports
Class 250, Radiant energy
Class 252, Compositions
Class 281, Books, strips and leaves
Class 282, Manifolding

Class 210, Liquid purification or separation
Class 211, Supports, racks
Class 214, Material or article handling
Class 294, Handling, hand and hoist-line implements
Class 317, Electricity

The patent classification, indexed according to subject material, may be found in the U. S. Dept. of Commerce Patent Office "Index to Classification," July, 1963.

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18

The Literature of Wood Naval Stores

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Aside from the technical sales bulletins and product data sheets of industry, there is no specific literature on wood naval stores. The literature of this industry is found throughout the general literature. Patent literature is particularly significant in tracing the industrial development of wood naval stores and its products. This paper reviews the significant literature of wood naval stores and of the chemistry of naval stores products, rosin and terpenes, and documents the principal discoveries and developments. The cited literature was selected to provide the reader with the most important primary literature of wood naval stores and of the chemistry of naval stores products. To complement the most important primary literature, a general bibliography of the best secondary literature is included.

It took the experience, knowledge, and efforts of Homer T. Yaryan to begin the history of the wood naval stores industry (*108*, *113*). Yaryan had perfected a process to extract linseed oil from flaxseed with a petroleum fraction. In 1906, he adapted this process to the extraction of rosin from waste pine wood and stumps. In 1910, after several unprofitable starts, the Yaryan Naval Stores Co. plant at Gulfport, Miss., began regular operations. A second plant was built at Brunswick, Ga., in 1911 (*80*).

The plant at Brunswick, Ga., and one at Hattiesburg, Miss. (1920) are the centers of Hercules wood naval stores production. The Newport Co. (now Heyden Newport Chemical Corp.) entered wood naval stores through plants at Bay Minette, Ala. (1913) and Pensacola, Fla. (1916); the Mackie Pine Products Co. at Covington, La. (1918); the Continental Turpentine and Rosin Corp. at Laurel, Miss. (1921); Acme Products Co. at DeQuincy, La. (1922); Dixie Pine Products Co. at Hattiesburg, Miss. (1928); more recently, Crosby Chemicals, Inc., at Picayune, Miss. (1937) and DeRidder, La. (1946); and

[1] Hercules Powder Co., Hattiesburg, Miss.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Gulf Naval Stores Co. at Gulfport, Miss. (1946) and Andalusia, Ala. (1953) (*74, 92*). In 1957 Gulf Naval Stores built a plant at Arcadia, Fla. and subsequently closed their Gulfport, Miss. operation.

From the Stumps to Chips

Stumps, which constitute the feed for the wood naval stores plants, are found in the vast cut-over lands of Mississippi, Georgia, and Florida. A gasoline or naphtha extract of a typical virgin longleaf pine stump, which has remained in the ground eight to 10 years after felling of the tree to weather off or rot away bark and sapwood, analyzes 18% water, 5% terpene oils, 22% rosin, and about 4% of a gasoline-insoluble resin. Harvesting the stump, during the early years, depended upon mule-power and dynamite. With the advance of the motor age, mechanical stump pullers were designed to travel easily over the cut-over land and remove the whole stump (*28, 73, 75, 82, 84, 97*).

Between 1920 and 1930, attempts were made to purify wood rosin by three approaches: distillation, extraction, and adsorption (*24, 50, 54, 96*). The most successful process was the selective solvent refining of FF wood rosin with furfural and which produced rosin of all color grades (*48,49*). This process is now operated commercially on a continuous basis (*49, 58*). Another commercial process for refining wood rosin uses fullers earth for adsorbing the color bodies from a naphtha solution of the FF wood rosin (*78*).

Although the earlier processes involved a steam distillation prior to extracting wood chips, the patent literature is relatively large on directly extracting unsteamed chips—the process which has been used for many years. According to a recent patent (*20*), the use of ketone solvents in extracting wood chips increases the efficiency of this step.

The Constituents and Composition of Rosin

The literature on the composition of stump wood is relatively meager. Bottini (*10*) thoroughly studied the composition of stumps as a function of tree and stump age. Other important studies are those of Dupont (*25*), Tolkachev (*102*), Schmidt-Nielsen and Refsnes (*94*), and Goldblatt and Burgdahl (*36*).

The literature on the constituents and chemistry of rosin is voluminous. It was recognized as early as 1827 (*105*) that rosin is a mixture of resin acids. The name abietic acid was introduced in 1826 by Baup (*5*) for the resin he isolated from *Pinus Abies*. Until very recently, the literature has been dominated by confusion, errors, and misleading generalities. The difficulty in many studies was the inability to differentiate between a mixture and a single component. Readers of the literature written prior to about 1935 should be alert to this situation.

The major contributors who elucidated the structures of rosin components were:

A. Tschirch, whose most important contribution was consolidating the literature as well as his early work on isolating different acids from American gum rosin (*103*).

A. Vesterberg, who by fractional crystallization of the sodium salts of gum rosin, was able to isolate levopimaric and pimaric acids (1887) (*107*).

G. Dupont, who isolated the first relatively pure abietic acid by means of its 3:1 salt and reported the instability (isomerization) of the acid components (*26*).

F. Balas, who did considerable work on the amine salt separation of resin acids, but was unsuccessful in applying the technique (*3*).

L. Ruzicka (*86*), who proved the structure of abietic acid first proposed by Fieser and Campbell. He also did considerable work on proving the structure of levopimaric and pimaric acids.

W. Sandermann, who did considerable work on proof of structure and studied biochemical origins by radioactive tracer work (*90*).

S. Palkin and E. E. Fleck, who improved the isolation of abietic acid and first obtained dehydroabietic acid and prepared lactones (*77*).

L. F. Fieser and W. P. Campbell (*30*), who isolated pure dehydroabietic acid, and proposed the correct structure for abietic acid.

G. C. Harris, who developed the amine salt method for isolating pure resin acids, isolated two new resin acids, neoabietic and isopimaric, by combining the amine salt method with the Diels-Alder addition reaction of maleic anhydride with resin acids and ultraviolet spectra, and completed the structure proof of pimaric acid (still inconclusive from Ruzicka's work), and isolated and characterized isopimaric acid (*40, 41*). Harris classified the acids into abietic-type and pimaric-type, as shown in Figure 1.

D. H. R. Barton (*4*) and W. J. Klyne (*57*), who established that the A-B ring union in the diterpenoids is the same as in triterpenoids and steroids.

G. Stork (*100*), who recently announced the first successful total synthesis of *dl*-dehydroabietic acid.

Two new acids, palustric acid and caribeic acid, have been isolated recently from gum rosin. The structure of palustric acid and its presence in wood rosin have been established by R. V. Lawrence and co-workers at the Naval Stores Laboratory, U.S. Department of Agriculture (*62, 63*). Hampton (*39*), who isolated and partially characterized caribeic acid, was unable to find it in wood rosin and suggested that it is the factor responsible for the lesser tendency of gum rosin to crystallize.

In recent years much attention has been given to stereochemistry of the pimaric acids by E. O. Edwards (*27*) and R. E. Ireland (*52*), and to their role in biogenesis of the diterpenoids by E. Wenkert (*110*). Also there have been excellent articles on applying new instrumental methods of analysis to resin acids: gas liquid partition chromatography by J. A. Hudy (*47*), infra-red by E. A. Cherches (*18*) and by P. Kajanne (*55*), mass spectrometry by H. H. Brunn (*13*) and C. A. Genge (*35*), and nuclear magnetic resonance by J. C. W. Chien (*19*).

The current practice of most investigators and journals in writing and numbering the diterpenoid ring structure is illustrated in Figure 2 for abietic acid.

The numbering is that of the phenanthrene ring system (*see* "The Ring Index"), and the method of projection with the ring I to the lower left is con-

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

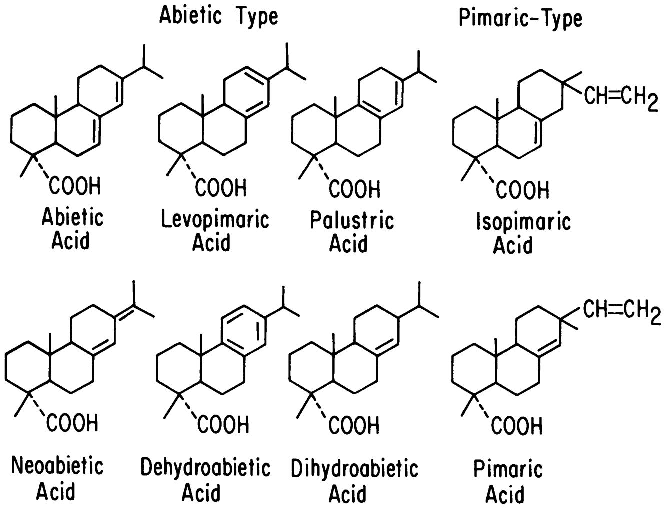

Figure 1. Structural formulas of resin acids ($C_{19}H_{29}COOH$)

sistent with the most commonly used method of projecting the structural formulas of the polyterpenoids and the steroids. In the older literature, carbon atoms 4a, 4b, 8a, and 10a were numbered 12, 13, 14, and 11, respectively.

The composition of the neutral fraction of rosin is not completely known. However, various investigators have isolated resin and fatty acid esters from the saponifiable portion of wood rosin. From the unsaponifiable portion 3,5-dimethoxystilbene (*21*), the aldehyde of isopimaric acid, and a trace of 1,8-terpin (as terpin hydrate) have been isolated (*40*).

Grades of wood rosin vary from X through WW (water-white), WG (water glass), N, M, K, I, H, G, F, E, and D with increasing color. The official U.S. color standards are based on the work of Brice (*11*) and are specified in terms of the 1931 Commission Internationale de l'Eclairage colorimetric coordinate system. A printed color chart was developed by Hercules Power Company (*44*).

Chemical Properties of Rosin and Resin Acids

The reactivity of resin acids essentially lies in the carboxylic acid group and in the double bonds. The literature on reactions of rosin and its component resin acids is vast and has been complicated by the fact that rosin is a mixture of the several resin acids.

Isomerization is particularly important inasmuch as it occurs during the processing of rosin and increases its stability. Isomerization is carried out by heating or by subjecting rosin to an acid medium. The maleic anhydride adduct of rosin is possible because this isomerization of the double bonds in abietic acid occurs easily giving levopimaric acid at equilibrium (*53, 59, 63, 85, 87, 88*).

Because it is unsaturated, rosin is highly susceptible to air oxidation, the products being dark in color and insoluble in oils and solvents. This property prevented wood rosin's entry into fields for which its other properties indicated potential usefulness. The hydrogenation of rosin, the literature of which is largely confined to patents, led to a product quite resistant to oxidation. It is quite apparent from the early literature that the hydrogenation proceeded smoothly and quickly to saturate one double bond; considerably more vigorous conditions and more effective catalysts were necessary to hydrogenate the second double bond (*12, 16, 72, 88, 96*). A commercial hydrogenated rosin, "Staybelite," differs from rosin in having about 3% as against 50% of abietic-type acids and 60% as against 6% dihydroabietic acids.

Rosin ester hydrogenation is likewise confined mostly to the patent literature and follows the processes described for hydrogenating rosin.

Disproportionation of rosin also renders it less susceptible to oxidation by air. Although this reaction has been known for some time, it has been only relatively recently that commercial disproportionated products, such as "Resin 731" (Hercules), "Gorite" (Dixie Pine Products), "Galex" (G. and A. Laboratories), and "Nilox Resin" (Newport), have been available. Dehydroabietic acid is the main component of disproportionated rosin, and its preparation and characterization has been the subject of several studies (*30, 34, 42*).

The abietic-type acids in rosin can be stabilized towards oxidation by polymerization. Since Grün and Winkler's (*37*) description of this process which used sulfuric acid, many patents have been issued involving many types of catalysts under varying conditions and with further treatment, such as hydrogenation and esterification.

Oxonation of rosin and resin acids to yield rosin carbinols and hydroxymethyl resin acids was reported in 1952 (*61*).

The physical and chemical properties of commercial rosins and modified rosins are described in technical trade bulletins and booklets such as those of Hercules Powder Co.

The sodium salt of rosin has been used extensively for many years in sizing paper (*2*), and its patent literature is quite extensive. Limed rosin, or calcium resinate, known since 1884 (*56*), has found important use in the protective coating industry as a varnish resin. Other heavy metal salts have been similarly applied.

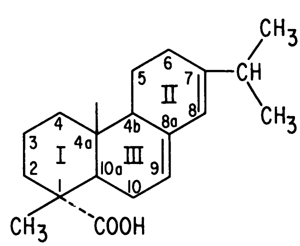

Figure 2. Numbering of the diterpenoid ring structure of abietic acid

Since Maly (*66*) first announced in 1865 the esterification of rosin, practically every conceivable ester has been prepared. Many have become commercially important, for example, the glycerol ester of rosin (*91*), known as ester gum, and the pentaerythritol ester of rosin (*6*). A significant commercial development was the continuous rosin esterification process to give alkyl rosin esters in high conversion (*15*). Results of a recent study of the mechanism of resin acid esterification were reported in 1957 (*98*).

The carboxylic function in rosin and rosin esters has been hydrogenated to the alcohol (*60*). In the process, the double bonds are partially hydrogenated, and the product obtained is essentially hydroabietyl alcohol. The early literature, however, called the product abietyl alcohol (*89*).

Rosin has been converted to the nitrile (*83*), which, in turn, is readily hydrogenated to the amine. Both of these products are relatively new commercially.

Decarboxyation of rosin, accompanied by dehydrogenation, to give retene as the major product has been known since 1887 (*1, 89, 107*). Decarboxylation to rosin oil has been reported by Humphrey (*57*), Vassilev (*106*), and Whitmore and Crooks (*111*), in which the main products were decarboxylated resin acids.

Hydroxyethylation of rosin to produce an emulsion-breaking composition has been described by Moeller (*71*).

The dark-colored, gasoline-insoluble fraction from the extraction of stump wood has found many uses. However, the literature on its composition and chemistry is limited to trade bulletins and patents.

Constituents of Turpentine and Terpene Oils

Wood turpentine is not the total terpene hydrocarbons from the wood extract. It is a distillation fraction enriched in the lower-boiling terpene hydrocarbons and is approximately 80% α-pinene. The remainder consists of 5% camphene and other bicyclics, and 15% monocyclics including dipentene, *p*-menthane and *p*-cymene (*76*). Table I outlines the components of wood terpene oils (3-carene and heptane are found in significant quantities only in

Table I. Components of Wood Terpene Oils

A. Turpentine
1. Bicyclic terpenes
   a. α-Pinene
   b. Camphene
   c. 3-Carene
2. Monocyclic terpenes
   a. Dipentene
   b. α-Terpinene
   c. Terpinolene
3. Miscellaneous hydrocarbons
   a. *p*-Cymene
   b. *p*-Menthane
   c. Heptane

B. Pine Oil
1. Bicyclic terpenoids
   a. Borneol
   b. α-Fenchyl alcohol
   c. Fenchone
2. Monocyclic terpenoids
   a. α-Terpineol
   b. β-Terpineol
   c. Terpin hydrate
   d. 1,8-Cineole
3. Miscellaneous derivatives
   a. Estragole

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western stump wood). The extraction of one ton of chips yields on the average about 85-90 pounds of crude oils, of which about 50 pounds is turpentine (*45, 49*).

The greatest use of turpentine used to be as a thinner and solvent for paints, varnishes, and enamels. However, now the greatest demand for turpentine is as a chemical for the synthesis of camphor, pine oil, terpineol, terpene resins, insecticides, and many other products. However, instead of using turpentine for these chemical conversions, a distillation fraction enriched in the desired constituent is used: for example, α-pinene, or dipentene. The fact that distillation fractions enriched in dipentene are by no means pure often has not been recognized in publications.

Chemical Properties of Terpene Hydrocarbons

The following discussion pin-points the reactions of terpene hydrocarbons which have arisen at least in part from research on products from the wood naval stores industry.

The bicyclic terpenes, particularly α-pinene and camphene, are very important commercially. Their uniqueness lies in their ready conversion to monocyclic terpenes and in their rearrangement reactions. A typical example is the conversion of α-pinene to camphene and other bicyclic and monocyclic terpenes (*43, 69*).

Camphene readily adds acids to form isoborneol esters, for example, the formate, which is readily converted to isoborneol. Many patents have been issued for preparing camphor, and a plant for its manufacture has been in production since 1932 (*38*). Camphene is an intermediate in the production of two commercially important insecticides: Thanite (isobornyl thiocyanoacetate) and toxaphene (chlorinated camphene) (*8, 14*).

Derivatives of pinene which have been of interest recently are pinic and pinonic acids (*33, 99*).

Terpene-derived resins are produced by reaction of terpene hydrocarbons or alcohols with phenol in the presence of acid catalysts, followed by reaction of the substituted phenol with formaldehyde (*104*).

Polymerization of terpenes by metal coordinate catalyst systems has been described recently (*68*).

Terpenes react with sulfur to form complex sulfurized compounds, which have found wide use as extreme-pressure lubricant additives (*46, 109*).

Air oxidation of terpenes and terpene derivatives yields hydroperoxides (*32, 93, 101, 112*). *p*-Menthane hydroperoxide is produced commercially by this process (*29*). Under some oxidation conditions hydroperoxides are not isolated, but are only intermediates providing other oxidation products. For example, the oxidation of terpinolene in aqueous dispersion gives three isomeric triols (*9*).

The menthadienes, for example, dipentene, can be dehydrogenated to *p*-cymene or disproportionated to a mixture of *p*-cymene and *p*-menthane. The *p*-cymene can be air oxidized to the hydroperoxide (*65*) and converted to 8-hydroxycymene (*64, 65*) or *p*-cresol (*31*).

The cracking of dipentene yields isoprene (*7, 22, 24*).

The menthadienes, for example, terpinene, terpinolene, react with maleic anhydride to give valuable adducts (*23, 38, 79*).

Pine Oil and Terpene Alcohols

The most distinctive product of wood naval stores is pine oil, which is not found in the exudation of living pines. Pickett and Schantz (*81*) reported the components of pine oil to consist of terpene hydrocarbons, α-terpineol, borneol, fenchyl alcohol, and terpene ethers. The constituents of pine oil, that is, the alcohols, ketones, and ethers, have an extensive literature of organic chemistry.

The chief commercial source of cyclic terpene alcohols is pine oil. An efficient distillation of pine oil yields commercial α-terpineol. Pine oil, and also α-terpineol, has become so valuable that it has been supplemented by a synthetic pine oil, prepared by the hydration of α-pinene in the presence of acids (*95*).

Dehydration of 1,8-terpin with acid catalysts (*90*) yields a mixture of α, β, and γ-terpineols known as "terpineol extra" or "prime terpineol." 1,8-Terpin hydrate is obtained from the crude oils recovered by steaming the residual rosin after distilling the more volatile terpenes and terpenoids (*67*). It is also produced synthetically by the hydration of α-pinene.

The literature on the uses and applications of pine oil and terpineol is large.

A summary report of past and current practices and recommendations for the future in writing structural formulas and in numbering and naming the monoterpenes was prepared by M. W. Grafflin for the American Chemical Society's Nomenclature Committee and published as ADVANCES IN CHEMISTRY SERIES NO. 14.

Summary

The literature of wood naval stores begins with the Yaryan patents and is dominated mostly by the industrial developments and research of a relatively few American companies and by the publications of The Naval Stores Station, U. S. Department of Agriculture. The literature has borrowed heavily from and contributed generously to the general literature of organic chemistry and chemical engineering. Principal discoveries and developments in wood naval stores have been related to their significant and critical literature. In addition to specific documentation of these discoveries and developments, a bibliography of the general naval stores literature is included. Chemists new to the chemistry of terpenes and resin acids may gain an excellent background by consulting the references marked with an asterisk in the bibliography of this paper.

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Patents

Class—subclass *Material*

106—Compositions, Coating or Plastic
Carbohydrate or derivative containing
—200 With natural resin or derivative

162—Paper Making and Fiber Liberation Processes and Products
Non-fiber additive
—173 Hydrocarbons
—180 Natural Resin
252—Compositions
—367 Soaps (Alkali-Metal Salts of Water-Insoluble Fatty or Rosin Acids)
—368 Products
—369 Including saponification
—370 With subsequent operations
260—Chemistry, Carbon Compounds
—97 Natural Resins and Reaction Products
—97.5 Tall oil and reaction products thereof
—97.6 Separation of constituents of tall oil
—97.7 Purification and recovery
—98 Sulfur containing
—99 Oxidized
—99.5 Polymerized
—100 Hydrogenated
—101 Reaction products with terpenes and/or polycarboxylic anhydrides
—102 Reaction products with ammonia, amido or amino compounds
—103 Esters of natural resin acids
—104 With polyhydric alcohol (e.g., ester gum)
—105 Salts of natural resin acids
—106 Pyrolytic or heat isomerized products (e.g., rosin oil)
—107 Purification, preservation or recovery
—108 Resins of pine origin
—109 Oleoresin
—110 Extraction from cut wood
—111 Treatment of pine origin
Carbocyclic or Acyclic
Esters and processes of making same
—489 With terpenes
Ketones
—587 Terpene
Hydroxy
—631.5 Terpene derived
Hydrocarbons
—675.5 Cyclic terpenes

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19

Literature of Leather and Adhesives

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Skins of animals comprise the raw material for the leather industry. Its important by-products include gelatin and glue; in their manufacture the osseous, cartilaginous, and muscular tissues, as well as hoof and horn, are also utilized. This discussion presents a two-part survey: (1) the literature pertinent to the principal phases of leather manufacture, and (2) the ever-growing literature of adhesives including glue, sizes, cements, and gums. Brief discussions of dissertations and translations, patents, and statistics pertinent to both leather and adhesives are also included. Selected periodical articles are generally omitted. Emphasis is placed upon books published in the preceding decade.

The skins, bones, and fibrous tissues of animals and their products—leather, gelatin, and glue—are mostly colloidal materials and have almost indefinable properties about which little is known. They consist of many different complex proteins, which vary in structure in different animals and even vary in different parts of the same hide. The complexity of the art of leather manufacturing is augmented by the many active substances that affect the skins—enzymes, bacteria, alkalies, acids, tannins, tannin substitutes, oils, fats, and salts. Part one is concerned with principal phases of its manufacture. The chemistry and engineering behind the leather industries are so complex that scientific control has developed comparatively slowly.

The leather industry is constantly searching for new chemicals to make better leathers at a cheaper price. In considering the literature of the leather industry, it is impossible to confine it only to items of importance from a processing viewpoint. One cannot separate treatises on the purely chemical aspects of the subject from the technological aspects. Modern material sciences,

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

cross-fertilization of fields of knowledge, automation, and systems engineering place no limit on the imagination of the searcher.

Encyclopedias, Dictionaries, Handbooks, and Yearbooks. Representative titles—those which contain either recent authoritative data or general background information—have been included in the accompanying bibliography. The Kirk-Othmer "Encyclopedia of Chemical Technology," with many volumes of the second edition now in print, is an excellent source of information on manufacturing processes as well as for an over-all view of the industry. "Ullmann's Enzyklopäedie der technischen Chemie," now in its third edition, is also important. For a brief summary of leather manufacture, the "McGraw-Hill Encyclopedia of Science and Technology" can be used to advantage. A collective encyclopedic compilation, often referred to in the literature, is the "Handbuch der Gerbereichemie und Lederfrabrikation." Gnamm's "Fachbuch" and Block's "Handbuch der Haut" are useful books that come within the above classification, as well as Küntzel's "Gerbereichemisches Taschenbuch." A starting point for reviewing progress in the field is Proctor's "Leather Industries Laboratory Book," first published in 1897, but superseded by more recent treatises.

Bibliographies, Abstracts, and Indexes. The best and most recent comprehensive bibliography for the chemical processing of leather possibly is a composite of the references accompanying the 64 chapters of O'Flaherty's "Chemistry and Technology of Leather" (listed under Books and Monographs). For example, Chapter 37 of the third volume contains 106 citations to machinery and chemicals used in leather manufacture. As is true in the above instance, one is more likely to find bibliographies covering various phases of leather processing than he is to locate a classified bibliography covering all aspects. The last volume of "Handbuch der Gerbereichemie" by Sagoschen is devoted to bibliographies, and Malcles, in her source list, states that the British Leather Manufacturers' Research Association features a current bibliography. Some periodicals maintain an abstract section such as the *Journal of the Society of Leather Trades Chemists.* For recent as well as older lists one can consult published abstracts which indicate whether or not a bibliography accompanies the article, as in *Chemical Abstracts* (*CA*). One can also use *CA* to locate serial articles in a subject field. To supplement this source, especially for the pre-World War II era, three foreign abstract journals are useful: *British Abstracts*, *Chemisches Zentralblatt*, and *Chimie et Industrie*. Abstract journals are also the one best source for compiling bibliographies on a subject-chronological basis. *Bibliography of Reviews in Chemistry* should also be checked. Two government publications—"Leather, Hides, and Shoes," and *Index of Federal Specifications and Standards*—include a basic index and cumulative supplements as issued. Although quite old, Dean's bibliography of tanning materials is useful. The "Bibliographical Index," specifically covering leather, is obsolete. There are no specific indexes for the leather industry worthy of mention, but the *Biological and Agricultural Index*, *Engineering Index*, and *Applied Science and Technology Index* may occasionally be useful to the engineer. Strauss, although covering over 20 special subject bibliographies in

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her Appendix, does not include leather but is an excellent source for data on basic reference publications.

Books and Monographs. The last volume of the indispensable treatise, "The Chemistry and Technology of Leather," by O'Flaherty *et al.* has recently been published. The first volume, subtitled "Preparation for Tannage," includes a discussion of the chemical structure of skin and its preparation for leather manufacture. Volume 2, "Types of Tannages," includes the chemistry, processing, and mechanism of tannery. Volume 3, "Process Control of Leather Quality," covers the role of finishing operations in establishing the utility of leather and the procedures for various types of leather. The fourth volume, "Evaluation of Leather," discusses the technical knowledge available on the basic properties of leather and the various methods of evaluating these properties such as moisture and ash analysis, lipid extraction, and estimation and composition of fat liquor emulsions. Aspects of past and present methods are discussed in detail by authorities in the industry.

Before publication of the above reference book, McLaughlin and Theis' "Chemistry of Leather Manufacture" was regarded as a necessity by the chemical engineer; it contains a thorough review of the literature through 1944. Wilson's monograph, "The Chemistry of Leather Manufacture," as well as his "Modern Practice in Leather Manufacture," were for many years, regarded as basic reference books, but these, along with the book by McLaughlin and Theis, have been largely replaced. In this connection, "Progress in Leather Science" should be mentioned; voluminous citations to it appear in the literature, so this title takes its place among the monumental reference books.

Several titles which appear in the bibliography refer to some specific phase of manufacture such as Gustavson's "Chemistry of the Tanning Processes" rather than to general discussions of leather manufacture. In fact, White, in Volume 2 of O'Flaherty, states that, in addition to those already mentioned, essential reading to gain a broader view of complex tannin chemistry includes earlier surveys by Gnamm, Rottsieper, Thorpe, Dekker, Howes, Stather, Pavlovich, Perkin and Everest, Nierenstein, Freudenberg, Fischer, and Procter and Paessler. Some other titles listed may contain only one or more chapters applicable to leather manufacturing such as Disserens' "Chemical Technology of Dyeing and Printing," but the information contained therein is essential. Many older titles which, though not indispensable in modern leather manufacture, may be needed because they constitute bibliographical references cited in later publications. Although no particular emphasis has been placed upon books published in languages other than English, several titles have been included as a result of frequent mention in bibliographies.

Reports and Technical Bulletins. The so-called report literature has increased vastly since World War II. To attempt a classification and listing of titles pertinent to the leather industry alone would result in an inadequate summary. Nor can one point to a published compilation sufficiently broad in scope. Only some typical reports prepared by representative agencies are listed as examples of this literature source, provided available indexes are checked and a choice made therefrom. Technical bulletins often contain illustrations, data sheets, and uses for specific chemicals—information which may not be readily available elsewhere under one cover. Many are published by commercial organizations, kept up to date, and distributed gratis to potential customers. To compile a list available on an industry-wide basis would be impracticable; hence only a few titles are mentioned to indicate this type of literature—e.g., "Calgon Data for the Leather Tanner." Several trade associations are also responsible for technical publications; a list of U. S. organizations in this category is found in "Sources of Business Information." Government agencies are an important source of report literature and technical bulletins (*see also* section under Bibliographies) as are laboratories maintained by professional associations, such as the Tanners' Council of America.

Reviews, Symposia, and Special Publications. This type of literature varies considerably in format and source. Review articles are especially helpful for orientation in a field. This type of literature may contain references to unindexed ephemeral material sometimes of value. There are many organizations representative of various facets of the leather industry whose conference papers and minutes often contain information unavailable elsewhere. These organizations may sponsor symposia which result in publication such as "Comparative Evaluation of Various Solvent Tannage Systems" by Buechler. ASTM's "List of Special Technical Publications" are the published results of symposia on materials and collected technical papers presented at their meetings. Occasionally a collection of periodical articles, representing several authorities in the industry but pertinent to one or more of its aspects, is published with the hope that the convenience of "under-one-cover" form will be useful or that a wider audience will be reached than that gained through the original articles which are published singly. Otto's "Contributions to the Study of the Interactions in the System Hide-Tanning-Dyestuff" is an instance wherein the author's articles appearing individually in *Das Leder* were translated into English and privately printed separately. Occasionally journals devote special issues to one subject which might be regarded as falling in the above category, especially the issues which honor a prominent scientist such as the "Stiasny Festschrift." For convenience some titles representative of all types mentioned above have been placed in one list.

Standards and Specifications. Both domestic and foreign agencies promulgate standards. Individual associations have been responsible for developing and publishing test methods, specifications, and standards for the leather industry. The International Union of Leather Chemists' Societies maintains a division called the Physical Testing Commission. In the United States, the Tanners' Council is representative of the laboratories maintained by industry, universities, and government where new and improved testing methods are developed. The American Society for Testing and Materials (ASTM), organized in 1910, with its various committees, publishes over 3200 standards including not only those for leather but also for adhesives as well. Many authorities in the field cooperate to meet the needs of scientists and engineers. There is a host of government specifications published by military agencies to meet their needs, many for purchasing materials of a specified quality. The usual need is for a specific standard or requirement; suggestions for locating these appeared in "Literature Resources for the Chemical Process Industries," together with a general discussion of the subject which includes a definition and clarification of terms. The Appendix to Strauss' "Scientific and Technical Libraries" (listed under Bibliographies, Abstracts, and Indexes) contains an excellent annotated list of agencies which publish standards and specifications of which the U. S. National Bureau of Standards is one example. Standardization activities of other countries should also be checked.

Periodicals. This category includes those publications issued regularly on a time-frequency basis. With the exception of reviews and collections, specific references to periodical articles have not been included. Based on the quantity of references made to them in O'Flaherty's book, the more important titles are the *Journal of the American Leather Chemists' Association, Journal of the Society of Leather Trades' Chemists, Collegium, Leder, Shoe and Leather Reporter,* and *Cuir Technique.* To the first journal listed, 91 of 100 references were made by Downing in Volume 4 of "Chemistry and Technology of Leather." Leather research institutes are maintained in several countries; some are sponsored by scientific organizations, some by governmental agencies, some by trade associations, and a few by groups of individuals. Many issue publications based upon investigations of their scientists such as *Gesammelte Abhandlungen* of the Deutschen Lederinstituts in Germany and *Kožarství* published by the Leather and Allied Trades Research Institute of Gottwaldovo, Czechoslovakia, both of which have become increasingly important. Current awareness of these publications is possible by checking publication notices appearing in sources such as *Chemical Abstracts.* Biochemical journals which contain articles on proteins, enzymes, and collagens in relation to leather manufacturing and botanical journals which contain articles on tannins, have not been included in the list. The "Directory of House Organs" published by Gebbe Press does not have a classification for leather; however, one will find information on products of interest to the leather industry in publications of the pertinent chemical process industries. Coman's "Sources of Business Information" lists 16 house organs, including one each devoted to gelatin and glue; several of these associations publish periodicals having a controlled free distribution.

Adhesives

Hundreds of available formulations, capable of holding materials together by surface attachment, supplement the multiplicity of adhesive products on today's market. Modern adhesives may be classified in several ways—*e.g.*, by their use in bonding various types of materials such as structural adhesives, or by their composition based on a principal component such as thermoplastic resin. Therefore, the more or less general term, adhesives, embraces many types.

Animal glue is the oldest type of adhesive, having been used for over 3000 years. Casein and starch adhesives reached commercial importance in the early part of this century; soybean-protein adhesive has been developed in the last 30 years while the synthetic resin adhesives reached commercial

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importance since 1940. Modern plastics have now become indispensable raw materials. A list of the principal materials classified as adhesives for statistical purposes is shown in Table I.

Table I. Adhesives, Including Glues, Sizes, Cements, and Gums[a]

Animal glue (dry forms)	Other adhesives, glues, and cements
Hide	Lacquer base
Extracted bone	Nitrocellulose types
Green bone	Other
Flexible and nonwarp glue	Synthetic resin adhesives
Liquid glue (not glue stock)	Bonding and laminating types
Protein adhesives	Rubber cements
Casein	Rubber and synthetic resin combinations
Other (blood, albumin, soybean)	Cements (for porcelain, furnaces, etc.)
Vegetable adhesives	Gum adhesives except rubber
Dextrins	Mucilage
Starches	Other formulations
Sizes	Gelatin in four grades (technical, edible, photographic, and pharmaceutical) included in original table, omitted from this adaptation)
Rosin	
Other, including dextrin sizes	

[a] List adapted from "Statistical Summary No. 4," p. 57, Manufacturing Chemists Association, Washington, D. C., 1961.

In addition to the base, binder, or chief component, adhesives contain many types of chemicals, each having a specific function in the formulation. For example, the thin paper film used to support the phenol-formaldehyde resin in phenol-resin glues is known as a carrier. Among other ingredients are solvents, catalysts, hardeners, fillers, extenders, preservatives, fortifiers, and diluents, each used in the composition to meet a special condition.

No attempt has been made to compile a comprehensive bibliography of adhesive literature for two reasons: (1) references are not only vast but widely dispersed, and (2) many treatises and reports on leather processing, as well as those on plastics and other raw materials, contain sections covering adhesives.

Encyclopedias, Dictionaries, Handbooks, and Yearbooks. Many of the general references listed for leather are useful for information on adhesives, particularly the first volume of the second edition of the "Encyclopedia of Chemical Technology." Skeist's handbook is a valuable aid as is McGuire's. To make or to select an adhesive, "Modern Plastics Encyclopedia," an annual publication sponsored by *Modern Plastics,* is useful. "Plastics Engineering Handbook" and Simond's two books on plastics contain valuable information on bonding technology. Katz' "Adhesive Materials," although not strictly a handbook, provides an excellent guide to those who need to know of adhesives designed to fulfill a specific purpose; this author also gives the precise number and title of specifications covering the chemical, physical, process, and performance qualities of many types. The first volume of a comprehensive source for polymer science and plastics technology with international coverage is the "Encyclopedia of Polymer Science and Technology," edited by H. F. Mark *et al.;* each article is provided with a bibliography. Future lists should be checked constantly to keep abreast of publication in this rapidly expanding field.

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Bibliographies, Abstracts, Indexes, and Information Sources. Literature sources for adhesives, as for leather, are found with plastics and related subjects. Three of the best known tools are *British Plastics Federation Abstracts, Literatur-Schnelldienst,* and *Resins-Rubber-Plastics. Chemical Abstracts* contains subdivisions pertinent to the subject; a section on plastics also appears in the *Journal of Applied Chemistry.* McGuire's "American Adhesives Index" is an index of products rather than an index of items leading one to periodical articles and reviews. Among other bibliographies available are the OTS Selective Bibliographies. Forest Products Laboratory has a recent excellent list of publications on glue, and a quarterly abstract bulletin published in England is also an important source. The "Encyclopedia of Polymer Science," to be published in several volumes, will have bibliographies accompanying each article. "British Technology Index" is a new publication of the general type, a current subject guide to British technical periodicals. "Adhesives," recently published by the Institute of Paper Chemistry, is an excellent source for bibliography; for example, the last section contains 664 references.

Books and Monographs. Among the newer books on adhesives is the second edition of "Adhesion and Adhesives" by Houwink and Salomon which emphasizes the technology of adhesive processing and the use of adhesives as engineering materials. "Adhesives: General Applications, Theory, and Testing" by Weiner and Roth, and "Adhesion" by Eley are also among the more recent general discussions. Various specialized books include metal bonding by Epstein; wood adhesives by Knight; adhesives for paper and packaging by McGuire; structural adhesives by Guttmann; epoxy resins by Lee and Neville and by Skeist; soluble silicates by Vail; and amino resins by Blais. Among books on polymers are several in which adhesives are discussed, including those by Voyutskii, Meyer, and Smith and Montgomery. Plant gums and polysaccharides are reviewed by Smith and Montgomery, also by Whistler and BeMiller. Sutermeister has covered casein as an adhesive in his book on its industrial applications, and starch is discussed by Kerr.

Reports and Technical Bulletins. Reference has previously been made to the OTS Selective Bibliographies (available from the Clearinghouse for Federal Scientific and Technical Information). The OTS collection also contains many PB reports. Most of these relate to a specific subject such as "Starch and Adhesives Industry," "Oil, Thinner for Marine Glue," "Development of Special Cements Used by the Oil-Drilling Industry," and "Use of Gum Arabic with Type IX Photographic Paper." Many technical and trade associations issue reports on special areas of interest; thus it is usually possible to find material on almost any phase of adhesives by checking indexes. Commercial organizations publish and distribute data sheets describing the use of their products and quite often supply reprints of periodical articles pertinent to the performance of a particular formulation. Examples of available material are two titles distributed by the Pittsburgh Plate Glass Co. They also have available a pictorial leaflet, "Adhesives for Every Industrial Material for Every End-Use Service Requirement for Every Application Method."

Reviews, Symposia, and Special Publications. Bibliographies and current abstracts can be checked to locate reviews such as those by Ward, Chen, and

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others. Symposia papers are typified by the publications of Bodnar and Weiss. Announcements of such meetings to be held are of interest to those who cannot attend since publication usually follows. Examples of special publications are those on adhesives by the Institute of Paper Chemistry and the ASTM.

Standards and Specifications. The ASTM publishes standards for adhesives which are revised annually. Katz' new book, listed under handbooks, contains hundreds of specifications precisely classified, identified, and described. Several technical organizations are interested in testing adhesives—*e.g.*, TAPPI. The numerous governmental agencies such as the U.S. Federal Supply Service and others listed by Strauss have publications describing their standards which certainly include adhesives of all types. The book by Lever and Rhys on testing plastic materials, in its revised and enlarged edition, contains over 3000 references to the world-wide range of plastic publications of which many cover testing to achieve standardization.

Periodicals. Most of the periodical articles on adhesives will be found in titles covering plastics; a few of those that currently devote space to adhesives are listed. Some engineering journals such as *Chemical Engineering Progress* occasionally contain articles on adhesives; therefore these potential sources should not be overlooked in searching either for current or earlier articles. Although no house organs devoted to adhesives are listed by Gebbie, several publications of manufacturers do contain articles on their products.

Other General Sources

Dissertations. Theses of graduate students sometimes contain information unavailable elsewhere under one cover, especially those based on original investigation. No listing of titles has been made chiefly because (1) it is next to impossible to find an evaluation of them and (2) it is not easy to obtain copies even on interlibrary loan. O'Flaherty lists slightly over a dozen such studies, but, in most cases, complete information is lacking. More complete data of such investigations in this category, especially if unpublished, are difficult to locate but sometimes pertinent subjects may be found through indexes. *Dissertation Abstracts,* published since 1938, is one source which lists subjects in all fields. Translations of articles appearing in foreign language journals have, for several years, been collected by the Special Libraries Association and deposited in a loan collection maintained at the John Crerar Library in Chicago and serviced under a grant from the National Science Foundation.

Patent Literature. Patent references and specifications are of interest to the chemical engineer, and he is familiar, as a rule, with procedures in the event either an exhaustive or a limited patent search is demanded. If he wishes to obtain patents pertinent to his problems through his own initiative but lacks experience, there are guides to searching the patent literature which may be of help. Likewise, the U.S. Patent Office publishes a series of classification bulletins which define classes and subclasses listed in their "Manual of Classification of Patents" and will supply them, as well as cross-reference lists, in response to a request which adequately describes as well as limits the subject matter of interest. Using *Chemical Abstracts* to locate specific patents or to make a

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preliminary search must not be overlooked. Many basic patents covering various phases of the leather industry appear in the four volumes of "Chemistry and Technology of Leather." This source contains citations to 225 patents, the majority of which are domestic. The "Index of Patents, 1790-1960" has been announced for early publication by a board of editors with K. M. Held as chairman.

Statistics. Statistical information of many types is needed by the chemical engineer; this may vary from the production figures for raw materials to sales figures related to the products of enhanced value, from current enrollment in engineering schools to the percentage of chemicals consumed by his own industry in relation to all others in chemical process industries. Major agencies of the U.S. Government which produce statistics useful to the chemical engineer are the Bureau of Mines which publishes statistics on coal and coke chemicals among others; the Tariff Commission which issues information on production and sales of organic chemicals; the Bureau of the Census which is responsible for figures on inorganic chemicals, foreign trade statistics, and the *Annual Survey of Manufacturers.* The Bureau of Labor Statistics, the Department of Agriculture, the Department of Health, Education, and Welfare, and the Federal Reserve System are also among the governmental agencies which may contribute statistical data. Trade associations and trade publications are additional sources of information. The Manufacturing Chemists' Association publishes *Chemical Facts and Figures* at regular intervals and offers specific aid upon request.

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1962	45. Leather and Glue
1963-1966	55. Leather and Related Materials
1967	41. Leather and Related Materials

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Chemical Engineering Progress, American Institute of Chemical Engineers, 345 East 47th St., New York, N. Y. 10017, monthly.
Gelatine, Leim, Klebstoffe, replaced by *Adhaesion,* which see.
Industries des Plastiques Modernes, Les Publications Techniques Associees, 40 rue du Colisee, Paris 8e, France, monthly.
Journal of Applied Chemistry, Society of Chemical Industry, 14 Belgrave Square, London SW1, England, monthly.
Journal of Polymer Science, Interscience Publishers, 440 Park Ave. South, New York, N. Y. 10016, monthly.
Modern Metals, W. B. Griffin, 435 North Michigan Ave., Chicago, Ill. 60611, monthly.
Modern Pakaging, Modern Pakaging, 575 Madison Ave., New York, N. Y. 10022, monthly.
Modern Plastics, Modern Plastics, Inc., 770 Lexington Ave., New York, N. Y. 10021, monthly.
Paper Trade Journal, Lockwood Trade Journal Co., Inc., 49 West 45th St., New York, N. Y. 10036, weekly.
Plastics, Temple Press Ltd., Bowling Green Lane, London EC1, England, monthly.
Plastics Design and Processing, Lake Publishing Corp., 311 East Park Ave., Box 270, Libertyville, Ill., monthly.
Plastics Technology, Bill Brothers Publications, Inc., 630 Third Ave., New York, N. Y. 10017, monthly.
Plastics World, Cleworth Publishing Co., Inc., 1 River Rd., Cos Cob, Conn., monthly.
Reports on the Progress of Applied Chemistry, The Chemical Society, Burlington House, London W1, England, annual.
Resin Review (supersedes *Adhesives and Resins*), A. S. O'Connor & Co., Ltd., 331 Grays Inn Rd., London WC1, England, monthly.

Other General Sources for Leather and Adhesives

Dissertations, Patents, and Statistics

Annual Survey of Manufacturers, U. S. Bureau of the Census, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, annual.
Chemical Facts and Figures, Manufacturing Chemists Association, 1825 Connecticut Ave., N.W., Washington, D. C. 20036, periodically.
Dissertation Abstracts, University Microfilms, 313 North First St., Ann Arbor, Mich. 48107.
"Index of Patents, 1790-1960," Rowman & Littlefield, Inc., New York.

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"Manual of Classification," U. S. Patent Office, Superintendent of Documents, updated periodically.
Official Gazette, U. S. Patent Office, Superintendent of Documents, weekly.

U.S. Patent Classes and Subclasses

Material	*Class*	*Subclass*
Leather	69	
Bating	8	94.17
Fermentive	195	6
Beltmaking	154	3+
Stretching	69	1.5
Beveling machines	69	9+
Bobbins or spools	242	118.32
Cop type	242	118.7
Coating of	117	142
Fibers or particles precoated	117	28
Plural coating	117	69+
Printing combined	117	15
Striping, bordering or edging	117	44
Surface deformation combined	117	11
Compositions containing	106	155+
Rubber containing	260	748
Degreasing	8	139+
Dyeing	8	10+
Electrolytic treating of	204	135
Embossing	69	2
Embossing	101	3+
Extracting oil from	260	412
Fertilizers from	71	18
Fluid treatment e.g. tanning	8	94.1+
Manipulative	8	150.5
Fulling apparatus	69	33+
Hammering apparatus	69	1+
Impregnating compositions for biocidal	167	38.5+
Preserving	8	94.1+
Punching	83	
Receptacles	150	
Rougheners	69	1
Sewing machines	112	28+
Shoes	36	
Making	12	
Skiving and Splitting	69	9+
Softening	69	
Stretching frames	45	24
Stuffing with oil	8	94.21+
Tanning	8	94.19+
Drums	69	29+
Treating compositions	252	8.57
Worker's irons, forging dies	78	72
Working	69	
Adhesive		
Applying		
To labels and wall paper	216	43
Compositions		
Alkali metal silicate	106	74+
Biocide with	167	42
Carbohydrate gum	106	205+
Cellulose liberation liquor	106	123
Core oils	106	38.2+
Protein	106	124+
Rubber	260	726+
Starch	106	210+
Synthetic resin	260	29.1+
Vermin catching	167	49
Insect catching and destroying	43	136
Insect trap	43	114+
Joining or joint	154	
Moisteners	118	
Envelope sealing combined	120	6
Separator for sheet feeding	271	33
Tape	117	122
Coated on both sides	117	68.5
Holder with edge for tearing	225	6+
Laminated	154	53.5
Medicated	167	84
Rolls	206	59
Glue (*see* adhesives)	260	117+
Compositions	106	125+
Containing	106	125+

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The Literature of Gelatin

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Gelatin, the partial-hydrolysis product of a variety of animal bone and skin raw materials, is a valuable natural colloid, used in many industries, with widely varying specifications. This discussion is an annotated basic bibliography. References include those of interest to the manufacturing and use industries, particularly food, pharmaceutical, and photographic. Included are review papers with extensive specific bibliographies.

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This discussion is not a state-of-the-art report, such as that by Idson and Braswell (*see* Selected Periodical Articles), but a survey of the most pertinent literature covering new uses and new ways of applying the old uses for gelatin.

The literature of gelatin has its own peculiar pitfalls, partly since most of the literature grew out of its application rather than manufacture, and partly because of the lack of uniformity among gelatin products derived from loosely regulated raw materials and varied processes of manufacture. This has led to numerous subdivisions according to use and quality.

Some of these variations result from the many types of skin and bone used in making gelatin. Commercial gelatin is only a partially hydrolyzed collagen, meaning that the substance is not a single entity but a mixture of fragments of chain molecules having a variety of molecular weights and substituents. For mass uses, such as food, physical properties of reasonable uniformity are obtained by blending lots of varied gelatins to meet a set of compromise specifications. Specialized manufacturing processes are used to prepare lots with particular physical and/or chemical properties for unique purposes.

Physical properties to be considered by all users, usually of a 6-2/3% solution, are as follows:

(1) Viscosity. Ranging from 10 to 70 millipoises.

(2) Stiffness. Also called bloom value, after the inventor of a standardized gelometer to measure the pressure required to fracture the surface of set gelatin.

(3) Setting Point. Reported in terms of time and temperature.

(4) Melting Point. Determined on set, "aged" gelatin.

(5) pH of the Solution. Differs from isoionic pH.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

(6) Isoionic pH (and Isoelectric pH) or Point. This is the point on the pH scale at which the solution of the gelatin has the same number of protons combined on basic groups as it has dissociated from acidic groups; for alkaline-processed gelatins this value will range from 4.8 to 5.1, and for acid-processed gelatins it will be around 9.0 to 9.4. In the absence of other ions, this is the same as the isoelectric pH, but conditions often result in a different value since the latter is defined as the pH value at which the net charge is zero. This is of practical importance because for many solution properties, maxima or minima occur at these points—*i.e.*, an opalescence owing to aggregate formation is highest at these points.

(7) Color and Turbidity. Kept to specific limits for various uses.

(8) Ash. Expressed as percent, usually below 2%, although certain uses require lower levels.

(9) Sterility of the Dry Gelatin. USP limit is 10,000 per gram; normally food gelatins test out at about 10% of this value.

(10) Stability in Solutions. An important property in pharmaceutical capsules or other preparations in which the gelatin must be held for a length of time before setting.

Although food gelatin is judged mainly by the 10 physical properties listed above, other properties are important to pharmaceutical and photographic users, who require greater care in handling and segregating raw materials and more quality control testing.

For photographic gelatins, for example, the above properties are only the beginning of a characterization because "trace" impurities present in a few parts per million or billion have critical effects on the performance of photographic emulsions. Limits of a few p.p.m. are usually specified for heavy metals, sulfur compounds, aldehydes, and other such impurities. For instance, one photo gel sets the limit for thiosulfate, usually sodium thiosulfate, at 10 to 25 p.p.m. Tin and mercury can both cause heavy fog in a photographic emulsion at 0.5 p.p.m. Since analytical methods are seldom able to detect such small concentrations, the emulsion must be tested by actual photography.

Because manufacturing methods also affect the gelatin's properties, one must know something about the procedure being used in order to select a gelatin appropriate to the need. The demineralized bones of animals (called "ossein") and clean, dehaired animal skins are the two basic raw materials in gelatin. These are soaked in a dilute acid or alkali to "condition" them for easier hydrolysis. The hydrolysis itself is a short cooking process usually performed in stages, resulting in dilute gelatin solutions of varying properties which are then blended together to form large lots at a mean quality. Because all types of gelatin are usually made in the same plant, the Food and Drug Administration regulations on sanitation prevent the bacterial damage which can occur in all grades of the product.

There are two main groups of technical grade gelatins—(1) the low quality materials just below good grade, which are available at lower prices and are used for paper sizing, adhesive, and other non-critical purposes, and (2) the higher quality materials selected for some special property, such as high bloom, which cost more.

Therefore, to match need to the characteristics of the supply, close cooperation between the user and the supplier is necessary. Unfortunately, misunder-

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standings about the properties of a given type of gelatin often arise from contradictory lab results caused by minor changes in procedure. In addition, the tradition of secrecy among producers may bind a user to a particular supplier and prevent both the user and other suppliers from obtaining information on new, improved preparations.

Because of the difficulty in obtaining uniformity from batch to batch, much work has been done to develop substitutes, with little success. Because gelatin usually performs more than one function in a given application, synthetics have often been found helpful in one aspect and defective in the others. Therefore, the trend has been toward developing specialized gelatin derivatives rather than turning to a wholly unrelated substitute; in many products "compatible" synthetics are used with gelatin, particularly to increase its stability to temperature or humidity.

Two broad sources of information on the topic merit special attention. The trade associations, such as the Gelatin Manufacturers' Institute of America and the British Gelatin and Glue Research Association, are excellent starting points for a literature search on gelatin.

The patent literature is more specialized, and in this country at least is aimed primarily at modes of application rather than manufacture. Gelatin itself is included in Class 260, subclasses 117 and 118 being most important, especially for purification and recovery. Some patents will be found under Class 303 (Colloids), subclasses 315 and 316. Hardening is covered under Class 95 (Photography), subclasses 7 and 111. Other photographic uses will be found under Class 96, including colloid transfer in subclass 28 and diffusion transfer reversal processes in 96-29. Class 95-7 also includes gelatin derivatives and their uses, while Class 96-114 includes synthetic co-polymers used with gelatins. Coacervation techniques such as those found in the currently active field of microcapsules will be found in Classes 252-316. In other cases gelatin used as a raw material is classified under the finished product.

While gelatin is derived from the bones and skins of animals, glue is a product of the horns and hooves. This distinction is important in many uses, particularly in adhesives where only about 3% of the lowest quality gelatin is used along with glues. However, in Europe, especially Germany and Great Britain, glue and gelatin are often made in the same plants and are therefore discussed together in the trade and technical literature and share the same trade associations.

The leather industry, as discussed by Shreve and Strieby in this volume, contains reference of interest to the gelatin user because tanning agents, such as alum and the aldehydes, were the original hardeners for gelatin. Also in this volume the chapters on the food industry and on photographic chemicals contain references concerning gelatin. The biomedical literature also contains studies of collagen from a medical or scientific angle.

There are many ways of subdividing the literature of gelatin. In addition to a division into different applications, sources may be listed according to raw materials, process, or physical properties. Hence the bibliography here is a collection of information sources which should be valuable to any searcher, coded to indicate the application it emphasizes. Should this bibliography fail

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to uncover the desired information, the reader is invited to query the author, who has a more extensive file at hand. As the literature contains more technology than science, the reader must expect to encounter frequent statistical inconsistencies stemming from defects in the methods of testing and the materials tested.

The bibliography is coded according to primary uses as follows:

A	Food Gelatins	A1	General applications.
		A2	Special types emphasizing specific properties.
		A3	Special uses requiring special colors.
B	Pharmaceutical Gelatins	B1	Hard capsules.
		B2	Soft capsules.
		B3	Other, such as silver proteinates, etc.
C	Photographic Emulsions	C1	Non-sensitive layers, base-paper coatings.
		C2	Photographic emulsions, highest purity gel.
		C3	Graphic arts uses, collotype, etc., where physical properties are central.
D	Technical Gelatins	D1	Uses requiring high quality with definite specifications.
		D2	Uses tied to certain property.
		D3	Uses requiring only low quality gelatin with a wide range of properties; scrap.
		D4	Scientific laboratory uses, such as a source of amino acid and derivatives.
		D5	Scientific laboratory uses as a "model protein" for structural purposes, etc.

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Chemical Abstracts, American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036, weekly:

Year	*Sections*	
1912	5.	Photography
1915	5.	Photography
	29.	Leather & Glue
1962	11.	Radiation Chemistry & Photochemistry
	45.	Leather & Glue
1965	11.	Radiation Chemistry, Photochemistry, & Photographic Processes
	45.	Synthetic High Polymers
	55.	Leather & Related Materials
1967	35.	Synthetic High Polymers
	41.	Leather & Related Materials
	74.	Radiation Chemistry, Photochemistry, & Photographic Processes

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21

The Literature of Resins and Plastics

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The proliferating literature of polymer chemistry and technology, in order to be viewed in perspective, must be projected on two coordinates: type of source material and subject matter. The literature now includes many books and primary journals exclusively dedicated to the field, as well as periodic reviews, symposia collections and commercial standards. Encyclopedic treatises are under way. Primary and secondary sources are reviewed with regard to basic polymer science, processing of plastics, and specialized areas such as synthesis, analysis, physical properties, and patents.

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The decade which has elapsed since the first edition of "Literature Resources of the Chemical Process Industries" has seen a spectacular growth in polymer science and technology. Therefore, updating the seven papers which appeared in the 1954 book to form one short chapter seems a formidable undertaking. The specialist in the polymer field draws his information from sources pertaining to many scientific disciplines, and many scientific journals include articles on different phases of polymer chemistry, physics, and technology. Consequently, this article is meant as an introduction for the newcomer in the field, and for the searcher with occasional questions on the subject.

Books

The publishing activity in the polymer field includes several sets of monographs. Interscience Publishers initiated their "High Polymers" series with the "Collected Papers of Wallace Hume Carothers on High Polymeric Substances" in 1940 and has issued 17 volumes since that time, all by distinguished scientists. Among them are "Physical Chemistry of High Polymeric Systems" by H. F. Mark and A. V. Tobolsky, "Mechanical Behavior of High Polymers" by T. Alfrey, "Polymer Processes" edited by C. E. Schildknecht, and "Analytical Chemistry of Polymers" in three parts, edited by Gordon M. Kline.

"Polymer Reviews" is another series issued by the same publishers, under the editorship of Herman Mark and E. H. Immergut, which covers special

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

subjects of basic polymer science. "Polymerization of Aldehydes and Oxides" by Furakawa and Saegusa, "Linear and Stereoregular Addition Polymers" by Gaylord and Mark, "Polymer Single Crystals" by P. H. Geil, and "Newer Methods in Polymer Characterization" by Bacon Ke are among the volumes published.

More industrial in approach is the Reinhold "Plastics Applications Series." These small volumes introduce the reader to the technology of specialized areas such as "Acrylic Resins" by M. B. Horn, "Polyester Resins" by J. R. Lawrence, and "Polycarbonates" by W. F. Christopher and D. W. Fox. The "Plastics Engineering Series" of the same publisher is sponsored by the Society of Plastics Engineers (SPE), and these volumes include "Processing of Thermoplastic Materials" by E. C. Bernhardt and "Engineering Design for Plastics" by Eric Baer.

In addition, there are many excellent monographs, all of which cannot be individually mentioned. The books of Mark and Tobolsky, Flory, and Tobolsky, are classics in the field of basic polymer science, while Billmeyer fulfills the need for a basic textbook.

Polymer preparation is discussed by D'Alelio in "A Laboratory Manual of Plastics and Synthetic Resins" and by Sorenson in "Preparative Methods of Polymer Chemistry." The 4th edition of Houben-Weyl, "Methoden der Organischen Chemie" dedicates the two parts of Vol. 14 to a comprehensive review of laboratory as well as industrial methods of polymer synthesis. A 100 page bibliography at the end of part 2 is worth mentioning. "Macromolecular Synthesis" is a periodic publication of preparative methods similar to "Organic Synthesis" and "Inorganic Synthesis."

Individual polymers are covered by monographs such as "Polythene" edited by Renfrew, "Epoxy Resins" by Lee and Neville, and "Vinyl and Related Polymers" by Schildknecht. "Kunststoffe-Handbuch," a comprehensive treatise edited by R. Vieweg, is projected by Carl Hanser Verlag, Munich, to have 11 volumes and index.

The physical chemistry of polymers is discussed by Bueche and Tanford, rheology by Eirich, and polymer processing is covered by Fisher and McKelvey.

Dictionaries and encyclopedias are convenient primers for many search questions. Both editions of the Kirk-Othmer "Encyclopedia of Chemical Technology" have extensive treatments, with bibliographies, on plastics subjects, as has "Ullmanns Enzyklopaedie der Technischen Chemie." However, polymer science has already deserved an encyclopedic treatise of its own, "Encyclopedia of Polymer Science and Technology." This set is edited by Mark, Gaylord, and Bikales and will have approximately 12 volumes. It is similar in both quality and format to Kirk-Othmer.

In a hurry for a word or definition? Dickinson's "Plastics Dictionary," or "Modern Plastics Encyclopedia" may be helpful. Annemarie Wittfoht has authored several bilingual plastic dictionaries, and her "Plastics Lexicon" lists 1200 words in the field of plastics processing and machinery in German, English, French, Italian, and Dutch.

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Bibliographies and Reviews

Bibliographies and periodic reviews are secondary sources which can be most helpful in approaching new subject matter. In addition to serving as an introduction to the field, they are written, generally, by outstanding workers whose papers may be followed in the author indexes of *Chemical Abstracts;* a different and, at times, surprisingly fertile approach to literature searching.

There are few bibliographies specifically dealing with polymer science. "Guide to the Literature and Patents concerning PVC Technology" was updated in 1963 and now includes polymers and copolymers containing at least 75% vinyl chloride. "The Bibliography of Rubber Literature" periodically published by the Division of Rubber Chemistry of the American Chemical Society, covers patents and journal literature and includes rubberlike plastics. The sections on elastomers, synthetic resins, and plastics of "The Bibliography of Chemical Reviews" can be consulted for the years 1958 through 1962. Kharasch's, "Index to Reviews, Symposia Volumes and Monographs in Organic Chemistry" has been updated to 1964 and covers journals, symposia, and nonperiodical publications.

When bibliographies are not available, some hunting in periodic reviews will lead to interesting information. "Fortschritte der Hochpolymeren Forschung" contains papers in English, French, and German on the physics and chemistry of high polymers. Papers and discussions at the British Plastics Convention have been published in book form as "Plastics Progress" for some years but are now included in the journal, *British Plastics.* Other books containing review articles on different aspects of polymer science are "Modern Materials—Advances in Development and Applications," "Advances in Petroleum Chemistry," "Annual Review of Physical Chemistry," "Advances in Catalysis and Related Subjects," "Review of Textile Progress" and "Reports on the Progress of Applied Chemistry."

Abstracting and Indexing Services

For any extensive retrospective search *Chemical Abstracts* is the classic tool that assures best results, thanks to thorough coverage and careful cross-indexing. *Applied Science and Technology Index* can be recommended for locating current information in a limited number of trade journals. *Engineering Index* covers periodicals in the applications and processing fields, and is now publishing a separate plastics section, in cooperation with the Society of Plastics Engineers.

Two new services of CAS aim at current awareness of all aspects of the plastics field: *POST-P* and *POST-J* give reference to papers and patents providing indicative abstracts, keyword-, formula-, author-, and patent indexes and magnetic tape for computer searching. *Plastics Industry Notes* is geared to inform business and production management on new developments in the industry.

Specialized abstracting services dealing with plastics include *Resins-Rubbers-Plastics,* suspended by Interscience in 1962 but continued by Information for Industry, Inc. since 1963. These abstracts go into considerable detail and include graphs and tables. They are published in loose-leaf form and may be assembled in chapters by subject. *Plastics Abstracts* and *RAPRA Abstracts*, formerly British Plastics Federation Abstracts, cover journal and patent literature with short indicative abstracts. *Rheology Abstracts* and *Journal of the Textile Institute, Abstracts* cover closely related fields.

In the highly competitive plastics industry awareness of patent developments is of utmost importance. In addition to the abstracting sources mentioned above, several services deal exclusively with patents. The *Uniterm Index to U.S. Chemical Patents* may be searched either manually or by computer. The latter service is available on either a single question basis from the publishers, or on a subscription to tape basis for in-house use. As is the case with most Uniterm Systems, extreme care should be exercised in the selection of keywords for searching.

Derwent's *PLASDOC* patent documentation system has been in operation since early 1966. *PLASDOC* provides for its subscribers current awareness and retrieval tools for patents on plastics, raw materials, processing, and applications by a systematic classification system, punched cards, magnetic tape, and computer-produced indexes as well as abstracts and complete specifications on microfilm.

Specifications, Standards, and Testing

Careful standardization of procedures is of paramount importance in testing a highly complex material, as is even the simplest polymer. The American Society for Testing and Materials (ASTM) has made an invaluable contribution to industrial technology by working out and revising test methods, and adapting them to new materials and new applications. The "1968 Book of ASTM Standards" supersedes all previous editions, and its index refers to definitive and tentative standards in their latest form.

The society's activity is not limited to the issuance of testing procedures. *International Symposium on Plastics Testing and Standardization,* 1958, *Symposium on Tension Testing of Non-Metallic Materials,* 1956, *Symposium on Adhesion and Adhesives,* 1959, *Symposium on Reinforced Plastics,* 1961, and *Symposium on Thermal Ablation,* 1959 are but samples of the many symposia sponsored by committees of ASTM. Anyone interested in the field will find valuable information by scanning the list of ASTM publications.

Several agencies of the U.S. Government such as the Department of the Army, Department of the Navy, Federal Supply Service, etc., have issued their own specifications and standards, and the General Services Administration issues the *Index of Federal Specifications and Standards.* The Plastics Technical Evaluation Center (PLASTEC) has compiled federal specifications related to plastic materials of potential defense interest.

The American Standards Association (ASA) serves as a national clearing house and correlating agency for standards emanating from specialized sources such as ASTM, the Society of Plastics Engineers and the Society of Plastics

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch021

Industry. Similar standardizing bodies exist in most industrialized countries and are correlated by the International Organization for Standardization in Geneva.

Let us now turn to the results of testing—physical, chemical, mechanical, and electrical data on plastic materials. In spite of the many existing compilations, searching for a particular property of a particular polymer can still be a frustrating enterprise. It must be remembered that such data do not refer to chemical species but to industrial products. Their properties depend on their history and additives, as well as details of the testing procedure, and generally, not all of these items are specified.

The trade literature, manufacturer's catalogs and guides, such as "Modern Plastics Encyclopedia," "British Plastics Yearbook," "Materials Selector Issue," "SPI Plastics Engineering Handbook," and "Technical Data on Plastics," will acquaint the searcher with property ranges of the commercially available products. An impressive compilation of physical and chemical constants and parameters is "Polymer Handbook" edited by Brandrup and Immergut. The 6th edition of the Landolt-Bornstein tables includes a relatively short section on physical properties of rubbers and plastics. A well documented compilation of data can be found in "Ullmanns Enzyclopaedie der Technischen Chemie," with reference to, and description of American, as well as German, testing procedures. We cannot leave this section without mentioning several efforts to review the physical data and testing literature widely scattered in primary sources. They are: "Retrieval Guide to Thermophysical Properties Research Literature," "Handbook of Thermophysical Properties of Solid Materials" and, exclusively concerned with plastics, A. Lever's "The Properties and Testing of Plastic Materials."

Journals

Comparing today's sources of primary information on polymer chemistry with those given in earlier bibliographies, one discovers a noticeable change. Journals of a more general character have been displaced by ever more specialized publications. The *Journal of Polymer Science* is now published in three sections: A—General Papers, B—Polymer Letters, and C—Polymer Symposia. *Journal of Macromolecular Science* covers physics and chemistry of polymers and issues two yearly review numbers. *Macromolecules,* a bimonthly of the American Chemical Society, started publication in January 1968. Other journals dealing exclusively with basic polymer science are *Die Makromolekulare Chemie, Polymer, Kobushi Kagaku* and *Polymer Science USSR* which is a partial translation of *Vysokomolekularnye Soedineniya.*

Articles related to the applied and industrial aspects of polymer chemistry and plastics technology are found in the *Journal of Applied Polymer Science, The Plastics Institute* (*Transactions* and *Journal*), *SPE Journal,* and *SPE Transactions. Kunststoffe* and *Faserforschung und Textiltechnik* are published in German; the former may be purchased with English translations included, and the latter contains English abstracts. *Soviet Plastics* is the English translation of *Plasticheskie Massy.*

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch021

There are several other periodicals in which articles related to polymer science appear quite frequently. These include: *Journal of the American Chemical Society, Journal of Organic Chemistry, Journal of Colloid Science, Journal of Applied Physics, Journal of Research of the National Bureau of Standards,* the former *ASTM Bulletin,* now issued as *Materials Research and Standards, Industrial and Engineering Chemistry,* and its quarterly *Product Research and Development* issue, and *Pure and Applied Chemistry.*

British Plastics, Modern Plastics, Plastics (London), and the host of trade magazines which, for lack of space, we cite only in the bibliography deal with the technical and processing aspects of plastics.

Chemical Reviews, the English *Quarterly Reviews,* and *Russian Chemical Reviews,* should be consulted routinely for polymers, as for any other field of chemistry.

The appended bibliography contains many items that have not been cited in this paper, but even the bibliography does not contain all of the valuable references available. It does, however, contain those references which can lead the individual to additional material in his particular field of interest.

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1912	26. Pigments, Resins, Varnishes and India Rubber
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U.S. Patent Classes and Subclasses

	Class	*Subclass*
Plastic		
Block and earthware apparatus	25	
Compositions	106	
Dyeing of	8	4+
Metalworking	72	253+
Plastics	18	
Structures		
Brush or broom tuft socket	15	193
Coffins	27	7
Fence connections rail	256	66
Fence connections wire	256	50+
Fences	256	19
Lacing eyelet	24	142
Lacing studs	24	148
Railway ties	238	84
Seat covers	297	219+
Settable material masonry	52	
Splints	128	90+
Synthetic resins building component	52	309
Testing of	73	150

	Class	*Subclass*
Plasticizing		
Casein containing compositions	106	147
Gelatine containing compositions	106	136
Rubber	260	761
Reclaiming	260	714+
Synthetic resins	260	29.1+
Textiles	8	130.1+
Resins		
Dyeing	8	4
Mineral oil	208	22+
Making, treating and recovery	208	39+
	260	97+
	51	300
	106	
	260	755+
	260	25+
Synthetic	260	2+
Abrasives containing	51	298
Reaction induced by electrical or radiant energy	204	154+
Wtihin a nuclear reactor	176	10+

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22

Literature Guide for the Printing Ink Maker

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Literature of interest to printing ink makers is surprisingly complex for such a small industry because historically the ink maker has been responsible not only for his own product but often for those of his customer; these range from book to bottle, from printed circuit to cigarette cork tips. The ink maker must be up to date in the physical sciences; in the rapidly changing technologies of surface coatings and graphic arts, of publication and packaging, of paper, foil, and plastic films. The advanced ink maker must be an active participant in the institutions and societies concerned with his industry. The bibliography which accompanies this paper lists books, periodicals, abstracts, indexes, and information services, patents, and societies and institutions which will orient the newcomer to the field and keep him up to date.

To understand the complexity of the literature of printing ink, it is necessary to understand why this complexity exists. The printing ink industry, totaling U. S. yearly sales of only about $300,000,000, seems to be a relatively small industry, highly specialized in a narrow field. However, printing inks are an indispensable part of the graphic arts field, which is a multibillion dollar a year industry in the United States alone. At present the graphic arts field embraces not only publications of all kinds but also the rapidly expanding and diversifying field of packaging. In addition, the graphic arts industry is rapidly making inroads into the architectural, automotive, and appliance fields as well as into such modern fields of machine communication as the printing of magnetic, electroconductive, or optical scanned materials. There are still other minor and even some major highly specialized applications with which the progressive ink maker must be familiar.

Further, the printing ink industry is a so-called "service industry"; it not only makes and sells its products, but it is responsible for its functioning. This can only be understood from the historical point of view. Originally, printing

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

inks were made by the printers themselves. Only when the volume of inks used grew, was it convenient to split off the ink manufacturing units from the print shops. At any rate inks had to perform satisfactorily on the press, and they could not spoil or harm the end product. If any difficulty occurred or if new printing processes or new end application were developed, the ink maker was —and still is—called in. He has to prepare or to adjust his inks to perform properly. The printing ink industry is process-dependent and must incorporate into its product—the ink—all that is necessary to make it behave properly under widely differing conditions. Consequently, the ink maker must be well informed about all widely differing conditions. This is the reason for the disproportionate complexity of the relatively small industry.

The invention of printing, as we know it today, dates back about 500 years. At that time it was a major breakthrough in automation and could be considered the automation of human handwriting or drawing. However, with the perfection of the different printing processes, today it has become much more than that. The printing press is an excellent way to apply rapidly, precisely, and economically thin surface films to many substrates besides paper. These surface films can be of contrasting color, single color, multicolor, or even colorless. Printing presses are used to apply ("print") thin surface films giving not only contrasting color for reading or seeing purposes, but giving such sometimes invisible properties as gloss, chemical resistance, slip or non-slip, heat-sealability or heat-seal resistance, adhesive properties for lamination, specific chemical reaction—e.g., color changes under given conditions, specific optical properties, conductivity, magnetization, and many more. To illustrate the above-mentioned points, some of the lesser-known but widely-used applications of the still so-called printing inks are: wood-grain or otherwise-patterned plastic table tops; blackboard surfaces; cork tips on cigarettes; magnetic imprints on bank checks or ledgers; miniaturized printed circuits.

Still newer processes and applications are being studied and developed. Even new terms, like "imaging processes," "graphic communication," and "electrostatic printing" are slowly becoming familiar terms to "printers."

Printing Inks

Printing inks are usually defined as solutions or dispersions of coloring matter in vehicles. This definition is certainly no longer correct. In view of the discussion above, the only definition wide enough to embrace all products sold as printing inks would be: "materials which can be applied from printing presses." However, for most cases the older definition still holds and is convenient because it gives a good starting point as long as one remembers that there are inks which contain no coloring matter at all.

Consequently, printing inks are solutions or dispersions of coloring matter in a vehicle. While the term "coloring matter" can be described easily as either pigment or dyestuff, a definition of "vehicle" is not so easy. An attempted definition would be: "everything in the ink aside from color," meaning a "vehicle" (varnish, binder, etc.) necessary to carry the coloring matter from the fountain to the substrate, and to hold it there more or less permanently.

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The vehicle could consist of drying or non-drying oils, solvents, plasticizers, resins, catalysts, waxes, and various other chemicals such as surface-active agents and optical brighteners—i.e., materials which are needed to make the ink as well as the printed product perform properly.

The ink maker must be familiar with chemistry and physics in general, but particularly with the special fields involving the materials outlined above. In addition, he must know the techniques of varnish making and of mixing and dispersion, as well as the physics and measurement of color, rheology, modern analytical and testing procedures, including chromatography, spectroscopy, and infrared spectroscopy.

Since these printing inks are applied from presses, the ink maker must be familiar with all kinds of printing equipment, including presses and printing processes, drying systems and ovens, rollers, plates and plate-making, chemicals and fountain solutions (which more often than not are produced by the major ink makers), as well as cylinder-making procedures and techniques, screens and screen-making procedures.

The printing press then applies the ink to the substrate which includes not only paper and board but also certain metals and metal foils such as tin, steel, aluminum, lead, and all types of plastic materials used mainly in the packaging field. The final print on the given substrate must stand up to the required end use, with which the ink maker should also be familiar. Furthermore, he has to know the required testing procedures, specifications, government specifications, Food and Drug Administration rules, and ASTM specifications.

Finally, the printing ink industry is considered a part of the larger field of surface coatings in general. With regard to raw materials and manufacturing procedures, the ink makers of the past especially—but even the modern ink maker—has followed the advances of his big brother in the paint field, in many instances with good results. The conscientious ink maker, therefore, cannot afford to neglect the rich literature of the general surface coatings field.

The subjects of vital interest to the ink maker include:

(A) Surface coatings in general—printing inks in particular; printing processes; graphic arts.

(B) Chemistry in general—specifically, dye and pigment chemistry, including metal powders, luminescent materials, magnetic and electroconductive materials; polymer chemistry; drying-oil chemistry; colloid chemistry; surface chemistry; analytical chemistry, including chromatography.

(C) Physics in general—specifically, color physics, including spectrophotometry and infrared spectrophotometry; rheology; electrostatic processes (deposition).

(D) Chemistry and technology of substrates (paper, board, metal, plastics, etc.).

(E) Publication and packaging (an intimate knowledge of these two fields is paramount because at present they are the two areas where the greatest volume of ink is used. Furthermore, these fields change rapidly, adapting new processes and using newer equipment almost daily).

(F) Testing procedures, standards, and specifications.

(G) Reference materials.

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Literature Sources

In 1933, H. J. Wolfe wrote in the preface to his book on printing inks:

> . . . being interested in learning more about the technology of printing inks, I asked the chief chemist . . . for a list of books on the subject that would give me the information I required. He advised me that there were no really satisfactory treatises on the subject, and that I would simply have to keep my eyes and ears open, and learn by experience. . . .

This, surely, is no longer true. Now, we have a good—if small—series of books on printing inks, written from different points of view. These books can be considered a fairly good starting point because they give the ink maker a broad review of the entire field up to the day when that particular book was written. These books are textbooks, treatises, and even encyclopedias. Most of them have extensive bibliographies, referring the reader to other, more specialized sources for more detailed information in the respective field of science or technology.

However, as in most other fields of scientific or technical endeavors, a rapid expansion in many directions is occurring, and at the same time, rapid progress is taking place in each of these different directions. Therefore, the researchers, as well as others connected with the printing ink industry in technical or even sales or managerial capacities, must use some of the more modern tools of "current awareness" for the rapid but rough information which they can offer. Of course, a great variety of periodicals in the fields outlined must be read by the specialist to keep up to date.

Again, as in so many other areas, the most recent important work can only be followed properly by participating, attending, or reading the proceedings of the more or less regular meetings of the different scientific or technical organizations listed in the accompanying bibliography.

As stated previously, the situation has changed drastically during the last 30 years, when practically no important reference tool was available for the novice. But, alas, the poor novice might be worse off today because the good series of textbooks available now will only serve to introduce him to a highly complex technology. Because of the wide expansion of the industry during the last 30 years, he must consult textbooks, periodicals, and current awareness tools in all of the areas in which the modern printing ink maker is so vitally concerned.

The bibliography which accompanies this paper is divided into four categories—namely:

(1) Textbooks, encyclopedias, and treatises to serve as the broad basis from which to start.

(2) Serials and periodicals—a listing of those in which original as well as review articles appear regularly; these would serve to keep us informed and up to date.

(3) Current-awareness tools—abstracts, indexes, information services, and patents which serve for rapid but rough information on recent work.

(4) Institutions and societies publishing their findings regularly, holding meetings, conferences or seminars; these are of greatest interest to the researcher, keeping him informed in depth on the latest work.

It is hoped that these sources will help to introduce the newcomer to the printing ink field and keep him up to date on its rapid development.

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Year	*Section*
1912	26. Pigments, Resins, Varnishes, & India Rubber
1915-1960	26. Paints, Varnishes, & Resins
1961	26. Paints, Varnishes, & Resins
1962	43. Organic Coatings, Inks, & Related Products
1963-1966	52. Coatings, Inks, & Related Products
1967	42. Coatings, Inks, & Related Products

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American Association of Textile Chemists and Colorists, P. O. Box 886, Durham, N. C. 27702; "Colour Index"; *Technical Manual; Yearbook; American Dyestuff Reporter;* test methods.

American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036; Chemical Abstracts, "Abstracts of Paper" (given at the meetings), ADVANCES IN CHEMISTRY SERIES, other publications of chemical interest.

American Management Association (AMA), 1515 Broadway, New York, N. Y. 10036; *Manager's Letter; Management News; Management Review; Management Reports; Research Studies.*

American Newspaper Publishers Association, 750 Third Ave., New York, N. Y. 10017; R. I. Bulletin, standards, reports, and conferences.

American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103; *Materials, Research, and Standards; Proceedings; Yearbook;* special technical bulletins; standards and tests; symposia.

Battelle Memorial Institute, 505 King Ave., Columbus, Ohio 43201; *Battelle Technical Review;* occasional publications; programs (service basis).

Carnegie Institute of Technology, Department of Printing Management, Pittsburgh, Pa.; occasional publications.

Deutsche Gesellschaft für Forschung im Graphischen Gewerbe, E. V., Brunner Star. 2, Meunchen-13, Germany; *FOGRA Mitteilungen; Instituts Mitteilungen;* frequent reports and publications.

Food and Drug Administration, Department of Health, Education and Welfare, Washington, D. C. 20201; *Federal Register* reprints; circulars; quarterly bulletins; technical bulletins.

Flexographic Technical Association (FTA), 157 West 57th St., New York, N. Y. 10019; "Technical Manual"; "Flexographic Pressman's Manual"; proceedings; technical conferences; seminars.

Federation of Societies for Paint Technology, 121 South Broad St., Philadelphia, Pa. 19107; *Journal of Paint Technology;* meetings of local groups; technical committee reports.

Graphic Arts Technical Foundation (GATF) (formerly Lithographic Technical Foundation, till 1963), 131 East 39th St., New York, N. Y. 10016; *Lithographic Abstracts, Research Progress; Newsletter;* test methods; conferences and seminars.

Gravure Research Institute, 22 Manhasset Ave., Port Washington, N. Y.; reports; conferences and seminars; *Newsletter.*

Gravure Technical Association (GTA), 30 Rockefeller Plaza, New York, N. Y. 10020; *GTA Bulletin;* technical conferences.

Instituut voor Grafische Techniek TNO, Postbus 4150, Amsterdam, Netherlands; *IGT-Nieuws;* occasional publications.

Intersociety Color Council (ISCC), Photographic Technology Division, Bldg. 65, Rochester, N. Y. 14650; *ISCC Newsletter;* occasional publications; conferences.

National Association of Printing Ink Manufacturers (NAPIM), 39 West 55th St., New York, N. Y. 10019, "Printing Ink Handbook"; "Printing Inks, A Manual"; occasional publications.

National Paint, Varnish, and Lacquer Association (NPVLA), 1500 Rhode Island Ave., N.W., Washington, D. C. 20005; *Abstract Review; Coatings;* raw material indexes; scientific circulars; special scientific circulars.

Packaging Institute (PI), 342 Madison Ave., New York, N. Y. 10017; *The News Packet; Marketing Packet; Technical Packet; Proceedings;* advisory service reports; forum publications; special reports; standard tests; technical conferences.

Paint Research Institute (PRI), 121 South Broad St., Philadelphia, Pa. 19107; occasional publications; technical committees.

Printing Industries of America (PIA), 20 Chevy Chase Circle, N.W., Washington, D. C. 20015; *PIA Management Reports;* coordination of research programs, conferences.

The Printing, Packaging, and Allied Trades Research Association, PATRA House, Randalls Rd., Leatherhead, Surrey, England; *PATRA Journal; Printing Abstracts;* frequent publications and reports; test methods; conferences.

Research and Engineering Council of the Graphic Arts Industry, Inc., 1411 K St., N.W., Washington, D. C. 20005; *R & E Coordinator; Listings;* conferences and proceedings.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch022

Rochester Institute of Technology, Graphic Arts Research Department, 65 Plymouth Ave., South Rochester, N. Y. 14608; *Graphic Arts Progress* (includes *Graphic Arts Index*); library service-bibliographies; conferences.
Society of Photographic Scientists and Engineers, Inc. (SPSE), Box 1609, Main Post Office, Washington, D. C.
Stanford Research Institute, Menlo Park, Calif.; *Journal;* releases; research bulletins (service basis).
National Printing Ink Research Institute (NPIRI), Lehigh University, Bethlehem, Pa.; *Ink Spots; NPIRI Literature Review; NPIRI Research Reports and Bulletins;* NPIRI Standards and Test Methods; project reports, bulletins; conferences.
Technical Association of the Graphic Arts (TAGA), P. O. Box 3064, Federal Station, Rochester, N. Y. 14614; *TAGA Proceedings; Newsletter,* conferences.
Technical Association of the Pulp and Paper Industry, 360 Lexington Ave., New York, N. Y. 10017; *Abstract Bulletin; TAPPI;* standard tests; meetings and conferences; monographs; bibliographical series.

Patent Classes and Subclasses

73. Measuring and testing
    150. Coating materials; ink, adhesive and/or plastic
96. Photographic chemistry, processes and materials
    28-38 (mainly). Processes including exposure or use of image recorder
101. Printing (mainly equipment, but also includes processes)
106. Compositions, coating, or plastic
    20-32 (mainly). Inks (important material in many other subclasses)
117. Coating: processes and miscellaneous products
    38 (especially). Printing, masking, stenciling (see also other subclasses)
118. Coating apparatus
148. Metal treatment
204. Chemistry, electrical and wave energy
252. Compositions (many ink and ink vehicle patents in different subclasses)
260. Chemistry, carbon compounds (many ink and ink vehicle patents in different subclasses)

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Literature for the Coatings Industry

DELLA WILSON

National Paint, Varnish, and Lacquer Association,
1500 Rhode Island Ave., N.W., Washington, D. C.

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Almost every branch of life is concerned with some aspect of surface coating. Therefore, information on the subject is widely disseminated, under topics ranging from inks to economics. For the sake of convenience, the literature is arranged under two headings: technology and performance of coatings. General and specialized sources include books, magazines, government, trade, and company publications. The suggested sources, augmented in the bibliography of books, periodicals, and abstracts, are by no means a complete collection. However, the advent of key-word coding and information retrieval techniques has brought reasonable coverage within reach.

Although paint-making was one of man's earliest endeavors, historical literature on the subject rarely applies to today's technology. Cro-Magnon cave paintings date back at least 20,000 years, while 2000 years ago the Egyptians painted their mummy cases for preservation as well as decoration.

In more recent times, paint manufacture has developed as a father-to-son craft, using jealously guarded "secret" recipes. In the United States, painting for preservation accompanied the spread of iron and steel for building.

By general agreement among manufacturers, technical details of production were kept secret. A rare exception are the records of America's earliest varnish maker, Christian Schrack and Co., Philadelphia, which may be examined by the public at the Eleutherian Mills Historical Library, Wilmington, Del.

Modern coatings literature touches upon numerous aspects of life; therefore, articles on the subject may be found in almost any publication under categories ranging from food to electrical engineering. This material may be separated into two divisions: (1) the technology of manufacturing and the properties of raw materials used, and (2) the use and performance of the coating.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Technology and Properties

Periodical literature pertaining to the first division—technology and raw materials—is concentrated in a relatively few sources. In the United States, the *Official Digest,* published by the Federation of Societies for Paint Technology, covers the area well. A comparable British publication, *Journal of the Oil and Colour Chemists' Association,* does a fair job.

The American trade press carries occasional technical articles in such periodicals as the *American Paint Journal, Paint and Varnish Production,* and *Western Paint Review.* Their British counterparts are *Paint Technology, Paint Manufacture,* and *Paint, Oil and Colour Trades Journal.* The basic scientific coverage of organic and physical polymer chemistry often touches upon coatings.

Smaller journals in France, Germany, Austria, Italy, and the Netherlands often carry articles of interest, which are abstracted in *Chemical Abstracts* (Macromolecular section), *Review of Current Literature on the Paint and Allied Industries* (British), and the *Abstract Review.* Abstracts are likely to be classified under the substance coated, rather than under "coatings."

Basic texts on coatings technology include "Basic Principles of Paint Technology," "The Physical Chemistry of Paints" by P. M. Fisk, and "Organic Paint Technology" by H. F. Payne.

Use and Performance

Routine technical literature is easy to find, while material pertaining to the uses and performance of coatings is more widely disseminated. The end use of a particular coating is apt to be found in a trade journal specializing in final uses, or in a periodical focusing on a related field such as engineering, art, optics, toxicology, architecture, printing, or plastics. Rubber, fibers, and inks are especially pertinent technologies.

Periodicals involving specialized aspects of the coatings industry include: *Color Engineering, Fire Journal, Forest Products Journal, House and Home, Modern Plastics,* and *Materials Protection.*

Parts 20 and 21 of "Standards," published annually by the American Society for Testing and Materials (ASTM), deal with "paint." These contain fully adopted standards, tentative rulings, and standards in the formative stages presented for their general information value only. The monthly ASTM journal, *Materials Research and Standards,* describes many new testing techniques. "ASTM Technical Publications" are individually published symposia held to advance knowledge in a particular area prior to proposal of specific standards.

Company pamphlets, bulletins, and house organs, issued by the manufacturers themselves, are often helpful. Little of this information is abstracted or indexed.

The "company" pamphlet is usually well illustrated, giving brief product descriptions and suggestions for their use. It becomes outdated rapidly but

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch023

can be a useful source. Goodyear Chemical Division's pamphlet on "Pliolite" is an example.

Product bulletins are published and updated regularly by the raw materials suppliers to the industry, and provide much basic information on the properties and performance of various coatings. Topics vary from discussion of fundamental problems to specific formulations recommended for particular tasks. The Goodyear series "Tech Book Facts," and DeSoto Chemicals' bulletin "Hydrocide Super Colorcoat," are typical.

The manufacturer's house organ, originally designed to keep employees abreast of happenings within the company, has often developed into a well-written and beautifully illustrated magazine. Both technical and non-technical features on products and materials appear regularly and may be obtained by "outsiders." *Chemist Analyst,* a quarterly published by the J. T. Baker Chemical Co., and *Hercules Chemist,* published three times yearly by the Hercules Powder Co., are examples of house organs which have become nearly equivalent to journals. Oxbridge Publishing Co.'s "Standard Periodical Directory" lists several house organs as well as many other useful sources.

Government Publications. The U. S. Government publishes a significant amount of material. Some of the technical articles may be run in other periodicals and therefore appear in abstracts and indexes, but many manuals, reports, specifications, and patents contain data not found elsewhere.

Military laboratories involved in coatings include the Ordnance Tank-Automotive Command, Detroit Arsenal Materials Lab, Puget Sound Naval Shipyard Paint and Plastics Lab, Wright Air Development Center Aeronautical Materials Lab, Naval Air Material Center (Philadelphia), and Rock Island Arsenal Lab (Illinois).

In 1964, the Office of Technical Services in the Department of Commerce distributed a "Selective Bibliography on Paints and Varnishes," listing reports and translations added to its collection between 1945 and July 1963. This agency has been replaced by the Clearinghouse for Federal Scientific and Technical Information; recent entries for the Bibliography may be obtained from them.

Government-Wide Index to Federal Research and Development Reports is a new Clearinghouse publication initiated in 1963. This is a combined index of Atomic Energy Commission, National Aeronautical and Space Administration, Defense Department, and Clearinghouse reports. It has a subject, author, source, and correlated report number index.

German technical papers confiscated at the end of World War II form the basis of the Clearinghouse's PB collection. The rest of the papers are the unclassified results of the United States' $15 billion research and development program. The latter group contains 350,000 reports, supplemented by 3,000 reports monthly. This combination of resources supplies a wealth of coating information.

The National Aeronautical and Space Administration (NASA) publishes a "Scientific Technical Abstract Registry," containing 285,000 NASA reports

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch023

and 155,000 reports accumulated from foreign technology. It is updated bi-weekly and notes where the reports are available. Coatings are a major NASA concern.

"NASA's Contribution to Technology of Inorganic Coatings" by Jerry Plunkett of the Denver Research Institute is particularly germane, and may be purchased from NASA or the Government Printing Office.

Several other government agencies provide manuals outlining specifications for official projects. "The Paint Manual," published by the Bureau of Reclamation, and the Bureau of Public Roads' "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects" are good examples. A non-government publication along the same lines is the "Guide to U. S. Government Paint Specifications," put out by the National Paint, Varnish, and Lacquer Association; this contains brief abstracts of various specifications, and for more detail one may wish to consult the original specifications issued by the agency concerned.

Patents. In the patent field, the *Official Gazette,* issued weekly by the U. S. Patent Office, discloses the new patents granted every Tuesday. The claims are summarized briefly but help the searcher identify patents of interest.

The patent system provides three helpful tools to assist those unfamiliar with its workings. They are: "The Class and Subclass Definitions," "The Manual of Classification," and "Index to the Classification System." To aid in their use, the Commerce Department puts out a pamphlet titled, "How to Obtain Information from U. S. Patents," which may be ordered from the Government Printing Office, Washington, D. C.

Texts. Books on coatings tend to become outdated rapidly; however, they are an essential form of information, especially in the area of testing methods, where "Paint Testing Manual—Physical and Chemical Examination. Paint, Varnishes, Lacquers and Colors" by H. A. Gardner and G. G. Sward is an excellent source. For general as well as specialized approaches to the subject, the following are recommended: "Varnish Constituents" by H. W. Chatfield, "Fundamentals of Paint, Varnish and Lacquer Technology" by Elias Singer, "Understanding Paint" by W. R. Fuller and "Industrial Paints, Basic Principles" by L. A. Tysall. J. J. Mattiello's "Protective and Decorative Coatings: Paints, Varnishes, Lacquers and Inks" is considered a classic in the field.

Coatings literature is conspicuously lacking in data on marketing research. Figures on the end use of products in the paint industry are almost non-existent. The only authentic source, the "U. S. Census of Manufacture" is usually too detailed to be convenient. The "Statistical Handbook," published by the National Paint, Varnish, and Lacquer Association summarizes the material available from the Census Bureau, U. S. Tariff Commission, Department of Agriculture, Department of Labor, and others, but is also deficient in marketing information.

In general, it might be said that locating 80% of the information available on coatings is relatively simple, but uncovering the remaining 20% will require a persistent sleuth.

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Year		*Section*
1912	26.	Pigments, Resins, Varnishes, & India Rubber
1915	26.	Paints, Varnishes, & Resins
1961	26.	Paints, Varnishes, Lacquers, & Inks
1962	43.	Organic Coatings, Inks, & Related Products
1963	52.	Coatings, Inks, & Related Products
1967	42.	Coatings, Inks, & Related Products

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U. S. Patent Classes and Subclasses

Material	*Class*	*Subclass*
Coating		
Anticorrosive	106	14
Apparatus	118	
Applicator type	15	
Detearing	118	639
Electromagnetic	118	623
Electrostatic	118	621+
Match dipping	144	50+
Mold metal casting	118	
Mold plastics	118	
Paper hanging combined	156	574+
Pipes	25	38
Xerographic transfer	118	637
Classifying, separating, assorting solids by	209	47+
Coated surface or mass	209	49+
Cleaning by	134	4
Combined with other manufacturing operations (see particular art)		
Composition (see composition coating)		
Window glass to prevent deposit and freezing of moisture	106	13
Electrical barrier layer	117	200
Composition	252	62.3
Electro less	117	
Paper making combined		
Apparatus	162	265+
Process	162	135+
Paper undried	162	158+
Processes	117	
Abrasive tool	51	295
Battery linings	136	181
Catalysts	252	410+
Cathode sputtering	204	192
Dyeing combined	8	18
Electrically conductive	117	201+
Electro less	117	
Electrolytic	204	14+
Electron emissive	117	201+
Electrophoretic or electro osmotic	204	181+
Electrostatic	117	93
Foods	99	166+
Metals by chemical action	148	6+
Molds	117	5.1+
Ornamentation combined	41	17+
Textiles chemical modification combined	8	115.6
Removal		
By electric spark or arc	219	19
Lacquer (*see* Varnish)		
Cellulose ether or ester	106	169+
Synthetic resin containing	260	13+

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Material	*Class*	*Subclass*
Synthetic resin containing	260	29.1+
Drying oil containing	260	18+
Paint	106	
Anticorrosive	106	14
Antifouling	106	15+
Brushes	15	159+
Drier	106	310
Luminous	252	301.2+
Radioactive	252	301.1+
Signs	40	134
Mill	241	
Removing	134	38
Varnish		
Asphalt	106	273+
Fatty oil	106	246+
Natural resin		
Fatty oil	106	220+
Solvent	106	236
Synthetic resin combined	260	24
Removing	134	38
Materials	252	89+
Synthetic resin		
Cellulose ether or ester	260	13
Fatty oil	260	18+
Solvent	260	29.1+
Varnishing	117	

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The Jargon of the Rubber Industry

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The jargon in the rubber industry, as in any specific group or industry, consists chiefly of common words or phrases to which special and not common meanings are ascribed. To individuals within the group or industry, jargon is colorful and expressive, often connoting ideas or effects difficult to describe in more precise language. Jargon has been used too long to be abandoned. It is too expressive to be frowned on and often is so concise that it is a great aid to readability or hearability. When used with understanding, its use may be encouraged.

The *crude* was *broken down* in two passes in the *Gordon* using 0.1% *peptizer*. It was later *banbury* mixed by the *upside down* method because of the heavy *pigment* loading. To avoid *scorching* the *cure* was left out of the batch and added on the *warm-up mill*. The *green stock* had little *nerve* and *tubed* smoothly. When molded it did not *back-rind* or *blow*. The *cured* stock had a *Shore* of 65.

Here are 75 words, 18 of them jargon, that are understandable to rubber technologists but would mean little to people not familiar with the rubber industry. To be understood by others it was rewritten in about 350 words.

The use of jargon in industry is not new. It was undoubtedly used by the early guilds to protect their secrets from outsiders. These special terms were to have meaning only for guild members. However, whether jargon consisted of new words coined to describe a condition, or of existing words to which special meanings were given, the net result was descriptive, colorful, and especially meaningful to a select few. It is doubtful if jargon is purposely created to add color to a language, though this is certainly a net result. It is also doubtful if such words are coined or given special meanings deliberately because they convey so much meaning concisely. Jargon is created by accidental or even ignorant usage, sometimes by people too uneducated or inarticulate to describe something precisely. In some cases it might be called the caricature of a concept, burlesquing a salient feature of an idea. An example of this might be

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In Literature of Chemical Technology; Smith, J.;
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fish eyes or *cat eyes,* which are undissolved bits of rubber in a solvent solution. They are probably the gel portion of incompletely broken down rubber, the balance being sol. As long as a person conveys his meaning clearly to another the result is good.

The jargon of the rubber industry begins with the Amazon Indians who discovered the rubber tree long before America was discovered. They called it cahuchu or cauchu, which means, the weeping tree. Vicki Baum told the story of rubber most interestingly in her book, "Weeping Wood." In 1736 La Condamine, a French scientist who had spent several years in South America, reported rubber to the French Academy. It is not surprising that the French name "caoutchouc" was adopted as a variation of the Indian name "cauchu." With respect to the English name "rubber," E. C. Holt (U. S. Department of Commerce, "Rubber Industry of the United States" 1939) says that "in 1770 Joseph Priestley, the English chemist and discoverer of oxygen, invited attention to a substance excellently adapted to the purpose of wiping from paper the marks of a black lead pencil. It is believed that others, not Priestley, gave the substance its English name—rubber."

Although jargon is concise, it is not always precise. It has meaning only in context, and its meaning often varies with context. Consider the word *cure,* one of the most widely used in the rubber industry. As a verb, it means "to vulcanize," and as a noun, "the act of vulcanization." It means a condition causing vulcanization, as in "a cure of 10 minutes at 307° F." It is also used more loosely to mean the ingredients which cause or contribute to vulcanization as in, "the cure was added on the warm-up mill," referring, of course, to the *accelerator,* zinc oxide, and/or sulfur.

For our definition we may say that jargon consists of words or phrases which are given meanings other than, or additional to, those commonly used. Hence, jargon may properly be used only when readers or listeners belong to the group, class or industry familiar with the special meanings. To use it with others is confusing, and to define the terms is cumbersome. However, definitions of jargon should be available and included in a glossary. The rubber industry, or elements in the industry, have produced several helpful glossaries and have recently, through the American Society for Testing and Materials (ASTM), formulated a very comprehensive one. Of course, glossaries are not limited to jargon, but practically all words considered to be common jargon should be included.

Let's drift around the *gum shop* which is, of course, jargon for rubber shop or rubber manufacturing plant. "Gum shop" suggests that the user of the term may be from Akron since the term was more prevalent there some years ago than in New England. The Wolf brothers in their book "Rubber" even refer to "Akron's gum mines," and they didn't mean synthetic rubber producing plants because none existed there at that time. In the storeroom we can see the bales of natural rubber and bags of synthetic—now referred to often as *elastomers,* a word coined to cover both natural and synthetic materials capable of being vulcanized to have elastic properties. This distinguishes them from plastics. Sometimes the difference between elastomers and plastics is hard to define.

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We will see packages of all the ingredients that help give rubber the specific characteristics of the final product. "To the rubber man," say the Wolfs, "all of these materials are *pigments*, no matter what they are or what their use." This statement applies to usage in Akron, more than in other parts of the country. It is still a fact that "pigment" is not limited to mean "a coloring matter." The word is commonly used to mean all manner of dry powder compounding ingredients, and especially those used for reinforcement and dilution. *Fillers* is another word for these dry components. This is not too "jargony," yet most of us would never say a stock was "filled" with whiting, clay, or carbon black. We would say *loaded*. Conversely, the dry ingredients would not be "loaders" but rather fillers or loading materials.

All of the compounding ingredients are taken to the *mill room*—not just a room in a rubber mill—but one in which are located the mixing devices on, or in which, the ingredients are incorporated into the rubber matrix. Mixing mills consist of two heavy, horizontal rolls between which the rubber and powders are ground and mixed. The *banbury*, an internal mixing machine name for its inventor, is probably located here also. The rubber is first *broken down*, jargon for masticated, or mechanically plasticized, to render it soft enough to take up the fillers and other ingredients. This operation eliminates or reduces the *nerve* of the rubber. This word is usually applied to unvulcanized rubbers or compounds and refers to a degree of toughness or resistance to deformation. Vicki Baum expressed this most colorfully. "When the sheets (rubber) are brought to the mill room they've got to be broken up. (We say broken down.) For this they're fed to the mills by the mill hands. There are mills and mills in a long row, and it's very hot in the mill room, because the rubber gives off an awful heat and a burning stench and an angry crackling when it's broken up. The rolls turn and turn and take the rubber between the bite and chew it and chew it and chew it. When it's been through several mills it comes out all sizzling hot and angry, but it's a soft, pliable, tacky mass."

Nerve is a state that must be experienced personally to be understood. Ball says *nerve* is "synonymous with elasticity in the uncured state." Out of context this definition oversimplifies the meaning. The mill man who physically manipulates the rubber on the *breakdown mill* understands it well. *Nerve* is destroyed or reduced by mechanically working (breaking down) the rubber or by using a chemical plasticizer, sometimes called a *peptizer*. A *peptizer* is not a pepper-upper but quite the reverse, a deadener, a plasticizer. A petroleum oil softens rubber but it is not a *peptizer*, or nerve reducer. We would like to measure nerve accurately but just don't know how. We may mill rubber and note how long it stays rough or *lacy*, and call it a measure of *nerve*. We distort a piece of rubber and time its comeback, and call that a measure of *nerve*. These measurements may show part of the effect but not all.

Master batch is rubber jargon. It does not have a meaning like master list or master key, however. A master batch is a mixture of rubber with a particular compounding ingredient (sometimes more than one ingredient) in a higher concentration than that in which it occurs in a normal mix. Master batching provides a convenient means for handling small amounts of critical ingredients

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like color pigments or accelerators and for making dispersions of carbon black. Accelerators and sulfur may be master batched and withheld from the balance of the mix to avoid *scorching* or *burning* the batch during mixing. The ingredients that produce scorch are thus held out while mixing temperatures are high and added at a time just prior to further processing when the batch is cool. *Scorch* means premature vulcanization, which renders an unvulcanized compound tough, nervy, and less capable than otherwise of being processed smoothly. The heat of mixing may cause a stock to scorch but with some ultrafast acting accelerators—*hot* accelerators—scorch can occur at room temperature.

Usually, in banbury mixing, the fillers and other ingredients are added after the rubber is partially masticated. Sometimes when the filler load is unusually great the fillers are put into the mixer first and the rubber added a little later. This is *upside down mixing*—more jargon. The mixed stock may be calendered next. A calender is a machine with steel rolls arranged vertically that forms the stock into a sheet to be applied to fabric or taken from the machine as an unsupported film. "Calender" is a good dictionary word and not jargon. Prior to calendering, the stock passes through a *warm-up* or *feed mill* where the cold compound is replasticized by milling and from which the warm, soft stock is fed to the calender. A special type of mill is a *refiner,* which John Ball says "is similar in construction to a mixing mill, but is operated with the rolls held very close together by tremendous pressure. The tight rolls grind down and iron out the mass into a smooth sheet free of devulcanized particles or *tailings,* thoroughly dispersing any compounding ingredients previously added during blending." Since Ball put "tailings" in quotes, he evidently considered it jargon.

When rolls of a calender are adjusted to run at certain differential speeds, it is called a *friction* calender. It is used to push a soft stock into the weave of a fabric. Vicki Baum describes it; "Next it (the rubber compound) goes into a three-roll calender where it's squeezed into a strip of fabric. The calender men call it frictionizing; and (tire) casings are made of this fabric." I think we would always say "frictioning" not "frictionizing." It is a means for applying an adhesive coating to fabric. Bicycle or tire tape is often called friction tape because the coating is applied by the friction calender. *Friction* is jargon that requires context to define specifically. A *friction* may be the soft, sticky stock, the operation for applying it, or the coated fabric. It is also used to mean adhesion, though this use of friction seems erroneous enough to be discouraged. The term *friction pull,* however, is used often to denote adhesive strength, whether determined in shear or peel.

When *calendering* or *frictioning* a smooth rolling *bank* gives the best results. *Bank* is jargon for the supply of stock held at the bite of the rotating rolls. A *pencil bank* is the size of a pencil or a bit larger in diameter. It suggests a nicely mixed, well plasticized stock to roll uniformly at such a small diameter. Defects on the surface of the calender sheet, are known variously as *crows feet, air marks, pockmarks, chatter marks* or *spits.* These are caused perhaps by poor stock condition, too little or too much heat on the calender rolls, imperfectly ground calender rolls, or poorly meshing drive gears. The

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surface effects noted are significant to experienced operators. They suggest what he may have to do to improve the final product. Then too, the calendered film, whether applied to fabric or taken off as a film, may shrink and hence distort badly when it cools. This is *nerve* again—or a manifestation of nerve.

Tack is rubber jargon. In one rubber glossary *tack* carried the comment "see tackiness." After tackiness it said, "the property of being tacky." Most enlightening. In the dictionary, tack means to fasten with a small nail, the small nail itself, or to change the course of a sailing vessel. But to the rubber man it simply means stickiness. *Tack* in raw rubber or an uncured stock is generally good, except when there is too much of it, and the stocks stick to the mixing mills or calender. *Tack* can be a surface characteristic of cured rubber, where generally it is not good. In adhesives, stickiness is of course a prime property, so much so that we are not likely to use the term *tack* in connection with such cements—unless possibly there is a deficiency of stickiness. In adhesive cements we may talk about legs, short and long. Short legs in a cement or adhesive bond connotes bond strength, a good property. Long legs suggests a weak adhesive that stretches out. A cement with long legs would be very sticky, like molasses, but with little strength in the strings or legs.

We referred to *chatter marks* on calendered sheet as resulting from vibration from poorly meshing drive gears. This is quite understandable jargon—if it be jargon. However, I encountered chattering in a book on rubber processing with this explanation, "chattering is a type of distortion resulting from continued thermal expansion of the center of a large article after the surface has cured." With this definition, *chattering* is surely jargon—of the kind that confuses me. I had not previously known of such *chattering*.

An extrusion machine is like a meat grinder or spaghetti machine. It is referred to as an *extruder, tuber,* or *strainer,* depending on its purpose. Extruder, which is probably not jargon, is the better word for broad usage, because many extruded products are strips with odd shaped cross-sections like window channels and refrigerator door gaskets. No longer is the process limited to production of hollow tubes or round solid rods. The *strainer* is the same machine with a screen in the head, in front of the die plate, to remove, or strain out dirt and foreign material of mixed compound. It accomplishes what a refiner mill does. *Tuber* and *strainer* can be considered jargon.

When we get to molding, we find some real jargon. *Back-rind* is a nice example. Jargon synonyms for *back-rind* are *back-flash* and *suck-back*—terms which are descriptive of distortion at the parting or separation line of a mold, usually in the form of a ragged or torn indentation. It is not easy to describe, but no rubber man who has experienced back-rinding and excessive defective parts has any difficulty in understanding what back-rinding is. *Flash* and *rind* are somewhat synonymous and denote material, often a thin fin, protruding from the surface of the molded part, appearing at the mold parting line or mold vent points. When the flash or rind partly sucks back or curls under we have back-rind—a kind of inverse rind or flash.

In molding we deal again with "cure." When we time the vulcanization to include the mold loading, the period during which the mold is in the press, and the time of removal and unloading of the mold, we have the vulcanization or curing cycle. We say we can get x number of cures per hour or day. Here *cure* denotes more than the act of vulcanization or the exact time and temperature of vulcanization. A synonym for cure in this sense is *heat*. And we could say, "with a 4 minute cure, 10 heats per hour can be obtained." Heat is jargon. We shouldn't leave "cure" without mentioning *CV* or *CV cure*. This means continuous vulcanization, a system pertaining to the vulcanizing of insulation on wire or cable. And we have all kinds of cures—overcure, undercure, precure, aftercure, semicure, optimum cure, cold cure and many others.

A *mold-wash* is not a mold cleaner; it is a coating which prevents adhesion of the rubber mix to the mold surfaces during cure. It is a mold lubricant or release agent. It is the butter or grease on the cake pan. The industry is gradually dropping the term *mold-wash* and using the more precise term *release agent* but the jargon term will no doubt persist for a long time.

The hardness of rubber, usually cured rubber, is measured with an instrument called the Shore Durometer. Actually it measures the resistance to the penetration of an indenter point into the surface of the rubber. The resistance is provided by a standardized spring so that a numerical value can be recorded over a range from 0, soft or no resistance, to 100, or so hard there is no indentation. This Shore Durometer is so universally used in the rubber industry that the statement "a hardness of 65" means 65 on the Shore Durometer scale. When we say, which is very common, a *durometer* of 65, we mentally do not capitalize the "D" and hence have jargon. We often say also, 65 *Shore*.

Our cured rubber product may *bloom, bleed, chalk, frost, blush* or *crock*. There are similarities and differences in the condition these jargon words describe. A glossary might define them as follows: *bloom* is a surface appearance or change in appearance caused by the migration of a liquid or solid to the surface. *Bloom* must not be confused with surface dust or a coating from an external source. Waxes used in excess of their solubility point in rubber migrate to the surface. Sulfur and many organic chemicals also do this. *Bleeding* is the migration to the rubber surface of an oil, wax, or plasticizer as a film or in drops. Sometimes called "sweating," it is similar to bloom but not usually applied to powder materials, except in case of organic colors if they migrate into adjacent stock of a different color, or when they are removable at the surface by water or other solvent. An inorganic pigment like red iron oxide may crock but not bleed. *Crocking* is the color in rubber which may not appear at the surface as a bloom but which will rub off and thus discolor an adjacent surface. This is again a migration of a material to the surface and hence very similar to bloom. *Chalking* is the formation of a powdery surface condition that might look like a bloom but is not caused by migration in the rubber. It is caused by oxidation or some kind of deterioration of the rubber surface or binder, generally from weathering, that permits the fillers and/or color pigments to appear at the surface. It is definitely a condition different from that which causes *crocking*. *Frosting* is another surface effect that appears as a whitening or graying, sometimes like a clouded surface. It is probably caused by a chemical reaction at the surface. *Frost* is often seen on so-called transparent rubber as cloudy effect, perhaps from the accelerator used. It is not

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a *bloom* for it cannot be scraped off or removed with a solvent wash. In some cases it might be referred to as a *blush*. *Blushing* is usually a cloudiness caused by moisture condensation on the surface of a wet cement film from evaporation of solvent. It disappears usually when solvent is completely evaporated.

Another series of jargon words having related meanings includes *cracking, crazing, checking,* and *alligatoring: Cracking* is a fissured surface condition which develops on rubber articles exposed to light, heat, or repeated bending or stretching. It is generally caused by oxidation or ozone. When the fissures (cracks) are very small, the condition is called *checking*. The use of antioxidants, proper cure, elastomer itself, and compounding ingredients influence *cracking* and *checking*. *Crazing* is very similar to *checking* but often applied to appearance and growth of minute cracks in rubber held under strain in sunlight and weather.

Another group of words whose meanings run together relates to *creep: Creep* is the deformation occurring with the lapse of time, in both cured and uncured rubber, in a body under stress in addition to the immediate elastic deformation. The glossary giving this definition then refers us to hysteresis, damping, flow, compression set viscosity, cold flow, and drift. Naunton says, "*Creep,* sometimes called drift, is the increase in strain due to flow under continued stress." *Drift,* in addition to being continued deformation under strain, is the term applied to change in a given durometer reading after a period of time. Hysteresis occurs when stretched or deformed rubber is allowed to retract, and the energy given up by retraction is less than the energy applied in stretching the rubber. The difference in energy of deformation and retraction is hystersis loss. *Fatigue* is the weakening or exhaustion caused by constantly repeated stress. This meaning is, of course, exactly what one would expect. *Stress relaxation* and also creep relaxation, stress decay as the loss of stress accompanied by constantly decreasing compressed thickness—decrease in stress from internal relaxation under strain.

To use a language peculiar only to one industry, we don't always need to call it jargon. As Naunton says, "the engineer and the rubber technologist do not even speak the same language. An engineer uses the term resilience to denote strain energy per unit volume; applied to rubber it is a measure of rebound properties." Again he says *modulus* applied to metals means either the shear or elastic modulus and is a measure of stress to strain; applied to rubber, modulus means a stress to cause a somewhat arbitrary elongation and is used loosely as a synonym for stiffness. *Flexure* means bending to an engineer, but in the rubber field the term is applied widely to all forms of straining."

The term, *shelf life* needs context to indicate its meaning. If it refers to a cured specimen or product, it means the change or lack of change that takes place over a considerable period of time. Room temperature and no more than indirect light are implied. This is shelf aging. When an uncured compound is involved, shelf life is the time it remains soft, millable and decently processible. It has not *set-up*; has not become partially cured. However, if the uncured stock is a tread for recapping a tire, it is likely that shelf life means the time the stock will stay vulcanizable through retention of accelerator activity. This is quite the reverse of the former meaning.

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To a rubber man *camelback* would never mean transportation. The uncured recapping tread referred to previously is known as *camelback,* a name derived from the humped shape of the cross-section.

With rubber cements the terms *pot life* and *can life* might be presumed to have the same meaning. However, pot life is the time during which an open can of cement will stay brushable or free from excessive thickening or gelation. If the cement is highly accelerated to cure rapidly at room temperature, the pot life will be short. Pot life is usually a matter of minutes, hours, or days. Can life is measured in terms of weeks, months, or perhaps years because it is the time sealed cans of cement may be stored under good conditions and be usable when opened.

In recent years *popcorn* has crept into rubber jargon. *Popcorn* is a product of synthetic rubber manufacture—literally and figuratively. Actually, it means hard, tough, insoluble, and nonuseful particles formed by overpolymerization of dienes in fractionating columns, storage containers, or other places where complete polymerization should not take place.

Of course only correct jargon must be used or there will be confusion. The Wolf Brothers tell of Christner, an Akron "pug," who once won a fight with Jack Sharkey and who was the idol of the gum workers. The Akron molders, mill men and other rubber operators were baffled by references of Eastern sports writers to the "Akron *rubber puddler,*" a term that did not exist in their language.

As material was gathered for this paper, and more so as it was written, it became increasingly clear how important jargon is. So many words had to be used to express or try to express the meaning of the special terms of jargon. If all words called jargon were discarded, we would soon create a new set just for ease of expression. It is probably true that as rubber technology passes from its old status as an art and approaches that of a science, we will use new descriptive words, possibly very precise words, and perhaps colorful ones. However, they will include many that will fall in the jargon category.

GLOSSARY

Accelerator—An organic or inorganic chemical which hastens the vulcanization of rubber, natural or synthetic, causing it to take place in a shorter time or at a lower temperature. Accelerators, particularly organic, are not mere catalysts of vulcanization, however, because they produce different and generally beneficial states of cure and different degrees of stability or resistance to chemical attack in the vulcanization.

Activator—A chemical which may act on the accelerator to change the rate of cure and the properties of a vulcanizate—activators may be organic or inorganic—They may be zinc oxide or other metallic oxides, fatty acid like stearic, organic compounds which are mild accelerators if used alone.

Alligatoring—A type of crazing or surface cracking of a definite pattern, as indicated by name. The effect is often caused during weather aging.

Anchorage—Adhesion of rubber to fiber, fabric, metal or other material to which the rubber compound is applied by calendering, welding, cement spreading, or other means.

Apron Mill—An endless, wide fabric belt, partly under rolls, used carrying rubber compound during mixing to the bite or bank between the mixing rolls.

Back-Rind—Also flash-back and suck-back—Distortion of a mold cured product at the mold line, usually in the form of wrinkles, folds, tears, or indentations. The effect is often caused by sudden release, on opening of the mold, of internal pressure resulting from thermal expansion of the compound during rise to curing temperature.

Bleeding—Migration to the rubber surface of an oil, wax, or plasticizer as a film or in drops, sometimes called sweating. Also a term applied to organic pigment colors if they migrate into an adjacent stock of a different color, or when they are removable at the surface by water or other solvent.

Blocking—Immediate adhesion of layers of mixed compound when they touch each other.

Bloom—Similar to bleeding, in that it is migration of liquids or solids to the surface of a rubber compound to cause a change of appearance in color cloudiness at the surface. Waxes used in excess of their solubility point in rubber come to the surface as a wax bloom, as does sulfur that remains as an excess over the amount actually chemically combined with the rubber.

Blush—A surface effect similar to bloom, but often a cloudiness due to moisture condensation on the surface of a wet cement film from evaporation of solvent. This type of blush occurs when the solvent has completely evaporated.

Boot-legging—Separation of plies progressively occurring in conveyor, transmission of other belts made of separate plies of rubber and fabric.

Blowing—Porosity or sponginess occurring during cure, either deliberately through use of a gas releasing material to form sponge or expanded rubber or inadvertently due to entrapped moisture to cause undesirable porosity.

Bank—rubber mill—A relatively small amount of unvulcanized rubber compound rolling in the space between two mill rolls, while the major portion of the compound is bonded around the first roll. A pencil bank is a small, smooth rolling amount of compound between a calender roll and fabric surface being surface or frictioned coated.

Breakdown—To soften or plasticize rubber by working it on a rubber mill or in an internal mixer. Also same as to mill or masticate.

Chalking—Formation of a powdery surface condition due to oxidation of surface of rubber and release of pigments and fillers at the surface. Not to be confused with bloom which looks similar.

Camelback—Uncured recapping tread. So called from humped shape of cross section.

Cat eyes—Also called *fish eyes*. Undissolved gobules of rubber in a cement generally made from only rubber and solvent.

Chatter marks—Appear on surface of calendered rubber due to poorly meshed gears or vibration of machine.

Checks—Rough surface due to fine cracks from weathering. Also roughness formed on calendered sheet when temperature of calender rolls is too low or when the sheet is chilled too suddenly.

Cracking—Surface condition formed by weather aging, also by repeated flexing or stretching. Also called crazing. Cracking is also the treatment of rubber, uncured and cured, by passing it through moving corrugated rolls, as in preparing tires and other vulcanized rubber for reclaiming.

Crawl—Shrinkage of milled and calendered stock after removal from rolls.

Crazing—Surface pattern produced on rubber articles exposed to weather, caused by formation of an oxidized film. Same as alligatoring.

Creep—Deformation occurring with lapse of time, in both cured and uncured rubber, in a body under stress in addition to the immediate elastic deformation. Also called drift, cold flow, compression set, and strain relaxation.

Crocking—Color pigment in rubber which may not appear on the surface as a bloom but which will rub off and discolor an adjacent surface. Staining of a white cloth by rubbing lightly over a colored surface.

Cure—Synonymous with vulcanize as a verb and vulcanization as a noun. It includes time and temperature of vulcanization.

Air Cure—With the use of ultra or fast acting accelerators, vulcanization can take place at room temperature.

Acid Cure—through use of sulfur monochloride in liquid or vapor form. This is a surface effect only suitable for thin articles like fabric coatings or sheet gum like dental dam, bathing caps, and similar articles. Often called a cold cure since no heat beyond that necessary to vaporize the sulfur chloride is necessary.

Bin Cure—is partial or complete vulcanization of a mixed compound while stored in a bin or pile waiting for molding or further processing. Also called pile burning or premature vulcanization.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

After-cure—is a continuation of the process of vulcanization after the cure has been carried to the desired degree and the source of heat removed, generally resulting in over-cure and a product less resistant to aging than properly cured products.

Over-cure—Caused by an after-cure as above or by being subjected to too high a temperature or too long a period at a proper temperature and resulting in a product less resistant to aging.

Ammonia cure—A modification of a hot air pressure cure, often used for footwear, in which ammonia gas is used to accelerate vulcanization and to prevent the deteriorating effect of air.

Semi-cure—A preliminary, incomplete cure given to certain rubber articles to cause the rubber to set in some desired shape. Full vulcanization is subsequently completed by a final cure.

Tight cure—Sufficient vulcanization to give a product good tensile strength and good snap or elasticity.

Dumbbell—A piece of rubber cut in the shape of a dumbbell used for physical testing.

Fin, Flash or Rind—Overflow material protruding from surface of cured, molded rubber articles, usually appearing at mold separation line or mold vent points.

Fillers—Any compounding ingredient, usually in dry, powder form, added to rubber in substantial amount to improve quality or lower cost. Fillers have various effects; some are relatively inert, like whiting or barytes, and provide loading for cost reduction; others, like carbon blacks, have a definite and desirable reinforcing effect with improvement in abrasion resistance and other properties.

Frosting—A clouding of the surface of some rubber and synthetic rubber goods, appearing within a few hours or days after vulcanization. The frosted appearance is different from bloom or blush and cannot be readily removed by washing with a solvent. It may disappear if the article is heated moderately but will generally reappear on cooling. It is thought to be caused by ozone in the air which produces a maze of minute cracks. Some antioxidants have definite anti-frosting effects.

Green Stock—Raw or uncured rubber stock, ready for vulcanization. The term is not applied to crude rubber or synthetic rubber that has not been compounded.

Inhibitor—A negative catalyst which prevents or retards vulcanization or oxidation. A good inhibitor will retard vulcanization at room temperature to prevent pre-cure but will not retard at normal curing temperatures.

Legs—The stringy effect that is apparent when cemented surfaces are separated shortly after the bond is made. Long legs or strings are indicative often of a weak bond whereas short legs indicate a strong bond.

Logy—Sluggish, low snap or recovery. A condition formed in poorly cured or overloaded vulcanizers.

Mold Wash, Mold Lubricant, or Release Agent—A material that will prevent adherence of cured rubber to a mold and will facilitate removal of the cured product. The material is often a water solution or slurry of a suitable material sprayed or brushed on the hot mold prior to filling it with the rubber to be molded.

Masticate—To work rubber on a mixing mill or in an internal mixer until it becomes soft and plastic. Synonymous with breakdown.

Nerve—A condition difficult to define fully but commonly used to denote the qualities of firmness, strength and elasticity in crude rubber. In crude rubber, nerve is reduced or destroyed by milling or breakdown.

Peptizing Agents—Substances that act as chemical plasticizers for natural and synthetic rubbers. They act as catalysts for oxidation breakdown of rubber during the milling or mastication period. Additional plasticization can be accomplished without further milling by heating the rubber containing the peptizing agent, thus reducing power consumption in breakdown.

Pigment—Used properly, this term means a dry colored powder for coloring rubber and other products. In rubber, the word is often used to denote fillers and reinforcing agents, as well as coloring materials.

Pop Corn—A name for non-useful, hard, tough, insoluble polymer, resembling popcorn, formed by polymerization in the manufacture of synthetic rubbers.

Proofing—The process of rubberizing fabrics, to render them impervious to water. It is an operation most commonly done by spreading a rubber cement of high viscosity or dough on the fabric, allowing the solvent to evaporate and curing in dry heat ovens or with sulfur chloride.

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Retarder—A material which in small amount added to a rubber compound retards vulcanization or slows down the activity of the accelerator. Specifically phthalic anhydride and salicylic acid are retarders. The most valuable retarder is one which slows the vulcanization at processing and early curing temperatures but does not affect or may even activate the rate of cure at full curing temperatures.

Refiner—A machine similar to a two roll mixing mill, operated with rolls very close together to crush undispersed ingredients and hold them in the bite of the rolls for removal and discarding when the mass has passed through. Refiner rolls are shorter and have a much greater diameter than mixing rolls, and are operated at a higher surface speed ratio to provide more grinding effect.

Reversion—The softening of vulcanized rubber (natural usually but sometimes synthetic rubber) when heated too long or at too high a temperature. Reversion is evidenced by increase in extensibility, decrease in tensile strength, and lowering of the stress to produce a given elongation. Extreme reversion results usually in tackiness.

Scorching or Burning—A term denoting premature vulcanization of a rubber compound, occurring during the mixing operation when the compound is calendered or extruded. Scorch is often controlled or prevented by selection of proper accelerators or by use of retarders. Scorched or burnt stock is generally not processible.

Set-up—In an uncured compound, set-up due to incipient vulcanization occurs and is akin to scorch in a lesser degree usually. Set-up stocks are difficult or impossible to process smoothly and will not dissolve completely in solvent.

Staining—Discoloration produced by a rubber stock on organic finishes, lacquers and fabrics, owing to presence of discoloring type antioxidants in the compound. The condition is aggravated by exposure to heat, pressure, or sunlight. Also discoloration of a surface due to migration of an ingredient from one rubber compound to an adjacent compound even though they may not be in actual contact with each other.

Strainer, Tuber, Extruder—An extrusion machine in which unvulcanized rubber or reclaimed rubber is forced through a screen backed by a perforated plate, to rid the stock of contaminating particles.

Tack—The natural adhesiveness of rubber in raw state. Also the property of raw or compounded rubber which causes layers of stock to cohere. It is a desirable property only when adhesion or cohesion is desired.

Warm-up—A milling operation to platicize uncured rubber compounds before calendering, extruding, or molding.

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25

The Literature of Natural Rubber

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The literature of natural rubber covers a wide range of subjects and comes in many forms. The most important are: books, official and government reports, trade literature, periodicals, patents, and standards and specifications. Since an increasing number of rubber papers now appear in foreign languages, an effective, cooperative, translation service, on an international scale, is badly needed. Effective use of the literature depends on being able to find information as and when required. This calls for an efficient system of classification of rubber information to make the literature available, intelligible, and retrievable.

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To separate the literature of natural rubber completely from that relating to other polymers, particularly synthetic rubbers and plastics, is impossible. This is reflected in the experience of the library of the Rubber and Plastics Research Association of Great Britain (RAPRA) where the writer has worked for many years. When he began, in 1923, natural rubber was the only star in the firmament, but now the Association's library has expanded to embrace all rubbers and all plastics, reflecting and keeping pace with the great changes which have occurred in the last 25 years.

Those who wish to study the literature of the remote past can do so with the aid of RAPRA Information Circular No. 216: "Early Publications in the RAPRA Library, 1627-1860," and No. 217: "Early Publications in the RAPRA Library, 1861-1900." Further, "The Science of Rubber" (Memmler), translated from the German by Dunbrook and Morris, 1934, carries a bibliography of all rubber publications known to them at that time. Additional items have been uncovered since, but they are of academic interest only. The history of the industry, in all its aspects, is authoritatively covered by "The History of the Rubber Industry," edited by Schidrowitz and Dawson for the Institution of the Rubber Industry, and published in 1952.

Only in comparatively recent times has the literature had to deal with any other kind of rubber than natural. Up to the end of 1928, it was more than

[1] Deceased.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

99% on natural; to the end of 1932 more than 98% natural; and to the end of 1935 more than 97% natural. From then on, the literature on natural rubber began to yield ground to synthetic rubber, first slowly and then more rapidly. At present probably not more than one-quarter of "rubber" literature is concerned with natural rubber.

Subject Coverage

If the natural rubber industry is considered in all its branches, quite a wide range of subjects comes within its scope.

The planter is interested in botany; in biochemistry and plant physiology and pathology; in soil chemistry and management, as well as that bearing directly on rubber cultivation; in diseases and pests of the rubber tree; propagation; harvesting; latex; preparing the raw rubber; packing; and shipping.

The rubber scientist must keep up with developments in physical and colloid chemistry; in organic chemistry for an understanding of problems connected with the molecular structure and behavior of his product (oxidation, aging, preserving, compounding, processing, vulcanization, and reclaiming) as well as modern methods of analysis and instrumentation. The physicist demands information on all aspects of mechanical, electrical, acoustical, rheological, thermal, optical, and spectral properties and testing in relation to rubber and rubber goods. He is concerned, too, with the technology of fine powders.

The designer of rubber goods has to cover, if he can, all fields in which his wares are used. He must therefore follow developments in engineering (aeronautical, automobile, chemical, electrical, marine, mechanical, mining). He must study the uses and behavior of his product in sports, agriculture, brewing, building, catering, fire fighting, footwear, roads, the office, home and garden, textiles and clothing, surgery, to mention only a selection of the more obvious outlets of his goods.

The works manager must have at least an elementary knowledge of medicine so that he can recognize hazardous materials and safeguard the health of men using them. He must not fall behind in his knowledge of developments in processing machinery; and he must know the best methods of packaging the products of his factory.

In the office, the buyer needs information on prices, new materials, and new sources. The sales manager must not fail to keep abreast of trends in the trade and take account of ever-changing markets and marketing methods. Management, too, must study statistics and is very much concerned with patents and trade marks; with laws and regulations; with import and export duties and restrictions; with standardization in the industry; with education and training; and with the activities of competitors. The busy executive, called upon at short notice for an after-dinner speech will demand factual material and this must be seasoned with humor!

Lastly, the historian and the biographer have their needs, as has the student entering the industry or reading for recognized qualifications. He needs his textbooks at intermediate and advanced levels.

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Forms of the Literature

Like any other subject the literature of natural rubber comes in many forms. Of these, perhaps six may be regarded as of major importance, and these will be surveyed briefly.

Books. Here we meet the difficulty of separating the modern literature into "natural" and "synthetic." A book of any pretensions will carry chapters on both.

We have already referred to textbooks, and in this respect the industry is tolerably well served. Then there are monographs, such as the series being sponsored by the Institution of the Rubber Industry; also reports of symposia and conferences. There is also the reference book, which heading includes tabulations of numerical data, dictionaries, glossaries, handbooks, yearbooks, trade directories, and address books. With these, America, Britain, Germany, and France are adequately supplied. Worthy of special mention in this connection are the "Red Book" for the U.S.A., and the "Blue Book" for Britain. Finally there are books on history and biography.

Official and Government Reports. These publications stem from official enquiries, government-sponsored research, surveys of particular products, and official statistics. At the conclusion of World War II a great deal of technical information was collected at government level concerning war-time rubber activities in Germany and Japan. For rubber, this information was summarized by T. R. Dawson in "Rubber Industry in Germany during the Period 1939-1945." Reports under this heading are usually listed in the official catalogs of government publications.

Trade Literature. Much of this is extremely well produced and is invaluable to the practical rubber technologist, however much he may profess to discount it as advertising matter. The leading suppliers of materials to the rubber goods manufacturing industry have long equipped and maintained some of the finest rubber laboratories in the world, and the results of their work are available for the help and guidance of clients. Some of it is published in the hope of attracting new business. The expansion and continued prosperity of these firms argue strongly in favor of the usefulness and reliability of the literature they produce. Some companies date their publications; it is greatly to be regretted that their example is not more widely followed.

Advertisements, too, often carry scientific and technical information of real worth, and these are helpful in providing revenue for the trade periodicals without which industry would be severely handicapped.

Periodicals. These are many and varied. They include the trade journals, some of which are devoted wholly to rubber, natural or synthetic, and which cover all aspects of the industry. Others deal with only a special field, e.g. planting, adhesives, tires, and the like.

Of the periodicals issued by learned societies and trade associations; some are devoted entirely to rubber; some are of wider interest but frequently carry rubber papers; still others only occasionally publish a rubber paper.

Very important indeed are the abstract periodicals. These too may be devoted wholly to rubber or may provide only a section.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch025

Many large companies issue their own house organs, and all countries of any standing issue their patent and trademark journals.

Patent Specifications. These are one of the most (some would say *the* most) significant sources of original information available. They are not only a record of technical invention but also legal documents which can be of immense financial importance. The organization with which the writer is connected has for many years made it a firm practice to examine all U.S. and British patents in the form of their complete specifications, to be sure of catching every one of rubber significance.

Standards and Specifications. Steadily increasing unification and international cooperation has focussed attention on the need for standardizing manufactured goods of all kinds. The immense amount of skilled time and effort devoted to this end has led to the production of thousands of industrial standards, in which the rubber industry is deeply involved. Manufacturers of goods, whether for home consumption or for export, must attend to these documents. There are also many purchasing specifications drawn up by large buyers, to which sellers must make their wares conform. Finally, there are specifications for all the main testing procedures employed for testing rubber and rubber goods; rubber laboratories the world over endeavor to meet the requirements of such specifications.

So much for the major forms of natural rubber literature. Other forms include: manuscripts and correspondence; university theses; bibliographies; lantern slides and transparencies; photographs; films; microfilm; micro-cards; micro-fiches; maps; drawings; cigarette cards and postage stamps with a natural rubber theme and even at least one gramophone record, and embossed Braille type for the blind. Examples of all these are on file in the RAPRA library.

Putting the Literature to Work

If the enormous literature is to be useful, it must be read. There are still some who boast that they "never read the literature," whose glory is in their shame. But the modern industrialist is fully aware of the vital need of keeping in touch with the published literature. To this end, three operations for the literature are necessary:

(a) Making it available—Library work;
(b) Making it intelligible—Translation Work;
(c) Making it retrievable—Intelligence Work.

Library Work. As to this there is nothing peculiar to the literature of natural rubber to distinguish it from that of any other subject. Collection, cataloging, and making the collection available for loan are all straightforward operations and are well understood.

Translation Work. Here the English-speaking peoples, though privileged in that the majority of technical and scientific papers are still published in English, have difficulty because so few technical men have even a nodding acquaintance with a second language. This condition must be rectified because first, the amount of worthwhile literature in "foreign" tongues is rising; and,

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch025

second, these countries which are, or in the near past have been, technically backward are making strenuous efforts to catch up, and it may well be that among them, rather than among our own peoples, new and altogether original ideas may arise. The condition may be corrected by individuals learning one or more foreign languages, and also by systematic, large-scale, international cooperation in translation. Fortunately, both trends are now developing, especially the latter.

Money is lavished in the West on original research. It is only right that at least a proportion of it be employed to keep us informed, by means of an adequate translation service, as to progress in other countries.

Intelligence Work. Of the three operations mentioned above, this is the most difficult. It is also the most rewarding, involving two necessary factors. First, collecting the information (not to be confused with collecting the literature); second, having a place for it. The first of these operations is abstracting; the second is classification. If both steps are properly taken, the information can be retrieved, possibly years later, either to answer specific inquiries, or for literature research.

A third need is a name index of authors of all books, journal articles, patents, etc., so that particular items can be traced if the name of the author is known.

It is impossible to overrate the importance of the classification system. More than two dozen systems have been prepared for rubbers and polymers, but the most comprehensive (covering the whole industry) and widely used is that devised in the RAPRA Library over 30 years ago, which has enjoyed an international reputation. Based on natural rubber, it was found possible to insert synthetics, and some plastics as the need arose, but it has now served its purpose. From the beginning of 1965 a completely new system, but retaining many of the attractive features of the old, has been drawn up. In this, natural rubber no longer enjoys any special prominence but takes its place as just one of many useful substances coming under heading of Rubbers or Plastics. It is the product of wide cooperation within the industry, so necessary if widespread use is to be achieved.

The writer is well aware that the swelling flood of published material may well demand a mechanization technique to handle it. In fact, this is just coming round the corner, and for a highly restricted field good results are to be expected. But for a far-flung, industry-wide information service, one feels that the technique would need to be supplemented by the trained human mind.

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The selective bibliography and appendix have been prepared in support of this contribution, and include:

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U. S. Patent Classes and Subclasses

	Class	*Subclass*
Rubber	260	709+
Bale cutter	83	
Cutting	83	
Dyeing	260	764
Preformed	8	5
Electromagnetic treatment	204	160
Electrophoretic processes	204	182+
Plant source extraction	47	10+
Punching	83	
Reclaiming	260	710+
Cutting tire from	82	
Roughing file	29	78
Diolefine	260	94.2+
Natural rubber with	260	4+
Vulcanization	260	775+
Molding processes	264	
Working apparatus	18	2
Rubber	260	709+
Vulcanization	260	755+
Wave energy processes	204	159.11+
Wave energy processes	204	160.1
Contact coating (See Pencil)	401	49+

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APPENDIX

Popular Books with a Natural Rubber Theme

D. R. DAWSON

This unusual list has been conceived in a lighter vein than the bibliography. It may serve, however, to remind readers of the wide field of less serious reading which the subject of natural rubber penetrates, and may also supplement the more usual technical rubber bibliographies. Clearly, it has been necessary to be selective, and the selection has been made from among books in the RAPRA Library. This is particularly true in relation to the section on travel. There are many works on travel in some other countries which contain passing reference to rubber but this library has not felt justified in purchasing such, relying on generous donors who are aware of our interests.

The terms of reference for this paper confine the entries to books on natural rubber and this has led to the exclusion of some interesting fiction based on the search for, or the discovery of, the "formula" for synthetic rubber.

The bibliography has been divided into:

(1) Biography; (2) Books with a Natural Rubber theme for the layman; (3) Fiction; (4) Travel.

Biography

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A Lief, "Harvey Firestone: Free Man of Enterprise," New York, McGraw-Hill, 1951, 334 pp.
Fresneau, Francois
F. de C. Laubat, "Francois Fresneau: Seigneur de la Gataudiere: Pere du caoutchouc," Paris, Librarie Plan, 1942, 265 pp. Seigneur of Gataudiere: father of rubber.
Goodyear, Charles
P. W. Barker, "Charles Goodyear, Connecticut Yankee and Rubber Pioneer," Boston, Mass., G. L. Cabot, Inc., 1940, 109 pp.
B. K. Pierce, "Trials of an Inventor: Life and Discoveries of Charles Goodyear," New York, Carlton & Porter, 1866, 224 pp.
A. C. Regli, "Rubber's Goodyear: the Story of a Man's Perseverance," New York, J. Messner, Inc., 1941, 248 pp.
R. F. Wolf, "India Rubber Man: the Story of Charles Goodyear," Caldwell, Idaho, Caxton Printers, Ltd., 1939, 291 pp.
Litchfield, Paul Weeks
"Autumn Leaves: Reflections of an Industrial Lieutenant," by P. W. Litchfield, Cleveland, Ohio, Corday & Gross, 1945, 125 pp.
"Industrial Voyage, My Life as an Industrial Lieutenant," by P. W. Litchfield, Garden City, N. Y., Doubleday & Co., Inc., 1954, 347 pp.
Macintosh, Charles
G. Macintosh, "Biographical Memoir of the Late Charles Macintosh," F.R.S., of Campsie and Dunchattan, Glasgow, W. G. Blackie & Co., 1847, 198 pp.

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Raffles, Sir Thomas Stamford Bingley
E. Hahn, "Raffles of Singapore: a Biography," Garden City, N. Y., Doubleday & Co., Inc., 1946, 599 pp.
S. Raffles, "Memoir of the Life and Public Services of Sir Thomas Stamford Raffles, Particularly in the Government of Java, 1811–1816, Bencoolen and Its Dependencies, 1817–1824," with details of the commerce and resources of the Eastern Archipelago and selections from his correspondence. London, J. Duncan, 1835, 2 vols.
Swettenham, Frank Athelstane
"Also & Perhaps," by F. Swettenham. London, J. Lane the Bodley Head, Ltd., 1922, vii, 304 pp.
Swindin, Norman
"Engineering Without Wheels: a Personal History," London, Weidenfeld & Nicholson, 1962, 255 pp.

Books with a Natural Rubber Theme for the Layman

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Dunlop, J. B., "History of the Pneumatic Tyre," Dublin, Thom, 1924, 103 pp.
Firestone, H. S., Jr., "The Romance and Drama of the Rubber Industry," Akron, Ohio, Firestone Tire & Rubber Co., 1932, 127 pp.
Goodyear Tire & Rubber Co., "The Story of the Tire," Akron, Ohio, 1948, 63 pp.
Goodyear Tyre & Rubber Co. (Great Britain), Ltd., "The Story of the Tyre," Wolverhampton, 1952, 60 pp.
McKay, H., "Rubber and Its Many Uses," London, Oxford University Press, 1940, 76 pp.
Perry, J., "The Rubber Industry," 2nd ed., New York, Longmans, Green & Co., 1946, 127 pp.
Reliance Rubber Co., Ltd., "Plastic Gold: The Story of Rubber in the Service of Mankind," London, 1939, 64 pp.
Tudor, R. J., "Story of Rubber," London, Burke Publishing Co., Ltd., 1947, 96 pp.

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Arnold, A. W., "So Runs the Brook: the Story of a Shop and Other Stories," London, A. Moring, Ltd., 1939, 253 pp.
Baum, V., "Weeping Wood," London, M. Joseph, Ltd., 1945, 508 pp.
Boussenard, L., "Chasseurs de Caoutchouc," Paris, Tallandier, 1926, 224 pp.
Butze, H., "Zauberstoff der Tropen: die Abenteuerliche Gesichichte des Kautschuks," Leipzig, Jugendbuchverlag Ernst. Wunderlich, 1955, 145 pp. (Magic Substance of the Tropics: the Adventurous Story of Rubber).
De Castro, F., "O Selva: Romance," 4th ed., Lisbon, Guimaraes & Ca., 1934, 302 pp. Jungle: A Tale of the Amazon Rubber-Tappers. (English, Czechoslovakian, Dutch, German, Italian, and Swedish translations available).
Dominik, H., "Kautschuk. Ein Roman aus der Industrie," Berlin, E. Keils Nauchfolger (A. Schere) GmbH, 1930, 284 pp. Rubber: A Novel of the Industry.
Driant, Commandant (Capitaine Danrit, pseud.), "Robinsons de l'Air," Paris, E. Flammarion, 1909, 498 pp.
Fauconnier, H., "Soul of Malaya," trans. by E. Sutton, London, Mathews & Marrot, 1931, 247 pp.
Field, R., "All This and Heaven Too," London, Collins, 1939, 544 pp.
Lee, M. H., "In the Land of Rubber," New York, T. J. Crowell Co., 1939, vi, 99 pp.
Lulofs, M. H., "Rubber: a Romance of the Dutch East Indies," translated by G. J. Renier and I. Clephane (from the Dutch), London, Cassell & Co., Ltd., 1933, ii, 314 pp.
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Rivera, J. E., "The Vortex," translated by E. K. James (from the Spanish), London, Putnam, 1935, 379 pp.
Stanley, G., "Rubberface," Modern Fiction, Ltd., 19?, 64 pp.
Székely, L., "Tropic Fever: the Adventures of a Planter in Sumatra," translated by M. Saunders. London, H. Hamilton, Ltd., c. 1936, iv, 352 pp.
Taut, F., "Kautschuk am Caquetá: Abenteurerroman" (Rubber on the River Caqueta), Bremen, C. Schünemann Verl., 1953, 241 pp.
Trumbull, R., "The Raft," New York, H. Holt & Co., Inc., 1942, vii, 205 pp.
Wallace, E., "India-Rubber Men," London, Hodder & Stoughton, c. 1938, 128 pp.

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Ahl, F. N., "Two Thousand Miles Up the Amazon," Boston, Mass., Christopher Publishing House, 1941, 244 pp.
Bates, H. W., "Naturalist on the River Amazon," a record of adventures, habits of animals, sketches of Brazilian and Indian life, and aspects of nature under the equator, during eleven years of travel, 2nd ed., London, J. Murray, 1864, xii, 466 pp.
Burke, W. P., "Señor Burky," the adventurous life-story of William P. Burke, London, G. G. Harrap & Co., Ltd., 1935, 271 pp.
Clark, A., "Ceylon," London, A. & C. Black, 1910, vii, 88 pp.
de la Condamine, C. M., "Relation abrégée d'un voyage fait dans l'interieur de l'Amerique Meridionale," Paris, 1745, xvi, 216 pp.
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Gibson, A., "Malay Peninsula and Archipelago," London, J. M. Dent & Sons, Ltd., 1928, xiv, 236 pp.
Hake, H. B. E., "New Malaya and You," London, L. Drummond, 1945, 107 pp.
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Viannay, A., "Au Pays du Caoutchouc: Voyage d'etude a la Cote d'Ivoire," Marseille, Typographie et Lithographie Barlatier, 1904, 71 pp.
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26

The Literature of Synthetic Rubber

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The literature of synthetic rubber has grown rapidly because of the variety of rubbers and the scope of their applications. The scientist or engineer must find the facts he needs in order to increase the lead time on an important project and to avoid needless duplication. It is essential to know the sources of information such as journals, patents, and conferences for current information and books, abstracts, and indexes for review information. The volume of literature published has led to the establishment of a computer-based center for Information Services, by the Division of Rubber Chemistry of the American Chemical Society, which collects, indexes, and abstracts this literature.

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The literature of synthetic rubber has grown rapidly within the last 10 years since the surveys of Straka (*3*) and McGavack (*1*). This past decade has witnessed the birth of many new journals devoted primarily to polymer science. Over 200 books on this subject have been published, in English and various foreign languages, in the last few years. This growth in the literature is caused partly by the increased variety of rubbers developed by the manufacturers and by their ever-widening scope of interests from raw material sources and production, through rubber manufacture and processing, and finally by the broad range of applications of rubber products.

Thus, the newcomer to the synthetic rubber field is faced with the problem of where to find information both on rubber and on other materials as well. Although this article previews the recently published literature on synthetic rubber, sources of basic scientific and engineering research work will also be considered. Marketing information on rubber is covered in a separate article by Stevens (*2*). Although some overlap with the natural rubber and the plastic literature occurs, these subjects are covered by others in detail.

Sources which must not be overlooked are government reports and company information. Access to and methods of handling internally generated information—*i.e.*, reports, letters, and bulletins of companies—differ in each organization, so that no guidelines for their use can be set up.

In Literature of Chemical Technology; Smith, J.;
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Books

Books provide the background necessary for a newcomer to grasp the broad and basic information on a given subject. They give a unified presentation of information drawn from various sources such as journals and patents.

Encyclopedias. Some encyclopedias cover many topics as does Kirk-Othmer's "Encyclopedia of Chemical Technology," which summarizes concisely many aspects of rubber technology and provides extensive bibliographies to journal and patent literature; the second edition is edited by Mark, and 18 volumes are planned.

Clauser's "Encyclopedia of Engineering Materials and Processes" consists of one volume of 300 articles covering rubber, steel, wood, plastics, and ceramics. For rubber, types and classifications, forming and fabricating, selection and specifications are discussed.

Another encyclopedia which promises to be useful is the "Encyclopedia of Polymer Science and Technology." Mark, Gaylord, and Bikales are the editors, and the approximately 450 articles which are planned will be written and reviewed by specialists from all over the world. The articles will cover pertinent chemical substances, polymer properties, methods and processes, uses and general background. Thirty-one articles from ablative polymers to amino acids, were included in the first volume, published in 1964. Eight to 10 volumes are planned, but no publication date for these has been set. The articles are theoretical and practical, and the format is similar to that of the "Encyclopedia of Chemical Technology."

Bostrom's five volumes of "Kautschuk-Handbuch," in German, and Genin's "Encyclopedie Technologique de l'industrie du Caoutchouc," in French, are comprehensive compilations of information on different types of rubber and products thereof.

Handbooks and Reference Books. Handbooks and reference books are used when one is seeking specific facts rather than background reading. Most handbooks cover many topics including synthetic rubber; a list of these is given in the bibliography.

However, there are some handbooks specifically oriented for the rubber industry that are of particular interest. *Rubber World* has published two excellent reference books—"Compounding Ingredients for Rubbers" and "Machinery and Equipment for Rubber and Plastics." The "Rubber Handbook" and the "Latex Handbook," published by the R. T. Vanderbilt Co., are also useful compilations. Annually, the mid-October issue of *Materials in Design Engineering* gives the properties and uses of many rubbers and plastics. *Rubber Age* publishes the "Rubber Red Book" annually, which is a directory of the rubber manufacturers and suppliers, organizations, and products of the rubber industry in the U. S., Canada, and Puerto Rico. It also includes a Who's Who in the rubber industry, classified lists of products, chemicals, equipment, and trade names. The Rubber and Plastics Research Association (RAPRA) of Great Britain has published a series which list tradenames in the rubber and plastics industries, gives their composition if known, and the manufacturer.

A large portion of rubber literature is published in languages other than English, so that dictionaries for this field are particularly valuable, especially

"Elsevier's Rubber Dictionary." The ASTM "Standards on Rubber," now published annually, and the "Glossary of Terms Relating to Rubber," are indispensable.

Reviews. Developments in the field of rubber are regularly summarized and evaluated by several publications. Some journals publish review articles of this type regularly. For example, Acres in *Rubber Journal,* summarizes each year the products, plant expansions, events, and people in the rubber industry that have made news. Critical selected reviews of the published literature on elastomers, hard rubber, and polymerization, have been published by *Industrial and Engineering Chemistry* since 1947 and are continuing at irregular intervals. *Analytical Chemistry* gives a review with a comprehensive bibliography of analytical procedures for natural and synthetic rubbers biennially. Jennings, in the "Views and Reviews" section of each issue of *Rubber Journal,* critically surveys the current literature.

The Institution of the Rubber Industry (IRI) has published an "Annual Report on the Progress of Rubber Technology" since 1916, in which articles and extensive bibliographies are written on specific topics such as tires, belting, synthetic rubber, compounding ingredients, and footwear.

The Society of Chemical Industry presents a similar survey of applied chemistry, in which rubber is usually covered in one chapter.

Bedford published in 1923 a "Systematic Survey of Rubber Chemistry."

Other Polymer Books. There are, of course, many other books on synthetic rubber that are useful. An excellent compilation of books published from about 1940 to 1956 is given by Straka (*3*).

No single bibliography lists all books published on synthetic rubber. However, the Division of Rubber Chemistry Library, located at the University of Akron, has compiled a union list of books related to the fields of rubbers, resins, and plastics (*4*). Available for $1.00, it lists alphabetically, by author, the books on these subjects which are available in eight technical libraries and which can be loaned from the Division of Rubber Chemistry Library. Although this list is extensive, covering books published from the early 1900's to 1962, it is not necessarily comprehensive.

A significant trend in polymer science has been the publication of several series of monographs, which document developments in this area. The excellent series entitled "High Polymers," edited by Mark *et al.* has issued 20 volumes, all listed in the bibliography. A new series of monographs, edited by Mark and Immergut, entitled "Polymer Reviews," was initiated in 1958. Each volume reviews a field of current interest to polymer chemists and physicists while the field is still in a state of development. The published volumes are listed in the bibliography. In 1961, another series, edited by Robb and Peaker, and entitled "Progress in High Polymers," was begun in 1961.

The bibliography of books given at the end of this article has been subdivided into categories for ease of use. The first group includes books recently published up to about 1964; the second group includes books published prior to 1960.

Although the bibliography includes many excellent books, there are a few that deserve special note. Alliger's "Vulcanization of Elastomers," describes the fundamentals and technology of general- and special-purpose elastomers and discusses the selection of curing agents, accelerators, curing temperatures, and curing rates. Bateman's book on "Chemistry and Physics of Rubber-Like Substances," is a compilation of the main studies undertaken by the Natural Rubber Producers Research Association in the past 25 years. For properties of polymers, Nielsen's "Mechanical Properties of Polymers" and Bueche's "Physical Properties of Polymers" are important contributions. The newest edition of Billmeyer's "Textbook of Polymer Science" and Morton's "Introduction to Rubber Technology" are good texts for beginners. The latter is used as a text for an extension home study course on rubber technology offered by the Division of Rubber Chemistry of the American Chemical Society through the University of Akron.

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Journals

Books provide basic information on a subject, but with the rapid progress today, the information is often obsolete by the time it gets into print. The basic principles are usually unchanged, but materials, processes, and numerical data change rapidly. Technical journals or periodicals keep readers up to date on the newest information in a subject field and normally assume that the readers understand the basic principles of rubber manufacture and technology. Journals, therefore, rarely publish articles explaining the elementary principles found in books.

A union list of over 300 journals relating to the field of rubbers, resins, plastics, and textiles, alphabetical by title, is available for $1.00 from the Division of Rubber Chemistry Library (*4*). A list of journals was also included in Straka's article (*3*). *Rubber Abstracts* publishes a yearly comprehensive list of journals it scans for abstracting. The "Rubber Red Book" also has a section listing technical journals.

The editorial approach, subject matter, and format of all of these journals differ, and no two are exactly alike; each seeks a particular audience. A researcher will do well to examine several journals from the many given in the bibliography and determine for himself the contribution which each can make to his understanding of rubber. This article only highlights some well-known and/or new journals rather than giving a comprehensive listing of journals in the field of rubber.

News-Type. The following are some of the key news-type journals in the rubber field which cover briefly, without much detail: general developments; business conditions; production; sales; personalities; new books, patents, company and trade publications; forthcoming meetings and events. Some of these also contain important technical articles: *Rubber Age, Rubber and Plastics Age, Rubber Digest and Newsletter, Rubber Highlights, Rubber Journal,* and *Rubber World.*

Theoretical. The scholarly or theoretical journals which are primarily concerned with the chemistry and physics of polymers include all the other journals listed in the bibliography.

An analysis of the references given in the 1963 and 1964 reviews of elastomer technology by Alliger in *Industrial and Engineering Chemistry,* revealed that approximately 30% of the references were to *Rubber Age* and *Rubber World.* An additional 20% of the references in 1963 were to *Rubber and Plastics Age, Chemical and Engineering News, Rubber and Plastics Weekly, Journal of Applied Polymer Science.*

However, in 1964, the additional 20% of the references were to *Revue Generale de Caouthcouc, Rubber Chemistry and Technology, Journal of Applied Polymer Science, Kautschuk und Gummi.*

The remaining 50% of the references are scattered in over sixty journals. However, these statistics are based only on two articles whose bibliographies are not intended to be comprehensive, and the statistics may not be valid for other articles. Nevertheless, they do illustrate the wide scatter of journals in which information on rubber is published.

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Abstracts and Indexes

Obviously, the number of journals to be scanned regularly multiplies rapidly. Several publications have been developed specifically for scanning the contents of a number of journals; these are usually designated as current-awareness, indexing, or abstracting journals. Abstracts are designed to furnish enough information to enable the researchers to select, for detailed reading, the articles which seem important to him. There is no one source which the researcher can use to ensure a complete search; he must go to several sources; these are listed in the bibliography. Of these, *Rubber Abstracts; Resins, Rubbers and Plastics;* and *Kunstoffe und Kautschuk* cover rubber literature in particular while the remaining sources cover other scientific fields as well as rubber.

The Division of Rubber Chemistry of the American Chemical Society is sponsoring a computer-based information retrieval project at the University of Akron in which over 300 journals covering rubber, plastics, and synthetic fibers are scanned for articles of interest. These are indexed, abstracted, and then published in a weekly current-awareness bulletin sent to subscribers. Any company wishing to subscribe may obtain more information regarding cost and service from the Center for Information Service.

Retrospective Searches. After a certain time lag, most significant articles are indexed and/or abstracted by another journal or service, and they become part of the published literature which can be searched at any future time. Retrospective searches mean a review of the literature to find some or all of the information published on a specific problem.

Of the abstracting and indexing services listed, the following are used for retrospective searches also: *Applied Science and Technology Index; Chemical Abstracts; Engineering Index; Technical Survey; Rubber RAPRA Abstracts.* The "Bibliography of Rubber Literature" published by the Division of Rubber Chemistry is also useful for retrospective searching. The subject and author indexes to these publications may be scanned to find original references, and the references then can be obtained.

The University of Akron Information Retrieval Project mentioned previously also provides retrospective journal searches back to 1960 to subscribing members. The information searched is the indexed and abstracted for the "current awareness" service mentioned earlier. Index terms would be consistent so that the index could be searched by computer after analysis of the question.

Patents

Patents are an important source of information. However, in the United States a patent is usually not issued until about three years after application, which is usually the first public disclosure of a novel material or process; journal articles are usually not published on these until patent possibilities have been examined.

One of the best methods for keeping up with new patents is to establish a standing order with the Patent Office for all patents as they are issued within a certain classification. However, in many cases, interests of an individual or organization do not coincide with the U. S. Patent classification. The *Official Gazette,* issued weekly, may be scanned for patents of interest, which can be ordered subsequently. The *Gazette* is also available on microcards or microfilm. Also, various current journals publish patent digests or lists of new patents as a regular feature.

Foreign countries also issue patents, but their methods may differ from U. S. practice. For example, Belgian and Republic of South Africa patents are issued with little delay and with little prior investigation of the claims. Derwent Publications in England issues a series of bulletins with English abstracts of patents in various patent classifications.

Derwent Patents Abstracts cover all British, German, and Soviet patents issued but only the chemical groups for Belgian, French, and Japanese patents. The *Derwent Patents Bulletins,* issued monthly cover all British, German, French, South African, and Indian Patents in specified groups of the Derwent classification. The groups of interest to the rubber industry are mainly chemical processes, organic, and polychemicals. The *Derwent Patents Journals,* issued weekly, covers the same countries as the *Bulletin* but for the following fields: fine chemicals, petrochemicals, and plastics.

Chemical Abstracts and *Rubber Abstracts* are the principal indexes used to review or locate U. S. and foreign patents, but their coverage is incomplete. For U. S. patents, there are two additional sources which can be searched: (1) *Index of U. S. Patents,* published annually by U. S. Patent Office, lists patent numbers by classification and assignor and assignee; (2) *Uniterm Index,* published by Information for Industry, indexes all chemical patents issued by U. S. Patent Office. This index is a compilation of index terms and is available in card form for manual searching and on magnetic tape for computer searching.

For foreign patents, the coverage in index journals is even less extensive than it is for U. S. patents. The Derwent bulletins at present do not contain cumulative periodic indexes to the contents.

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Conferences

Last but not least, the value of attending conferences must not be overlooked. Conferences have a unique advantage; since the author is usually present, he can be asked to clarify any points in his presentation which are unclear to his audience. As with patents, the material presented at conferences is usually new and hence, more up to date. A by-product of attendance at conferences is, of course, contact with other individuals doing similar work quite often resulting in a fruitful exchange of ideas.

The most important conferences held regularly in this field are those by American Chemical Society (ACS) Divisions and the Gordon Research Conferences. The Division of Polymer Chemistry and the Division of Rubber Chemistry of the ACS hold conferences at the national meetings. Gordon Research Conferences of interest are those on elastomers, polymers, catalysis, and adhesion. The program is usually published in one of the March issues of *Science*.

There are, of course, many other conferences which are held and are announced in news-type journals mentioned previously. Both the *World List of Future International Meetings* and *Scientific Meetings* list forthcoming meetings in various fields.

Most, but not all conferences, have printed copies of the papers available for purchase. The Division of Polymer Chemistry publishes preprints in book form which are available before the meetings. The Division of Rubber Chemistry does not publish a book-type compilation of the papers presented, but the individual papers are available for purchase after the meeting from the Division of Rubber Chemistry Library at the University of Akron. Abstracts of all the papers of the various Divisions presented at the national American Chemical Society meetings are available before the meetings. There are no proceedings published for Gordon Research Conferences.

There are numerous other individual papers or complete proceedings published either in books or in journals. For example, the *Journal of Polymer Science, Part C, Symposia,* contains the papers presented at various conferences. Some of the proceedings on various subjects which have been published as books have been included in the bibliography section on books.

Summary

This article has presented guidelines on where to find information on rubber. The sources include books, journals, abstracts, indexes, patents, and conferences. Although these sources contain some duplication of information, no one of them can be used to the exclusion of the others because each type of publication has a specific use.

Knowing where to look is only part of the battle to obtain information. Knowing the sources, how does one find the information he needs—*i.e.*, what approaches—subject, author, number, etc.—are used to locate the information. This knowledge is gained largely by using the sources frequently; guidelines for using them could be given but have not been included here. Furthermore,

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having located a reference on the subject in question, one usually needs to consult the book, patent, or journal referred to in order to complete the literature search and obtain the information. If the reference is not immediately available, one must know where to buy or borrow it; this in itself is a large topic not covered here.

Acknowledgment

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1915	30. Rubber and Allied Substances
1961	30. Rubber and Other Elastomers
1962	46. Rubber and Other Elastomers
1963	49. Elastomers, Including Natural Rubber
1967	38. Elastomers, Including Natural Rubber
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- *Organic Patents Bulletin,* monthly.
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U.S. Patent Classes and Subclasses

	Class	*Subclass*
Rubber	260	709+
Synthetic	260	2+
Buna s	260	83.7+
Butyl	260	85.3
Chloroprene	260	92.3
Diolefine	260	94.2+
Dispersions or solutions	260	29.1+
Factice	260	399
Natural rubber with	260	4+
Perbunan	260	83.7+
Plasticizer containing	260	29.1+
Reaction induced by electrical or	204	154+
radiant energy	176	10+
Within nuclear reactor	260	79.5
Sulfurized	260	79.5
Synethic resin containing	260	3+

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27

Sources of Market Information on Rubber, Rubber Raw Materials, and Rubber Products

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Sources are given for the following: statistics on crude rubber production, prices, and trade; for statistics on raw materials for making synthetic rubber, including butadiene, styrene, isobutylene, and acrylonitrile, synthetic rubber production, synthetic rubber prices, and synthetic rubber trade; for reclaimed rubber production, prices, and trade. The literature on current consumption of all types of rubber is reviewed. End-use data are given for all kinds of rubbers in major consuming countries, and reference is made to the most complete recent U.S. studies on the amounts of various rubbers used in different rubber products. Sources of general economic statistics on the rubber industry are discussed.

Market research in the rubber industry might appear relatively uncomplicated to the casual observer. Under the standard industrial classification system used by all U.S. Government agencies, rubber products constitute a major group about which statistics are collected and published. Data concerning value added by manufacture, employment, wages and salaries, corporate sales and income, and other basic economic information are readily available. Examination of the whole rubber industry, however, reveals that it is not the well-defined entity which these statistics indicate. Many of the products of the rubber industry do not contain rubber or anything resembling rubber. The rubber industry competes directly with many other industries such as the textile, chemical, fabricated metal products, and transportation equipment industries. Under these circumstances successful market research requires a breadth of knowledge which cannot be gained by studying rubber industry statistics alone.

The rubber industry is, in general, well documented, and there is a wealth of statistics relating to its operations. The statistics are often reprinted in a number of sources which will be mentioned as a convenience to those who may have only limited library facilities available.

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Crude Rubber

Production. The *Rubber Statistical Bulletin* publishes monthly figures on total world production of crude rubber and individual figures for the principal rubber-producing territories. *Rubber Trends* analyzes the raw statistics of the *Rubber Statistical Bulletin* in informed depth. The *Rubber Statistical News Sheet* publishes statistics of natural rubber production by country. Crude rubber production statistics compiled by the International Rubber Study Group are reprinted in *Rubber World, Rubber Age,* and *Rubber News. Natural Rubber News* publishes quarterly information compiled by the Rubber Research Institute of Malaya on the production of natural rubber by estate. "The Chemical Economics Handbook" contains historical and current statistics on natural rubber production which are updated regularly.

Prices. Daily quotations of crude rubber prices on New York markets are contained in the *Wall Street Journal* and in the *Journal of Commerce.* Crude rubber prices in the London, New York, Singapore, Djakarta, and Colombo markets are covered monthly in the *Rubber Statistical Bulletin.* Annual average prices and monthly average prices (New York) of No. 1 RSS are reported in *Rubber Age.*

Trade. The *Rubber Statistical Bulletin* has the most complete statistics on international trade reporting monthly net exports of crude rubber from principal Asiatic and African countries and miscellaneous rubber-producing areas, imports of crude rubber into the United States, United Kingdom, and other countries, re-exports of crude rubber from the United States and the United Kingdom, and imports and re-exports of crude rubber latex. Current statistics on the United States imports and re-exports of crude dry rubber and latex are published monthly by the Bureau of Census in FT110 and FT410. *Rubber Age* and *Rubber World* reprint detailed statistics of imports with separate date on balata, jelutung, and gutta-percha derived from the Bureau of Census reports. "Chemical Economics Handbook" contains statistics on imports and exports in less detail. RMA (Rubber Manufacturers Association) also reprints statistics on crude rubber and latex imports and re-exports. *Current Industrial Reports* contain statistics on the imports and re-exports of natural rubber for the two most recent months and for the corresponding months for the previous years.

Synthetic Rubber

Raw Materials. Production, sales, and value data on the principal synthetic rubber raw materials—butadiene, styrene, and acrylonitrile—are published by the U.S. Tariff Commission. Background information on all of these chemicals is contained in "Industrial Chemicals" by Faith *et al.* These chemicals are included in the lists of current prices printed in many different papers and magazines. "Directory of Chemical Producers" identifies producers, their plants, and in some cases their capacities of monomers. The *Oil, Paint and Drug Reporter* reports rubber raw material prices and contains editorial matter of general interest in the rubber field.

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In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Production. For world figures on synthetic rubber production, *Rubber Statistical Bulletin* contains monthly statistics on the estimated production of synthetic rubber by country and type. *Current Industrial Reports* contains statistics on the production of S-type rubber by type, butyl, neoprene, N-type rubber, stereoelastomers, and other elastomers. *Rubber Age* reprints the statistics from the U.S. Department of Commerce, and *Rubber News* and *Rubber World* reprint those from the International Rubber Study Group. *Annual Survey of Manufacturers* publishes historical statistics on the production of synthetic rubber by type. The Attorney General's report also contains information on the production of S-type rubber, butyl rubber, and N-type rubber. "Directory of Chemical Producers" identifies producers, their plants, and in some cases their capacities of synthetic rubbers.

Prices. *Rubber World* reports bimonthly on the prices of many different grades of synthetic rubber. *Rubber Age* periodically publishes synthetic rubber prices. Prices of synthetic rubbers also appear in *Rubber Journal* each month. *European Chemical News* publishes weekly European synthetic rubber prices.

Trade. The U.S. Tariff Commission Reports FT110 and FT410 contain monthly information on the imports and exports of various types of synthetic rubber. The information is also contained in *Current Industrial Reports* and RMA reports. "Chemical Economics Handbook" also gives information on the imports and exports of synthetic rubber.

Reclaimed Rubber

Production. *Rubber Statistical Bulletin* contains statistics on world reclaimed rubber production by countries. *Current Industrial Reports* contains information on domestic production of reclaimed rubber which is also reported in *Rubber World*, *Rubber Age* and RMA reports. The "Chemical Economics Handbook" contains statistics on the production of reclaimed rubber, and the Attorney General's Report contains charts also.

Prices. Reclaimed rubber prices in the United Kingdom and the United States are reported in *Rubber Statistical Bulletin.* More detailed information about reclaimed rubber prices by grades is published by *Rubber Age*.

Trade. Exports and imports of reclaimed rubber by country are reported by *Rubber Statistical Bulletin.* U.S. imports and exports of reclaimed rubber are reported by the U.S. Tariff Commission in Reports FT110 and FT410. *Current Industrial Reports* gives these data in convenient form, and the various reports by the U.S. Department of Commerce form the basis of reclaimed rubber trade data published by *Rubber Age, Rubber World,* and RMA.

Stocks of Rubber

Rubber Statistical Bulletin publishes information on stocks of crude rubber in producing and consuming areas, stocks of synthetic rubber in the United States, United Kingdom, Brazil, France, Canada, Germany, Japan, Australia, and India, and stocks of reclaimed rubber in the United States, United Kingdom, Germany, Australia, and Canada. (Less complete information is pub-

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lished by *Rubber World* and *Rubber Age.*) *Current Industrial Reports* contains detailed information on stocks of total synthetic rubber, S-type rubber, butyl, neoprene, N-type rubber, stereoelastomers, other elastomers, natural rubber, and reclaimed rubber. "Chemical Economics Handbook" contains graphs on government stocks and releases.

Rubber Consumption

World consumption of natural, synthetic, and reclaimed rubber by various countries is reported by *Rubber Statistical Bulletin. Current Industrial Reports* has detailed information on the U.S. consumption of total synthetic rubber, S-type rubber, butyl, neoprene, N-type rubber, stereoelastomers, other elastomers, natural rubber, and reclaimed rubber. These two publications form the basis of the compilations by *Rubber World, Rubber Age,* and RMA. "Chemical Economics Handbook" also contains statistics on rubber consumption.

Rubber Statistical Bulletin contains world wide end-use data on crude and synthetic rubber. Consumption by type and main products in the United Kingdom, Canada, France, and Japan is reported monthly. U.S. data are broken down only into tire and tire products and non-tire products segments.

In the United States, an important source of figures on domestic rubber products is the information supplied by the RMA. Shipments, production and inventories for passenger casings, truck and bus tires, inner tubes, tractor implement tires, and tread rubber are reported. Much of this information is reprinted by *Rubber World* and *Rubber Age. Annual Survey of Manufacturers* contains figures on domestic shipments of tires, inner tubes, footwear, reclaimed rubber, fabricated rubber products, belts and belting, hose and tubing, sponge and foam rubber goods, floor and wall covering, mechanical rubber goods, rubber heels and soles, and druggist and medical sundries.

Economics, Production, and Consumption

Economic statistics on the rubber industry are published by U.S. Government sources. The Bureau of Labor Statistics publishes information on employment, payrolls, hours, earnings, labor, average wholesale prices, and production indices for the rubber industry. The Office of Business Economics publishes information on manufacturers' sales, inventories and orders, corporate income, dividends, and the tax situation for the rubber industry. Much of this information is reprinted in *Rubber World* and *Rubber Age.* The *Federal Reserve Bulletin* contains wholesale price indices for crude rubber, tires, miscellaneous rubber products, and for total rubber and plastics products.

Predicasts contains forecasts for consumption, production, exports, capacity, and shipments for various products. Forecasts are collected for total synthetic rubber, monomers for rubber, additives for rubber, styrene-butadiene rubber, SBR rubber, SBR latex, butyl, neoprene, nitrile, stereo-regulated, polybutadiene, polyisoprene, urethane, EPR, EPT, and miscellaneous rubbers. Rubber products are also covered in detail, as tires and tubes, footwear, etc. *Chemical Market Abstracts* also contains market information about rubbers, rubber raw materials, and rubber products.

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Although there is characteristic disagreement among market researchers as to what the future holds for the rubber industry, it is generally agreed that it is a dynamic and growing business. As such it offers a good opportunity for market researchers to interpret the prospects in such a manner that their companies can capitalize fully on the expanding opportunities for profitable manufacturing operations open to the rubber industry.

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Rubber Trends, The Economist Intelligence Unit Ltd.
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Wall Street Journal, Dow Jones & Co., Chicago, Ill., daily.

U. S. Government Publications

The following publications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

Board of Governors of the Federal Reserve:
Federal Reserve Bulletin; Index of Industrial Production
Business Indexes

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Department of Commerce, Bureau of the Census:
Annual Survey of Manufacturers
Current Industrial Reports (M30A)
Business and Defense Services Administration, Chemical and Rubber Division:
Chemical and Rubber Bimonthly Industry Report
Office of Business Economics:
Survey of Current Business
"National Income"; Survey of Current Business (suppl.)
Department of Justice:
Reports of the Attorney General on Competition in the Synthetic Rubber Industry
Department of Labor, Bureau of Labor Statistics:
Employment and Earnings
Monthly Labor Review
Tariff Commission:
Synthetic Organic Chemicals
United States Exports of Domestic and Foreign Merchandise (FT410)
United States Imports of Merchandise for Consumption (FT110)

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28

Rubber Compounding Information

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The principal sources of information on the compounding of rubber are books, journals, and technical releases of suppliers of raw materials to the rubber industry, as well as abstracts covering the field. The richest source of practical information for the factory compounder is in releases of suppliers. Books furnish a review of known information while journals serve to keep abreast of new developments, some not yet in commercial production. It is important to keep internal records in a form to assure easy availability of the information for future consultation and comparison with published literature. An annotated bibliography lists principal sources of information in all four categories, with specific comments on each publication regarding the type and amount of information to be found.

Thirty years ago the subject of literature on rubber compounding was relatively simple because only natural rubber had to be considered. In 1935 T. R. Dawson and B. D. Porritt authored a technical handbook, "Rubber Physical and Chemical Properties," in which they were able to include, in one volume, the properties of all combinations of compounding ingredients which had been published up to that time. Since then rubber compounding has been complicated by the introduction of a large, continuously increasing number of synthetic elastomers, each requiring different compounding techniques and knowledge.

Dawson and Porritt gave, in tables of data taken from the original references, the then-known information on the effects of each compounding ingredient on every property of rubber considered interesting. The book includes an "Index of Mixings," which lists every combination of rubber ingredient which had been published, with a reference to the appropriate table in the book. The number of compounds listed was 3226. Therefore, when natural rubber was the only polymer to consider, only 3226 different compounds had been published up to that time. By contrast, *The Rubber Formulary,* which

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

reports only the most useful compounds from the literature, has reported over 20,000 compounds since the beginning of 1948.

When we consider the number of elastomers and new types of products developed in the last 30 years, we begin to understand the problem of using the accumulated literature on rubber compounding. Furthermore, the compounder of today, who needs this literature to carry on his work effectively, is often located in a small to medium-sized rubber factory. He does not have available the services of a librarian or trained abstractor but must find this source material for himself. This situation is also often aggravated by lack of time for extensive literature searching as well as the lack of an extensive library.

There are four general sources of information on rubber compounding, the first two being books and journals. In the field of rubber compounding, however, a peculiar situation exists, in that most of the available information is not in books or technical journals, but in the technical releases issued by the chemical manufacturers supplying the rubber fabricating industry. This is particularly true of the type of compounding information sought by the factory compounder. Another important, and usually the most frequently consulted source of compounding information, is the file of one's own compounds (in older times known as the "little black book").

The rubber compounder thus has four categories of information at his disposal: books, journals, company releases, and private records. The annotated bibliography contains a list of books, periodicals, and suppliers' releases which are considered the principal sources of compounding information. This list is by no means complete and has been restricted to publications giving practical information of interest to compounders.

Books

Basic books are the first logical source of information on any subject. The bibliography lists basic books on rubber which contain enough information on compounding to be considered a source of formulations. However, these books are quickly outdated because new polymers and compounding ingredients continually appear on the market.

Nevertheless, these books are useful to the young chemist seeking general information and to the experienced compounder starting to work in an unfamiliar field. They are also important to the research worker who needs a condensed review of known information on a subject. For the usual compounding problem which arises for the factory compounder, basic books lose their usefulness soon after they are published. Nevertheless, it is important to have them on hand to refresh one's memory and to double check on facts.

The section of the bibliography listing publications of suppliers to the industry cites a number of manuals and handbooks which use a looseleaf form to remain current. These books are kept up to date by adding new material or replacing portions which have become outdated by new developments. The companies supplying these manuals keep a list of subscribers who receive supplements as they are issued. The usefulness of ringbooks depends on keeping the book up to date and in good order.

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Two books which do not contain compounding information in the strict sense, but are invaluable in any library on rubber compounding, are "Materials and Compounding Ingredients for Rubber and Plastics," published by *Rubber World,* and "Rubber Red Book," published by *Rubber Age.* Although information on compounding ingredients is more detailed in the former, "Rubber Red Book" is revised every year and is, therefore, more up-to-date. Compounders and purchasing agents do well to consult both books.

"International Rubber Directory" and "Rubber Trade Directory of Great Britain" fall into the same category.

Periodicals

The list of periodicals in the bibliography is rather short, and only those published in the United States and Great Britain are included. Although other periodicals also contain articles on rubber, only those which regularly publish information on compounding are listed. It would not be practical to try to include every periodical which ever published a paper on compounding. Foreign journals (except British) are also omitted from the listing, although a number of them regularly present papers on rubber compounding. To a compounder in this country their usefulness is limited by the fact that so many of the ingredients, as well as the polymers, used in the formulations are not readily available here.

The journals of the American Chemical Society (ACS)—the *Industrial & Engineering Chemistry Product Research and Development,* and the Division of Rubber Chemistry's *Rubber Chemistry and Technology*—report studies on rubber compounding. Many of these studies are on materials which are still in the experimental stage because ACS papers report new scientific work. In rubber compounding this frequently means development of new polymers or compounding ingredients.

These publications present information which the compounder needs to keep abreast of developments in the field. However, until the polymers and compounding ingredients become available commercially, this information provides little help in day-to-day problems. With these particular journals the situation is the reverse of that with basic books, in that back issues are more valuable than the latest issues.

Of the periodicals containing extensive compounding information the most useful for the factory compounder are *Rubber Age, Rubber World,* and the *Journal of the IRI. Rubber Age* and *Rubber World* frequently publish compounding studies which are both timely and practical.

The *Journal of the IRI* is a particularly valuable source of compounding studies on natural rubber, a subject which takes second place in publications of this country. British compounders depend to a greater extent on varying the composition of natural rubber mixes rather than on selecting special polymers to achieve various properties.

The French journal, *Revue Générale du Caoutchouc,* for some years has included English abstracts of its technical papers and a complete translation of the principal article.

Releases of Suppliers to the Industry

The rubber industry is perhaps unique in that technical information, rather than being available predominantly from journals or books, is for the most part, free from suppliers to the industry. This information provided in suppliers' releases is both basic, in that it pertains to systematic studies on variations of ingredients, and specific, in that it suggests recipes to meet given requirements.

The list of suppliers' releases in the bibliography is not comprehensive. Almost every chemical supplier to the industry publishes valuable information on compounding concerning the use of his ingredients in rubber mixes. The releases in the bibliography have been selected as those which appear frequently and offer a wide range of information.

Publications of suppliers are reviewed as they are released in the book review sections of both *Rubber Age and Rubber World.* Hence, any chemist interested in acquiring compounding literature may keep his library of suppliers' literature up to date by writing regularly for the latest releases. Many of the booklets are also mentioned in the Literature portion of the "New Products This Week" section of *Chemical and Engineering News.* Compounding recipes and their properties published in suppliers' literature are also available to compounders through *The Rubber Formulary,* which presents this information to subscribers monthly on marginally punched cards.

Journal advertisements often invite readers to write for literature, an invitation usually worth accepting. A telephone call to the local sales agent of any supplier will also place an organization or individual on the mailing list for technical releases on rubber compounding.

The fourth category of sources for compounding information, private records, needs no special discussion except for ways of keeping records so that this information is both up to date and easily available. This aim is served by proper cataloging, abstracting, and indexing of records.

Abstracts and Indexes

The most important aspect of the literature on any scientific subject is the availability of information. A specialist in any field cannot and need not know all the facts, but he must know where and how to find them. Before discussing the available abstracting and indexing services for rubber compounding, indexes of individual publications should be mentioned. Not only do the journals in the field print annual indexes, but those suppliers who publish extensively issue either annual subject indexes or cumulative indexes.

It is not possible to discuss indexing services on rubber compounding without again mentioning the work of Dawson and Porritt. Although it covers

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the literature only up to 1935, it provides a means of finding anything published to that date.

Of current abstracting and indexing services, those in the English language which most extensively cover the field of rubber compounding are *Chemical Abstracts, RAPRA Abstracts,* "Bibliography of Rubber Literature," and *The Rubber Formulary.*

Most compounding articles published in technical journals, as well as patents are abstracted in *Chemical Abstracts.* However, since such a large proportion of the source material in this field (suppliers' releases) is not found in journals, much information will be in sources not listed in *Chemical Abstracts.*

RAPRA Abstracts (until 1952 called *Summary of Current Literature*), is published monthly by the Rubber and Plastics Research Association of Great Britain. It is the most outstanding publication in the field for reporting and summarizing the current literature on rubber. The coverage is complete and includes journals from all over the world, patents, books, and company releases. Abstracts range from a few lines to as much as half a column, and include literature references to other abstracts.

"Bibliography of Rubber Literature," edited by M. E. Lerner, was started by *Rubber Age,* and is now published by the Division of Rubber Chemistry of ACS. It is essentially an index to the literature, and only one-sentence abstracts are given. Coverage is complete, citing books, journals, patents (since 1940), and company releases. References to more comprehensive abstracts are given.

Presently the volumes published cover from 1935 through 1962. The committee working on this bibliography hopes within the next two years to bring the abstracts completely up to date.

The Rubber Formulary. *The Rubber Formulary* differs considerably in nature from other abstracts. First, it is published on marginally punched cards, and second, the abstracting is done on the basis of individual compounds, each reported on a separate card. Each entry gives the original reference, the formulation, and all properties reported in the original reference. Perhaps this publication might be described more accurately as a catalogue of published rubber compounds. *The Rubber Formulary* covers all articles appearing in technical journals in United States and Great Britain which report formulations with test data, and also technical releases of suppliers containing this type of information.

This method of abstracting by individual compounds, which are coded by definitive properties and ingredients makes it possible to find the kind of information which is difficult or impossible to locate through a subject index.

J. D. Morron was the first to suggest using punch cards for filing and retrieving rubber compounding information in 1930 when he described a system he had devised for use in his laboratory (*1*). By means of coding compounds on IBM punched cards he was able later to find all compounds he had mixed having a given combination of physical properties.

The laboratories of the Research Association of British Rubber Manufacturers worked out a punched card system for filing compounds mixed and tested in their laboratories. The compounds were indexed according to

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ingredients used in the mix and tests which had been performed on the compound. The system was described in a bulletin issued to the members of the association in 1948 (*2*).

The classifications used in *The Rubber Formulary* for selecting cards from the file are Shore hardness, tensile at break, elongation, type of elastomer, and whether or not the compound contains carbon black as a filler. These classifications are used because they define a rubber compound in general terms, are nearly always reported, are of interest to anyone who deals with rubber compounds, and will ordinarily select from a file a small enough number of cards to be looked over by hand for final selection. The card used for recording compounds is shown in Figure 1. Detailed explanations for operating the file have been reported previously (*3, 4, 5*).

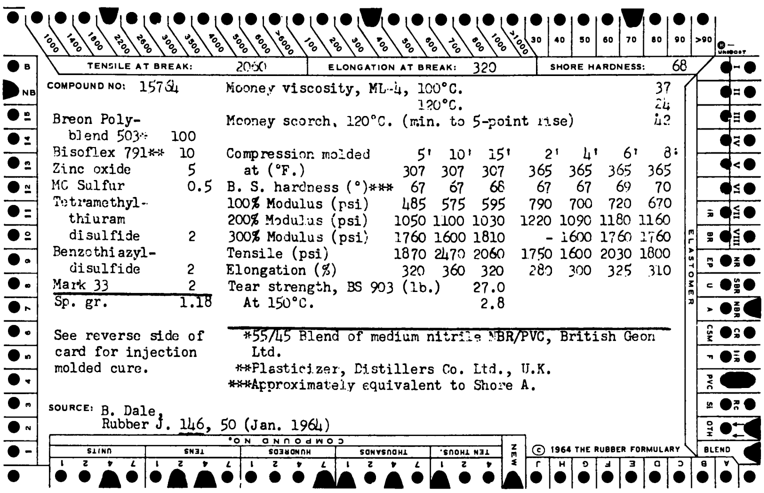

Figure 1. Punched card used for recording compounds

There are, of course, many other classifications for codifying a compound in a punched card file. The card shown in Figure 1 has a number of holes to which no meaning has been assigned, and which are left free to be used for any further classification the owner desires. Thus, a user of a file of marginally punched cards might classify his compounds by type of goods for which they were intended, according to ingredients in the mix, or according to physical properties other than tensile, elongation, and hardness.

Filing Internal Records

In the field of rubber compounding the problem of finding information is by no means confined to finding references in the literature. Much work is duplicated in laboratories because of the difficulty of finding data on previously mixed and tested compounds. The larger the organization and the longer the laboratory has been operating, the more inefficient it is to depend on the memory of chemists regarding whether or not compounds of any given composition or properties have been mixed before.

A marginally punched card file effectively eliminates this difficulty. If all compounds are recorded and put into an efficiently coded and well maintained punch card file as fast as they are mixed and tested, it will eventually place all experience of the organization, previous and current, at the fingertips of any member.

Many laboratories now use this method of keeping internal records. In fact, *The Rubber Formulary* as a literature abstracting service grew from a file of cards of the same type for internal compounding records used some years ago at the Engineering Experiment Station of the University of Delaware. A number of laboratories are using the same type cards at present (*The Rubber Formulary* supplies blank cards for this purpose).

Summary

The preceding discussion has pointed out the variety of sources available to those seeking information on rubber compounding and suggested means for making this information conveniently accessible. A file of marginally punched cards for rubber compounds has been suggested as a way of filing and retrieving technical information from private records as well as from the literature.

The annotated bibliography which follows lists sources of compounding information available in the form of books, periodicals, company releases, and abstracts, listing those which are considered by the author to be the richest sources for actual formulations. Particular emphasis is on the type of information sought by the compounder working on practical factory problems.

Literature Cited

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(2) Research Association of British Rubber Manufacturers, "Punched Card Indexing for Mixing Data," Bulletin I. D. **5111** (April 2, 1948).
(3) Rostler, K. S., *India Rubber World*, **120**, 698 (1949).
(4) Rostler, K. S., *Rubber Age*, **82**, 678 (1958).
(5) Rostler, K. S., "Instructions for the Use of The Rubber Formulary and Recommendations for Filing," Bakersfield, California: The Rubber Formulary (1964) (Booklet issued to subscribers).

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Books

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Compilation of lectures given under the auspices of the Akron Rubber Group, covering the vulcanization of all types of elastomers.
American Chemical Society, "Proceedings. International Rubber Conference, Washington, D. C., November, 1959." Washington, American Chemical Society, 1959.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch028

Preprints of papers, many concerned with compounding, presented at the conference sponsored jointly by Division of Rubber Chemistry of American Chemical Society, Committee D–11 of American Society for Testing Materials, and Rubber and Plastics Division of American Society of Mechanical Engineers.

Ball, J. M., "Manual of Reclaimed Rubber," New York, Rubber Reclaimers Association, 1956.

Brief discussion of types of reclaim available and general compounding principles plus extensive tables of suggested formulations for utilizing reclaimed rubber in various types of rubber goods. The first half of this book, concerning basic compounding principles, has recently been revised and reissued as "Technical Bulletin No. 10" of the Rubber Reclaimers Association.

"Bureau of Ships Rubber Formulary," Washington, D. C., U. S. Department of Defense, Department of the Navy, Bureau of Ships, Elastomers Section. Revision 5, 1958.

Looseleaf. Lists suggested formulations with their physical properties to meet federal and military specifications for rubber goods of interest to the Navy Department.

Systematic list, by groups, compiled by the editors of *Rubber World* of all raw materials used in compounding, giving properties, function and suppliers.

Davis, C. C., and Blake, J. T., eds., "The Chemistry and Technology of Rubber," New York, Reinhold, 1937, (ACS Monograph No. 74).

Published under auspices of Division of Rubber Chemistry, American Chemical Society, each chapter by an authority in the field; effects of type and proportion of compounding ingredients and a chapter on practical compounding of natural rubber with examples of typical formulations.

Dawson, T. R., and Porritt, B. D., "Rubber—Physical and Chemical Properties," Croydon, England, Research Association of British Rubber Manufacturers, 1935.

A comprehensive treatise including results of all rubber research up to March, 1934; greatest portion devoted to results of compounding variations; bibliography of 1400 items, glossary of terms used in rubber technology, descriptions of test methods, various conversion tables, and a compound index giving every published compound up to that date with reference to places where it appears in the tables of the book.

Institution of the Rubber Industry, "Proceedings of the Rubber Technology Conference," 1938, ed. by T. R. Dawson and J. R. Scott; "Proceedings of the Second Rubber Technology Conference," 1948, ed. by T. R. Dawson, C. M. Blow and J. R. Scott; and "Proceedings of the Third Rubber Technology Conference," 1954, ed. by T. H. Messenger. All published in Cambridge, England, by W. Heffer and Sons.

Papers given at the international conferences held under the auspices of the Institution of the Rubber Industry, many of which deal with the subject of compounding.

"International Rubber Directory," Zurich, Verlag für Internationale Wirtschaftsliteratur, 9th Edition, 1967.

In German, French and English. Includes a brief list of chemicals and raw materials with suppliers in the principal countries.

Kraus, G., ed., "Reinforcement of Elastomers," New York, Interscience, 1965.

Thorough coverage of the subject of reinforcement of elastomers by black, white and organic fillers, from both theoretical and practical aspects.

"Materials and Compounding Ingredients for Rubber and Plastics," New York, Bill Brothers Publishing Corp., 1968.

Morton, M., ed., "Introduction to Rubber Technology," New York, Reinhold, 1959.

Lectures presented before local Rubber Groups sponsored by the Division of Rubber Chemistry of ACS compiled under the auspices of the division as an elementary textbook on natural and synthetic rubber; chapters on several types of compounding ingredients giving general principles of compounding.

"Natural Rubber Technical Information Sheets," Welwyn Garden City, The Natural Rubber Producers Research Association.

Looseleaf. New series of releases, started in 1964; general information on the compounding of natural rubbers, as well as examples of special natural rubbers in specific goods; available in U. S. from Natural Rubber Bureau.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch028

Penn, W. S., "Synthetic Rubber Technology," Vol. I. London, Maclaren and Sons, 1960.

Extensive information on general compounding principles and on compounding for specific applications. Vol. I covers butadiene-styrene copolymers, neoprene, and butyl, nitrile, silicone and polysulfide rubbers; Vol. 2, in preparation, is to cover newer materials and polymers for specialized applications.

"Rubber Red Book," (Directory of the Rubber Industry). New York, Palmerton Publishing Co., 20th Edition, 1967.

A comprehensive annual directory compiled by the editors of *Rubber Age.* Includes classified listings of elastomers and latices, and compounding ingredients by their trade names, composition, and suppliers.

"Rubber Trade Directory of Great Britain," London, Maclaren and Sons, 5th Edition, 1966.

Includes lists of suppliers in Great Britain of rubber chemicals and natural and synthetic elastomers.

Scott, J. R., "Ebonite. Its Nature, Properties and Compounding," London, Maclaren and Sons, 1958.

Condensation of extensive work carried out by Research Association of British Rubber Manufacturers on effects of compounding variables on ebonite properties, including a complete list of the original papers.

"Technical Bulletins on Natural Rubber," London, The Natural Rubber Development Board.

Looseleaf. Consists of British Rubber Producers' Research Association Bulletins reporting new developments in modified natural rubbers and new compounding techniques for natural rubber; available in United States from Natural Rubber Bureau, Washington, D. C.

Van Alphen, J., "Rubber Chemicals." New York, Elsevier, 1956.

In German and English. Systematic listing of rubber accelerators, activators, antioxidants, blowing agents, peptizing agents, retarders, vulcanizing agents, and emulsifying agents, giving principal physical properties, trade names and suppliers; the alphabetical index by trade name, international in scope, is a particularly valuable feature.

Whitby, G. S., Davis, C. C., and Dunbrook, R. F., eds., "Synthetic Rubber," New York, Wiley; London, Chapman and Hall, 1954.

Published under auspices of Division of Rubber Chemistry, ACS each chapter by an authority in the field; includes considerable information on compounding synthetic elastomers, illustrating general characteristics of compounds by tables with test data, and giving typical recipes for rubber goods.

Periodicals

Progress of Rubber Technology, Institution of the Rubber Industry, 4 Kensington Palace Gardens, London W8, annual.

Review articles on all phases of rubber technology; considerable information on compounding; extensive bibliography of articles, patents and company releases.

Industrial & Engineering Chemistry, Product Research and Development. American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036, quarterly.

Publishes some papers from Division of Rubber Chemistry reporting new developments in compounding elastomers, many being studies of new polymers and compounding ingredients still in experimental stage.

Journal of Chemical and Engineering Data, American Chemical Society, quarterly.

Includes papers from Division of Rubber Chemistry reporting compounding studies, principally of new polymers and compounding materials, many still in experimental stage.

Revue Générale du Caoutchouc, 42 Rue Scheffer, Paris, monthly.

Articles of theoretical and practical interest. Includes abstracts of journal and patent literature, and English translations of some articles.

Rubber Age, Palmerton Publishing Co., Inc., 101 West 31st Street, New York 10001, monthly.

Papers on compounding published almost every month; usually timely and of practical interest. Book review section covers new books and company releases.

Rubber and Plastics Age, Rubber & Technical Press, Ltd., 25 Lloyd Baker St., London, WC1, monthly.

Several articles on compounding published during each year.

Rubber Chemistry and Technology, Administrative Secretary, Division of Rubber Chemistry, ACS, Inc., Box 123, University of Akron, Akron, Ohio 44304, 5 a year.
First four issues each year consist almost entirely of reprints from other journals and translations from foreign language journals; fifth issue composed of original review articles; some papers on compounding.

Rubber Journal (formerly *Rubber and Plastics Weekly*), Maclaren & Sons, Ltd., Davis House, 69/77 High St., Croyden, Surrey, monthly.
Several articles on compounding published during each year. "Views and Reviews" section in each issue discusses papers in other journals and new releases from suppliers.

Rubber World, Bill Brothers Publishing Corp., 630 Third Ave., New York 10017, monthly.
Papers on compounding published almost every month; usually timely and of practical interest. Book review section covers new books and company releases.

Soviet Rubber Technology, Maclaren & Sons, Ltd., monthly.
Translation of the Russian journal, *Kautchuk i Rezina*, containing papers, largely of a practical nature many of which are concerned with compounding.

Journal of the IRI (formerly *Transactions of the Institution of the Rubber Industry*, and *Proceedings of the Institution of the Rubber Industry*), 4 Kensington Palace Gardens, London W8, bimonthly.
Papers on compounding of rubber, mostly natural rubber, published in almost every issue.

Publications of Suppliers

American Cyanamid Co., Rubber Chemicals Department, Bound Brook, N. J.
"Rubber Chemicals Technical Bulletins." Each bulletin covers one product, giving description, properties, and a number of formulations with physical properties illustrating its use.
"Rubber Chem Lines," monthly. Four-page bulletins each ordinarily including a brief article on compounding, and each mentioning more extensive literature available.
"Elastomer Data Sheets." Information on compounding the company's acrylic and urethane polymers.

American Synthetic Rubber Corp., P. O. Box 360, Louisville, Ky.
"ASRC Manual." Looseleaf. Properties and specifications of each of the company's SBR polymers and suggestions for typical factory stocks.

Ashland Chemical Co., Carbon Black and Synthetic Rubber Division, P. O. Box 1503, Houston, Texas.
"Development and Status of Carbon Black," by I. Drogin, 1945; "Today's Furnace Blacks," by I. Drogin and H. R. Bishop, 1948; "Extrusion Factors of Black Rubber Compounds," by I. Drogin, H. R. Bishop and D. Wiseman, 1954 (reprinted from Rubber Age, February, 1954); "The Role of Intermediate Level Carbon Blacks in Rubber," by I. Drogin, 1954 (Reprinted from "Proceedings of the Third Rubber Technology Conference"). Comparative studies of different types and brands of carbon blacks at different loading in natural and synthetic rubbers. Very extensive test data reported. All the foregoing issued by United Carbon Co., now part of Ashland Chemical Co.
"Carbon Blackboard" and "SBR Technotes." Brief releases published initially as advertisements, then reprinted, giving results of compounding research. The former series deal with carbon blacks, the latter with polymers.

Cabot Corporation, 125 High St., Boston, Mass.
"Cabot Technical Reports." Reports of laboratory studies on effects of compounding variations.

Columbian Carbon Co., 380 Madison Ave., New York, N. Y.
"Columbian Colloidal Carbons." Series of booklets. Fundamental information on carbon blacks and their use in rubber. Recent issues have been reprints of journal articles.
"Columbian Carbons in Natural and Synthetic Rubbers." Looseleaf. Tables and graphs reporting the effects of increased loadings of various carbon blacks in several elastomers.
"Technical Service Reports." Both general studies and representative factory formulations. Designed for insertion in loose-leaf book mentioned above.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch028

Dow Corning Corp., P. O. Box 592, Midland, Mich.
"Bulletins." Some are brief leaflets, others substantial books, giving properties of silicone rubber compounds and compounding information on silicone gums and bases.

E. I. du Pont de Nemours and Co., Elastomer Chemicals Dept., Nemours Bldg., Wilmington, Del. 19898.
"Formal Reports." Each deals in detail with the basic principles of compounding with one of the company's elastomers or compounding ingredients. Several formerly issued each year. None issued in recent years.
"Informal Reports" (Blue Sheets). Brief reports, with formulations and test data, each dealing with a specific and timely practical compounding problem.
"Hypalon Reports," "Viton Bulletins," "Adiprene Bulletins." Extensive compounding information, both general studies and practical formulations, for the company's chloro-sulfonyl-polyethylene, fluorocarbon, and urethane polymers, respectively.
"Chemical Bulletins." Brief leaflets, each covering one of the company's rubber chemicals.
"Mechanical Molded Goods: Neoprene and Hypalon," D. C. Thompson, 1955. Processing and compounding of mechanical molded goods with the two types of elastomers. The compounding section includes basic information on compounding to obtain desired properties and an extensive table, arranged by hardness and tensile strength, of recommended formulations for mechanical goods.
"Neoprene Latex: Principles of Compounding and Processing," John C. Carl, 1962. Comprehensive information on compounding, including description of all latices, handling recommendations, effects of compounding variables, all illustrated by extensive data in tabular and graphic form.
"The Neoprenes," R. M. Murray and D. C. Thompson, 1963 (Revised edition of the book by N. L. Catton published in 1953). Comprehensive description of all types of neoprenes with discussions, illustrated by extensive tables and graphs of vulcanizate properties, of the effects of compounding variables; numerous bibliographical references to journal articles and company reports.

Enjay Chemical Co., Inc., 60 West 49th St., New York 10020.
"Enjay Polymer Laboratories Technical Information Sheets." Report sheets giving compounding information, usually of a practical nature, on butyl and ethylene-propylene rubbers. Distributed through technical representatives.
Booklets (such as "Butyl Compounding Handbook," "EPR 404 Ethylene-Propylene Rubber") issued from time to time giving extensive information on the compounding of the company's polymers.

Firestone Synthetic Rubber and Latex Co., Division of Firestone Tire and Rubber Co., 381 W. Wilbeth Road, Akron, Ohio 44301.
"Synthetic Rubber Facts." Vol. I covers SBR polymers, Vol. II, poly(butadiene); looseleaf; information on polymers produced by the company, including reprints of papers on compounding principles with suggested formulations for a number of specific types of rubber goods.

General Electric Co., Silicone Products Dept., Mechanicville Rd., Waterford, N. Y.
"Silicones Product Data" sheets. Brief releases giving properties of the company's silicone rubber compounds and compounding studies with silicone gums.
"Technical Data Books." Booklets on silicone rubber compounds and compounding with silicone rubber gums and bases.

Golden Bear Oil Division, Witco Chemical Co., P. O. Box 378, Bakersfield, Calif.
"G. B. Reports." Original reports and reprints of articles giving basic compounding information pertaining to the use of petroleum-derived compounding ingredients.

B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland, Ohio 44115.
"Hycar Technical Manual." Looseleaf. Sections, published from time to time, each deal in detail with one or a group of the company's polymers or compounding ingredients. Included are basic compounding information illustrated by data on test series and recommendations for factory compounds.
"Hycar Technical Newsletter." Formerly published monthly, then irregularly. Information on new products, new compounding techniques, and suggestions for factory compounds.
"Hycar Technical Supplements." More recent series of releases, giving information of the same nature as formerly published in the "Newsletters."

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch028

Goodrich-Gulf Chemicals Inc., 1717 East 9th St., Cleveland, Ohio.

"Ameripol Technical Data Releases." Brief reports, most of which give descriptions and specifications for one of the company's SBR or poly(butadiene) polymers. Some contain reports of compounding studies in factory-type formulations.

"Ameripol SBR Recipe Data." Suggested factory formulations.

"Ameripol CB Technical Data Reports," and "Ameripol CB Recipe Data." Booklets on compounding poly(butadiene), the first series concerned principally with basic principles, the latter supplying practical factory formulations for specific goods.

"Ameripol SN Polymer Data," and "SN Technical Data Reports." New series of releases giving information on *cis*-poly(isoprene).

Goodyear Tire and Rubber Co., Chemical Division, 1144 East Market St., Akron, Ohio 44316.

"Tech-Book Facts." Series of releases issued frequently comprising both extensive compounding studies and factory compound suggestions with the company's elastomers, resins, and compounding ingredients.

J. M. Huber Corp., Thornall St., Menlo Park, N. J.

"Huber Rubber Products Manual." Looseleaf. Description of the company's carbon blacks, clays, and other compounding ingredients and their use in various elastomers and types of compounds, illustrated by basic test series and practical formulations with test data. Replaced in 1965 by a bound book, "Huber Products for the Rubber Industry."

International Synthetic Rubber Company Ltd., Brunswick House, Brunswick Pl., Southampton, England.

"Technical Information Sheets." Brief releases giving formulations with test data for compounding specific products with the company's SBR and EPDM polymers.

Petro-Tex Chemical Co., 8600 Park Place Blvd., Houston, Texas.

"Butyl Technical Data Bulletins." Reports on specific compounding problems, or recipes for a specific article with the company's butyl polymers.

Phillips Petroleum Co., Chemical Dept., Rubber Chemicals Div., 318 Water St., Akron, Ohio.

"Rubber Chemicals Bulletins" (formerly called "Philblack Bulletins"). Reports of basic compounding studies on the company's carbon blacks, polymers, and plasticizers, with extensive test data.

"Bulletin P–1, etc." This series consists of booklets giving extensive test series on compounding various polymers with the company's carbon blacks. Some of the series have been reprints of journal articles.

"Philprene Polymers." Catalogue of SBR polymers giving composition and specifications for each with suggestions for factory formulations accompanied by test data; spiral bound so insertions may be made as issued.

"Bulletins." Series of releases which contain both basic compounding studies and practical suggestions for factory compounds. Issued in two series; those numbered in the 100's dealing with carbon blacks, those numbered in the 200's dealing with SBR and poly(butadiene) polymers.

Pittsburgh Plate Glass Co., Chemical Division, One Gateway Center, Pittsburgh, Pa.

"Calcene Bulletins; Silene Bulletins; Hi-Sil Bulletins." Results of compounding studies with the company's white fillers, usually illustrated by practical factory formulations. Recent issues have been reprints of journal articles.

Polymer Corp. Ltd., Sarnia, Ont., Canada.

"Polysar Handbook," 1956. Extensive compounding information on the company's styrene, nitrile, and butyl rubbers, including both basic compounding studies and suggested factory formulations. Appendix contains many useful tables, including conversion tables and lists of compounding ingredients by trade names.

"Polysar Handbook, Vol. 2," 1960. A continuation of the original handbook, covering new polymers developed since publication of the first volume.

"Polysar Butyl Handbook," 1966. A book of similar character to the first two handbooks, but devoted entirely to butyl rubbers.

"Polysar Technical Reports." Brief reports, issued frequently, giving new compounding developments, some concerned with basic principles, others presenting recommendations for factory compounds.

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Rubber Reclaimers Association, New York, N. Y.
"Technical Bulletins." Brief releases on compounding with reclaimed rubber; concerned with factory handling properties and formulations.

Shell Chemical Corp., Synthetic Rubber Division, 113 West 52nd St., New York, N. Y.
"Technical Bulletins." Data sheets on new SBR and poly(isoprene) rubbers, reports on basic compounding studies, and recommendations for factory compounding of specific types of rubber goods.
"Shell Synthetic Rubber," 1956. Descriptions of and specifications for the company's SBR polymers.

Texas-U. S. Chemical Co., 777 Third Ave., New York, N. Y.
"Data Sheets." Descriptions of and specifications for new polymers.
"Product Bulletins." Each describes and gives specifications for one of the company's SBR or poly(butadiene) polymers with recipes and test data for applications in specific types of goods.
"Application Bulletins." Each covers one type of goods, giving compounding recommendations illustrated by tables of compounds and test data.
"Technical Service Reports." Each gives extensive suggestions for formulating a particular class of goods with the company's polymers.

Thiokol Chemical Corp., 780 North Clinton Ave., Trenton, N. J.
"Bulletins." Compounding information, principally of a basic nature, illustrated by extensive test data on the company's poly(sulfide) polymers (CR, CS and LP series), acrylic polymers (AR series), urethane polymers (UE series), and rubber chemicals (RC series).

Union Carbide Corp., Silicones Div., 270 Park Ave., New York, N. Y. 10017.
"SF" releases. Leaflets or small booklets each describing a single silicone rubber compound, or series of compounds, giving extensive test data.
"Product Information Bulletins." Each release reports the properties of a silicone rubber compound, or series of compounds, or gives compounding recommendations with a series of silicone gums.
"Customer Service Bulletins." Releases giving general information on the compounding of silicone rubber.

UniRoyal Chemical, Div. of UniRoyal, Inc., Naugatuck, Conn.
"Compounding Research Reports." Each deals either with one group of the company's compounding ingredients or with one type of rubber compound. Information in the series includes both basic compounding information illustrated by test series and suggestions for factory formulations.
"Paracril Technical Bulletins." Information on compounding the company's Paracril elastomers. Each bulletin deals with either one phase of compounding or one class of practical formulations.
"Technical Data Bulletins." Brief, initial releases on new chemicals and polymers, giving uses and a few suggested application formulations.
"Royalene Technical Bulletins." New series with compounding information of both basic and practical nature on the company's ethylene-propylene terpolymer.
"Naugatuck Rubber Chemicals and Paracril." F. L. Holbrook, 1954. First half of this book consists of descriptions of compounding ingredients and elastomers offered by Naugatuck Chemical, with brief recommendations for their use. The second half consists of recommended formulations with test data for a variety of different types of rubber goods.
"Forms 510-B1, etc.; 510-G1, etc.; 570-B1, etc.; 570-G, etc." These brief releases present suggested formulations with test data for various factory compounds, the first two series with NBR polymers, the latter two, with EPDM polymers.
"Findings." Frequently issued releases reporting briefly new developments in compounding with the company's polymers and compounding ingredients.

R. T. Vanderbilt Co., 230 Park Ave., New York, N. Y. 10017.
The Vanderbilt News, Bimonthly. Each issue consists of several articles on various phases of compounding, illustrating the use of the company's wide range of compounding ingredients, giving formulations and test data.
"The Vanderbilt Rubber Handbook," ed. by G. G. Winspear, 10th edition, 1958. A practical manual explaining basic principles of compounding and giving recommendations for specific types of goods, illustrated with numerous compound

formulations and test data; also includes a section describing frequently used physical test methods and a section of useful tables.

"The Vanderbilt Latex Handbook," ed. by G. G. Winspear, 1954. A practical manual on the handling and compounding of latex. Includes descriptions of latices and of compounding ingredients, compounding recommendations, both general and specific, descriptions of test methods, and a section of useful tables.

Abstracts

"Bibliography of Rubber Literature," M. E. Lerner, Editor-in-Chief, New York, Division of Rubber Chemistry, American Chemical Society (Years through 1939 compiled by D. E. Cable and published by *Rubber Age,* New York).

Very complete coverage of journals, patents (since 1940) and company releases. One-sentence abstracts, with reference to more detailed abstracts where available, are arranged in systematic order by subject. Literature coverage to date comprises the years 1935 through 1962.

Chemical Abstracts, American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036, weekly.

Year	*Section*
1912	26. Pigments, Resins, Varnishes and India Rubber
1915	30. Rubber and Allied Substances
1961	30. Rubber and Other Elastomers
1962	46. Rubber and Other Elastomers
1965	49. Elastomers, Including Natural Rubber
1967	38. Elastomers, Including Natural Rubber

Resins, Rubbers, Plastics, Information for Industry, Inc., 1000 Connecticut Ave., N.W., Washington, D. C., semimonthly. Discontinued in 1965.

Condensations of articles from foreign and domestic journals, including articles on rubber compounding, published in looseleaf form for insertion in a binder according to subject. Abstracts include tables and figures from original references.

Resins-Rubbers-Plastics Yearbook, Information for Industry, Inc. Discontinued in 1965.

Compilation in bound form of the looseleaf abstracts cited above, each volume covering the year indicated. Includes subject and author index.

RAPRA Abstracts, Shawbury, Shrewsbury, Shropshire, England. Rubber and Plastics Research Association of Great Britain, monthly. (Formerly *Summary of Current Literature,* published with *Journal of Rubber Research*)

Abstracts range from a few lines to half a column and include references to other abstracts. World-wide coverage of journals, patents and company releases. Annual subject, author and patent indices.

The Rubber Formulary, Materials Research & Development, Inc., 2811 Adeline St., Oakland, Calif., monthly.

Elastomer formulations with complete test data from domestic and British journals, and from releases of suppliers, recorded individually on marginally punched 5" x 8" file cards. Published since 1948; approximately 1000 new cards per year.

"The Rubber Formulary Starter Set," ("Condensed Set I"), Bakersfield, California, 1960. (Sold through Materials Research & Development, Inc., Oakland.)

Selection of 2365 rubber formulations from the first ten years (1948 through 1957) of regular issues of *The Rubber Formulary.* Published on marginally punched 5" x 8" file cards as in the regular monthly publication, supplied with dividers and presorted for ease of retrieval by polymer, black or nonblack, hardness, tensile and elongation.

"The Rubber Formulary Condensed Set II," Oakland, California, Materials Research & Development, Inc., 1964.

Supplement to "Condensed Set I," the original "Starter Set" listed above. Consists of 2418 cards from those published in *The Rubber Formulary* monthly issues from 1958 through 1963. Presorted and supplied with file dividers.

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U.S. Patent Classes and Subclasses

	Class	Subclass
Rubber	260	709+
Synthetic	260	2+
Buna s	260	83.7+
Butyl	260	85.3
Chloroprene	260	92.3
Diolefine	260	94.2+
Dispersions or solutions	260	29.1+
Factice	260	399
Natural rubber with	260	4+
Perbunan	260	83.7+
Plasticizer containing	260	29.1+
Reaction induced by electrical or radiant energy	204	154+
Within nuclear reactor	176	10+
Sulfurized	260	79.5
Synthetic resin containing	260	3+
Vulcanization	260	775+
Molding processes	264	

RECEIVED October 20, 1964. Presented on the symposium, "Literature of Rubber," sponsored by the Division of Chemical Literature and the Division of Rubber Chemistry at the 130th Meeting of the American Chemical Society at Atlantic City, Sept. 18-19, 1956. Published in limited edition by the Division of Rubber Chemistry and reprinted by permission of the Division. Adapted from the original paper published by *Rubber Age* (Jan. 1958) and reprinted with permission. Updated 1968.

Standards and Specifications For Rubber and Rubber Products

JOHN J. ALLEN[1]

The Firestone Tire and Rubber Co., Akron, Ohio

In order to measure the performance requirements and to maintain an established quality of the many rubber products in use, it is necessary to have standard test methods and specifications acceptable to both producer and consumer. This article describes the activities of the several technical societies and industry technical committees which are made up of qualified technical representatives from both the producing and consuming segments of the industry. Anyone interested in rubber and rubber products will find the list of sources and their addresses very helpful.

In the rubber industry, producers and consumers use the common language of specifications. A rubber specification usually includes the physical characteristics of the rubber compound, numerical limits for various measurable properties, test methods, and the performance and acceptance requirements of the product.

Many specifications which are issued and accepted by producers and consumers serve merely as satisfactory descriptions of the product. However, they are not necessarily Standard specifications. A specification may become a Standard when it has been prepared and approved by a representative group qualified in the particular field of application. In the rubber industry therefore, a number of technical organizations have been formed whose memberships include adequate representation of all phases of the industry. Approvals by these groups generally create Standard Specifications.

The sources of Standards and Specifications for the rubber industry in this country fall into four groups: (1) Technical Societies; (2) Technical Committees of Industry Associations; (3) Federal and Military Technical Groups; and (4) Individual manufacturers and consumers. This is not necessarily their order of importance. The bibliography lists a number of these sources of rubber

[1] Retired. Present address: 11628 Balboa Dr., Sun City, Ariz. 85351.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

specifications, but not necessarily all. The type of work done and the type of specification issued by several of these will be discussed briefly.

Test Methods

There are three sources for standards and specifications covering Testing Procedures for rubber and rubber products: The American Society for Testing and Materials (ASTM), The USA Standards Institute, and the Federal Test Method Standard No. 601.

Specifications published by ASTM are issued as Standard or Tentative Methods, or Recommended Practices. Recommended Practices applies to processes and methods not ordinarily subject to contract between purchaser and manufacturer. The approved Standard and Tentative Methods and Specifications are published annually in the "Book of ASTM Standards." Individual Standards and Specifications are also available in pamphlet form.

A very complete compilation of standard test methods for rubber has been issued by the Federal Supply Service, General Services Administration, as Federal Test Method Standard No. 601. It incorporates many of the standard methods prepared by ASTM and methods prepared and used by many government services. As stated in its scope, "It was prepared in order to eliminate unnecessary or undesirable variations in the general sampling and testing procedures. This Standard does not include special test methods, nor does it include all the test methods for natural and synthetic rubber materials used in the industry."

Rubber Product Specifications

Rubber Product Specifications are prepared and issued by a large number of rubber product consumers. However, the development of standard specifications for many rubber products eliminates the need for individual consumers' writing their own specifications.

The Society of Automotive Engineers (SAE) and ASTM, through their joint Technical Committee on Automotive Rubber, publish a specification, "Rubber and Synthetic Rubber Compounds for Automotive Use." This specification is known as ASTM D 2000, SAE Standard J 200 "Classification System for Elastomeric Materials for Automotive Applications." This standard classifies the numerous rubber compounds according to their oil and heat resistance and provides a code for indicating many other properties desired. These specifications provide a method of describing a desired rubber compound by means of a grade number. This grade number is composed of a prefix letter indicating the type of polymer, a three-digit number indicating hardness and tensile strength, and suffix letters indicating other special properties and their values.

Service requirements and the design to be employed will govern the ultimate quality of the rubber compound, and the supplier of the samples tested will be able to advise the exact classification that should be specified

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in cases where the engineer has relied on the producer to determine the rubber compound.

These specifications therefore, enable both producers and consumers to condense a long list of requirements into a simple code. This means of specifying the type of rubber compound required for a product has been very well accepted by the automotive segment and is making headway in other branches of the rubber industry. It is intended to apply primarily to molded and extruded goods, and is not intended for tires, inner tubes, sponge rubber, hard rubber, belts, hose, mats, and insulated wire and cable.

ASTM has also developed and published specifications for individual products including sheet packing, fire hose, electrical protective equipment, insulated wire and cable, gaskets, cellular rubbers, latex foam, and sponge rubber. These may be found in the publications already referred to and are available from ASTM.

A number of ASTM specifications and test methods have been approved as USA Standards by the USA Standards Institute.

SAE has developed and published a number of specifications and recommended practices covering such products as automotive hose of various types and applications, mats, gaskets, O-rings, latex foam, and sponge rubber. In addition, the aeronautical group in SAE has developed numerous Aeronautical Material Standards (AMS) for rubber compounds having application in the aeronautical industry. These and the SAE specifications are available from SAE.

Probably the source of the largest number of rubber product specifications is the U. S. Government. Owing to the large number of rubber items purchased by the various branches of the Government, it has been necessary to develop standard specifications. For many years each branch of the military issued its own specifications. Now the government specifications have been classified into two main groups: federal and military.

Federal Specifications and Standards are divided into three types: Federal —approved for mandatory use by all federal agencies; Interim Federal— developed and issued by an individual government agency; and Emergency— designed for immediate use in an emergency to conserve critical materials.

The General Services Administration has primary responsibility for Federal Specifications. Assistance is given the General Services Administration in preparing specifications by other federal agencies through the assigned agency system. In this system, the General Services Administration assigns to other federal agencies, with the agency's consent, the responsibility for preparing and coordinating a specification for a material or product. When the specification has been completed, it is sent to the General Services Administration with the recommendation that it be promulgated as a Federal Specification.

An Index of Federal Specifications with monthly supplements may be purchased from the Government Printing Office. Individual Federal Specifications may be obtained from the General Services Administration in Washington or from regional offices of the General Services Administration.

Military Specifications are divided into two main groups: Co-ordinated, for general use, and Limited Co-ordination, for use by one or more Services.

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This latter group carry a suffix name to indicate the issuing agency. Some of these, as shown in the Bibliography are: CMLC—Chemical Corps; ORD—Ordnance; Navy—Department of the Navy; Ships—Bureau of Ships; USAF—Department of the Air Force.

A custodian for each of the military departments (Army, Navy, and Air Force) is designated for each specification. This custodianship is based on the technical responsibility for the items covered by the specification. The Military Index is divided into three volumes which may be purchased from the Government Printing Office. Individual specifications used by the Army and Air Force may be obtained from the custodian Service as indicated in the Index. Navy specifications may be obtained from the Navy Supply Depot.

The Bureau of Ships has recently prepared a series of "Visual Inspection Guides" which, by means of photographs, illustrate acceptable and nonacceptable major and minor defects. They are extremely useful in judging the acceptance of a product. At present they include rubber "V" belts, sheet material, extruded goods, molded items, cellular rubber items, hard rubber, O-rings, hose, and rubber gloves (except surgical). These may be obtained from the Bureau of Ships, Code 244, Navy Department, Washington, D. C.

The Rubber Manufacturers Association (RMA) through its Technical Committees, prepares and issues some specifications for rubber and rubber products. These include a classification system for natural rubber, specifications for foam latex, V-belts, belting, hose, and packing. They also assist other industrial technical groups in preparing adequate specifications on these items. Information pertaining to these products may be obtained from RMA.

The Association of American Railroads (AAR) issues specifications on rubber products used in interchange service by the railroads, including air-brake and train air signal hose, fuel hose, gaskets, and other items. These may be obtained from AAR.

In the bibliography are a number of other industrial associations reviewing existing specifications on products common to their industries.

The writer wishes to thank the Firestone Tire & Rubber Co. for permission to publish this paper. The sources of information given are from the publications of various agencies mentioned.

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Separate Standards in pamphlet form.
Index to ASTM Standards including Tentatives. Annual.

(2) *USA Standards Institute,* 10 East 40th St., New York, N. Y. 10016
USA Standards.

(3) *General Services Administration, Business Service Center, Region 3, Seventh and D Streets, S. W., Washington, D. C. 20407*
Federal Test Method Standard No. 601. Rubber: Sampling and Testing.

(4) *Society of Automotive Engineers, 485 Lexington Ave., New York, N. Y. 10017*
Automotive Rubber Product Specifications. These Specifications are published yearly in the SAE Handbook and are also available in separate pamphlet form.
Aeronautical Material Specifications. These Specifications apply to Rubber and Synthetic Rubber Compounds for aeronautical use.

(5) *The United States Government*
Federal Specifications and Standards
Federal—Approved for use by all interested government departments
Interim Federal—Developed and issued by an individual government agency
Emergency—Designed in emergency for conservation of critical materials.
Index of Federal Specifications and Standards and monthly supplements may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20401
Copies of Federal Specifications are available from the General Services Administration, Business Service Center Region 3, Seventh and D Streets, S. W., Washington, D. C. 20407 or from Regional Offices.
Military Specifications—Army, Navy, Air Force (Formerly Joint Army-Navy-JAN).
Co-ordinated: For general use
Limited Co-ordination: Carry a suffix name indicating issuing agency.

Army			
CMLC	Chemical Corps	AMC	Quartermaster Corps
CE	Corps of Engineers	Sig C	Signal Corps
Med	Army Medical Service	TC	Transportation Corps
Ord	Ordnance Corps		
Navy			
Navy	Department of the Navy	Pers	Bureau of Personnel
Aer	Bureau of Aeronautics	Ships	Bureau of Ships
MC	Marine Corps	S&A	Bureau of Supplies & Accounts
BuMed	Bureau of Medicine & Surgery	Docks	Bureau of Yards & Docks
NOrd	Bureau of Ordnance		
Air Force			
USAF	Department of the Air Force		
ASG	Aeronautical Standards Group		

Index of Specifications and Standards, Department of Defense.
Part I. Alphabetical Listing
Part II. Numerical Listing
Part III. Federal Supply Clarification Listing.
Index may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. 20401.
Copies of individual specifications used by the Army and the Air Force obtained as indicated in the applicable volume of the Index.
Copies of the Specifications used by the Navy may be obtained from the Commanding Officer, Naval Supply Depot, Scotia, N. Y., except for aeronautical items bearing numbers 5000 to 9999. These latter specifications are issued by the Technical Records Div. United States Naval Air Station, Johnsville, Pa.

(6) *Rubber Manufacturers Association, 444 Madison Ave., New York, N. Y. 10022*
Classification System for Natural Rubber
RMA Buyers Specification—Latex Foam
Belting, V-Belts, Hose, Packing
Technical information referring to these products may be obtained from RMA.

(7) *Association of American Railroads, 59 East Van Buren St., Chicago, Ill. 60605*
Specifications on hose and other rubber parts used in railroad service.

(8) *Underwriters Laboratories, 207 East Ohio St., Chicago, Ill. 60611*
Cotton Rubber Lined Fire Hose
Standard for Chemical Engine Hose

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Standard for Hose for Conducting Liquefied Petroleum Gas
Other Rubber products

(9) *Other Industry Associations*

National Electrical Manufacturers Association (NEMA), 155 East 44th St., New York, N. Y. 10017
National Fire Protection Association (NFPA), 60 Batterymarch St., Boston, Mass.
National Coal Association, Southern Building, 1425 H St., N. W., Washington, D. C. 20005
Aircraft Industries Association of America, 806 Fifteenth St., N. W., Washington, D. C. 20005
American Society of Agricultural Engineers, Box 229, St. Joseph, Michigan
Agricultural Ammonia Institute, Hotel Claridge, Room 304, Memphis, Tenn.
Flight Safety Foundation, Inc., 2 East 64th St., New York, N. Y.
Federal Civil Defense Administration, National Headquarters, Battle Creek, Michigan
Public Administration Clearing House (PACH), National Association of State Purchasing Officials, 1313 East 60th St., Chicago, Ill. 60637

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30

Services Provided by the Library for the Division of Rubber Chemistry

VIRGINIA ALLANSON

University Library, The University of Akron, Akron, Ohio 44304

The Library for the Division of Rubber Chemistry at Akron, Ohio collects source materials in the field of rubber, plastics, and resins and attempts to bring material and user together. Services of the library consist of arranging interlibrary loans of books and journals, supplying prepared bibliographies, and answering information requests including literature searches. Individual bibliographies are for sale, while copies of the list of Bibliographies are available free of charge. Copies of papers given at Rubber Division meetings are also available for a fee.

The Library for the Division of Rubber Chemistry is located at The University of Akron Library, Akron, Ohio. The library is sponsored and supported by The University of Akron, The Division of Rubber Chemistry of the American Chemical Society (ACS), and the Rubber Manufacturers Association. Research libraries of six major industries in the Akron area contribute assistance through loan of their individual library holdings. The library is in its twenty-first year of operation.

The library attempts to answer any reasonable inquiry on rubber or materials relating to rubber. Answers are restricted to those which can be obtained by referral to or search of appropriate literature. Requests are handled in order of receipt of inquiry. At present the library has the services of only one research librarian on a half-time basis; therefore, requests which require a lengthy literature search should include an approximate date as to when an answer is needed.

When the answer to a request results in a suitable bibliography with abstracts, this bibliography is reproduced in quantity and offered for sale as follows: to ACS members—$2.50 each; to others—$5.00 each. Copies of the list of the bibliographies are available at no charge. Union lists of serials and of books held in the six cooperating libraries and The University Library may be purchased for $1.00 each.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

The library also acts as a clearinghouse for duplicating copies of papers delivered at the meetings held by the Division of Rubber Chemistry. Charges for copies of meeting papers are $2.00 to members, $4.00 to non-members. If photocopies must be made, the cost is 10¢ per page to members, 15¢ to non-members, minimum $1.00. Payments must accompany orders for bibliographies and union lists. An invoice will accompany delivery of meeting paper copies. Checks should be made out to Treasurer, Division of Rubber Chemistry.

All requests for service or for purchase should be addressed to: The Library for the Division of Rubber Chemistry, The University of Akron, Akron, Ohio 44304.

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The following is a list of bibliographies prepared after 1962. These bibliographies and a complete list of bibliographies may be obtained by writing to the Library for the Division of Rubber Chemistry, University of Akron, Akron, Ohio 44304.

Cost per bibliography to members of the Division:
published before 1963—$1.00
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Cost per bibliography to non-members:
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Material forwarded upon receipt of payment.

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31

Patent Searching in the Field of Rubber Technology

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The U. S. Patent Office lists patents on rubber technology by its own classification system. The searcher is aided by three references to the patent files: the Classification Manual, the Index to Classification, and the Classifications Bulletins. All of the patents are cross-referenced. Since rubber technology has greatly expanded since World War II, patents relating to this field have been widely distributed throughout the patent files. Elastomers, monomers, catalysts and modifiers, and manufacturing methods are arranged according to chemical nature. Patents on rubber articles are listed under the class for the particular type of article. A collection of patents may be obtained from the Patent Office and kept up to date by subscribing to the Official Gazette of the U. S. Patent Office.

Any patent search involves exploring a mass of 3,150,000 United States patents, (as of September 29, 1964), not to mention those issued by France, Germany, Great Britain, and the smaller industrial countries.

These patents are being reviewed constantly for several reasons. An inventor may be interested in determining previous work done in a given field, and thereby avoid duplication of the work of others. A factory may pursue an infringement search among unexpired patents before investing in the manufacture and sale of a product or article. Another type of search may be conducted to invalidate a patent, previously determined to be infringed, by discovering an earlier patent describing the same or a similar thing.

The Patent Office Examiners continually review patents to verify the novelty of the claim in each patent application which comes to them for evaluation and decision. This procedure, incidentally, results in adding several hundred patents each week.

[1] Deceased.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Consequently, this mass of patents must be arranged so that it is possible to find a description of a particular process, device, or product with a minimum expenditure of time and effort. At the same time, the arrangement must be flexible so that new patents may be continually added without disturbing the systematic arrangement. This framework has to embrace the old while standing ready to accept the new. This is accomplished by distributing all U. S. patents into more than 300 categories or classes, with titles ranging from Abrading to Work Holders. Patents on every process, machine, manufacture, or composition of matter have a place in these classes. Patents on the automobile, the airplane, the radio and television were classified, each as it came along. At the same time, the classes devoted to harness and whips were not abolished.

The titles of these classes do not readily indicate the patents they contain relating to rubber, tires, or any of the other main divisions of the rubber industry. However, this is only because these titles must be sufficiently generalized to embrace a constantly expanding technology.

In order to make the enormous number of patents easily accessible, the Patent Office has provided certain tools for searching the patent files. One of these is the Classification Manual. This manual lists the more than 300 classes mentioned above, with the number and title of each. The classes are listed alphabetically and numerically, and according to their distribution in the examining groups of the Patent Office. Within each class the particular subject matter is broken down into numbered subclasses. The titles of these subclasses are arranged in columns, progressively indented, to indicate the extent to which each subclass is generic to, or includes, those below it. To illustrate, in Class 152, Resilient Tires and Wheels, will be found Subclass 151 relating to Resilient Tires and, indented under this, a Subclass 246 relating to Cushion Tires and, similarly indented, Subclass 330 relating to Pneumatic Tires. Finally, below and embraced by this last item, is Subclass 349, entitled Inner Tubes, or, more specifically, Subclass 350, limited to those tubes which are fabric-reinforced. By using this indentation arrangement we can quickly find the patents we are looking for.

The patent copies are located in the search room of the Patent Office, now located in Alexandria, Va., and are arranged in bundles, one or more to a subclass, corresponding to their disposition in the Classification Manual. These are accommodated in stacks easily accessible to the searcher. There are about 50,000 subclasses thus arranged. Many of the patents are cross-referenced, i.e., inserted into more than one place in the system so that it may be found under two or more subject headings. This improves the chances of finding the patent and increases the number of patent copies in these stacks to about nine million.

The classification system attempts to distribute the patent subject matter into divisions and subdivisions which ultimately embrace a small enough number of patents to permit scanning of each one. However, one should not assume that the broader subclasses are merely guideposts. Each contains patents corresponding to its title minus those included by narrower subclasses indented below it. Accordingly, each should be investigated as the search is broadened to include less pertinent but related patents.

Since the Classification Manual titles must be fairly general, they may not adequately indicate the placement of certain subject matter. Therefore, the Patent Office provides the Index to Classification which lists the subject matter alphabetically from Abacus to Zweiback. Using this Index, any desired subject may be located, such as rubber or vulcanizing or tires. Indented under the main subject, will often be a more specialized heading, such as coating or reclaiming under rubber, molds and presses under vulcanizing, or patches and retreading under tires. Opposite each of these subjects, is a class and subclass number. These numbers direct us to the place in the Classification Manual which indicates the location of additional pertinent subject matter.

The Index to Classification, then, directs us alphabetically to the appropriate class; and the Manual of Classification enables us to narrow the area by proceeding to narrower subclasses with titles which include the subject matter we are concerned with.

Since the brief titles of the classes and subclasses may not be sufficiently informative the Patent Office provides another tool, namely, the Classification Bulletins. These bulletins contain definitions of each class and its subclasses which are listed in the Classification Manual. To illustrate their function, suppose that we wish to find patents on synthetic rubber and, in particular, patents on Buna-S or GR-S. Looking first in the Index to Classification we find, alphabetically, the term "rubber" and, indented under this, the term, "synthetic rubber," which directs us to Class 260, Chemistry, Carbon Compounds. Turning now to the Classification Bulletin of Class 260 we find that Subclass 2 and indented subclasses are defined as containing patents related to the preparation and treatment of the so-called synthetic resins,. Reading the definitions of the subclasses indented under Subclass 2, we pass from one to another until we reach the narrowest definition which will include the objective of our search. In this case, we find a note appended to the definition, stating that the subclass includes Buna-S or GR-S.

The Patent Office system of classification constantly undergoes expansion and revision as it absorbs a steady influx of new patents. Therefore, classes and subclasses and their definitions cannot be fixed. Furthermore, foreign patents, in general, are classified according to the system used by the patent office of origin. In this respect they will require somewhat different treatment if a search is to include them. Therefore, the person who makes the search must rely upon his own knowledge and experience to supplement any system of classification or manual aid.

Patents pertaining to the rubber industry are widely distributed throughout the classification system. This is because rubber is used as construction material for many articles owing to such properties as resilience or corrosion resistance. These patents usually must be sought where the article itself is classified, whether made of rubber or some other material. However, some classes contain more patents related to the rubber industry than do others and a few of these will be mentioned.

Patents on methods and apparatus for collecting natural rubber from the tree will be found in Class 47, Plant Husbandry, Subclass 10, Turpentine and Rubber, with further subdivision concerned with buckets and spouts and with tools. The treatment of natural rubber, collected in this way, is located in Class 260, as previously mentioned. This class is so large that a subclass within it, Subclass 709, serves in a generic capacity to encompass patents concerned with various treatments of natural rubber. Thus, indented under this are Subclass 710 related to Reclaiming of Waste Rubber, and Subclass 722 related to Sponge Rubber. Also within this section of Class 260 are numerous subclasses related to vulcanization, as with a new accelerator or a new anti-oxidant. Again, the subject matter has been subdivided to enable the searcher to concentrate on his particular interest.

Class 18, Plastics, is important to the rubber industry since it includes subclasses which contain patents on tire molds and on presses for holding and molding rubber while heating and vulcanizing. However, the actual building of tires or similar rubber articles will be found in Class 156, which embraces Adhesive Bonding and Miscellaneous Chemical Manufacture. Here, under separate headings, many methods constituting important units of our industry, such as belt making, hose making and tire making, are located. The making of golf balls also warrants its own subclass, broken down into still finer subdivisions, depending on whether we are concerned with the filling feature or the winding feature in making the golf ball.

Since tires are the subjejct of patents in Class 152, its subclasses are related to various features of rubber tires, such as side walls, carcasses, breaker strips, beads, etc. Thus, within the general classification of tires, the search may be initiated at the point of greatest interest, as indicated by the subclass titles or subclass definitions.

Another important branch of the rubber industry is represented in Class 36, Boots, Shoes and Leggings. This class is liberally sprinkled with subclasses calling for items made of rubber. There is a subclass for rubber boots and shoes, generally, and another for rubber overshoes, specifically. Still others are provided for rubber soles and for cushion heels. Class 150, Cloth, Leather and Rubber Receptacles, is mentioned since it covers receptacles in their vast variety. Many of these such as key pouches, mail bags, and golf bags set in subclasses of their own, may be made wholly or partly of rubber.

The importance of rubber coatings is reflected by their representation in Class 117, Coatings: Processes and Miscellaneous Products. Appropriately named subclasses separate coatings according to characteristics which enable the searcher to concentrate on one type to the exclusion of others. Thus, there is a subclass directed to superposed coatings in which at least one coating contains rubber; other subclasses pick out patents having to do with a metal base or a wooden base or a paper base, in each case, coated with rubber; or, a subclass may select patents in which the coating, of whatever nature, is placed on a base which is made of rubber.

Still, another class in which rubber is well represented is Class 267, Spring Devices, containing provision for patents on rubber-type lever springs, compound springs and torsion springs. Each of these has a subclass devoted to it, so that our search may be limited, for example, to torsion springs made by the use of rubber. Patents related to other types of springs are sifted out beforehand. Patents on the so-called "air spring" will also be found in this class.

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The foregoing classes have been mentioned either because they are of general interest to the whole rubber industry or because they concern major segments of it. Obviously, many kinds of articles made wholly or partly of rubber have not been listed, although the Patent Office classification system provides a place for each of them. Further, a comprehensive search for patents pertinent to a rubber article, such as a tire, may involve investigation of other classes in addition to the main class in which the article is found. Thus, an exhaustive search on a tire would involve the manner in which it was made, individual features of its construction, such as treads and beads, tire-building machines and molds, and vulcanization procedures.

The wide distribution of patents related to various rubber products makes it advisable to collect the patented art in which we are interested. A collection of all patents concerned with tires, boots and shoes, or with an assortment of miscellaneous articles, such as belts, hose, mats, floor covering, gaskets, cushions, etc., may be started by ordering from all patents in pertinent subclasses from the Patent Office. This collection may be kept up to date by entering a standing order for all new patents in those subclasses as they are granted. In addition, a wider and more selective choice may be made by subscribing to the Official Gazette of the U. S. Patent Office and ordering, weekly, each pertinent patent found there. This is conveniently done by establishing a deposit account with the Patent Office. If patents are ordered by number, books of coupons may be purchased, each good for one patent copy.

In this way, patents may be collected from widely scattered points in the Patent Office classification system. This collection may be classified according to the needs of the company maintaining it and used to keep abreast of developments in the particular branch of the rubber industry to which it relates. Of course, it is still advisable to make use of the facilities afforded by the Patent Office itself when a complete search is necessary.

In the past few years abstract services in the English language have become available in selected technological fields, presenting details of activities particularly for Great Britain, Germany, France, South Africa, India, Belgium, Japan and the Soviet Union. Searching services have been established in Germany and Holland which can be useful in reviewing the patent art.

Patents, then, constitute a large and growing source of information. They are useful to the worker in research or development and to the company making and selling the products of such research and development. From the time that Charles Goodyear received his Patent No. 3633 for the vulcanization of rubber on June 15, 1844, the rubber industry has made an increasing contribution to the patented art. For this reason, patents constitute a valuable repository of information on developments in the rubber industry and one which is being worked on constantly to keep that information as accessible as possible despite the growing difficulties of such a task.

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32

Literature of Carbon Black

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Carbon black is a finely divided form of carbon produced by incomplete combustion or thermal decomposition of hydrocarbons and used chiefly as a reinforcing filler for both natural and synthetic rubber; other applications are in printing ink, paints and varnishes, plastics, adsorbents, etc. Carbon black represents a typical case of a limited field on which information is recorded throughout a wide variety of sources, varied both in form and subject coverage. Information on carbon black is found throughout the literature of such materials as rubber, petroleum, plastics, paints, inks, and colloids. Information on carbon black manufacture is found mainly in patents.

The point of departure for a literature search on carbon black depends on the investigator. A laboratory chemist, believing that carbon black is some type of soot, may reach for *Chemical Abstracts* or for one of the rubber trade journals since he knows that carbon black is used in rubber. A literature chemist will turn first to an encyclopedia, hopefully Kirk-Othmer's "Encyclopedia of Chemical Technology." At present it contains the best and most recent general review article on carbon black by W. R. Smith, including a section by D. C. Bean on acetylene black, a related product.

Besides encyclopedias the usual sources of general information are textbooks and review articles. Until the recent publication of "Carbon Black Technology—Recent Developments" by R. Powell, there was no "text book" on carbon black. Mantell's "Carbon and Graphite Handbook" contains several pertinent chapters, and Walker's "Chemistry and Physics of Carbon" is another useful source. Several other recent books include chapters on carbon black technology, and a two-volume reference work, "Les Carbones," was published in 1965, in French. A comprehensive, relatively recent review of carbon black technology by Slaniceanu is an excellent source for general background and references to the literature, particularly in conjunction with a separate bibli-

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

ography and other appendices which are obtainable from the librarian of the Research Council of Alberta.

Strictly speaking, the term carbon black could be any form of finely divided carbon. However, it generally means only those forms of carbon which are produced by incomplete combustion or thermal decomposition of hydrocarbon gases, vapors or atomized liquids, such as natural gas, various petroleum fractions, or coal tars. When acetylene is the raw material, the product is a very finely divided carbon known as "acetylene black." "Lampblack" belongs to the same family as the carbon blacks but is made from liquid hydrocarbons in bulk and, for historical reasons, is usually considered separately in the literature. Until the late 1940's the term carbon black was synonymous with "gas black," which, in turn, usually meant "channel black." Now, it may mean black made from either gas or oil by any of the usual manufacturing processes. Translations, especially from French or Russian, often use the term "lampblack" when "carbon black" should be used. Both terms should be searched. Sometimes "active carbon black" is used in the German and Russian literature to mean carbon black for rubber reinforcement. This should not be confused with "active" or "activated" carbon as used in American terminology. Incidentally, the German word "Russ" can also mean "soot."

Three main processes are used to manufacture carbon black proper—the channel, furnace, and thermal processes—each of which can be adjusted to produce various grades for various purposes. The main consumer of carbon black is the rubber industry. For various reasons, many of which are still under investigation, carbon black acts as a reinforcing agent, to make both natural and synthetic rubber much tougher than unreinforced rubber. Other markets for carbon black include printing inks, coatings, plastics, paper, batteries, catalysts, greases, electrodes, metallurgy, propellants, and textiles. In many of these applications, carbon black functions as a pigment, and small amounts go a long way.

Economic and Industrial Information

Once the searcher knows how a material is made, what its properties are, and how it is used, he knows where to look for more specific information. His next question is: who makes it? The "Rubber Red Book," the standard directory of the rubber industry, gives a basic list of all U.S. carbon black producers as does the "Minerals Yearbook," which also includes plant locations; the preprint on carbon black is usually available several months before the whole yearbook is published. New plants and expansion plans of the industry are reported regularly in most of the petroleum periodicals—*e.g., Oil and Gas Journal, Hydrocarbon Processing,* and *Petro/Chem Engineer,* with summary tabulations appearing at regular intervals. *Hydrocarbon Processing,* for example, issues a list of new plants three times a year. Expansion is also reported in *Chemical & Engineering News, Chemical Week,* and the *Oil, Paint and Drug Reporter* and in the news sections of such journals as *Rubber World, Rubber Age,* and *Chemical Engineering.* The latter publishes a list of new plants and facilities twice a year. Carbon black plants outside the United States are also announced in foreign rubber trade publications. *Rubber and*

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Plastics Age periodically includes updated lists of carbon black producers in the form of removable edge-punched cards. A summary of plant expansion in Europe was published in *Chemical & Engineering News* (Feb. 22, 1965).

Production capacities for specific plants of individual companies are given in the "Directory of Chemical Producers." News items or detailed descriptions of new plants often include capacity data. Production of those carbon black plants in Texas which use natural gas as raw material are published monthly in *Texas Carbon Black Report.* The figures given in these reports are those of the Texas Railroad Commission.

Total U.S. production, consumption, exports, and imports are reported by the U.S. Bureau of Mines. Prices may be found in the *Oil, Paint and Drug Reporter* and, of course, in the price-lists of the suppliers. *Rubber Age* and *Rubber World* publish the prices of rubber-grade blacks in alternate monthly issues. European prices appear in the weekly *European Chemical News.*

Good secondary sources of economic and industrial information are the loose-leaf "Chemical Economics Handbook" which gives statistics in convenient tabular and graphical form and is updated periodically; the monthly *Chemical Market Abstracts;* and, for current awareness, the weekly *Chemical Horizons.* A brief profile of the U.S. carbon black market was published in the *Oil, Paint and Drug Reporter* (Sept. 7, 1964) and an up-dated version appears in "Chemical Profiles."

Technological and Scientific Information on Carbon Black Manufacture

Detailed technological information on carbon black manufacturing processes, equipment, and processing can be found in patents. An excellent review of carbon black patents is presented in "Carbon Black Technology—Recent Developments" by R. Powell.

The pertinent U.S. Patent Office class and subclasses are listed in the bibliography. Some patents on supplementary processing (*e.g.*, collection, pelletization) are classed according to the type of operation used, but a cross-reference copy will usually be found in one of the carbon black classes also. In searching carbon black patents outside the U.S. Patent Office, remember that most of the patents on manufacturing and processing of carbon black have been assigned to the following companies: Cabot Corp. (formerly Godfrey L. Cabot, Inc.), Columbian Carbon Co., Continental Carbon Co., J. M. Huber Corp., Phillips Petroleum Co., Sid Richardson Carbon Co., Thermatomic Carbon Co., United Carbon Co., and, more recently, Commercial Solvents Corp. and Ashland Oil and Refining Co. The most important foreign companies to which carbon black patents are assigned are Deutsche Gold-und Silber-Scheideanstalt, known as Degussa (Germany), and Shawinigan Chemicals Ltd. (Canada), manufacturers of acetylene black. Shell International Research Maatschappij (Netherlands) and Badische Anilin & Sodafabrik (Germany) hold a number of foreign patents, mostly on collection processes.

Since in some foreign countries patent applications are not processed as rigorously as in the United States, foreign patents based on U.S. applications are frequently published several years before the U.S. patent appears. Thus, Belgian, French and, more recently, Dutch and German patents can sometimes provide the first indication of a new process, device, or product developed in the U.S. or elsewhere. Derwent Information Service in London publishes several abstract services which are useful in keeping currently aware of such patents. Many of the actual patents can also be purchased through Derwent. Some aspects of carbon black process technology are covered in the recent Russian chemical, petroleum, and rubber literature. Much of this is now available in English translations. In addition, several papers on the mechanism of carbon formation and other fundamental aspects of carbon black technology have appeared in the proceedings of the Conferences on Carbon and of the International Symposia on Combustion and in such periodicals as *Carbon, Combustion and Flame,* and *Fuel.* Occasionally information appears in U.S. Government reports. Theses and dissertations are another source of information. A sampling of foreign theses is listed in the bibliography. For American theses, *Dissertation Abstracts* is probably the best source.

As a guide to the current literature on carbon black technology generally, Cabot Corp. issues *Carbon Black Abstracts,* a quarterly abstract bulletin. While primarily designed for Cabot personnel and customers, it is occasionally made available to others. Other secondary sources (all of which are used in the compilation of *Carbon Black Abstracts*) are listed in the bibliography, under Abstracts and Information Services.

Fundamental Properties of Carbon Black

Most of the literature on carbon black, apart from patents, is concerned with the properties and applications of the product. For example, the surface characteristics and other fundamental properties of carbon blacks have been studied extensively and have been reported in the rubber and polymer literature, in the proceedings of the Conferences on Carbon, in *Carbon,* and in American, French, German, British, and Russian journals in the fields of physical, colloidal, polymer, and general chemistry. The most important are included in the bibliography under Periodicals. A basic review paper on surface chemistry of carbon black in relation to its reinforcing properties was published by Studebaker in 1957. A review article by Heckman on the microstructure of carbon black appeared in 1964. In September 1963, a symposium on physical chemistry of carbon black was held in France; it included several important papers. Proceedings were published in *Revue Generale du Caoutchouc* and also as a separate volume. In July 1964, the Carbon Society of Japan sponsored a Symposium on Carbon in Tokyo. Other conferences were sponsored by the Societe de Chimie Physique in 1960 and by the Society of Chemical Industry, London, in 1957 and 1965.

Work on the physiological effects of carbon black has been reported in medical journals such as *Archives of Environmental Health.*

Rubber Applications

Since the rubber industry is the largest user of carbon black (approximately 95%), a large proportion of the literature appears in the scientific and trade journals on rubber and other polymers; the most important of these are included in the bibliography. *Kautschuk und Gummi* and *Revue Generale du Caoutchouc* also contain abstract sections which are useful secondary sources of the foreign journal and patent literature. Incidentally, many articles in *Revue Generale du Caoutchouc* have recently appeared in both French and English. The Russian *Kauchuk i Rezina* is being translated into English, but the English version does not appear for about a year. A large proportion of the articles in *Rubber Chemistry and Technology* are reprints or translations.

Other important sources are the various international conferences and symposia on rubber technology. Secondary sources which are sometimes helpful in locating rubber literature are the *Annual Reports of the Progress of Rubber Technology* and the *Bibliography of Rubber Literature;* the latter is published biennially, but very late, by the Division of Rubber Chemistry of the American Chemical Society. The latest volume at present covers the literature for 1963-64. A more up-to-date version may eventually result from the polymer information retrieval project established experimentally at the Center for Information Systems, University of Akron, in 1965. This Center currently publishes two weekly abstract bulletins, *Polymer Literature Abstracts* and *Polymer Industry News,* and maintains a computer-based information retrieval system, from which subscribers can obtain bibliographies on demand. This system covers only the periodical literature, where as Chemical Abstracts Service offers similar services based on both patents *(Post-P)* and journals *(Post-J).* As a guide to the current as well as the older rubber literature there is *RAPRA Abstracts,* an excellent abstract journal published by the Rubber and Plastics Research Association of Great Britain.

Good review articles appear in *Rubber Reviews,* which is the December issue of *Rubber Chemistry and Technology.* Several examples are included in the bibliography under Reviews. There is one recent textbook on rubber reinforcement, edited by Kraus, and chapters on this subject are included in many books on rubber technology (*e.g.,* the text by Naunton).

Information on carbon black properties and applications also appears in technical brochures issued by manufacturers and consumers. Bulletins of the major rubber companies, in particular, frequently include recipes and properties of rubber composition for specific applications. They are too numerous to be listed in the bibliography. A good secondary source for specific rubber compositions is the *Rubber Formulary,* issued as extracted data on coded edge-notched cards. The *Rubber Formulary* also includes formulations used by the rubber industry to meet specifications and standards issued by various organizations. Besides individual companies, the most important of these are the American Society for Testing and Materials and the British Standards Institution.

Specifications for all types of industries are also issued by the U.S. Government. A selection is included in the bibliography.

Non-rubber Applications

A few articles on carbon black appear in the trade journals of the ink, paint, and plastics industries and in the proceedings of conferences such as the FATIPEC Congress. However, information on carbon black in these applications is usually incidental in articles on some wider aspect. Not much of it is indexed under carbon black in *Chemical Abstracts* or elsewhere. In these areas it is especially useful to scan the current trade journals as well as current issues of *Chemical Titles, Chemical Abstracts,* and *RAPRA Abstracts* and to index relevant articles for future retrieval from the point of view of the carbon black manufacturer and user. Patents are another source of information on special applications. A comprehensive review of the applications of carbon black outside the rubber industry was originally presented as a sales talk by I. Drogin of United Carbon Co. and subsequently published (*see* Reviews).

This paper makes no attempt to give a comprehensive survey of the literature of carbon black, which currently amounts to about 1000 items per year, including patents. Rather, it is a guide to the carbon black literature and suggests how to make a comprehensive search of various aspects of carbon black technology.

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Year	*Section*	
1912	21.	Fuels, Gas & Coke
	22.	Petroleum, Asphalt, Coal Tar, & Wood Products
1915	21.	Fuels, Gas, Tar, & Coke
	22.	Petroleum, Asphalt, & Wood Products
1961	21.	Fuels & Coal Products
1962	53.	Coal & Coal Derivatives
1963	26.	Coal & Coal Derivatives
1967	52.	Coal & Coal Derivatives

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The following U.S. patent class and subclasses contain information on carbon black.

Class: Subclass
23: 209.1-209.9; 259.5-259.9; 314

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33

The Literature of the Coal Carbonization Industry

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The reasons for studying the literature of an industry can be: (1) to learn the history and current state-of-the-art of that industry; (2) to find a specific fact; or (3) to build up a reference literature collection to serve the first two purposes. This review· treats the literature of coal carbonization with the basic principles of literature searching in mind. The keys to the literature, namely reviews, monographs, and abstract collections are stressed since these will lead into the technical periodical literature. The periodical literature is reviewed critically for those who wish to build up reference collections in this field by the most effective use of funds available.

The coal carbonization industry began in England in 1709 when coke from coal replaced charcoal for iron making. By 1781 by-product recovery of tar was underway even though there were few commercial markets for it at the time. Tar disposal became a serious problem, however, with the advent of the gaslight industry in 1813 but was finally resolved in 1845 by such end-uses as wood preserving, road construction, and waterproofing of cloth. England's 160 years of development in the carbonization industry was halted ironically enough after the discovery of the first synthetic dyestuff made from coal tar in 1856. This "coal-tar" dye industry flourished until 1873 when its founder, W. H. Perkin, withdrew from active interest and sold his works. Modern chemists who had found inspiration in England returned to Germany.

In 1869 Germany adopted the "coal-tar" dye industry and developed it rapidly. This development coupled with the adoption of the by-product recovery oven established Germany as the world's dominant organic chemical manufacturer by 1914. Hence, the early literature of coal carbonization is essentially British and German.

[1] Deceased.

In Literature of Chemical Technology; Smith, J.;
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The advent of World War I dramatically changed the markets for coal tar, light oil, and their products. It was at this time that the U. S. chemical industry began its real growth, the by-product coke industry being the major and almost exclusive source of aromatic chemical raw materials until World War II. At that time the petroleum industry stepped in as a co-producer of aromatic chemicals, but coal carbonization remained firmly established as the producer of competitive pitch-products for most applications.

Because the objectives of this industry were quite different at various times in its history, the nature of its literature also varied. Since low-temperature tars were processed differently from high-temperature tars, separate literatures concerning each have developed. A highly developed system of specifications and test methods has been developed for tar products. It should be noted that although the synthetic dyestuff industry began with products recovered from coal tar, the very extensive literature of that industry will not be discussed in this chapter.

This literature discussion includes coal carbonization and its products, including tar, light oil, gas, and by-product ammonia products. The references have been grouped as follows: encyclopedias and handbooks; abstract, information, and index services (including general abstracts, specialized abstracts, reviews and indexes, and other related sources of abstracts); journals; government publications; specifications and test methods; books (including general coal chemistry and technology, carbonization, carbonization equipment and coke, coal gas manufacture, tar technology, and light oil technology); symposia and proceedings; patents; and commercial literature (trade literature, bulletins, house organs, advertisements, and prospectuses).

Encyclopedias and Handbooks

Encyclopedias give condensed summaries of subjects, usually from the standpoint of a general rather than a specialized interest. The entries concerning the coal carbonization industry in the larger technical encyclopedias adequately answer questions of general interest.

The more important modern handbooks having entries concerning the industry are listed in the bibliography.

Handbooks collect, organize and correlate the facts and figures essential to the operations of a technology, making such data readily available. While the data relating to fundamental constants change little with time, the information relating to "practical" operations becomes obsolete quickly in our rapidly moving technology. Much of the information in the handbooks of the manufactured gas industry is mainly of historical interest today.

Abstract, Information and Index Services

While *Chemical Abstracts* and *Chemisches Zentralblatt,* particularly in later years, had as their objectives the indexing and abstracting of all articles on the chemical aspects of coal carbonization, there is a wide range of trade, technological, and engineering literature concerning the industry which con-

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cerns aspects other than chemical and which are, therefore, outside the scope of these services. The literature of coal carbonization is indexed by specialized indexes, reviews, and abstract serials. Some phases of searching can be more easily carried out using these specialized services than by using the more inclusive general abstract journals. The most useful abstract, review, and index journals and serials concerning the industry are listed here.

Other Sources of Abstracts Relating to Coal Carbonization

The more important trade and technical journals in the field carry digests, reviews, and abstracts of papers presented at technical meetings soon after the meeting has occurred; abstracts of journal articles and patents; and reviews of books and annual reports of companies. The bibliography lists the names of journals which should be searched regularly for this purpose, as well as for original articles.

Journals

The list of journals in the bibliography includes those which now, or in the past, have carried the bulk of the literature relating to coal carbonization products. It does not include a number of minor journals in the less frequently used languages. Also, it does not include the common technical journals in the chemical and engineering fields because: (1) it is assumed that technical libraries of even moderate size will have them, or that they will be available readily to the reader; and (2) while they may carry important articles in the field, such articles are indexed by and abstracted in the commonly available abstract journals. Examples of such journals are: *Industrial & Engineering Chemistry, Chemical Engineering Progress, Chemistry and Industry, Chemical Engineering,* and *Chemical Week.*

Publication details of the listed journals may be found in several lists published by abstracting and indexing services, for example, by *Chemical Abstracts* (*1*), *Chemisches Zentralblatt* (*5, 6*); in *Ulrich's Periodicals Directory* (*8*), and *The Standard Periodical Directory* (*7*).

Government Publications

A major portion of the research on coal carbonization in the last half century has been carried on in the United States and abroad by government organizations or by organizations which were sponsored or aided by governments. While the research of these organizations has resulted in many journal articles, the more significant and definitive reports and reviews of such work are found in their serial and special reports. The government organizations most active in the field of coal carbonization are listed by countries. The latest lists of publications should be consulted for titles of interest. Many of these government publications are major works and deserve separate listings as books or monographs. They are sometimes the most authoritative available sources of information. Many of the more important older publications are out of print and difficult to buy. They should be available for reference in depository libraries.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch033

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Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Specifications and Test Methods

The methods for evaluating coal and its carbonization products are largely empirical. Because of the commercial importance of these materials there has been a need for standardizing and precisely defining methods. Unfortunately, until recently, these efforts have been only on a national or local scale. In recent years the International Organization for Standardization has been very active in the standardization of coal evaluation, analysis, and classification methods. The bibliography includes the publications of the more important national and international standardizing agencies and some individual compilations of methods. The list does not include individual issues of government or other serial publications, many of which are fundamental references in this area. Such publications may readily be found by references to the indexed lists of such serials.

Books

Compared with some of the newer technologies, the older technology of coal carbonization has a relatively small literature in book form. Its older literature is essentially British and German, plus a few volumes in French and Italian. After World War I, works from the United States were issued, and after World War II, an appreciable number of books in Russian appeared. Much of the Russian literature reproduces or repeats the earlier Western literature, but some of the newer material is quite advanced and worthwhile. Walter Farr (*3*) has made a thorough and excellent review and bibliography of Russian material from 1946 to 1962 including a chronological listing of books. Many of the more recent "books" in all languages are collections of papers presented at symposia and will be treated in a separate section.

The bibliography lists the more important historical classics and modern volumes other than those in Russian listed by W. Farr. It does not include major government publications series, many of which rank superior in content and reliability to many "books" on corresponding subjects.

Symposia and Proceedings

Symposia provide an incentive for review and state-of-the-art papers and progress reports in a specific area for presentation and discussion. The common practice of publishing such papers in collected form has made them conveniently available. Some of the more important of such symposia volumes in which coal carbonization is discussed are listed in the bibliography.

Patents

The "Letters Patent for Inventions" issued by the industrially important countries of the world form a very valuable but very troublesome and frustrating part of the technical literature. In most industrial organizations the maintenance and indexing of patent collections is a function of the company patent department since it is they who can be expected to need them most.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch033

It is usually of secondary importance to an industrial or technical library to have complete collections of patents in their fields of activity. Of primary importance is having available the systems which index and abstract the patents of interest to their readers. The individual patents of special interest can then be obtained in printed or copied form from the various collections of patents maintained in depository libraries or from the issuing patent offices.

Suggested procedures for searching the U. S. and foreign patent literature have been presented which, while directed primarily toward chemical literature, will serve equally well the technology of coal carbonization. (*4*).

Chemical Abstracts is a very useful and convenient, though not complete index to the patent literature of coal carbonization. A useful index to the chemical aspects of coal carbonization since 1950 is the *Uniterm Index to U. S. Chemical Patents,* published by Information for Industry, Inc., 1000 Connecticut Ave., N.W., Washington, D. C. 20036. The patents relating to coal tar chemistry and technology are covered by the *Review of Coal Tar Technology* of The Coal Tar Research Association.

The *Derwent Patents Manual,* 1964, 68 pages, available from Derwent Publications, Ltd., London is an excellent recent review of the patent procedures of the industrially important countries of the world. It also describes procedures for the public inspection of applications possible in certain countries, the availability and procedures for obtaining copies of patents and search procedures and rules.

A number of the technical and trade journals carry selected, classified and/or annotated lists of patents in their fields of interest issued b their own and foreign countries. For some countries, such listings give more prompt announcements of newly issued patents than do the official bulletins.

Derwent Publications, Ltd., Theobalds Road, London, England publishes broadly classified lists of abstracts in English of all British and German patents and of Belgian, French, and Japanese patents in the chemical field. In addition, virtually complete translations of all Russian patents are published. The patents relating to coal carbonization are found mainly in the chemical classes.

Patents relating to coal carbonization and its products are widely scattered among the classes of patents established by the U. S. Patent Office. The more important classes and subclasses of interest for coal carbonization are listed in the bibliography.

Commercial Literature: Trade Literature, House Organs, Advertisements, and Prospectuses

Trade literature is a useful part of the chemical literature; it provides much valuable information that is not available elsewhere. It is the primary source of information about commercially available chemicals, materials, processes, appliances, equipment, and apparatus; in the case of new ones, it is the only source for a considerable period of time. These publications, also, frequently contain technical information that appears much more tardily, if at all, in books and professional journals.

The above statement made by Crane, Patterson and Marr (*2*) at the beginning of their Chapter 6 on "Trade Literature" is especially valid for the literature of coal carbonization and coal chemicals. Many of the larger public and institutional libraries have collections of such material. Trade and industrial libraries should acquire, index, and file such material for the benefit of their clients. Further, it is not always desirable to throw away older literature and advertisements which have been replaced by newer versions. The older material describes qualities of materials previously available, and illustrates older constructions and styles otherwise not recorded. It also gives data for discontinued products and models. Attention to this part of a library should not be overlooked.

Acknowledgment

The author acknowledges the appreciable help furnished by E. P. Meckly, Library Manager, Research Department, Koppers Co., Inc., in preparing this review.

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Winter, H., "Taschenbuch für Gaswerke, Kokereien, Schwelereien und Teerdestillationen," 6th ed., 659 pages, Verlag Wilhelm Knapp, Halle (Saale), 1950.

General Abstracts and Indexes

Applied Science and Technology Index, (until 1957, *The Industrial Arts Index*), H. W. Wilson Co., 950 University Ave., New York, N. Y. 10452 (1913), monthly with quarterly and annual cumulative volumes.

Indexes about 200 scientific, technical and trade journals.

British Technology Index, The Library Association, Chaucer House, Malet Place, London, WC1, 1962, monthly with annual cumulative volumes.

Current subject guide to articles in British technical journals.

Chemical Abstracts, American Chemical Society, 1155 Sixteenth St., N.W., Washington, D. C. 20036, weekly, 1907.

Abstracts approximately 9000 journals, including most of those listed in this review.

Year	*Section*
1912	21. Fuels, Gas, & Coke
	22. Petroleum, Asphalt, Coal Tar & Wood Products
	25. Dyes & Textile Chemistry
1915	21. Fuels, Gas, Tar, & Coke
	25. Dyes & Textile Chemistry
1961	21. Fuels & Coal Products
	25. Dyes & Textiles
1962	44. Dyes
	53. Coal & Coal Derivatives

1965	26.	Coal & Coal Derivatives
	46.	Dyes, Fluorescent Brightening Agents, & Photosensitizers
1967	40.	Dyes, Fluorescent Brightening Agents, & Photosensitizers
	52.	Coal & Coal Derivatives

Chemisches Zentralblatt, Akademie-Verlag GmbH, Leipzigerstr. 3-4, Berlin W8, Germany, weekly, 1830.
The outstanding chemical abstract journal from 1830 to 1935. Annual indexes available but currently are several years late.

Journal of Applied Chemistry—Abstracts, Society of Chemical Industry, 14 Belgrave Square, London SW1, England, monthly, 1954. It appears as part of *Journal of Applied Chemistry.*

Referativnyi Zhurnal Khimiya, Institut Nauchnoi, Akademiya Nauk SSSR, Moscow, semimonthly, 1961.
Russian language abstract journal of the world's chemical literature.

Specialized Abstracts, Reviews and Indexes

American Chemical Society, Abstracts of Papers Presented Before National Meetings.
Gas and Fuel and the Petroleum Divisions are of prime interest here.

British Coal Utilisation Research Association Monthly Bulletin, Director of Intelligence and Publications, BCURA, Leatherhead, Surrey, England.
Excellent Abstract Section coverage of the field. The sections of prime interest are:

B—Coal: Preparation and Handling (and section 6)
C—Carbonization and Gasification (sections 1–6, 9)
D—Heat Generation and Utilization
E—Waste Products and Corrosion
F—Conversion of Coal to Special Products
H—General Science

Carcinogenesis Abstracts, National Institutes of Health, National Cancer Institute, Bethesda, Md. 20014, monthly, May 1963 (ceased publication 1965).
Free on application; abstracts on all phases of carcinogenesis.

Coke Review, British Coke Research Association, Chesterfield, Derbyshire, quarterly, 1952.
Narrative summaries of areas of coal carbonization and coke utilization science and technology followed by lists of works cited.

The Engineering Index, Engineering Index, Inc., 345 East 47th St., New York, N. Y. 10017.
Abstracts of engineering literature under "Coal Research," "Coal Tar," "Coal Carbonization," "Coke," "Fuels Combustion," among many others; the annual volumes carry author indexes.

Fuel Abstracts, Department of Scientific and Industrial Research (DSIR), Fuel Research Station, London, monthly, 1947 (discontinued 1958).
Abstracts of world literature on all technical and scientific aspects of fuel and power.

Fuel Abstracts and Current Titles (successor to *Fuel Abstracts*), The Institute of Fuel, 18 Devonshire St., Portland Place, London W1, England, monthly, 1960; (no volume of either journal published in 1959)
Sections currently of interest are:

B—Natural Solid Fuels: Sources and Properties
C—Natural Solid Fuels: Preparation
D—Manufactured Solid Fuels and Carbon Products: Properties
E—Carbonization
F—Gasification
H—By-products of Carbonization and Gasification
T—Analyses, Testing, Instruments

Information Bulletin, The Coal Tar Research Association, Gomersal near Leeds, England, weekly.
Weekly abstract service available only to members of Association. It is mentioned to indicate that it exists and is available to an appreciable segment of the industry.

Reports on the Progress of Applied Chemistry, Society of Chemical Industry, London; and Gordon and Breach, Science Publishers, Inc., New York, annual, 1916.
Reviews of coal tar, coal carbonization and coal gas technologies.

Review of Benzole Technology, the National Benzole and Allied Products Association, London, 1931. Ceased in 1967.

Review of Coal Tar Technology, the Coal Tar Research Association, semiannually, 1949.

Excellent reviews on all phases of coal tar technology and science, followed by references under the headings to the original literature:

1. Tars
2. Light Oils, Monocyclic Aromatic Hydrocarbons
3. Middle Oils, Polycyclic Aromatic Hydrocarbons
4. Pitch
5. Tar Acids
6. Tar Bases
7. Utilization
8. Analytical Techniques
9. Physical Measurements
10. Chemical Engineering

Journals

Aachener Blätter, Institut für Aufbereitung, Kokerei, Brikettierung, Technische Hoschschule, Aachen, Germany, irregular, 1950.

American Gas Journal, the Petroleum Publishing Co., P. O. Box 1589, Dallas, Tex., monthly, 1859.

Annales des Mines de Belgique, Editions Techniques et Scientifiques, 37-41 rue Borrens, Brussels, Belgium, monthly, 1896.

Archiv für das Eisenhüttenwesen, Verlag Stahleisen Stahleisen GmbH, Breite Str. 27, Postfach 8229, Düsseldorf, Germany, monthly, 1927.

Coke production and uses in blast furnaces and foundry cupolas.

Aromatikkusu, Japan Tar Industry Association, Inc., 2, 3-chome, Nippon-bashi-Kayabacho Chuo-ku, Tokyo, Japan, monthly, 1967.

ASTM Bulletin, now *Materials Research and Standards,* which see.

BCIRA Journal (formed by a merger of *British Cast Iron Research Association Journal of Research and Development* and *Bulletin and Foundry Abstracts of the British Cast Iron Research Association*), BCIRA, Alvechurch, Birmingham, England, bimonthly, 1960 (original journal 1949). Not available to public after 1964.

Technical articles on foundry practice; abstracts including "Blast Furnace Practice" and the "Production of Iron."

BCURA Gazette, British Coal Utilization Research Association, Leatherhead, Surrey, England, quarterly, 1948.

Activities and researches of the Association; text of "Coal Science Lecture."

Bitumen, Teere, Asphalte, Peche und verwandte Stoffe, Strassenbau, Chemie und Technik, Verlagsgesellschaft mbH, Muehlingstr., Heidelberg, Germany, monthly, 1950.

Technology and application of bituminous materials including coal tar processing, nature and properties of pitch, road-tar technology, coal-tar waterproofing and roofing, tar emulsions, etc.

Blast Furnace and Steel Plant, Steel Publications, Inc., 624 Grant Bldg., Pittsburgh, Pa., monthly, 1913

Technical and trade news concerning the iron and steel industry.

Braunkohle; Wärme und Energie, Verlag "Die Braunkohle," Feldstr. 30, Düsseldorf, Germany, monthly, 1949.

Brown coal mining and utilization in Germany; includes trade news and statistics.

Brennstoff-Chemie, Verlag w. Girardet, Essen, Germany, monthly, 1920.

Scientific and research aspects of fuel technology, especially solid fuels; abstracts, patents, reviews of meetings, trade news, etc.

Brennstoff-Wärme Kraft, V.D.I. Verlag GmbH, Düsseldorf, Germany, monthly, 1949.

Fuels and combustion; occasionally coal carbonization and coke combustion.

Canadian Mining and Metallurgical Bulletin, Canadian Institute of Mining and Metallurgy, 903 Drummond Bldg., Montreal, Que., Canada, monthly, 1908.

Production and use of coke in Canadian metallurgical operations.

Carbon, Pergamon Press, 122 East 55th St., New York, N. Y. 10022, irregular, 1963.

Formation and bonding of carbon; organic substances related to aromatic or tetrahedrally bonded carbonaceous solids or which can be transformed into them by heat treatment or other means; Biennial Carbon Conferences papers, beginning with the sixth conference held in Pittsburgh in 1963.

Coal Age, McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 10036, monthly, 1911.

Trade news mainly on mining and preparation; some material on coal use including carbonization.

Coal Mining and Processing, Maclean-Hunter Publishing Corp., 300 West Adams St., Chicago, Ill. 60606, monthly, 1964.

A coal mining and preparation trade journal.

Coal Preparation, Thunderbird Enterprises Ltd., 3 Clement's Inn, Strand, London WC2, England, bimonthly, 1965.

Devoted to coal preparation technology.

The Coal Tar (Japan), name changed to *Aromatikkusu,* which see.

Coal Tar Science, The Coal Tar Research Association, Gomersal near Leeds, England, irregular, 1954. Available only to Association members.

Coal Technology, AIME (discontinued 1948), succeeded by *Mining Engineering.*

Coke and Chemistry, USSR (English translation edition of *Koks i Khimiya*), The Coal Tar Research Association, monthly, 1959.

Coal carbonization and coal carbonization by-products, science and technology, generally restricted to Russian practice.

Coke and Gas, now merged in *Gas World.*

Excellent for earlier English practice.

Colliery Engineering, name changed to *Mining and Minerals Engineering,* which see.

Colliery Guardian, Fuel and Metallurgical Journals, Ltd., John Adam House, 17-19 John Adam St., Adelphi, London WC2, England, weekly, 1860.

British trade news of the coal mining and preparation industry, including carbonization and gas making.

Engineering and Mining Journal, McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 10036, monthly, 1968.

Erdol und Kohle, Erdgas, Petrochemie, (the official publication of the Deutsche Gesellschaft für Mineralöi wissenschaft und Kohlechemie), Industrieverlag von Hernhaussen KG, Rödingsmarkt 24, 2 Hamburg, Germany, monthly, 1948.

Mainly petroleum technology, abstracts, patents, discussions of government standards, etc.

Forest Products Journal, Forest Products Research Society, 417 North Walnut St., Madison, Wis. 53705, monthly, 1951.

Wood technology including preservation with creosote and coal tar.

Freiberger Forschungshefte, Series A, Akademie-Verlag GmbH, Leipziger Str. 3-4, Berlin W8, Germany, irregular, 1952.

Serially, under auspices of Bergakademie Freiberg (Saxony). A list of available issues which vary appreciably, with descriptions of contents is available from the publisher.

Fuel, Butterworth & Co., Ltd., 88 Kingsway, London WC2, England, bimonthly, 1922.

Scientific papers on fuel chemistry including coal carbonization, tar and pitch composition, etc; staff reviews of technical developments.

Fuel Society Journal, University of Sheffield, Sheffield, England, annual, 1949.

Gas Age, Moore Publishing Co., Ojibway Bldg., Duluth, Minn. 55802, monthly, 1883.

Natural gas; earlier years carried much trade and technical information on coal gas.

The Gas Council Research Communications (formerly *The Gas Research Board* (Great Britain), The Gas Council, 1 Grosvenor Place, London SW1, England, irregular, 1939.

Individual research reports in the manufactured gas field and committee reports.

The Gas Research Board (Great Britain), now *The Gas Council Research Communications.*

Gas Journal, Walter King, Ltd., 11 Bolt Court, Fleet St., London EC4, England, weekly, 1849.

Trade and industrial news of fuel gas and coal carbonization industry.

Gazovaya Promyshlennost (Gostoptekhizdat), Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo Neftyanoi i Gorno-Toplivnoi Literatury, Tret'yakovskii Proezd, 1/19, Moscow, K-12, USSR, monthly, 1955.

The journal of the Russian gas industry.

Das Gas- und Wasserfach, Verlag R. Oldenbourg, Rosenheimer Str. 145, 8 Munich 8, Germany, weekly, 1858.

Alternating issues deal with gas and with water and aqueous effluents.

Gas World, Benn Brother, Ltd., Bouverie House, Fleet St., London EC4, England, weekly, 1884.
Trade and industrial news.

Glückauf, Verlag Glückauf, GmbH, Huyssenallee 105, Essen, Germany, semimonthly, 1865. Bimonthly supplement, *Glückauf Forschungshefte.*
Technical articles on industry; reports on meetings, abstracts of journal articles, patents, trade, and personnel news, etc; excellent source.

Goudron pour Routes, Centre Technique Francais du Goudron Pour Routes, Paris, quarterly, 1956.
Road tar and tar road construction; in French with English abstracts.

The Institution of Gas Engineers Journal, The Institution of Gas Engineers, 17 Grosvenor Crescent, London SW1, England, monthly, 1961.
Technical articles on gas making, distribution, and use; trade & Institution news; supersedes the *Transactions* of the Institution.

Instituto Nacional del Carbon (Oviedo, Spain), Boletin Informativo, Instituto Nacional del Combustible, Oviedo, Spain, irregular, 1952. Ceased publication in 1963.
The main journal of coal research in Spain.

Iron Age, Chilton Co., Chestnut & 56th Sts., Philadelphia, Pa. 19139, weekly, 1855.
Trade magazine of the iron and steel industry.

Iron and Steel Engineer, Association of Iron and Steel Engineers, Empire Bldg., Pittsburgh, Pa. 15222, monthly, 1924.
Steel mill construction including coke ovens and coke plants.

Journal des Industries du Gaz, 95 F. 62 rue de Courcelles, Paris, monthly, 1877.
Outstanding French journal of manufactured gas industry.

Journal of Applied Chemistry, Society of Chemical Industry, 14 Belgrave Square, London SW1, England, monthly, 1951.
Occasional articles on coal carbonization, coal tar processing, chemistry and utilization of coal tar chemicals and products; abstracts.

Journal of the Japan Wood Research Society, Norinsho, Ringyoshikenshonai, Shimomeguro-cho 4-770, Meguro-Ku, Tokyo, Japan, monthly, 1955.
Wood preservation with coal tar products.

Journal of the Institute of Fuel, Institute of Fuel, 18 Devonshire St., Portland Place, London W1, England, monthly, 1927.
Fuel, including coal carbonization, coal carbonization by-products recovery and utilization.

Journal of Mines, Metals and Fuels, 6/2 Madan St., Calcutta 13, India, monthly, 1953.

Journal of the Institute of Wood Science, The Institute of Wood Science, Ltd., London, irregular, 1958.
Practice and research in all fields of wood science.

Journal of the Timber Development Association of India, The Timber Dryers and Preservers' Association of India, Dehra Dun U.P., India, quarterly, 1953.
Creosote and coal tar products as materials for timber preservation.

Khimiya i Tekhnologiya Topliva i Masel (Chemistry and Technology of Fuels and Oils), Gostoptekhizdat, monthly, 1956.
Available in English translation beginning 1965; a major Russian journal of fuel technology, including coal carbonization.

Koks i Khimiya, Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo Literatury po Chernoi is Tsvetnoi Metallurgii, Moscow, USSR, monthly, 1931.
Available in English translation as *Coke and Chemistry;* Russian articles on coal carbonization technology.

Koks, Smola, Gaz, ul. Stawowa 19, Stalinogrod, Poland, monthly, 1956.
Polish articles on coal carbonization and coal carbonization co-product technology. Many of the articles are being translated into English and published by the Clearing House for Federal Scientific and Technical Information.

Kooru Taaru, see *The Coal Tar* (Japan).

Materials Research and Standards, American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103, monthly, 1961.
Testing methods and their application, ASTM news, developments in materials testing, including those applicable to the coal carbonization industry.

Mining Engineering, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., 345 East 47th St., New York, N. Y. 10017, monthly, 1949.
Mainly ore mining and preparation; some coal and coke technology.

Mining and Minerals Engineering, Tothill Press, Ltd., 161-166 Fleet St., London EC4, England, monthly, 1964.

Mainly British coal mining; occasional article on coal plants.

Mining Technology, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., New York; succeeded by *Mining Engineering* in 1948.

Nenryò Kyokaishi (Journal of the Fuel Society of Japan), Nenryo Kyokai 3-1, Makimuchi, Chuo-ku, Tokyo, Japan, monthly, 1921.

Japanese with English summaries; scientific and technical aspects of coal and its utilization including carbonization.

Paliva, name changed in 1967 to *Plyn,* which see.

Pipes and Pipelines, Scientific Surveys Ltd., 11 A Gloucester Rd., London SW7, England, monthly, 1956.

Plyn, Statni Nakladatelstv, Technicke Literatury, Spalena 51, Prague, Czechoslovakia, 1967, monthly.

Scientific and technical research reports on fuels, mainly coal and coke.

Revue de l'Industrie Minerale, Société de l'Industrie Minerale, 19 rue du Grand Moulin, St. Etienne (Loire) France, monthly, 1855.

Coal and coke, largely French practice; summaries in Spanish and English.

Road Tar, British Road Tar Association, 9 Harley St., London W1, England, quarterly, 1947.

Road tar and tar road construction, principally British and European practice.

Stahl und Eisen, Verlag Stahleisen GmbH, Breite Str. 27, Postfach 8229, Düsseldorf, Germany, semimonthly, 1881.

The outstanding technical and engineering journal of the German iron and steel industry; summaries in English and French.

Stal', Mezhdunarodnaya Kniga, Moscow G-200, USSR, monthly, 1939.

In Russian; the outstanding journal of the Russian iron and steel industry; available in English since 1959; see next item.

Stal in English, Iron and Steel Institute, 4 Grosvenor Gardens, London SW1, England, monthly, 1959.

Strassenbau und Bautenschutz mit Steinkohlenteer (*Road Construction and Building Protection with Coal Tar*), Verkaufsvereinigung für Teererzeugnisse AG, Essen, irregular, 1952.

Tanso (Carbons), The Society of Carbon Research, Japan Science Bldg., Ueno Park, Taito-ku, Tokyo, Japan, 3 to 4 issues per year, 1953.

Science and technology of carbon and graphite; in Japanese with English summaries.

Ugol' (Coal), Gosudarstvennoe Nauchno-Tekhnicheskoe Izdatel'stvo Literatury po Gornomu Delu, Moscow, USSR, monthly, 1926.

Russian papers on coal technology.

Wegiel Brunatny, Rosenbergow 25, Wrodaw, Poland, monthly, 1958.

Wood Preserving, American Wood-Preservers Institute, 1707 L St., N.W., Washington, D. C. 20036, 1923.

Trade-oriented articles on wood preservation.

Government Publications

United States

U. S. DEPARTMENT OF THE INTERIOR, BUREAU OF MINES

Bulletins. These describe major Bureau investigations or studies that are considered to have permanent value. Sold by U. S. Government Printing Office, Washington, D. C. 20402.

Technical Papers (last No. 727). They have been incorporated in the *Bulletin* series. Sold by U. S. Government Printing Office.

Reports of Investigations. This is the largest single class of Bureau publications, reflecting efforts to get technological and other information to the mineral industries and to interested segments of the general public as quickly as possible. With a few exceptions which are sold by the U. S. Government Printing Office, they are issued free by the Publications Distribution Section, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Ave., Pittsburgh, Pa. 15213.

Information Circulars. These are digests, reviews, abstracts, and discussions of activities and developments in all phases of the mineral industries. With a few exceptions which are sold by the U. S. Government Printing Office, they are issued free by the Publications Distribution Section, Bureau of Mines, U. S. Department of the Interior, 4800 Forbes Ave., Pittsburgh, Pa. 15213.

See especially IC 8049 "Bibliography of Bureau of Mines Investigations of Coal and Its Products, 1910–60," U. S. Government Printing Office, 1962.

Cooperative Publications. These are reports usually published by organizations other than the Bureau of Mines, which describe work performed cooperatively by the Bureau on subjects of mutual importance and interest. They are usually distributed by the cooperating organization.

Minerals Yearbooks. These are definitive statistical and economic works, presently issued in three annual volumes, comprising reviews of the mineral industries in the United States and in many foreign countries. They include statistics on coke and coke chemicals production in the United States. From 1924 to 1932 they were published by the Bureau of Mines as *Mineral Resources of the United States* (which had been published from 1822 by the U. S. Geological Survey). Sold by U. S. Government Printing Office.

Mineral Resources. Predecessor of the *Minerals Yearbook.*

Mineral Industry Surveys, Coke and Coal Chemicals. A monthly statistical service which presents coke and coal chemical production and sales by months, year-to-date and preliminary annual totals. For copies and regular distribution apply to: Division of Publication Services, Bureau of Mines, U. S. Department of the Interior, Washington, D. C. 20240.

Special Publications. Important special publications of bibliographic nature are:

List of Publications Issued by the Bureau of Mines, annually from July 1, 1910 to December 31, 1966, with subject and author index.

List of Journal Articles by Bureau of Mines Authors, Published July 1, 1910 to January 1, 1960, with Subject Index

These special publications are sold by the U. S. Government Printing Office.

Coal Chronicle. A monthly summary of recently published information on coal and related subjects, prepared primarily to aid the Bureau of Mines, U. S. Department of the Interior, in planning and maintaining effective coal programs. Bureau of Mines, U. S. Department of Interior, Washington, D. C. 20240. Ceased publication in 1966.

U. S. Department of the Interior, Office of Coal Research (OCR)

Annual Reports. Reviews the progress of researches sponsored by the OCR, lists those activated and completed during the year, and presents over-all reviews of accomplishments and future plans.

Special Reports. Reports to the OCR by contractors on completion of projects are available in depository libraries throughout the U. S. Copies of most of them are also available from the OCR. They are reproduced from the report, usually in offset print from typescript as furnished by the contractor.

U. S. Tariff Commission

Synthetic Organic Chemicals, U. S. Production and Sales (year), annual. U. S. production and sales of organic chemicals including tar, tar crudes, and tar chemicals. Sold by the U. S. Government Printing Office.

Preliminary Report on U. S. Production of Selected Synthetic Organic Chemicals (months) and *Cumulative Totals* (year), SOC Series C. Monthly and cumulative totals of production and sales of selected products including tar, light-oil, and their crude products. On request from U. S. Tariff Commission, Washington, D. C. 20436.

State Sponsored Organizations

The Engineering Experiment Stations, Fuel Technology Departments, Chemical Engineering Departments, etc. of the state universities of the major coal producing states (for example, Alabama, Illinois, Indiana (Purdue), Ohio, Pennsylvania, and West Virginia) have carried on coal carbonization research more or less extensively and have usually published their results in the serial reports of their institutions.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch033

Several of the State Geological Surveys, notably that of Illinois at Urbana, Ill., have also carried out much coal carbonization work reported in their serial publications. The latest lists of publications of these organizations should be consulted for work of interest.

Lists of publications are usually available free from the organizations.

Australia

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION (CSIRO)

Coal Research in CSIRO, Division of Coal Research, CSIRO, Chatswood, New South Wales, Australia, quarterly, 1958. Outlines the investigations in progress at the Division's laboratories, including that on carbonization.

Coal Research Section Technical Publications. List and copies available from Division of Coal Research, CSIRO, Chatswood, New South Wales, Australia.

Canada

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

Mines Branch Publications 1902–1959

Reports and Maps, last number is 865. Further publications of this nature are called Monographs and commence with No. 866.

Memorandum Series, last number is 137. Further numbers are issued as *Mineral Surveys.*

Technical Papers, last number is 17. Further publications of this nature are issued by the Mines Branch as *Research Reports.*

Annual Reports

Mines Branch Publications 1958–1965

Monographs. Reports giving a thorough treatment of a particular subject or class of subjects and likely to be valuable as reference texts.

Research Reports. Original contributions to science and technology, based primarily on laboratory research conducted in the Mines Branch laboratories or under Mines Branch auspices.

Technical Bulletins. Describe investigations at the Mines Branch on specific materials by applications of established or lesser-known procedures, where the work is considered to be of wide interest to the industry or the technical public.

Information Circulars. Contributions of general interest which may include literature, statistical surveys, and short information bulletins.

Canadian Government Publications, Sectional Catalog No. 12, Mines Branch and Mineral Resources Division, Mines and Technical Surveys is a complete list of publications in and out of print and can be obtained from The Queen's Printer, Ottawa, Ont., Canada.

DOMINION BUREAU OF STATISTICS, INDUSTRY AND MERCHANDISING DIVISION

The Bureau publishes annual and monthly compilations of industry statistics as they are completed. Those relating to the coal and coke industry are:

Products of Petroleum and Coal—General Review (annual); *Coke and Gas Industry* (annual); *Miscellaneous Products of Petroleum and Gas Industry* (annual); *Preliminary Report on Coal Production* (monthly); *Coal Mining Industry* (annual); *Preliminary Report on Coal and Coke Statistics* (annual)

Copies may be purchased from Information Services Division, Dominion Bureau of Statistics or from The Queen's Printer, Ottawa, Ont., Canada.

Germany (West)

MAX-PLANCK-INSTITUT FÜR KOHLENFORSCHUNG, Mühlheim (Ruhr), Germany. (Present name for Kaiser Wilhelm Institute für Kohlenforschung), which published *Gesammelte Abhandlungen zur Kenntnis der Kohle,* Vol. 1–15, ceased publication with Vol. 15, 1937–1951.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch033

India

CENTRAL FUEL RESEARCH INSTITUTE

Annual Report; Reports; Monographs; Special Reports; Lists of Publications; F.R.I. News (monthly)

Available from The Central Fuel Research Institute, Jealgora, Bihar, India.

United Kingdom

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH (DSIR)

Fuel Research Board

Fuel Research Technical Papers No. 1–; Physical and Chemical Survey of the National Coal Resources No. 1–; Annual Reports

National Coal Board, The (successor to Fuel Research Board)

For complete list of publications in and out of print inquire of Warren Springs Laboratory, DSIR, Gunnels Wood Road, Stevenage, Herts., England. For review of past work, see Fuel Research 1917–1958, *A Review of the Work of the Fuel Research Organization of DSIR,* 120 pages, London (1960).

British official publications are available from Her Majesty's Stationery Office, London or British Information Services, New York, New York.

Specifications and Test Methods

American Association of State Highway Officials (AASHO), 917 National Press bldg., Washington, D. C. 20004. "Specifications for Highway Material," 8th ed., 401 pages, 1961. "Tests for Highway Materials," 8th ed., 617 pages, 1961.

Specifications and test methods for road tars and other tar products.

American Gas Association, Inc. (AGA), 420 Lexington Ave., New York, N. Y. 10017. V. J. Altieri, "Gas Chemists' Book of Standards for Light Oils and Light Oil Products," 1st ed., 1943, 352 pages.

Basic handbook of U. S. light oil specifications and test methods at time of publication.

American Society for Testing and Materials (ASTM), formerly American Society for Testing Materials, 1916 Race St., Philadelphia, Pa. 19103.

Book of ASTM Standards, revised periodically. Current set (1964) is in 32 parts, of which the following are pertinent to the present field:

Part 11. "Bituminous Materials; Soils"

Part 17. "Petroleum Products—Motor Fuels; Solvents; Fuel Oils; Lubricating Oils; Cutting Oils"

Part 18. "Petroleum Products—Measurement and Sampling; LPG; Engine Tests; Grease; Wax"

Part 19. "Gaseous Fuels; Coal and Coke"

Part 30. "General Testing Methods; Quality Control: Appearance Tests; Temperature Measurement"

British Standards Institution (BSI), 2 Park St., London, England. Sales agent in the United States is USASI.

The British Standards Institution has many standards and methods of interest in the fields of coal carbonization and coal carbonization products. Consult latest catalog.

Deutscher Normen Ausschuss (DIN), Beuth-Vertrieb GmbH, Berlin 15/Cologne. Publisher of Germany Industry Standards (DIN). See latest list for standards relating to coal, coal carbonization and coal carbonization products. Many DIN methods and specifications are available in English translation from Beuth-Vertrieb GmbH. The American sales agent for DIN is USASI, New York.

Himus, G. W., "Fuel Testing, Laboratory Methods in Fuel Technology," 3rd ed., 278 pages, Leonard Hill Ltd., London, 1954.

A textbook based on British methods.

International Organization for Standardization (ISO), The U.S.A. Standards Institute is the U. S. member-body of ISO and is the sales agent for ISO standards which are listed in the current USASI catalog. ISO standards and methods relating to coal and coke usually differ from ASTM standards and methods.

Jenkner, Adolf, "Analytische Methoden und Tabellen für die Überwachung und den Betrieb der Benzolfabrik von Kokereien und Gaswerken" (Vol. 36, "Kohle-Koks-Teer," J. Gwosdz, ed., 96 pages, Wilhelm Knapp, Halle (Saale), 1937.

Merck, E., Editor, "Chemisch-Technische Untersuchungs-Methoden: Vol. I, Kokerei-Industrie," 319 pages, Verlag Chemie GmbH, Berlin, 1943.

Seebaum, H. and Krecke, F., revisors, "Analytische Methoden für die Untersuchung von Kokereigas," 3rd ed., 94 pages, issued by the Ruhrgas Aktiengesellschaft, Vulkan Verlag Dr. W. Classen, Essen, 1950.

U.S.A. Standards Institute (USASI), 10 East 40th St., New York, N. Y. 10016. American standards relating to coal and coal carbonization are adopted by the USASI from ASTM. For the list of latest USASI standards, see the latest list of the organization.

United States Steel Corp., "Methods of the Chemists of the United States Steel Corporation for the sampling and Analysis of Coal, Coke and By-products," 3rd ed., 334 pages, Carnegie Steel Co., Pittsburgh, Pa., 1929.
Methods at the time of publication. For current methods, *see* ASTM.

Watkins, P. V., "Standard Methods for Testing Tar and Its Products," 6th ed., 662 pages. Standardization of Tar Products Test Committee, Gomersal, Leeds, England, 1967.

Zerbe, C., ed., "Mineralole und Verwandte Produkte, Ein Handbuch für das Laboratorium," 1,525 pages, Springer-Verlag, Berlin, Germany, 1952.
Methods of evaluation and analysis of petroleum and coal tar products.

Books

General Coal Chemistry and Technology

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2 Gas separation and purification
3 Heating & illuminating gas
75, 76, 114, 117, 119, 166, 181

Class 48, Gas heating & Illuminating

61 Generators
62 Cupola
(63-69, 71-87
89 Retort
90, 92-96, 98-113
118.5 Portable
119 Retorts
120 Compounds
122 Inclined
123 Vertical
124 Lids
126 Attachments
128 Purifiers
170 Center and by-pass valves
173 Exhausters
174 Holders

175 high-pressure safety escape
176 bell and tank
177 sectional bell
178 collapsible
179 tank
180 mixers
181 bell and tank
182 anterior
197 Processes
hydrogen
199 carbureting
200 coal, oil and water
201 coal and oil
202 coal and water
203 producer
204 water
205-208
209 wood
210 coal
211 oil
212-213
214 oil and steam injected
215 air

Class 196, Mineral oils: apparatus

98 Combined vaporizing and condensing
99 condensate returned to vaporizer
100 columns
102 condenser or collector in vaporizer
103 heads
104 vaporizing
105 systems
106 series stills
107 tube and drum
108-109
110 tubular
111 with partitions
112 rotary
114 vacuum
115 special shapes
116 furnaces and flues
117 internal flues
118 liquid baths
119 jackets
120 special means for heating
121 electric
122 carbon removers
123 circulators or agitators
124-126
127 fluid injectors
128 films or sprays
129 depending legs or spur tubes
130 bottoms
131 unheated
132 automatic control
133 special features of construction
134 heat recovery from vapor or residuum
135 feeders
136 vapor outlets
137 attachments
138 condensing
139 dephlegmators or fractionating columns
140 contact with cooling fluid
141 automatically controlled temperature
155 miscellaneous

Class 202, Distillation

2 processes
37 residue quenching
38 decarbonizing and cleaning
81 apparatus
82 systems
83-151, 215-230
239 elements
241-270

Class 214, Material or Article Handling

Various subclasses under heading "charging or discharging apparatus"

Class 251, Valves and valve actuation

The various valving systems for the control of regenerative heating systems of coke ovens, water gas plant operation, byproduct control, etc. will be found in this class.

Class 260, Chemistry, Carbon compounds

144 Azo
152 Heterocyclic
155-156, 164, 165
239 Heterocyclic carbon compounds
269 six-membered rings containing one hetero-n-atom
283, 290
350 carbocyclic or acyclic
617 hydroxy
618, 619, 627
666 hydrocarbons
668, 674, 675
684 Processes
701 Chemical purification
703 separation from sulfuric acid solution
704 physical treatments only
705-708

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34

Literature Resources for Petroleum Chemicals

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The field of petrochemicals has grown over the past 10 years to the extent that at present petroleum has essentially replaced coal as the primary raw material for preparing organic chemicals. In some cases, it has begun to penetrate the field of inorganic chemicals. In accordance with this growth, the literature of the subject has also grown tremendously. This article is a general guide to the sources of information in this area. It covers the general sources first and then particular processes, such as oxidation, hydrogenation, halogenation, and nitration. Representative books and articles are listed in the bibliography. Some general guides to the patent literature are also included.

The raw materials for the petrochemical industry are obtained from crude petroleum either by being present as such in the crude or by the chemical operations during refining to prepare the primary products such as gasoline, lubricating oils, heating oils, and asphalts. The products thus obtained include chemicals such as ethylene, propylene, butadiene, benzene, toluene, and the xylenes. These may be considered the primary petrochemicals. Many secondary derivatives are obtainable from these, including polyethylene, polypropylene, polystyrene, polyesters, polyurethanes, phenolic resins, various types of synthetic rubbers, ethylene chloride, trichloroethylene, ethyl chloride, ethanol, acetaldehyde, styrene, ethylene oxide, ethylene glycol, vinyl acetate, ethylene dibromide, acrylonitrile, and others.

The growth rate of petrochemicals continues to increase, and petroleum has essentially replaced coal as the primary organic raw material. According to the 1965 Petrochemical Handbook issue of *Hydrocarbon Processing,* oil and natural gas account for more than 93% of all basic organics. Petrochemical feedstocks account for almost 4% of U.S. crude petroleum production and imports. Demand for petrochemical feedstocks is growing about 11% per year. By 1970 it is estimated that petrochemicals should account for 70% of total value and 42% of total chemicals produced.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Thus, the importance of the industry and the need for knowing the sources of information is apparent. There are several ways in which these sources can be discussed—*i.e.*, by the individual chemicals and the products obtainable from them, chemical by chemical or type by type, or by the products obtained. Thus, we could have sections devoted to the preparation of paraffins, olefins, aromatics, etc., or we could have sections devoted to materials such as plastics, rubbers, textile chemicals, solvents, etc. However, since the limitations of the paper restrict, I discuss the subject on the basis of processing, such as oxidation, halogenation, nitration, etc. In this way the paper will be kept within bounds, and the subject will be adequately covered. I do not propose to be all inclusive. My object is to present general guidelines to sources of information on the various processing of petrochemical feedstocks. I list both special and usual sources and discuss their usefulness from the special aspect of petrochemistry.

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General Sources

The literature serves a dual purpose. First, it keeps the worker aware of current research and who is currently active in a particular field of endeavor. Second, it informs the worker of what has been previously done. This prevents duplication and serves to orient new workers in the field. Obviously, the type of material used in each of these functions differs. In the first area—current awareness—it is necessary that the worker be aware of all the primary journals which publish the results of new research. He must keep himself informed by reading them as they appear. It is also necessary that one be familiar with the patents issued each week since many technological advances are first announced in the patent literature. Thus, one must be aware of the sources of information for patents. The second type of use made of the technical information is served by a different type of publication. These may be trade publications, review journals or abstracts journals. Many of the abstracts journals are subject oriented and serve a specific industry or, like *Chemical Abstracts*, the entire field of chemistry. Each of these sources has its purpose and function.

Little has been published which is devoted solely to petrochemistry. Several books, a few magazines, some symposia, and an abstract bulletin are the sole fruits of this endeavor.

Petrochemistry is covered broadly by the books published since 1955, which are listed alphabetically by author in the bibliography. However, mention should be made of one standard reference work which was published in 1934 but which is still the best guide to the literature up to that date. It is Ellis' "Chemistry of Petroleum Derivatives," published in two volumes by the Chemical Catalog Co. Although out of print and rather old, it is still the basic book reviewing the literature up to the publication date. It contains many references to the early patents and literature and is essential in making searches.

Another useful book is "The Chemistry of Petroleum Hydrocarbons," by Brooks in three volumes. Volume 1 contains 21 separately authored chapters covering subjects such as hydrocarbons in natural gas, gasolines, kerosenes, gas oils, and lubricating oils; separation of aromatics by selective adsorption; preparation of pure paraffins and olefins; synthesis of low and high molecular weight hydrocarbons; and the Fischer-Tropsch process. Volume 2 contains 16 chapters covering acetylene by the pyrolysis of light hydrocarbons; pyrolytic reactions of aromatic hydrocarbons; hydrocarbon oxidation; synthesis of gas from methane, oxygen, and steam; partial oxidation of simple paraffinic hydrocarbons; and special oxidation reactions of unsaturated hydrocarbons. Volume 3 contains 22 chapters covering oxidation of *o*-xylene to phthalic anhydride; isomerization of olefins and saturated hydrocarbons; chlorination, fluorination and nitration of paraffins and cycloparaffins; Diels-Alder reactions; the Oxo reaction; alkylation; aromatic substitution; and sulfonation and nitration of aromatic hydrocarbons.

The volume by Brooks and Dunstan contains chapters covering chemicals for synthetic rubber, organic chemicals from hydrocarbons of petroleum, nitroalkanes, carbon black, and surface-active agents. Goldstein's book covers major products from a commercial and manufacturing point of view and contains much economic data. Groggins' volume covers unit operations such as alkylation, halogenation, and nitration. "Advances in Petroleum Chemistry and Refining," by Kobe and McKetta is an annual publication which presents current developments in the petroleum and petrochemical industries. The chapters are individually authored and cover subjects such as the manufacture of petrochemical acetylene; nitriles and amines; synthetic ammonia; aromatics from petroleum; manufacture of mono- and diolefins from paraffins by catalytic dehydrogenation; synthetic detergents from petroleum; nitrogen fertilizers; Oxo process; pesticides from petroleum; various aspects of the petrochemical industry; and similar subjects. There is a cumulative index in Volume 10.

Also of interest because they relate specifically to petrochemicals are the various symposia which have been held by the American Chemical Society at its semiannual meetings. These have generally been sponsored by the Division of Petroleum Chemistry. The American Institute of Chemical Engineers held a symposium on petrochemicals and petroleum refining which was reprinted in *Chemical Engineering Progress Symposium Series.*

Several books have been published which cover the physical properties of hydrocarbons and petrochemicals. These are other than the standard handbooks which are generally familiar and are listed with the general books in the bibliography.

There are many books which are of interest to the petroleum chemist but which are also of general interest to the chemist. These include the books on organic chemistry, inorganic chemistry, physical, analytical, and the other branches of the subject. These will not be discussed here. However, of primary interest are the following three compendia which cover both chemical technology and organic chemistry.

Kirk-Othmer's "Encyclopedia of Chemical Technology" is an excellent source of information for all petrochemicals.

"Ullmann's Enzyklopedia der Technischen Chemie" is in the same category as Kirk-Othmer except that it is in German. Many of the articles contain references to the original literature. Both of these are currently being revised. Houben-Weyl's "Methoden der Organischen Chemie" is an excellent source of information on organic chemicals, from the chemist's point of view. It contains volumes devoted to the chemistry and preparation of organophosphorus, nitrogen, sulfur, oxygen, and halogen compounds. All of the articles are individually authored and contain many references to the original literature.

Also of interest in this regard are the various publications which have appeared as a result of the American Petroleum Institute's research projects.

Periodicals, Abstracts, and Information Services. Several periodicals are of interest to the field of petrochemicals because of the annual special reports they issue. Examples of these are the annual petrochemical reports of the *Oil and Gas Journal.* The latest lists U.S. petrochemical construction projeets in elastomers, aromatics, ammonia, ethylene, and sulfur. It also contains the Journal's annual petrochemical survey which lists all U.S. and foreign plants and their products. The Petrochemical Handbook issue of *Hydrocarbon Processing* is another important source of information. This special annual issue gives flow diagrams for the industrial production of the important petrochemicals. The 1965 issue contains 131 flow diagrams. The information for each process includes raw materials, products obtained, a general description of the process, yields, commercial installations, and where to obtain additional information. Both these journals also publish articles of current interest, describing new processes or reviewing older processes. An example of these is the series on making ethylene and butadiene which the *Oil and Gas Journal* reprinted in 1957. The annual review issue of *Industrial and Engineering Chemistry,* which ceased publication in 1963, contained review articles covering recent advances in the field of alkylation, halogenation, oxidation processes, hydrogenation and dehydrogenation processing, and sulfonation and sulfation processes. In some of the issues polymerization was also covered. These reviews are now published with each issue and serve as good sources for reviewing the annual progress in these fields.

Economic information concerning petrochemicals is available from the usual sources of such information. Thus, the U.S. Tariff Commission issues its *Synthetic Organic Chemicals, U.S. Production and Sales* report annually. As the title indicates, the information is concerned with the production and sales of all organic chemicals during the period covered. Stanford Research Institute issues its "Chemical Economics Handbook" in loose-leaf form. This contains information on the basic economic data significant to the chemical industry. It covers economic data on individual chemicals and raw materials, on the principal chemical-consuming industries and on financial aspects of the chemical industry. The publication *Search* published by Compendium International Publishing Corp. regularly gives information on prices, sources of chemicals, production, exports and imports, new plants, etc. *Predicasts* abstracts information on forecasts and market data by product from articles appearing in over 250 trade journals. *Chemical Market Abstracts,* published monthly by Foster D. Snell, Inc. claims to be a comprehensive guide to the world's chemical markets. It also contains information on chemical production, prices, and markets. Although not primarily concerned with petrochemicals, mention should never-

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theless be made of the American Petroleum Institute's publication "Petroleum Facts and Figures." The latest edition (1965) is designed to bring together within a single volume the most complete and comprehensive record available of the petroleum industry's operations. The refining section contains tables on crude runs, refineries, stocks, production of petrochemical feedstocks, and finished products. Much statistical and economic information is contained in the various publications by the Noyes Development Corp. of Park Ridge, New Jersey. These publications generally give detailed accounts of the technical information available on the subject matter of the report along with some economic information. Some of the reports cover such topics as acetylene, acrylic acids and esters, acrylonitrile, ammonia and synthesis gas, aromatics, caprolactam, chemicals from ethylene, chemicals from propylene, etc. Finally, the U.S. Bureau of Mines has issued several bibliographies of investment and operating costs for chemical and petroleum plants covering the period 1930-1958.

Specific Sources According to Process

Oxidation. Many chemicals are produced by oxidizing petrochemical feedstocks. A number of articles have been written on this subject and have been included in some of the aforementioned books, such as the one by Brooks *et al.* on the chemistry of petroleum hydrocarbons and in Kobe and McKetta's "Advances in Petroleum Chemistry and Refining." Both of these should be consulted for review articles on oxidation. In addition to these, several books have also been published which cover the subject in greater detail. Examples of these are given in the bibliography. Shtern's book reviews research on the oxidation of paraffins, olefins, naphthenes, and aromatics. It covers the Russian work fully and contains extensive bibliographies to both Russian and non-Russian work. Articles with particular emphasis on petrochemical oxidation are also included in the bibliography.

Alkylation. Another important petrochemical reaction is alkylation, and much work has been done in this field. Booth and Martin's book includes a discussion of the use of boron trifluoride as an alkylation catalyst. The book by Egloff and Hulla is a compilation of patents on the alkylation of alkanes, classified according to process. The volume by Topchiev *et al.* is translated from the Russian and contains sections on the use of boron trifluoride in alkylation reactions. Williams' work discusses homolytic aromatic substitution, which includes alkylation reactions.

Too many articles have been written on alkylation reactions to list them all. However, those which review the subject well are listed in the bibliography. I should also like to mention the annual reviews of the literature which have been published in *Industrial and Engineering Chemistry.*

Isomerization. Isomerization is a reaction frequently used in the petrochemical industry but not to the same extent as alkylation or oxidation. However, it is a useful reaction and much work has been done with it. Moy discusses developments during the period 1952-1962 in catalytic isomerization, along with other processes. The work by Topchiev *et al.* previously mentioned contains a section on the use of boron trifluoride in isomerization reactions. A symposium on isomerization and related processes was held at the April 1959 meeting of the American Chemical Society, Division of Petroleum Chemistry.

Hydrogenation. Sources of information which cover hydrogenation and dehydrogenation are listed in the bibliography.

Halogenation. Halogenation has been extensively investigated, and many books and articles have been published. Representative ones are given in the bibliography. Here again the annual reviews in *Industrial and Engineering Chemistry* should always be consulted.

Nitration. Although not as important from a petrochemical point of view as any of the other reactions, some work has been carried out in this area, and the sources should be listed. Of interest is the symposium which was held at the 132nd American Chemical Society, Division of Petroleum Chemistry Meeting in New York in September 1957. The topic was nitrogen compounds in petroleum, and 10 papers were presented. Nitration is also covered by the *Industrial and Engineering Chemistry* annual unit processes review. Also worthy of mention is API Project 52 on the nitrogen constituents in petroleum.

Sulfonation. Here also the annual review of *Industrial and Engineering Chemistry* must be mentioned. API's Project 48, which has been in process for many years, is concerned with the synthesis, properties, and identification of sulfur compounds in petroleum. Other articles and books of interest are given in the bibliography.

Polymerization. Of all the areas of petrochemistry none has received more attention than polymerization, especially since the advent of the Ziegler catalyst. The subject has been discussed in great detail, and no attempt will be made to cover the sources here. However, some attempt will be made to indicate the magnitude of the material that has been published and to point out some of the books and articles which will serve as a start in becoming familiar with the field. I shall limit myself to the polymerization of olefins and diolefins in order to keep this section within bounds.

Interscience started issuing the digest service *Resins, Rubbers, Plastics* in 1947. This publication, later issued by Information for Industry, contains an annual index to the material digested, and the digests themselves are long and frequently contain data taken from the articles. This service was discontinued in 1965. There are also many periodicals devoted exclusively to polymers and polymerization. Examples are *European Polymer Journal, Fortschritte der Hochpolymeren Forschung, Journal of Applied Polymer Science, Journal of Polymer Science, Die Makromolekulare Chemie, Polymer, Polymer Previews,* and *Polymer Report.*

In addition to the journals many books have been written covering various aspects of the subject. One of the earlier publications and still excellent for the old material is Ellis' "Chemistry of Synthetic Resins." Published in two volumes in 1935, it covers most of the old literature and should always be consulted for information which may have been published prior to the publication date of the set.

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I have tried to give an overall view of some of the sources of information in the field of petrochemistry. Naturally, it has been impossible to cover the entire field and still keep this paper within bounds. However, I believe that the contents and leads given here will serve as a start to anyone wishing some basic information.

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U.S. Patent Classes

The following are the main classes of U.S. patents which are concerned with petrochemicals. These are purely representative, and if a search is desired, it is essential that the "Manual of Classification" be consulted.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch034

Class	
18	Plastics
23	Chemistry
71	Chemistry—fertilizers
106	Compositions, coating or plastic
117	Coating: processed and miscellaneous products
196	Chemistry, fermentation
204	Chemistry, electrical and wave energy
208	Mineral oils: processes and products
252	Compositions
260	Chemistry, carbon compounds

An essential tool in using the Patent Office Classification Manual is the recently published (1966) book entitled, "Development and Use of Patent Classification Systems." This was published by the U.S. Department of Commerce and is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.50. It provides details and illustrations on how the U.S. Patent Classification Systems are presently organized, on bases and techniques used in developing and administering the systems, and includes instructions for using the systems.

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The Literature of Explosives

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Explosives research takes place in the following specialized areas: (a) manufacture, handling, and testing methods; (b) synthesis of new compounds and formulation of new compositions; (c) applications research; and (d) fundamental studies on explosives and explosions. Those engaged in these activities require a knowledge of available explosives and their properties. Therefore, up-to-date reference sources providing such information readily are essential. While some books and reviews are available which deal exclusively with the different specialized areas, much of the important work is reported in publications of diverse scientific or industrial fields, such as metal working or mining. The specialized areas of research activity relating to explosives are discussed briefly, and the reference sources are grouped according to their applicability.

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The literature sources for the explosives industry covered here are limited to sources related primarily to condensed (solid and liquid) detonating or high explosives. Deflagrating explosives or propellants are in a specialized area which has developed a literature of its own. Since the literature of rocket propellants is reviewed in Chapter 36, the emphasis here is placed on the literature of high explosives. No attempt has been made to cover the sources for propellants except for those which provide ready and up-to-date information on high explosives as well. In addition, the various early references on explosives which have been supplanted by later sources of similar scope, and whose interest is primarily historical, have not been included.

Research and development activity related to explosives involves work on such various topics that their literature sources cover a wide spectrum of the technical literature, embracing publications in diverse fields of science and specific industries. Some topics covered in explosives research work concern problems during manufacture, improved techniques for carrying out manufacturing processes, handling and transportation techniques, improved testing methods, and field problems encountered when explosives are used in con-

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

ventional applications, as in industrial blasting operations. Research activity in explosives also involves the synthesis of new compounds having desired properties, and the synthesis of known compounds by new methods. Research on new applications of explosives involves studying the effects of explosives on materials to effect useful changes in the materials which cannot be accomplished as well by known methods. It also involves studying ways in which explosive energy can be used to replace other energy sources for transmission through geological formations, water, and so forth. Specific techniques and kinds of explosive charges are designed to provide the desired results. In addition, there is a great deal of fundamental study of explosions, chiefly the physical chemistry of the detonation process, including pressure characteristics, reaction and propagation velocities, initiation and mechanism of detonation, and so on.

Because of the variety of research topics in the field and the consequent variety of specialists working on these topics, the literature sources useful in one particular area differ somewhat from those which are useful in other areas, beyond certain reference works which are useful to all at one time or another. Therefore, the sources included in this discussion and bibliography have been arranged according to the research areas in which they find widest use. Such an arrangement is strictly arbitrary, and admittedly for some people there will be some "crossing-over" from one section to another. Nevertheless, the arrangement may be helpful to the degree that persons working in one particular area may find the sources they need most grouped together in one section, while recognizing that sources in other sections may be useful to them at times.

General Reference Works

All those whose work involves explosives require a basic knowledge of available explosives, their properties, and how they are used. Therefore, up-to-date reference sources providing such information readily are essential. Listed in Section I of the bibliography are general reference works which are frequently used for quick-reference purposes. The Davis book is a standard textbook on explosives, giving the history, properties, and methods of manufacture of the various explosives, grouped according to structural classes. Information on primary explosives, detonators, and primers is also included. The "Encyclopedia of Chemical Technology" (2nd ed.) contains a 78-page article with a selected bibliography and is indispensable when dealing with the properties of well-known explosive compounds as well as their mixtures, dynamite compositions, and descriptions of testing methods. Vol. 1 (1st ed.), Vol. 2 (2nd ed.), and the second supplement are useful sources on ammonium nitrate.

The book by Meyer is a general source on the various types of explosives, their chemistry, initiators and other devices employing explosives, applications of explosives, and elementary explosion theory.

The manual, "Military Explosives," issued by the Departments of the Army and the Air Force is a compact source of general and technical information on the chemistry, physics, manufacture, properties, handling, use, storage, and transportation of military explosives and related substances. The manual

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is revised from time to time, the present volume superseding the one published in 1940. Information on German and Russian military explosives can be found in Fedoroff's two dictionaries.

The "Encyclopedia of Explosives and Related Items," by Fedoroff *et al.*, of which three volumes have been published thus far, will be an invaluable reference aid. The encyclopedia contains, in addition to a brief discussion and references on each item, a description of the physical tests used to determine explosive properties, and a list of abbreviations, code names, and symbols in use in the explosives field.

The "Encyclopedia of Explosives" published by the Army Ordnance Liaison Group in Durham is a condensed compilation of the properties, manufacturing processes, and uses of the principal explosives. "Explosivstoffe" is a German dictionary defining a large number of the explosives currently used throughout the world. The dictionary also lists books and journals in the explosives field.

The "Blasters' Handbook" describes explosives and practical methods of using them. New editions are published periodically to cover the most recent materials and methods. This handbook covers types and grades of dynamite and blasting agents; blasting accessories, such as igniters, detonators, detonating cord, boosters, and primers; loading, firing, and storing methods; and miscellaneous uses of explosives.

The classic treatise on nitroglycerin is the book by Naoúm which gives a thorough technical treatment of the manufacture and properties of nitroglycerin, homologous nitric esters, and nitroglycerin explosives. The Nauckhoff and Bergström book brings the information on dynamite manufacture forward up to 1959.

The Orlova reference (translated from Russian) is a compendium in three parts giving comprehensive coverage on the properties and methods of manufacture of nitro compounds and nitrate esters as compiled from the literature.

Taylor's book gives the wide range of chemical compositions which have been developed as energy sources for various applications, and a description of the applications.

Ellern's textbook on pyrotechnics is concerned with the properties of ignition and delay compositions used to initiate explosives. The book is up-to-date, comprehensive, and includes an extensive bibliography. A very comprehensive source on initiators and initiating compositions available to government agencies and their contractors is the literature search with coordinate index compiled by Anzalone.

It is important to have available a data handbook on properties of explosives and their mixtures, particularly those which may not be well known or on which little work has been done. The A.D. Little work, "Punch Card Recording of Data on Explosives," is an important source of this type, covering the physical, chemical, and explosive properties of compounds and mixtures. The volumes contain printed tabulations made from IBM cards. Volume II contains classified information. Data on explosives useful in military items are found in Tomlinson and Sheffield's work.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch035

The two Picatinny Arsenal reports by Sheffield and by Abolafia are useful when information is needed on how particular explosives are affected by materials with which they may come into contact, for example, metals, plastics, and moisture.

Blatt's handbook is also a good source of data, and is perhaps easier for the novice to use than other handbooks.

Because of military interest in explosives and government sponsorship of certain research programs in the field, reports released by government agencies often contain the earliest information published on explosives. Although the same work often is published later in a variety of journals, the time lag between report issuance and journal publication may be over a year. Consequently, the most important periodical covering all areas of activity in the explosives field is the *U.S. Government Research and Development Reports* issued twice a month. In addition, the National Aeronautics and Space Administration (NASA) publishes a semimonthly journal, *Scientific and Technical Aerospace Reports (STAR)*, which covers world-wide report literature on the science and technology of space and aeronautics.

Other periodicals covering the explosives field broadly are foreign in origin. *Explosivstoffe,* which is a continuation of the well-known *Zeitschrift für das gesamte Schiess- und Sprengstoffwesen* and replaces *Sprengtechnik,* is a bimonthly journal containing articles of theoretical and practical interest, listings of new German patents in the field, trade news and regulations, and reports on books and review papers. This journal recently published a series of articles by A. M. Pennie entitled "Nitrogylcerin—A Century of Manufacture" which provide details on the procedures and equipment used in various countries to manufacture nitroglycerin, including a description of mechanized, continuous operations (*Explosivstoffe* **10,** 213-219, 242-247, 261-266 (1962); **11,** 21-24 (1963)). *Explosifs,* a quarterly journal of the Association of Belgian Explosives Manufacturers and of the Scientific and Technical Research Center for the Belgian Explosives Products Industry, provides the same kind of coverage as *Explosivstoffe,* but geared to Belgian practice.

Mémorial des Poudres is published annually by the French Service des Poudres. It provides lengthy articles on the manufacture, testing, and properties of explosives. *Mémorial de l'Artillerie Francaise* is a quarterly covering the science and technology of armaments. The theory of explosions is sometimes treated comprehensively, for example, in the series of papers by Louis Médard on the physics of explosives in the issues since 1957 to date, and in a series by S. Travers in 1950-1951 on the hydrodynamic theory of explosions and shocks.

The Japanese *Journal of the Industrial Explosives Society,* published bimonthly, is useful to the degree that it has a table of contents, summaries, and sometimes entire articles in English.

For the research worker in any one of the specialized areas of activity, the library of basic reference sources of the kind just described must, of course, be supplemented by books, periodicals, reports, and patents relating to topics

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

in his particular field. A list of the pertinent classes and subclasses for U.S. patents is given at the end of the bibliography.

Sources Pertaining to Explosives Manufacture, Transportation, and Field Use

Those responsible for handling and using explosives and explosive-containing devices in mass quantities must be well acquainted with the latest government regulations on manufacture, storage, transportation, use and disposition of these materials. The key source to such information is the *Monthly Catalog of U.S. Government Publications.* The I.C.C. regulations issued August 23, 1963, are the most recent ones on explosives. Amendments to the regulations are issued from time to time. State rules and regulations also should be on hand and generally are available from the state Department of Labor.

The regulations set forth in the "Ordnance Safety Manual" are useful guidelines for everyone handling explosives. Another useful safety manual is the Naval Ordnance Laboratory report of February, 1962 by McGill.

The latest Bureau of Mines list of permissible explosives by Hanna is an important reference source for all those engaged in field work in mining.

The Bureau of Mines Bulletin 346 by Munroe and the book by Bichel, although old, are useful adjuncts to the general reference sources for information on explosives testing, providing greater detail than the general references.

The compendium on ammonium nitrate is a complete treatment of the subject of the decomposibility of the salt and is an important reference source for all who manufacture or use, or otherwise handle, this material.

The papers presented at a symposium on the hazards and testing of explosives held by the ACS in 1963 provide information on the factors which influence explosives sensitivity, testing of explosives, and safety designs for handling explosives.

For those engaged in actual mining practice the book by McAdam and Westwater and that by Taylor and Gay both describe the various types of blasting explosives and accessories, and detailed applications in mining. The rock blasting manual by Fraenkel is based on practical experience, and is in loose-leaf form to permit the addition of new articles. The recent book by Langefors and Kihlström includes an introduction to the mechanics of breakage and such topics as charge calculation, loading procedures, blasting with ammonium nitrate explosives and slurries, short-delay blasting, electrical firing, tunnel driving, drilling and ignition patterns, careful blasting of contours, ground vibrations, underwater blasting, and blasting without uncovering the rock. The book also includes an English-Swedish-Spanish list of pertinent technical words.

Periodicals useful to those engaged in manufacturing and field work, in addition to those described previously, are listed. Both German journals chiefly deal with blasting techniques in coal mines, quarries, and oil wells and in construction work. *The Explosives Engineer,* published by the Hercules

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Powder Co. from 1923 to 1961, describes specific blasting operations and problems.

Journals in the field of analytical chemistry, especially *Analytical Chemistry,* are basic requirements for those involved in the analytical aspects of explosives manufacture. Of particular importance is the article by Pristera *et al.,* which contains many useful references.

For those involved in explosives manufacture and in developing methods and devices for using explosives in the field, the patent literature is a necessary reference source, either as a guide to determining infringement or novelty, or solely as a source of information on the state-of-the-art.

Sources Pertaining to Explosives Synthesis

The research worker engaged in the synthesis of new explosive compounds, the formulation of new compositions, or the synthesis of known compounds by new routes will need up-to-date references in organic chemistry, with emphasis on the chemistry of compounds having known energy-producing groups, for example, nitrogen-containing compounds. Chapter 10 by George F. Wright on the chemistry of explosives, which is found in "Organic Chemistry—On Advanced Treatise," Vol. IV, treats the developments in the field since 1943, thereby providing a useful supplement to the T. L. Davis book. A more recent source is the book by Urbánski, translated from Polish.

A very practical source primarily in the synthesis area, but also to a certain degree for those involved in manufacturing and field use, is the volume, *Reports on the Progress of Applied Chemistry,* which is published annually and has a chapter on explosives every two years. The extensive bibliography helps the user to obtain a more complete view of developments than he might obtain solely by reading primary sources.

Other useful reference sources in this area are those by Sidgwick, Astle, Berlow *et al.*, Topchiev, and Chapter 3 by Kornblum in "Organic Reactions," Vol. 12.

The periodicals previously listed, as well as patents, are important sources to the synthesis worker. In addition, papers relating to explosives synthesis currently are published in many chemical journals. Those in which the majority are published are listed in Section III. The "Unit Processes Review on Nitration," published annually by *Industrial and Engineering Chemistry,* is especially helpful for information up to 1963 when it was discontinued.

Sources on Explosives Applications

Reference sources required by those developing new uses for explosives and new techniques for using explosives, in addition to patents and the general references on explosives mentioned before, are found in the literature of the applied sciences and of the specific process industries in which explosives are, or can be, employed. Much of the work on explosives applications is reported in publications on applied physics, for example in the area of mechanics, geophysics, and acoustics, and in the publications of the mining and metals industries.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch035

For those interested in mining applications, the papers given at a number of symposia on mining held at different colleges are good sources on recent developments. The papers generally cover such topics as the properties and performance of new blasting agents, blasting techniques, and rock mechanics.

The earlier book by Rinehart and Pearson describes the phenomena involved when materials, chiefly metals, are subjected to rapidly applied loads of short duration. The more recent book by the same authors summarizes the state-of-the-art with respect to the explosive working of metals, providing first the physical basis of the techniques and then engineering fundamentals and practices. A number of related articles by these authors are found in such journals as the *Journal of Metals* (*e.g.*, Sept. 1960, p. 673) and the *Journal of Applied Physics*. "Response of Metals to High Velocity Deformation" is a compilation of papers given at a conference held in 1960 on the mechanism of deformation of metals, including several papers dealing with the effects of explosive shock. Explosive shock effects are also dealt with by Seitz and Turnbull, by Wilson, and in "Strengthening Mechanisms in Solids," and "Explosives —New Applications." The Kolsky book includes chapters on plastic waves and shock waves, and fractures produced by stress waves. The book edited by Paul and Warschauer treats the different aspects of research on the physics of crystalline solids at high pressures, Chapter 13 by B. J. Alder describing shock wave experiments.

A number of periodicals which occasionally contain articles on the applications of explosives are listed. To assist the searcher in the field, specialized abstracts journals such as the *Battelle Technical Review Abstracts* (terminated Dec. 1967) and *Metallurgical Abstracts* (now *Metals Abstracts*) are very useful, as are *Physics Abstracts* and *Chemical Abstracts*.

Sources on the Theory of Explosions

Two very useful sources which cover government-sponsored work carried out over a period of years are the PB reports, "Underwater Explosion Research" and "Physics of Sound in the Sea." Vol. I (PB 109,037) of the compendium of reports is devoted to the primary underwater shock wave; Vol. II (PB 114,314) to the gas globe formed by the explosion products; and Vol. III (PB 114, 315) to the effects of these phenomena on structures and to the measurement and calculation of the resulting damage. "Physics of Sound in the Sea," which reports the essential results obtained in the studies of underwater sound up to the middle of 1945, contains a chapter on explosions as sources of sound, and a chapter on the transmission of explosive sound in the sea, written primarily from the fundamental viewpoint (Chapters 8 and 9).

There are several reference books devoted to the subject of explosion theory. Those most useful in any particular situation will depend on the background and technical knowledge of the user. Vol. 5, p. 949 of the first edition of Kirk and Othmer's "Encyclopedia of Chemical Technology," and the book by Robinson are useful as a basic introduction to the subject for a novice. The books by Taylor and Cook give a more comprehensive treatment of the

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch035

physical chemistry of explosives, covering such topics as the hydrodynamic theory of detonation, measurement of velocity and factors influencing the velocity, explosive products, and systems for calculating the numerical values of the detonation parameters. The book by Zeldovich and Kompaneets contains the same kind of subject matter, and covers gaseous detonation as well. The books by Kinney and by Courant and Friedrichs deal more particularly with the generation and propagation of shock waves in air. Kinney's book also discusses the interaction of the explosive shock with various structures and objects, and typical structural responses. Cole's book gives a comprehensive account of the basic physical processes involved in underwater explosions, and gives attention to hydrodynamical relations, the detonation process in explosives, and shock wave theory as a basis for underwater explosion theory. W. E. Deal, Jr. in Chapter 11 of "Modern Very High Pressure Techniques" describes dynamic high-pressure techniques, including shock wave theory, and optical, electrical, radiographic, and recovery techniques employed in shock wave studies.

The book by Berger and Viard, published in French, discusses thermodynamic factors, fluid mechanics, methods of observing short-duration phenomena, detonation of solid explosives, and effects produced by explosives There is an extensive bibliography (92 references).

The two volumes of "High Pressure Physics and Chemistry," represent a combined international effort to provide a comprehensive and advanced study of the major aspects of high-pressure systems, mostly in the ultra-high pressure range, including theoretical and experimental work and static and dynamic pressures. Chapter 9 of Vol. II by G. E. Duvall and G. R. Fowles is on the subject of shock waves and has a useful bibliography.

Robinson's book deals with the theory of shock waves and the thermochemistry of explosive reactions, while Taylor's papers in Vol. III include discussions of the propagation of blast waves, pressures from explosions, and underwater explosions.

The bibliography compiled by Lockheed, "Shock Wave Propagation in Solids," includes references on the effects of explosive blast waves and/or hypervelocity impact on plastic, viscoelastic, and elastoplastic solids. The bibliography is well annotated and indexed. The bibliography on shock waves compiled at the Applied Physics Laboratory by Elder is not annotated, and references on a particular subject can be reached only through a broad subject index.

The circular issued by the U.N. Food and Agriculture Organization, "Effects of Underwater Explosives on Aquatic Life," contains a bibliography and includes a list of experts in the field. The effects of gravity on large-scale explosions in the ocean are discussed in Gilstein's thesis.

The book by Bowden and Yoffe, "Initiation and Growth of Explosions in Liquids and Solids," describes an experimental investigation into the mechanism by which an explosion can be initiated in a liquid or solid. "Fast Reactions in Solids" deals with subsequent researches in the field, particularly with the mechanism by which an explosive crystal can decompose when

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch035

subjected to heat, light, shock, or nuclear radiation. The review article by Maček surveys the fundamentals underlying the practical problem of the sensitivity of explosives, dealing with the basic question of the thermal decomposition of explosives, and discussing the general problem of the transition from deflagration to detonation. A bibliography of 140 references is included.

Theoretical aspects of explosive reactions have frequently been discussed at symposia which form a useful source in this area. Combustion symposia were held in 1948, 1952, and every two years thereafter. The papers usually are published in a single volume a year or two after the symposium is held.

The Office of Naval Research held the second and third symposia on detonation in 1955 in Washington, D.C., and in 1960 at Princeton University.

"A Discussion on Detonation" and "A Discussion on the Initiation and Growth of Explosion in Solids," held by the Royal Society were published in 1950 and 1958.

The "International Conference on the Sensitivity and Hazards of Explosives," held in 1963, covered experimental studies of shock initiation, theoretical studies of shock initiation, initiation processes, explosives technology, and tests and assessment.

A general discussion of the Faraday Society took place in September, 1956 at the University of Glasgow on the subject "The Physical Chemistry of Processes at High Pressures." The discussion included detonation and other high-temperature phenomena at high pressures, and is published as "Discussions of the Faraday Society No. 22."

Other symposia of interest are the earthquake symposium and those held by the American Physical Society, for example one held in January, 1954, on shock waves in liquids and solids. Abstracts of papers are published in *Physical Review.*

The periodicals which occasionally contain articles on explosion theory, in addition to those listed in Section I, are shown in Section V.

Those active in the field of explosives research will realize that the sources listed here will not provide the entire collection of reported work in the field. Since much of the research being done is of military interest, some of the recent reports are government-classified. Therefore, for those working for U.S. government agencies or their contractors, these sources will form only a part of their reference collection. Much of their information will be obtained from other agencies or contractors directly, or through a government information agency. However, it is hoped that, despite the restrictions imposed by security, these sources will be useful to all workers in this field.

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Journal of Chemical Physics, American Institute of Physics, monthly.

Journal of Fluid Mechanics, Cambridge University Press, 200 Euston Rd., London NW1, England, monthly.

Physics of Fluids, American Institute of Physics, monthly.

Proceedings of the Royal Society (London), Series A: Mathematical and Physical Sciences, Royal Society, Burlington House, Piccadilly, London W1, bimonthly.

Research (London), Butterworth & Co., Ltd., 88 Kingsway, London Wc2, monthly.

Review of Scientific Instruments, American Institute of Physics, monthly.

Russian Journal of Physical Chemistry (English translation of *Zhurnal Fizicheskoi Khimii*) Chemical Society, London, monthly.

Transactions of the Faraday Society, Faraday Society, 6 Gray's Inn Square, London WC1, monthly.

NOTE: AD = ASTIA Document
PB = Publication Board
OSRD = Office of Scientific Research & Development (World War II agency of U. S. Government).

Inquiries concerning AD, PB, OSRD, and other reports issuing from U. S. Government agencies can be addressed to the Clearinghouse for Scientific and Technical Information, 5285 Port Royal Rd., Springfield, Va. 22151, or to a Field Service office thereof.

U. S. Patent Classes for Explosives

Class 149—Explosive and Thermic Compositions or Charges
    All subclasses
Class 102—Ammunition and Explosive Devices
    All subclasses
Class 86 —Ammunition and Explosive-Charge Making
    All subclasses
Class 85 —Driven, Headed, and Screw-Threaded Fastenings
    Subclasses 1-9—Bolts
        37,40—Rivets
Class 73 —Measuring and Testing
    Subclass 35—Explosive-Detonation or Knock
Class 23 —Chemistry
    Subclass 266—Explosives
Class 29 —Metal Working
    Subclass 254—Percussion or Explosive Operator
        428–559—Assembly and/or Joining
Class 166—Wells
    Subclass 36—Processes with explosion
        55.4–55.5—Projectile-type Perforating Means
        63—Processes with Explosive or Gas-Generating Means in Well
Class 181—Acoustics
    Subclass .5—Miscellaneous (Includes Seismic Prospecting)
Class 18—Plastics
    Subclass 59.2–59.3—Compacting Particles to Form Coherent Mass

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The Literature of Rocket Propulsion

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Because of the interdisciplinary nature of rocket propulsion, its literature is scattered throughout many fields such as chemistry, physics, mathematics, mechanical and chemical engineering. The principal types of primary and secondary sources include abstract journals, indexes, bibliographies, surveys, reviews, periodicals, and society publications, symposia, conferences, books, government publications, and research reports. The bibliography includes about 500 titles.

The literature of rocket propulsion includes both combustion and non-combustion systems. Beginning with pyrotechnics, rocketry proceeded to ordnance, first projectiles, then missiles carrying warheads, and finally to the propulsion of vehicles, both single and multiple staged, manned and unmanned, for a wide range of applications, from terrestrial flight to interplanetary and interstellar missions. The literature of rocketry is concerned with engines, vehicles, and missions in advance of the existing technology, treated theoretically and tested step-by-step in the laboratory.

So far the hardware in flight has been put there by chemical propulsion, using solid or liquid propellants. In recent years liquid and solid propellants have been combined into hybrid propellants. Research in propellant composition, handling, and performance, in combustion, flames, ignition, and detonation and in the design of engines and components has continued under increasing needs for higher energies, larger payloads, and greater reliability.

As new technologies developed, a literature of "atomic" or "nuclear" rockets began to appear in the 1940's (*6*). As interest in astronautics increased and as the field of nuclear energy opened up, research in plasma physics (or the physics of ionized gases) expanded rapidly. Among the geometries of interest were those suitable for spacecraft, and electric propulsion became an area of extensive research. Electrostatic propulsion and arc and MHD (magnetohydrodynamic) plasma propulsion, with their ion engines, arc jet engines, and MHD engine systems, appeared in a rapidly growing literature. This literature continued to deal with even more advanced systems, such as solar propulsion and the photon rocket.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

The structure of the literature is about the same as that of any other discipline of engineering science. It includes highly organized treatises, monographs, and textbooks at various levels; periodical and society publications appearing serially at various frequencies; symposia, conferences, commemorative and other volumes by several authors; abstract journals and indexes; bibliographies; surveys and guides; government publications; government-sponsored research and development reports; dissertations and theses; patents; specifications and standards; and trade literature and manufacturers' bulletins. It is a literature which reaches into a number of underlying and related disciplines.

The Interdisciplinary Nature of Rocketry

The literature of chemical propulsion has natural roots in the literature of chemistry, including such *Chemical Abstracts* categories as Physical Chemistry, General Industrial Chemistry, and Explosives and Explosions. These in turn reach into the literatures of physics, chemical engineering, and mechanical engineering. Crane, Patterson, and Marr (*2*) point out the relation of the literature of physical chemistry to that of physics and list some principal journals.

The reader wishing to explore the extent of the literature of chemical propulsion in the literatures of chemistry, physics, and the engineering fields may do so readily by scanning the sample provided by the references in one or more books. Some good sources for this purpose are Barrère's "Rocket Propulsion," Kit's "Rocket Propellant Handbook," Siegel's "Energetics of Propellant Chemistry," Sutton's "Rocket Propulsion Elements," and Wilkins' "Theoretical Evaluation of Chemical Propellants."

The newer forms of propulsion are rooted in the literature of physics. Adding related disciplines of electrical and electronic engineering we note that physical chemistry, chemical engineering, and mechanical engineering are represented in the literature of nuclear, nuclear-electric, electrostatic, and plasma propulsion, as well as chemical propulsion. Nuclear engineering and plasma physics are disciplines of prime importance. Because of the greatly increased range of environmental conditions under which rocket-propelled vehicles are expected to operate, astrophysics becomes important, and atmospheric physics interest is extended across the entire range from the planetary surface to interplanetary space. The environmental conditions within and outside of the engine involve extremes of temperature and pressure, radiation effects, and a wide variety of safety considerations. The need is intensified for such related literatures as those of cryogenics and vacuum techniques. Instrumentation is essential in basic research, testing, and operation, and its extensive literature is constantly used in rocketry. The literature of applied mathematics, particularly on numerical methods and computer applications, is of increasing importance.

Two widely used papers of mathematical interest are the three-part paper by L. I. Rozonoér on the "L. S. Pontryagin Maximum Principle in the Theory of Optimum Systems," (*4*) and a later paper by V. K. Isaev on "L. S. Pontryagin's Maximum Principle and Optimal Programming of Rocket Thrust" (*3*).

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Combustion, heat and mass transfer, internal fluid flow, acoustics, and optics are other interdisciplinary fields widely applicable to rocket propulsion.

Abstract Journals and Indexes

The interdisciplinary nature of the literature of rocket propulsion is reflected in the list of abstract journals and indexes listed in the bibliography. The scientific and technical disciplines mentioned above are represented. Most of the types of literature are represented, and the needs of advanced theoretical research, experimental research, and technical development are all covered. Serious work in rocket propulsion requires the use of the standard archive repositories of abstracts in the physical sciences and engineering, covering the original contributions in journals and reports, symposia and conferences, and dissertations.

The use of abstract journals and indexes in literature searching in rocket propulsion has been discussed in part in a previous paper (5). The number of secondary sources needed for a systematic search can vary from one to a dozen, depending on the extent of the search, the required time of delivery, and the subject. The rate of return from abstract journals can diminish going backward in time, and the use of authors' citations in papers located during the progress of the search may prove to be time-saving and sufficient, but the exhaustive search, involving prior arts and all related minutiae, can well require the use of secondary sources going beyond those listed in this paper. For the most part, the titles in the bibliography apply to disciplines of broad scope, which include rocketry or special aspects of rocketry within their fields of interest. Of more than 40 titles listed, only the publications of the American Rocket Co. (*Rocket Reviews*) and the Chemical Propulsion Information Agency Abstracts deal exclusively with rocketry. One section of the *Referativny Zhurnal* deals with rocket technology and space vehicles. In all other cases, rocket propulsion is included within a wider discipline or in a wide coverage of a particular type of literature.

The chemical and chemical engineering aspects of rocket propulsion receive excellent coverage in *Chemical Abstracts,* and nuclear propulsion is covered well in *Nuclear Science Abstracts. International Aerospace Abstracts* includes all aspects of rocket propulsion, as do *Applied Mechanics Reviews* and the *Engineering Index.* Together, these five titles cover the journal and book literature of rocketry and are among the most widely available and most firmly established abstract journals and indexes applying to the subject. A few remarks about their coverage of the report literature is in order.

International Aerospace Abstracts came under the sponsorship of the National Aeronautics and Space Administration (NASA) in 1963. It is published by the American Institute of Aeronautics and Astronautics (AIAA), which was formed in 1963 by the amalgamation of the Institute of the Aerospace Sciences and the American Rocket Society. Its aim is "world wide coverage of books and scientific and trade journals on aerospace science and technology." It covers also meeting preprint papers of the AIAA and other societies interested in rocket propulsion.

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Before 1963 *International Aerospace Abstracts* was published under the sponsorship of the U.S. Air Force by the Institute of the Aerospace Sciences, first as a yellow page section in the monthly publication *Aerospace Engineering,* then as a separate monthly publication beginning in 1961. Under Air Force sponsorship it covered reports as well as journals, books, and preprints. Under NASA sponsorship reports are covered by *Scientific and Technical Aerospace Reports* (*STAR*).

In 1960 *Chemical Abstracts* began to cover reports as abstracted in *U.S. Government Research and Development Reports. Applied Mechanics Reviews* has always covered selected reports, and the *Engineering Index* has for many years covered such series as the *Technical Reports, Technical Notes,* and *Technical Memorandums* of the U.S. National Advisory Committee for Aeronautics (NACA, 1915–1958); the *Technical Notes* and *Technical Reports* of NASA; the *Bulletins* and *Reports of Investigations* of the U.S. Bureau of Mines; and the reports or bulletins of the state engineering experiment stations.

As discussed above in relation to the changed character of *International Aerospace Abstracts* in 1963, NASA, which was established in 1958 to succeed NACA, provides its laboratories and contractors with *Scientific and Technical Aerospace Reports* (*STAR*) and *Classified Scientific and Technical Aerospace Reports* (*C–STAR*). *C–STAR* is available only to organizations which have established their security clearance and "need-to-know" with NASA. *STAR* represents a change in coverage from the former *NACA Research Abstracts* and the *Technical Publications Announcements* of NASA. These were concerned originally with NACA and NASA formal publications and did not include contractor reports to NACA and NASA unless they were issued in one of the formal series, such as the *Technical Notes* or the *Technical Reports.* There were occasional exceptions, principally in regard to British and other overseas reports received. Beginning with Vol. 2, No. 1, April 1962, the *NASA Publications Announcements* included both NASA reports and non-NASA reports. Until the end of 1962 the extended coverage included some journal articles and other commercially available publications. When *STAR* was established in 1963, its coverage included the report literature only. The indexes of NACA and NASA publications include only the report series of those agencies, without abstracts.

The Department of Defense provides its laboratories and contractors with the *Technical Abstract Bulletin* and *Chemical Propulsion Abstracts.* These are available only to "qualified users"—*i.e.*, to federal military agencies and Department of Defense contractors who have registered through the appropriate office of their sponsor as users of the services of the Defense Documentation Center, including the *Technical Abstracts Bulletin* and the *Chemical Propulsion Abstracts.*

The Atomic Energy Commission issues *Nuclear Science Abstracts* to its laboratories and contractors. Its scope has reflected changes and expansions in the research programs pertaining to atomic energy, and the example set by *Nuclear Science Abstracts* has clearly influenced the development of indexing and abstracting services by agencies of the federal government, particularly in regard to the bibliographical control of reports.

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A conscientious effort is made to make these abstract journals available to the scientific community at large. *STAR, International Aerospace Abstracts,* and *Nuclear Science Abstracts* are available by subscription. The official agencies for public servicing of research report needs are the U. S. Government Printing Office and the Clearinghouse for Federal Scientific and Technical Information. The Clearinghouse was established in July 1964 to succeed the Office of Technical Services (OTS), which had been operating within the U. S. Department of Commerce since 1946. Its publication, *U. S. Government Research and Development Reports,* continues under the Clearinghouse and is available by subscription.

The U. S. Government Printing Office, through the Superintendent of Documents, announces publications of agencies of the federal government in the *Monthly Catalog of United States Government Publications,* without abstracts. Included are the publications sold by the Superintendent of Documents and those available directly from the issuing agencies. The *Monthly Catalog* includes also many publications available from the Clearinghouse.

Remarks are appropriate here on the development of the present Defense Documentation Center (DDC) and its cooperation with the present Clearinghouse. DDC was originally established in 1953 as the Armed Services Technical Information Agency (ASTIA), through an amalgamation of the Air Force Central Air Documents Office (CADO) and the Navy Research Section at the Library of Congress.

In July 1961 the white pages of the *Technical Abstract Bulletin,* covering security unclassified reports, were incorporated in the semimonthly issues of *U. S. Government Research and Development Reports,* and the Office of Technical Services undertook the sale of copies of the reports abstracted. The Clearinghouse continues this practice under a revised schedule of prices.

Table I. Principal Abstract Journals and Indexes and Their Coverage of Principal Types of Literature

	Books	*Journals*	*Government Publications and Reports*	*Dissertations*	*Patents*
Aerospace Engineering Index	x	x	x		
Applied Mechanics Reviews	x	x	Selected		
Chemical Abstracts	x	x	Selected	x	x
Engineering Index	x	x	Selected		
International Aerospace Abstracts	x	x	x (to end of 1962)		
Mathematical Reviews	x	x	Selected		
Monthly Catalogue			x		
Nuclear Science Abstracts	x	x	x	x	x
Science Abstracts	x	x			
Scientific and Technical Aerospace Reports (STAR)			x		
Technical Abstract Bulletin			x		
U.S. Government Research and Development Reports			x		
U.S. NASA Technical Publication Announcements	x (April-Dec. 1962)	x (April-Dec. 1962)	x		

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch036

Table I lists some principal abstract journals and indexes with the types of literature they cover. This is indicated in some detail above, particularly in relation to the report literature, which is important for research in rocket propulsion. A large amount of it is available, and familiarity with the abstract journals and indexes covering the report literature is essential for literature searching in rocketry. The new searching tools reflect a growing, more timely, and more varied literature and concern for its control by the government agencies most directly responsible for the sponsorship and execution of research and development in rocket propulsion.

Among the recent developments in the report-covering abstract journals has been the indexing of corporate sources and report numbers, as well as the traditional author and subject indexing in each issue, cumulating quarterly, semi-annually and annually. *Nuclear Science Abstracts* set the example for parts of this versatile and prompt indexing some years ago and brought it to its present form in 1959. A government-wide index, amalgamating those existing but not replacing them, began publication in 1965.

Chemical Titles is a valuable source of prompt announcements in the field.

Bibliographies, Surveys and Guides

Many of the published papers and reports in the field of rocket propulsion provide in their introductions or in sections reviewing previous or related work a survey of a specialized field. Written by specialists active in research, these are most valuable to the searcher, and research people often do not require more than one or two recent papers, citing the important references.

The survey by the specialist to establish the state of an art may cover a wider field. A list of several dozen on such subjects as propulsion and power, combustion and propellants, vehicle performance and operation, and heat transfer is given in the bibliography. Some general bibliographies and some general serial reviews issued annually or less frequently are listed also. A few of the bibliographies are compilations by librarians in cooperation with scientific and technical staff, but most are the work of authorities. They come from journals, review serials, reports, conference proceedings, and government publications. The list is representative but by no means complete.

The organization of author's literature citations on a broad scale makes their systematic use possible and is especially valuable in providing entry to the literature at any point in time. The "Science Citation Index" published by the Institute for Scientific Information in Philadelphia, includes principal journals in the physical sciences and therefore has a potential value for literature searching in rocket propulsion.

Periodicals and Society Publications

The periodicals used most by rocket people are naturally the publications of the societies whose members are directly concerned with research, development, design, testing, production, and operation of rocket propelled vehicles. Some examples include the publications of the American Institute of Aeronautics and Astronautics and its predecessors, the American Rocket Society

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch036

and the Institute of the Aerospace Sciences. The archive journals are the *Journal of Spacecraft and Rockets* and the *AIAA Journal,* which were preceded by the *ARS Journal* and the *Journal of the Aerospace Sciences.* The technical journal *Astronautics and Aeronautics* supersedes its predecessors, *Aerospace Engineering* and *Astronautics.*

The greater part of the papers of the American Astronautical Society is published in its *Advances in the Astronautical Sciences* rather than in its *Journal of the Astronautical Sciences.*

National societies in other countries with their own publications include the British Interplanetary Society, the Royal Aeronautical Society, the Canadian Aeronautics and Space Institute, l'Association pour l'Encouragement à la Recherche Aéronautique, l'Institut Français des Combustibles et de l'Energie, Deutsche Gesellschaft für Raketentechnik und Raumfahrtforschung, and Wissenschaftliche Gesellschaft für Luft-und Raumfahrt.

The important *Astronautica Acta* is published by the International Academy of Astronautics of the International Astronautic Federation. Some new journals include *Advanced Energy Conversion, High Temperature, Nuclear Applications, Pyrodynamics,* and *Revue des Hautes Température.* Among the journals established during the space age, the *Physics of Fluids* has been widely accepted from its beginning. During the 1950's, *Brennstoff-Wärme-Kraft, Combustion and Flame,* and *Explosivstoffe* appeared, continuing or branching off from older publications.

The abstract journals and indexes listed in the bibliography will provide the searcher with leads to specific rocket propulsion papers in the standard journals from the fields of applied mathematics, physics, chemistry, and engineering. Journal sources may also be pursued through the authors' citations in such books as those by Barrère, Bussard, Kit, Pederson, Ring, Seifert, Siegel, Stuhlinger, Sutton, and Wilkins.

Symposia and Proceedings

The symposium, the international, national, or regional conference and the volume in honor of the birthday or in commemoration of an eminent scientist are familiar customs in the scientific community. Their published form varies from a single volume to three or more for a large international congress and from carefully edited volumes to bound collections of papers printed "as received." Volumes of multiple authorship have increased rapidly in recent years. This category includes volumes of tutorial lectures and planned volumes whose chapters or sections approach monographic status.

The bibliography lists 130 titles of this kind. They form an appreciable part of the literature of rocket propulsion. Many are published through regular trade channels and thus become part of the book literature. Others are issued as part of the report literature. Examples of volumes from the report literature are the second and third ONR Symposium on Detonation, the seventh Symposium on Ballistic Missile and Space Technology, and the first Combustion Instability Conference.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch036

An example of a symposium published in a journal is the 15 papers on Combustion Instability in Solid Propellant Rockets, in the *AIAA Journal* (*1*).

Abstract journals and indexes vary in their treatment of symposia. *Chemical Abstracts, Nuclear Science Abstracts, International Aerospace Abstracts,* and *Scientific and Technical Aerospace Reports* abstract individual papers within their fields of interest. The *Engineering Index, Technical Abstract Bulletin,* and *U. S. Government Research and Development Reports* list the contents of symposia.

Books

Research in rocket propulsion has a firm basis in a growing book literature. The accompanying bibliography lists books on rocket propulsion; design, performance, and operation; combustion; and heat transfer and thermodynamics. The list can be expanded almost indefinitely into the extensive book literature of the underlying and related sciences and technologies. In the case of heat transfer and thermodynamics, for example, the number of titles goes beyond 50, not counting the items listed elsewhere under symposia and congresses. A working collection for research in rocketry goes considerably beyond the titles listed here.

This section includes some items distributed as reports. The "JANAF Thermochemical Tables" are compiled specifically for calculating rocket propellant performance.

Government Publications and Research Reports

National aeronautical research agencies were established soon after powered flight attracted wide attention. The earliest was the British Aeronautical Research Committee of 1909, now the Aeronautical Research Council (ARC). As previously mentioned, NACA was established in 1915 and was succeeded by NASA in 1958. Similar agencies and their national laboratories have existed for some years in France, the Netherlands, Sweden, and other countries.

The research and development agencies and laboratories of the military establishments in some cases preceded the aeronautical agencies by many years since ordnance, naval architecture, and other military disciplines were much older. As all technologies expanded, the laboratories of the defense establishments increased in number and size and included the new technologies in their programs.

With the advent of atomic energy, national agencies and laboratories in that field came into being. Their most prominent form of publication was the report, issued usually in a numbered series. This practice was continued by international agencies, such as the Advisory Group for Aeronautical Research and Development (AGARD) of the North Atlantic Treaty Organization (NATO) and the International Atomic Energy Agency.

An agency may publish its research in journal form, for example *La Recherche Aérospatiale* of the Office National d'Etudes et de Recherches Aérospatiale (O.N.E.R.A.), but reports in numbered series are more common in the cases of both the national aeronautical laboratories, the military labora-

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch036

tories, and the atomic energy laboratories. Publication in the established journals and in symposia of papers from these laboratories is widespread, and their scientists and engineers produce many books, but reports are still the most popular form.

In addition to the work carried out in these laboratories, the large volume of research sponsored by the national aeronautical agencies, the defense establishments, and the atomic energy establishments bring the considerable resources of industry and the universities into the picture. The results of the sponsored research and development work in industry and in the universities form a substantial part of the literature of rocket propulsion, much of it appearing in the journal and book literature, but even more in the voluminous report literature.

As in the case of the journals, the appropriate abstract journals and indexes, bibliographies and reviews, and the authors' citations encountered in the literature provide the best means for identifying the report series of interest in rocketry.

Dissertations

This paper has not done justice to the important and growing literature of doctoral dissertations and master of science or engineering theses. Some of the bibliography has been indicated, and dissertations or theses supported in part by government sponsored research are reported in the appropriate abstract journals. In the field of chemistry, dissertations have been reported for some years in *Chemical Abstracts*.

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1962	51. Propellants and Explosives
1963	28. Propellants and Explosives
1967	50. Propellants and Explosives

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37

The Literature of Rocket Construction Materials

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A review of the literature of rocket construction materials is complicated by a number of factors. Among these are the relative newness of the field, the variety, novelty, and complexity of the materials currently used in the various portions of a rocket, and the fact that a significant portion of the literature is classified or proprietary in nature. Within the limitations imposed by this situation, the literature review considers materials according to the region of the rocket in which they are used, types of materials, types of rockets, and technical problems encountered. The literature is available as periodicals, abstracts and indexing services, books and symposia volumes, and bibliographies.

A review of the literature of rocket construction materials is complicated by a number of factors. The discipline itself is not clearly defined, and the material problems relating to rockets are distributed over a wide and varied body of literature. Thus, one finds articles in periodicals devoted to rockets and missiles, aerospace, material science, metallurgy, ceramics, and plastics. In addition, a vast proportion of the literature is contained in government or industry reports, many of which require a "need to know" even if they are not classified or proprietary. Although the field is relatively new, the intense interest in aerospace problems has stimulated the production of a vast quantity of literature much of which is topical in nature, and there is a noteworthy lack of serious general reviews.

It is a great help in locating literature sources if the searcher is aware of some of the general materials problems in the rocket field. This allows him to confine his search to sources covering the proper kind of materials. It is especially important to realize that the environmental conditions to which rocket materials of construction are exposed run a gamut which extends from the

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In Literature of Chemical Technology; Smith, J.;
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cryogenic temperatures of liquid oxygen, nitrogen, and hydrogen to temperatures of from 5000-8000°F. which exist in the rocket throat. In addition, from a structural point of view, there are problems of vibration, noise, buffeting, fluttering, internal pressures, longitudinal thrust owing to the high acceleration and uneven heating caused both by aerodynamic friction and exhaust products. Furthermore, the materials employed must be resistant to the attack of extremely corrosive liquids and gases, light in weight, and of high reliability. The portion of the structure exposed to the atmosphere must be able to withstand high-temperature oxidation, and since the rocket may be designed for lengthy voyages in space, all components must be resistant to the effects of the space vacuum and radiation as well.

Liquid- and Solid-Propellant Rockets

There is a general difference between liquid-propellant rockets and solid-propellant rockets which is relevant to identifying and classifying material problems.

Liquid Propellant. The liquid-propellant rocket is designed around the fuel and oxidizer tanks in which the fuel and oxidizer (which may be either highly corrosive or cryogenic) are stored and fed to the turbo pump for delivery to the combustion chamber. This system involves considerable complex machinery, pumps, valves, piping, etc., all of which must be highly reliable. In general, the materials of construction for this type of rocket are high strength-to-density ratio metals such as magnesium, aluminum, titanium, and steel. Since the liquid rocket chamber is generally cooled by the circulation of propellant in the walls, it need not be made of an extremely refractory material, but strength, thermal conductivity, and vibration resistance are important.

Solid Propellant. The solid-propellant rocket is basically less complex since it is composed primarily of the solid fuel, the external case, and the rocket nozzle and exit cone. Solid-propellant rockets generally have a considerably higher acceleration than liquid systems; hence the thrust loads are higher, and the aerodynamic heating of the external skin may be quite severe. In addition, the solid system generates considerable pressure in the case so that high-strength materials are necessary. Since it is essential that the propellant remain intact and free from cracks during use, the system must be designed with a great deal of stiffness to eliminate bending. Finally, no cooling system is available for the rocket nozzle; hence recourse must be had to refractory or ablative materials. Thus, while the materials technology for liquid-propellant systems is based largely on metals, the materials technology for solid-propellant systems is frequently based on high-strength-to-weight composites which include (as well as metals) systems such as filament-wound plastics (for the casing) and either ceramics, refractory metals, or ablative plastics for the rocket nozzle.

Typical materials applications for solid and liquid rockets are indicated diagrammatically in Figures 1 and 2.

The problem of nuclear and related rockets is complicated by the requirement that many of the materials must withstand the effects of nuclear radiation as well.

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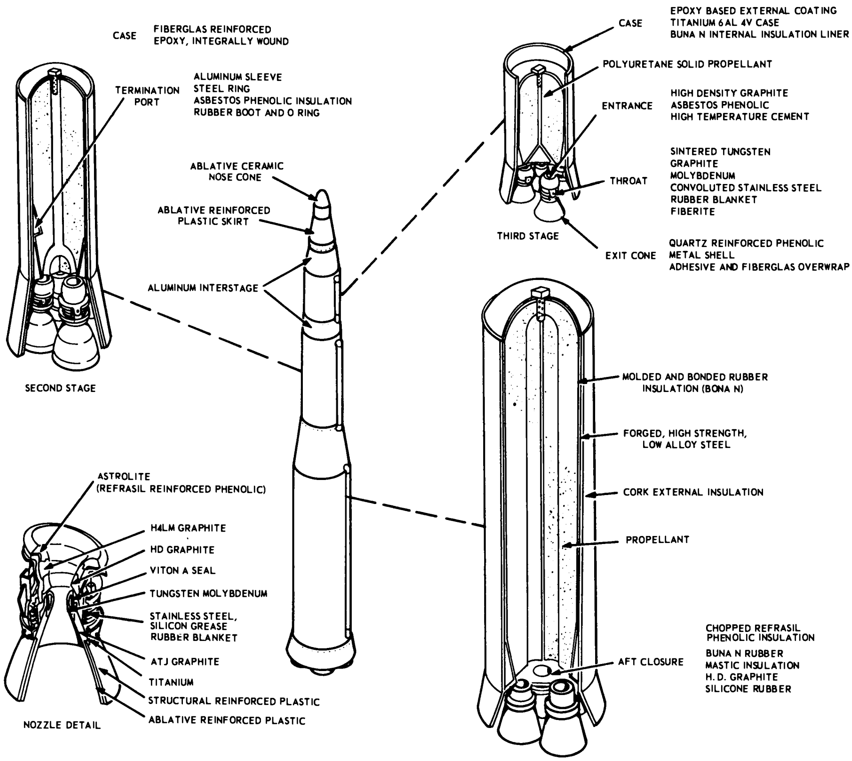

Figure 1. Representative materials in solid rocket construction (not to scale)

Future technological developments will complicate this somewhat over-simplified picture. Current work on "hybrid" systems, part solid and part liquid with problems and advantages of both systems, are an example, as is new work on expandable exit cones, partially liquid-cooled solids, and consumable cases.

In reviewing the literature, the term "rocket construction materials" has been taken to include all portions of the rocket, such as the case, fuel tanks, pumps, piping, insulation, nozzles, seals, lubricants, gaskets, and adhesives. Propellants are covered in another article in this book. Furthermore, the materials problems associated with the electronics and guidance and control portions of the system have been touched only indirectly.

General Abstracts and Indexes

Unclassified Literature. For the reader who is a nonparticipant in government contracts and has no "need to know," the best source is a combination of the *International Aerospace Abstracts,* which is published by the Technical Information Service of the American Institute of Aeronautics and Astronautics, and the *Scientific and Technical Aerospace Reports (STAR),* which is published by the Office of Scientific and Technical Information of the National Aeronautics and Space Administration (NASA). These two abstract services are coordinated; each is published twice a month so that one comes out each week. The *International Aerospace Abstracts* covers books, periodicals, and other published media. *The Scientific and Technical Aerospace Reports* covers scientific and technical reports of NASA and its contractors, scientific and technical reports of government agencies, universities, and research organizations throughout the world, and scientific and technical articles prepared by the Scientific and Technical Information Facility operated for NASA by Documentation Inc.

NASA is also the source for publications of the Advisory Group for Aeronautical Research and Development (AGARD). This group was initiated in 1951 and became an official agency of the Standing Group of the North Atlantic Treaty Organization (NATO) in 1954.

The technical activity of AGARD is conducted by panels of experts appointed from among the member nations. The approach is fundamental and the panels publish reports, manuals, and handbooks which are not only valuable

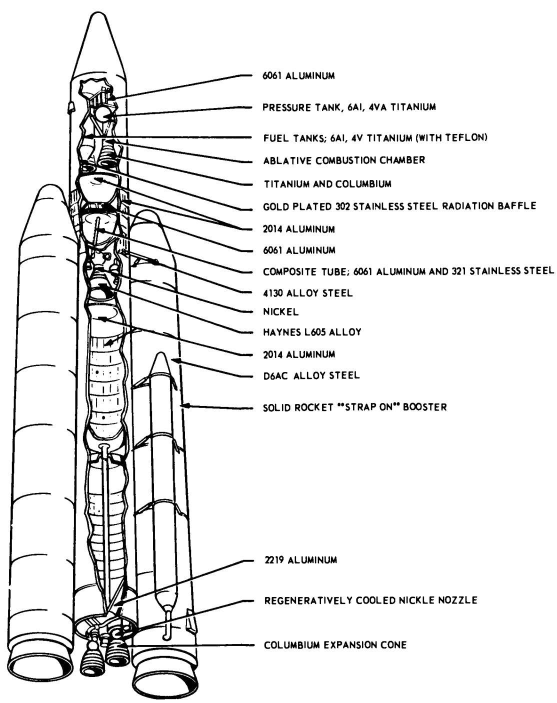

Figure 2. Representative materials in liquid rocket construction

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in themselves, but provide information on technical developments in some areas outside the U.S.

The "structures and materials" panel of AGARD was established in 1955. Among its functions are research and development problems of new structural materials, the application of modern methods of analysis to structure, aeroelastic analysis, and recently, composite materials and refractory metals programs.

During its existence, the panel has published handbooks on aluminum, steel, magnesium, nickel, and titanium; other handbooks on high-temperature alloys are in preparation.

The AGARD Technical Information Office has compiled an *AGARD Index* which contains titles and abstracts of all AGARD papers (published and unpublished) presented at AGARD meetings from 1952-1962. AGARD also publishes the *AGARD Information Bulletin* which provides a monthly listing of AGARD organization and technical report information. AGARD reports which have not been published may be obtained from NASA.

The Clearinghouse for Federal Scientific and Technical Information of the U.S. Department of Commerce provides extremely broad technical literature-searching services which cover all unclassified government research reports, patents, technical translations, and Atomic Energy Commission material. It will provide either a current periodic "awareness" bibliography, or a "retrospective" bibliography. The Clearinghouse has an information center which publishes U.S. government research reports (some 2000 new reports each month), technical reports and newsletters, and selected bibliographies such as "High Temperature Metallurgy and Heat Resistant Alloys" and "High Temperature Research."

A person with unclassified interests may also apply to the various Department of Defense information centers such as the *Defense Metals Information Center* at the Battelle Memorial Institute. This center collects and disseminates information on titanium, magnesium, beryllium, refractory alloys, high-strength alloys for elevated temperatures, surface corrosion, oxidation-resistant coatings, and thermal protection systems. The center is primarily oriented towards metals; however, it includes information on ceramic and organic materials where they are used as protective coatings, or as components of thermal protection systems. The center publishes outstanding reviews and state-of-the-art reports in its field.

Other Department of Defense information centers have recently been established to provide sources of specialized information. As of August 1964, those relevant to rocket construction materials are listed as follows: Chemical Propellant Information Agency, Applied Physics Laboratory, The Johns Hopkins University; Binary Constitution Information Service, I.I.T. Research Institute; Ceramics & Graphite Technical Evaluation Section, Research & Technology Division, Wright-Patterson Air Force Base; Electrical and Electronic Properties of Materials, Hughes Aircraft Company; Mechanical Properties of Materials, Belfour Engineering Company; Plastics Technical Evaluation Center (PLASTEC), Picatinny Arsenal; Radiation Effects Information Center, Battelle Memorial Institute; Thermophysical Properties Research Center, Purdue University; Centralizing Activity for Shock, Vibration and Associated Environment, U. S. Naval Research Laboratory; Nondestructive Testing Information Service,

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Watertown Arsenal. Addresses are listed in the bibliography. Only unclassified information will be supplied to those without clearance and a need to know.

The Engineering Index is a monthly bulletin published by Engineering Index Inc. which provides brief abstracts or articles of engineering importance. Information relevant to rocket construction materials may be found under headings such as Rocket-Engine Materials, Aircraft Materials, Refractory Materials, Aerodynamics, Missiles and Rockets, etc. The bulletin also lists specific materials and alloys such as, for example, titanium, beryllium, ceramics, etc.

Applied Mechanics Review, published monthly by the American Society of Mechanical Engineers, is a critical review of the world literature in applied mechanics and related engineering sciences. It provides a good source for references of rocket construction materials under such headings as, Prime Movers and Propulsion Devices, Mechanics of Solids, High and Low Temperatures, and Astronautics and Aeronautics.

As a supplement, the *Air University Library Index to Military Periodicals*, reviews 66 English language military and aerodynamic periodicals which are not indexed in readily available commercial indexing services. Headings are similar to those for the *Applied Mechanics Review*.

Among other sources which should be briefly mentioned are the indexing services of the *Pacific Aerospace Library*, the *Monthly Catalog of the United States Government Publications*, the *Index and Publications of the American Society for Testing and Materials*, the *Applied Science and Technology Index*, the *Battelle Technical Review*, the *JPL Astronautics Information Abstracts* (discontinued as of August 1963, material will be covered in *STAR* and *International Aerospace Abstracts*), *The British Technology Index*, and *Environmental Effects on Materials and Equipment* (Section B) published monthly by the Prevention of Deterioration Center, National Academy of Sciences-National Research Council. Other general sources are covered in the bibliography.

Classified Literature. For the individual with a need to know and who can complete the requirements for a facility clearance and the field of interest register at the Defense Documentation Center (DDC), this source provides by far the best access to both classified and unclassified literature. DDC publishes the *Technical Abstract Bulletin (TAB)* which is issued twice a month and lists all new reports in the DDC collection. *TAB* replaces the former *Air Technical Index and Technical Information Pilot*. DDC also publishes a *Bibliography of Bibliographies*, and a number of special bibliographies which are pertinent to rocket construction materials. Among these should be mentioned the unclassified bibliography on booster rockets, as well as classified bibliographies on *Compatibility of Rocket Fuels with Alloys and Plastics* (Confidential), *Filament Wound Rocket Cases and Pressure Vessels* (Confidential), *Aerospace Structures, Design and Analysis* (Secret), *Refractory Coatings for Metals and Alloys* (Unclassified), *Reinforced Plastics and Nonmetallics for Rocket Cases, Noses, Etc.* (Confidential). In addition, specialized bibliographies exist for seals, high-temperature lubricants, glass resin bonding, and fiber glass laminates (*see* bibliography).

In addition to DDC, individuals with clearance have access to all needed information in the various Department of Defense information centers described above and listed in the bibliography.

Prior to July 1963, the DDC was referred to as the Armed Services Technical Information Agency (ASTIA).

Current Periodicals. There are some 35,000, plus or minus 10%, scientific and technical journals in the world, and some 6200 in the U.S., not including patents and proprietary literature. A surprisingly large fraction of these contain information on rocket construction materials. Among the more productive sources are: *Missiles and Rockets, Aviation Week and Space Technology, Materials in Design Engineering, Astronautics and Aeronautics* (replaces *Astronautics,* the *Journal of Aerospace Sciences,* and the short-lived sequence to these, *Astronautics and Aerospace Engineering*), *AIAA Journal, Journal of Spacecraft and Rockets, Interavia, Royal Aeronautical Society Journal, Astronautics and Aeronautics, American Ceramic Society Bulletin, Space/Aeronautics, Astronautic Acta, British Interplanetary Society Journal, Industrial and Engineering Chemistry, Materials, Research & Standards, Chemical Abstracts, Journal of Metals, Journal of Applied Polymer Science, Revue Francaise d'Astronautique, Raketentechnick und Raumfahrtforschung,* and *Cryogenics.* Also worthy of note are the various state-of-the-art reports on structures and materials which are included in publications such as *Astronautics, Applied Mechanics Review,* and *Materials in Design Engineering.*

Technical Meetings and Symposia. Most of the journals and periodicals interested in rocket construction materials or other phases of rocketry publish advance notice of technical meetings and symposia of interest. In addition, the Special Libraries Association publishes an alphabetical listing of scientific, technical, and engineering organizations and universities that are sponsoring national and international meetings, symposia, and colloquia. The Special Libraries Assoication publishes *Scientific Meetings* three times a year; appearing in January, with supplements in May and September. The collections of papers and symposia which are often published as a result of these meetings are an important source of information in the field. A number of these are listed in the bibliography under "Books and Symposia."

Books. There are few books which are completely devoted to the general problems of materials of construction for rockets. Typical are, "Materials for Rockets and Missiles," by R. G. Frank & William Zimmerman, published by Macmillan in 1959, which, although out of date, provides tabular information on metals for the design engineer, and "Materials for Missiles and Spacecraft," edited by E. R. Parker and published by McGraw-Hill in 1963. The latter is based on a series of lectures sponsored by the University of California and provides a broad look at a number of problems which concern the materials engineer interested in rockets. In addition are the "Handbook of Astronautical Engineering," edited by H. Koelle and "Space Technology," by H. S. Seifert. Other sources which should be mentioned are "Advances in Cryogenic Engineering," Vols. 1 through 13, "Advances in Astronautical Sciences," published by the Plenum Press, "Progress in Astronautics & Aeronautics" (originally "Progress in Astronautics & Rocketry," edited by Bollinger *et al.,* and the

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AGARD Handbooks. In addition to the books oriented towards aerospace, the literature may be approached through a number of books on the physics or engineering of materials. Examples are, "Introduction to Solids," by Azaroff, and "Structure of Metals: A Modern Conception," by Raynor *et al.*

A number of other books and symposia are listed in the bibliography.

Bibliography. In compiling the bibliography, an attempt has been made to include references from a wide variety of sources in both the published literature, government sources, and, where possible, proprietary reports. It is not exhaustive; the bibliographies and indexes listed will provide further references. No attempt has been made to evaluate critically the sources in the bibliography. Very little foreign material has been included since (with the exception of the Soviet Union) the rocket construction programs outside the U.S. are still at a stage in which the primary reliance is on literature generated in this country.

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U. S. Patent Classes and Subclasses

Rocket	*Class*	*Subclass*
Aeronautics		
Airplane sustentation and propulsion	244	12
Airship sustentation and propulsion	244	29
Propulsion	244	74
Propulsion airplane sustained	244	15
Sustentation	244	23
Launchers	89	1.7
Motors	60	200+
Propulsion		
Aircraft	244	74
Composition for		
Self sustaining	149	
Explosive projectiles	102	49
Marine	115	11+
Pyrotechnic	102	34+

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38

Aerosol Industry Literature

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The remarkably quick acceptance of push-button, pressurized products by the consuming public has given birth to an entire new industry, popularly known as the aerosol industry. Although this industry is rapidly reaching maturity, if not already there, its technical literature is sparse compared with older, well-established industries. The bulk of the aerosol industry's technical literature is published in two trade magazines and in the proceedings of its trade association, the Chemical Specialties Manufacturers Association (CSMA). Additional literature is found in the technical bulletins of component suppliers and in the literature of industries allied to the many types of aerosol products produced.

The aerosol industry is composed of the companies engaged in manufacturing and marketing pressurized products. A vital part of the industry is made up of the suppliers of chemicals, containers, valves, packing machinery, and propellents. The diversity of aerosol products results in a very broad coverage of consumer markets including cosmetic, household, pharmaceuticals, and industrial markets. All aerosol products have the common characteristic of being packaged under pressure so that the material in the aerosol container is dispensed as a spray, foam, or paste by actuating a simple, finger-tip valve.

The use of the term aerosol to describe this industry is somewhat misleading, particularly to the scientist, but through common usage, the word aerosol has come to be the generic term describing push-button, pressurized packages. The early products of this industry were truly aerosols in that the first pressure-packaged insecticides produced sprays of sufficiently fine particles to be classified as true aerosols in the scientific sense. The term was never relinquished even when such products as shaving lathers were first marketed. Although many aerosol products today meet the scientific definition, the majority do not.

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Literature

As one might expect, in the case of a relatively new industry, the volume of technical literature available to the researcher is small. This statement should be qualified to include technical literature specific to the subject of aerosols. One must remember that very few aerosol products are entirely new. Most are based on active ingredients which have been known for some time, and the literature on a specific active ingredient may be voluminous but would be found elsewhere than in the aerosol literature. Thus, the common insecticides are well documented in the insecticide industry's literature while the aerosol industry's literature may only discuss them from the formulating standpoint. The researcher should keep this point in mind so that he does not miss a valuable source of information by depending upon the aerosol literature alone.

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Books

Two comprehensive volumes have been written on aerosols (*1*,*3*); both are divided into chapters dealing with principles, techniques, packaging components and products. The chapter titles indicate the range of technical subjects which concern the aerosol industry. In addition to the chemical problems of formulating and the end-use applications, the researcher must be well versed in the technology of valves, containers, and propellents. The volume edited by Shepherd *et al.* (*3*) is a valuable reference in technical areas unique to the aerosol industry. Each chapter of this book is written by an expert in his field. Sagarin also has written a detailed technical account of cosmetic aerosols (*2*) which includes considerable basic data on the science of aerosols.

Journals, Trade Publications, Proceedings, and Annuals

The trade association of the aerosol industry is the Chemical Specialties Manufacturers Association (CSMA). Through its Aerosol Division, considerable technical and marketing information is disseminated. This association meets biannually, and the technical papers presented at these meetings are published in the Association's proceedings (*17*). These are a valuable source of current technology. The official monthly publication of the CSMA is the periodical *Soap and Chemical Specialties* (*19*). This magazine and *Aerosol Age* (*4*) contain the bulk of current articles on the aerosol industry.

A number of other periodicals (*7, 10, 12, 15, 16*) directly related to other fields frequently contain pertinent articles on aerosols. As expected, these articles are confined to the particular field of interest of the periodical. Similarly the journals (*8, 13, 14, 18*) of scientific societies whose interests include materials which may be packaged as aerosols will occasionally contain specific articles on aerosols. These can be a valuable source of detailed information on a given class of products.

Besides the domestic periodicals mentioned, two monthly European publications (*5, 11*) are available which cover industry developments in Europe. While both periodicals tend to lean heavily on review articles, they also contain reports on original work.

Patents

During the past 19 years several hundred patents relating to the aerosol industry have been issued. The majority of these are mechanical patents covering valve and container designs, but several are basic in nature, disclosing considerable technology on aerosol systems and products. The efforts of some early inventors of aerosol containers are described in patents by Helbing and Pertsch (*23*), Gebauer (*21*), Moore (*25*), Mobley (*24*), and Rotheim (*26*). The work of Goodhue and Sullivan (*22*) resulted in what became known as the "insecticide bomb." Two of the periodicals (*4, 19*) mentioned earlier contain a monthly patent digest which the researcher will find helpful in keeping abreast of the current patent literature.

Mention certainly should be made of the bulletins and other trade literature available from suppliers to the aerosol industry. The propellent manufacturers have been especially prolific in supplying useful technical data through their company publications. Probably the most valuable data supplied by the propellent manufacturers are the extensive tables of thermodynamic properties of the propellent gases. Properties covered include not only those of the individual propellent gases, but also mixtures of the gases. The latter are far more widely used than the individual compounds. Lists of bulletins available probably can be obtained by writing directly to these companies. A comprehensive directory (*20*) of companies directly concerned with the aerosol industry, as well as suppliers, is published by the CSMA.

The analytical procedures and test methods used by the aerosol industry are not conveniently compiled in a single publication. However, the CSMA has published an aerosol guide (*9*) which contains several test methods specifically concerned with the aerosol package in addition to a number of technical compilations prepared by scientific committees of this Association. The researcher is advised to consult a second publication (*6*) of the CSMA concerned with government regulations pertinent to the aerosol package. The fact that aerosols are pressure packages has given rise to a variety of regulations, particularly concerning shipment. Any study of the industry should include these regulations since in many instances they severely limit the type of container and formulation which can be marketed.

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39

The Literature of Agricultural Pesticides

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This guide to the major sources of literature concerned with agricultural pesticides includes references to the early literature; general abstracting journals and listings; general pesticidal information; insecticides; fungicides, nematocides, and soil fumigants; herbicides; toxicology; residue analysis; and pesticide development and patents. The more important books, articles, and serials in each category are considered. A comprehensive bibliography is included.

The use of chemicals for plant protection dates back to Biblical times. In the past twenty years, however, progress has increased rapidly, and many complex problems have arisen. One does not have to go to the scientific literature to find instances in which the use of pesticides has caused great public concern. The newspapers almost daily make some reference to health hazards which have occurred. The amount of research related to pesticidal problems has resulted in a vast literature dealing with the use, application, development, modes of action, and other properties of pesticides. Since this literature does exist and is continuously growing, the investigator must spend a great deal of time searching the literature. It presents a great challenge to the newcomer. The situation is complicated because there are three relatively unrelated areas of pesticidal research—insecticides, fungicides, and herbicides. Each of these broad groupings has a similar function and yet differs in its characteristics because of the types of organisms to be controlled and the environmental conditions under which the chemicals are used. This paper presents a guide to familiarize the newcomer with the pertinent literature sources concerning pesticides and to assist scientists currently engaged in pesticidal research. Since the subject of pesticides embraces various topics, it is impossible to discuss each phase in detail, and no attempt has been made to do so.

Language barriers confront most scientists. However, because of the nature of the pesticide industry the problem is not as great here as in other areas of

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research. With few exceptions, pertinent literature is published in American and British journals or has been translated into English. Thus, the sources of literature in this paper are almost entirely limited to journals published in English.

A brief description of the type of information expected from the various texts and journals which deal primarily with pesticides is included in each section. Books and journals which infrequently contain information related to pesticides are listed in the bibliography. Reference books, with few exceptions, are restricted to those which have been published within the past ten years, and only the latest edition of any text is cited. Some state experiment stations have published many bulletins directly or indirectly concerned with pesticides; however, space and time do not permit the listing of these publications. Those bulletins of scientific value are commonly referred to in reference books and journals and can be acquired by writing to the respective experiment stations.

References to the Early Literature

Even though the pesticide industry expanded most rapidly during the past 20 years, there is some early information that remains important and to which reference should be made. It is intended that these citations serve primarily as a guide to the early literature.

Frear reviews the pertinent literature in his two-volume series, "A Catalogue of Insecticides and Fungicides." He lists approximately 6,000 references and has tabulated the properties of almost 10,000 pesticidal compounds of synthetic and plant origin. In his book, "Insect Control by Chemicals," Brown discusses the use of the early insecticides, structure-function relationships, equipment used to apply the chemicals, and toxicity and hazards to animals. The American Chemical Society has published a collection of papers in its ADVANCES IN CHEMISTRY SERIES on the uses, toxicity, and residues of certain early insecticides. Gough has reviewed the literature relating to soil insecticides in "A Review of the Literature on Soil Insecticides." Another source of general information on insecticides is West and Campbell's, "DDT and Newer Persistent Insecticides." Hoskins and Craig's review article, "Organic Insecticides" relates general information on the ramifications of insecticides. Authors of review articles concerning the early development of a specific compound or group of compounds are Bowen, Busbey, Carter, and Roark and Busbey. A valuable reference on early herbicides is an article by Zimmerman and Hitchcock entitled "Plant Hormones." They discuss the phenoxy-type growth regulators which were developed during the 1940's. Textbooks by Klingman, and Crafts and Robbins should also be consulted. Horsfall's "Principles of Fungicidal Action" and Sharvelle's "The Nature and Uses of Modern Fungicides" review the early development of fungicides.

General Abstracting Journals and Listings

Abstracting journals provide one of the easiest methods of keeping up with the current literature and finding pertinent information on a new subject. Several abstracting journals contain articles pertaining to pesticidal research.

Chemical Abstracts is very useful, and titles of the articles are listed in *Chemical Titles*. Much of the information in *Dissertation Abstracts* is usually published elsewhere, but occasionally valuable papers can be located only through this journal. *Biological Abstracts* and *Tobacco Abstracts* are also valuable. The Federal Government publishes several bulletins annually which contain information on pesticides; these are listed in the *Monthly Catalog of U. S. Government Publications*. The titles of publications from the Agricultural Research Service are published semiannually in the *List of Publications of the Pesticide Chemicals Research Station*. Other journals which publish article titles and are valuable for locating articles concerned with a specific topic are listed in the bibliography.

General Information

Books and journals concerning agricultural pesticides are numerous. "The Pesticide Handbook," which is revised annually, is a source for the trade, common, and chemical names, and names of manufacturers; and usage for all types of pesticides. Antidotes, the compatibility of certain pesticides, their hazards and residue tolerances are also described. Frear has listed in "Pesticide Index" all the pesticides marketed and has included detailed information on the chemical properties of the pesticides. A third book by Frear, but somewhat out of date, is the "Chemistry of the Pesticides." An extremely useful book which contains information not included in Frear's books is the "Farm Chemicals Handbook." It is revised annually and contains information on fertilizers, annual consumption and production of chemicals, and a list of distributors and manufacturers. The information on fertilizers is becoming extremely important in view of the trend to combine pesticides with fertilizers prior to application. In his two books, deOng discusses the principles of pest control and gives a limited amount of more specific information. Martin's "Guide to the Chemicals Used in Crop Protection" is a well-organized book relating information on various chemicals. The World Health Organization has published "Specifications for Pesticides, Insecticides, Rodenticides, Molluscicides, Herbicides, Auxiliary Chemicals, Spraying, and Dusting Apparatus" which serves as a very good guide. Until 1956, the Federal Government published a bimonthly report which included information about new chemicals. Although the journal is now defunct, much of the information is still useful. The serial, entitled *National Research Council: Chemical-Biological Coordination Center, Summary Tables of Biological Tests*, contains listings of the types of tests conducted, the screening agency, empirical formula, and the name of the compound. Three additional texts by Rose, Rudd, and Martin contain general information about the control of various pests. Current information on the development of new pesticides can be followed in such journals as *Chemical Age* and *Farm Research*. Most companies which produce agricultural chemicals publish a house organ which is solely or partially concerned with the progress of developing their own agricultural chemicals. Review articles relating to the interaction of soil microorganisms and pesticides can frequently be found in the *Annual Review of Microbiology*. Contamination of natural water streams and

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reservoirs has attracted much attention, but serials which contain information on this subject are not found in many libraries.

Insecticides

Chemicals used as insecticides have in the past received the greatest amount of interest because of the importance of insects as predators of crops and because of the animal and human hazards involved. Generally speaking, the LD_{50} values (dosage needed to kill 50% of a given population) of insecticides are much lower than for most other pesticides. As a result of this high degree of toxicity, greater precautions must be exercised in the use and application of insecticides, and much interest has been shown in the areas of residues, modes of action, and mammalian toxicity.

One text which provides vast information concerning the use of chemicals as insecticides, insect repellents and attractants is Gunther and Jeppson's, "Modern Insecticides and World Food Production." A more detailed text relating chemistry, structure-function relationships, modes of action, and mammalian toxicity is Metcalf's "Organic Insecticides: Their Chemistry and Mode of Action." A good description of the procedures for screening chemicals for their insecticidal value on plants and animals is found in Shepard's two-volume series, "Methods of Testing Chemicals on Insects." Busvine also presents a critical review of the various methods for testing insecticides and the importance of physiological standardization of insects in his text, "A Critical Review of the Techniques for Testing Insecticides." Since isotopes have become important for studying the modes of action and degradation of pesticides, two texts describing their use are listed. O'Brien and Wolfe include a good discussion of isotopes for studying the metabolism, alternative metabolic pathways, and cuticular penetration of specific insecticides. A book containing selected papers related to the use of isotopes for studying the metabolism of insecticides is "Radioisotopes and Radiation in Entomology." Müller has edited a two-volume series which includes a discussion of the various aspects of DDT. Volume 1 is concerned with the physical and chemical properties of DDT, modes of action, and methods of analysis. Volume 2 is an exhaustive treatise on the pharmacology and toxicology of DDT. Another text which relates material of a more specific nature is O'Brien's, "Toxic Phosphorus Esters: Chemistry, Metabolism, and Biological Effects." The nature of the text is very similar to that found in Müller's but is concerned with organophosphate insecticides. A good discussion of the literature concerned with insecticide resistance in those arthropods that affect man and animals is found in "Insecticide Resistance in Arthropods" by Brown. Papers presented at a recent symposium concerned with the use of insect attractants and chemosterilants as new approaches to insect control have been recorded in "New Approaches to Pest Control and Eradication." The *Review of Applied Entomology* contains many useful review articles pertaining to insecticides. A greater portion of the current information on insecticides is published in four periodicals, *The Bulletin of Entomological Research, The Canadian Entomologist, Journal of Economic Entomology, and Journal of Insect Physiology.* One other useful source, no longer published, is the *Index to the Literature of American Economic Entomology.*

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Fungicides, Nematocides, and Soil Fumigants

The application of chemicals to control phytopathogenic microorganisms is perhaps the oldest use of pesticides. Because of the low mammalian toxicity, there has been less emphasis on basic research in this field. Sharvelle's "The Nature and Uses of Modern Fungicides" discusses the history of fungicides and the uses of specific fungicides. The book is slanted toward the applied aspects of research. "Fungicides in Agriculture and Horticulture" is a more advanced text which deals with specific classes of fungicides. Horsfall's "Principles of Fungicidal Action" serves as a source of early references on the application, penetration, and modes of action of fungicides. A two-volume series edited by Torgenson is currently the most complete source of information concerned with fungicides. Thorn and Ludwig have a complete summary of the uses, modes of action, formulation, and analysis of the dithiocarbamate fungicides. "Plant Pathology—Problems and Progress" contains some information on fungicides and a limited discussion of nematocides. Horsfall and Dimond have edited a three-volume series entitled "Plant Pathology" which is a good starting point for reviewing the literature on fungicides. Rich has edited a series of papers which were presented at a symposium, and the papers appear as the monograph, "Perspectives of Biochemical Plant Pathology." The papers deal with plant chemotherapeutants and their absorption and translocation, modes of action, and structure-function relationships of fungicides. Other books by Chupp, Pirone, and Westcott, and the 1953 Yearbook of Agriculture have limited information on the use of fungicides for controlling specific diseases but do not include many of the new fungicides. Current information pertaining to fungicides, nematocides, and soil fumigants can be followed in *Phytopathology, Plant Pathology,* and the abstracting journal, *Review of Applied Mycology.* Articles concerning the control of a disease by a specific fungicide or nematocide can be found in *Plant Disease Reporter* and *Nematologica.*

Herbicides

Two texts which provide an excellent introduction to this area of pesticidal research and are of interest to both applied and basic investigators are Klingman's "Weed Control: As a Science" and Crafts and Robbins', "Weed Control." They are general in nature, but provide insight into the problems and usage of the various commercial herbicides. Special sections are devoted to the methods and equipment needed for application, the classes of herbicides and their modes of action, and discussions of several individual weed problems. Klingman's book carries an appendix which contains the scientific and common names and life span of approximately 750 plant species and their respective susceptibilities to 2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid, and 2(2,4,5-trichlorophenoxy)propionic acid, three of the more commonly used herbicides.

For those interested in more basic aspects of herbicidal physiology, two additional reference books are available. The first is A. S. Crafts' "The Chemistry and Mode of Action of Herbicides." The text is divided into a series of short chapters each containing a brief discussion of the history, usage, avail-

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able formulations, chemical and physical properties, and modes of action of a specific group of chemicals. Crafts has also provided a resumé on the mechanics of absorption and translocation of organic chemicals. More recently, Audus has compiled a text which provides an even greater review of the knowledge of the fate and modes of action of herbicides. The problems of chemical classification and methods used for the detection and assay of herbicides and their breakdown products are discussed. In addition, many chapters are devoted to the fate and behavior of herbicides in plants and soil as well as the physiological responses of plants to herbicides. The book terminates with a description of the problems involved in the design of newer and better herbicides. Additional material on the physiology of herbicides and their effects on plants can be found in Volumes 13 and 14 of the "Encyclopedia of Plant Physiology."

Weed Research and *Weed Science* are devoted entirely to carrying original research papers dealing with herbicides. *The Journal of Agricultural and Food Chemistry* and several other periodicals frequently contain articles related to herbicides and plant physiology. An extremely useful periodical for following the literature is *Weed Abstracts* which is published bimonthly.

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Toxicology

Because of the ominous presence and ever increasing number of pesticides now available, no other area of pesticidal research concerns the public more than toxicology. As a result of this interest and for public health reasons, there is considerable research in this area by scientists of the Federal Government, industry, and state universities. Investigations on the hazards of pesticides to man and animals are time consuming, complex, and expensive. This arises from the need for much information over a long time and may involve not only parent compounds but also degradation products in plants and animals. An excellent reference is the "Handbook of Toxicology" which is published in five volumes. Volume 1 contains the acute toxicities of various chemicals and subsequent volumes are devoted to antibiotics, insecticides, barbiturates, and fungicides. Two books, invaluable to all who come in contact with pesticides, are the "Clinical Toxicology of Commercial Products" and the "Clinical Handbook of Economic Poisons." The authors describe symptomatology, treatment, and general information on pesticides and other commercial toxicants. Other valuable references are by Barnes, DuBois, O'Brien, Stewart, and Brown.

Review articles on toxicology can be found in the *Annual Review of Pharmacology* and in the *Annual Review of Medicine*. Two useful indexing sources are the *Monthly Catalog of U. S. Government Publications* and *Index Medicus*. Periodicals containing current papers on this subject are numerous. Occasionally, information on the acute toxicity of various chemicals can be obtained from the manufacturer or is often included in the technical bulletin published by the company concerned.

Residue Analysis

Closely associated with toxicology and the clearance of pesticides for use on crops and livestock is the recovery and identification of pesticidal residues from plant and animal materials. In many cases, the fate of the pesticide is very important since the breakdown products may be more toxic to animals than the parent compound. Such information may even lead to the patenting of more potent products. An excellent starting point for those interested in residue analysis is Zweig's four-volume series, "Analytical Methods for Pesticides, Plant Growth Regulators, and Food Additives." The methods used in the isolation, analysis, and assay of pesticides and related materials are contained in Volume 1. Methods for residue analysis for 47 insecticides, 15 fungicides, five nematocides and soil fumigants, two rodenticides four food additives, and 29 herbicides are described in subsequent volumes. Burchfield and Johnson's two-volume series is very useful to the scientist concerned with the determination of pesticide residues. Since methodology plays an important part in this field of research, many texts are available for the investigator. Three such publications are Gunther and Blinn's, "Analysis of Insecticides and Acaracides," Stewart and Stolman's, "Toxicology: Mechanisms and Analytical Methods," and "Colorimetric Methods of Analysis." The "Official Methods of Analysis of the Association of Official Agricultural Chemists" and the Association's journal provide information not only on methodology but also on procedures for the isolation and characterization of specific pesticides. Recently, the Shell Chemical Co. has published a loose-leaf book, "Manual of Methods for the Determination of Residues of Shell Pesticides" in which procedures are described for the isolation and identification of their pesticides.

Review articles on methods, residue data, adsorption and translocation of pesticides, and human and animal responses to residues can be found in *Residue Reviews, Analytical Chemistry,* and *Advances in Pest Control Research.* Many journals such as *The Analyst, Analytical Abstracts, Analytical Chemistry,* and *Journal of Chromatography* carry articles useful in this area of research.

Pesticide Development and Patents

The development and patenting of chemicals as pesticides has become a specialized area of industrial research, and chemical companies normally have a patent division which is charged with this responsibility. While the research and development of new pesticides is carried out by industry, the regulation and setting of tolerances of the chemicals is the responsibility of the Food and Drug Administration of the Federal Government. *The Official Gazette, United States Patent Office* and its accompanying index contain a list of the U. S. patents as does the *Review of U. S. Patents Relating to Pest Control. Chemical Abstracts* publishes abstracts of foreign patents in addition to U. S. patents. Further assistance on searching the patent literature can be obtained from ADVANCES IN CHEMISTRY SERIES No. 30. The reports by the now-defunct Chemical-Biological Coordination Center are also useful. Information pertaining to the procedures for acquiring clearances for pesticides can be obtained from two other publications, *Pesticide Chemicals Official Compendium* and *Pesticide Official Publication and Condensed Data on Pesticide Chemicals.* The official FDA tolerances of chemicals are printed in the *United States Federal Register.* A more readily available publication is the *National Agricultural Chemical Asso-*

ciation News and Pesticide Review which has the official FDA tolerances of pesticides listed by crops.

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Pesticide Information Centers

Pesticides Information Center, National Agricultural Library, U.S. Department of Agriculture, Washington, D. C. 20250

Center has been established to support research related to reducing pesticide hazards and plant pest control and pesticide regulations; plans a biweekly publication and a computer-produced, permuted title index to three parts: Keyword Index, Bibliography, and Author Index; specialized literature searches available.

Plant Pest Control Division, Agricultural Research Service, U. S. Department of Agriculture, Washington, D.C. 20250

Develops and recommends new and improved methods and equipment for the use in the control and eradication of plant pests and diseases; is a national clearinghouse for survey information; issues insect survey releases; cooperates with Federal and State taxonomic units in providing pest identification.

Association of American Pesticide Control Officials, Inc., Office of the Secretary, C. Colton Carr, Michigan State University, Department of Agriculture, East Lansing, Mich.

Information on pesticide chemicals and law enforcement concerned with pesticide sale and distribution; inquiries answered or referred without charge; *Pesticide Chemicals Official Compendium* contains monographs about chemicals being used in the pesticide field.

Entomological Society of America, 4603 Calvert St., College Park, Md. 20740

Answers questions on taxonomy, biology, morphology, and physiology of insects; economic entomology; chemical, biological, and other control practices; toxicology, abnormal physiology; and applied entomology; requests for consulting service are referred to members.

Armed Forces Pest Control Board, Forest Glen Section, Walter Reed Army Medical Center, Washington, D.C. 20012

Answers technical questions and performs literature searches.

U. S. Patents Classes and Subclasses

	Class	*Subclass*
Herbicides	71	2.2+
Insecticides	167	
Coating or plastic compositions containing		
Fertilizer containing	106	15+
Fumigants	71	3+
Fumigation	167	39+
Food	21	
Soils	99	225+
Vermin destroying	47	58
Fungicides	43	125+
Animal dips and sprays	167	36
Cyanogen compounds	167	35
Fertilizers containing	71	3+
Fumigants	167	39+
Inorganic	167	14+
Oil emulsions	167	43
Organic	167	22+
Seed disinfecting	167	38

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40

Literature of the Food Industries

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Literature Research Group, Arthur D. Little, Inc., Cambridge, Mass.

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For most segments of the food industry, information is scattered; there has been no central guide such as an abstracting service. There are a number of primary and secondary sources for the industry as a whole. Special aspects of the industry and subject subdivisions for which sources are given are: history; technology, processing, preservation, sanitation, and quality control; chemistry and biology; composition and analysis; food additives, colorings, and flavorings; toxicity; nutrition; packaging and canning; baking and milling; beverages; candy, confectionery, cocoa, and chocolate; coffee and tea; dairy products; edible oils and fats; fish and fish products; fruits and vegetables; meat and meat products; poultry and eggs; and sugar and starch.

The literature of the food industries is extensive, comprehensive, and in most cases, extremely useful. Unfortunately, there has been no central guide, such as a food abstracting service or an index to the literature of the food industries, which might simplify the task of locating desired information in a reasonable time, with a minimum of effort. However, the industry has announced the planned publication of a central abstracting service—*Food Science and Technology-Abstracts*. It will be printed by the Institut für Dokumentationswesen (ID) of the German Federal Republic (Frankfurt, West Germany), monthly starting in 1969. A publication of the International Food Information Service, it will be a joint venture of the Institute of Food Technologists (IFT, 221 North LaSalle St., Chicago, Ill. 60601), the Commonwealth Agricultural Bureaux (CAB, Reading, England), and the ID.

For most segments of the food industry pertinent information is scattered in books, technical and trade journals, and publications of research organizations. Much useful information appears in publications not devoted to any particular segment of the food industry, or even to the food industry in general. The literature of some segments is closely woven into that of agriculture, biology, chemistry, nutrition, medicine, physics, and engineering, each of

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

which can be further subdivided into microbiology, botany, entomology, biochemistry, analysis, and rheology.

This sometimes confusing situation, which has existed for many years, has in some ways become even more complex during the past decade. Tremendous technical progress has been made in all areas of the food industry, in food processing, in mass production, in packaging, and even in the development of synthetic foods. Such advances make it mandatory for the food man to keep currently informed, a task not only complicated by the variety of the widely dispersed, pertinent literature, but also by the fact that the published technical literature in all fields is accumulating rapidly—doubling, in fact, every eight and a half years.

Complicating the situation, too, is the fact that the interdisciplinary relationships now current in science and industry make it imperative that those involved in any phase of food industry must know what is going on in other segments of the industry. The producer of fruit juices can adapt the techniques of the brewer; the dairy products man can learn from the miller; the meat man can benefit from the synthesis of protein-like material in a distant chemical laboratory.

The food industry has reaped tremendous technological gains by assiduously applying chemical, biological, and physical principles to an understanding of the basic mechanisms that take place, and to the factors affecting flavor, taste, color, and the psychology of food appreciation. The industry, however, realizes that it is still beset by many problems, which have been detailed on numerous occasions. They include the need to adapt foods to changing demands without nutritional loss; need to understand biochemical activity in cells to solve problems of the safe levels of synthesized chemicals; need for greater analytical accuracy; effects of fats in diet and the effects of calories, vitamins, etc., on fat utilization; study of food problems of the aged, the infant, and the developing countries.

Not from the literature alone can come the successful solution to these problems, but a useful literature can provide the seeds for many ideas that may help solve existing and future problems. Useful literature must not only be available, its availability must be made known, and its accessibility must be expedited.

As Earl D. Stewart said in 1954, "The necessity for keeping up with current publications is as great as in other fields of science and industry, and the problems of how to do it have similar solution" (3). With all the literature now published and that which will arise from new developments, there is need for an organized approach to minimize the effect required to explore the main and the peripheral sources of information.

This paper provides a guide, alerting the reader to available publications, and indicating the nature and extent of their contents. Literature sources pertinent to the food industries are first described generally in the text under selected categories, then more specifically in the bibliography under these same categories. The first major section describes general abstracting and indexing services useful to all workers in the food industries. This is followed by a section

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

describing other publications, which span a broad range of interests or provide an over-all insight into the industry. The next sections deal with the history of the industry, chemistry, biology, analysis, and similar topics. Finally, there are sections that consider within the various segments of the industry (baking, meat, etc.) those publications geared to the interests and needs of their personnel, from the technician to the management planner.

We hope this arrangement will best serve those who must regularly use the literature. For those who have only an occasional need for reference to the literature, various consulting firms offer specialized literature services ranging from bibliographies to evaluative surveys.

Sources of Information in Review

Generally speaking, the literature sources of the food industry fall into the same broad categories as those of most other industries. Most important are the original publications, usually identified as "primary sources," which include books, journals, trade publications, conferences and symposia, reports of scientific and trade organizations, and patents.

Unfortunately, it is seldom practical or feasible for any individual to have at hand every primary source of information necessary or useful. Hence, "secondary sources" of information exist to guide the searcher to specific primary sources. Included are the abstracting services, indexes, serial publications, and reviews. For quick introductions to food topics, encyclopedias and handbooks can often be valuable. For example, the "Encyclopedia of Chemical Technology," edited by R. E. Kirk and D. E. Othmer, includes much background information relative to food technology.

Primary Sources. Through the years numerous basic textbooks have been published ranging from those that cover the broad topics of food science, food technology, and food engineering to the more specific areas of history, chemistry, composition, analysis, nutrition, and on to the particular operations of dehydration, freezing, packaging, and the like. Other texts concentrate on industrial segments—coffee and tea, meat and meat products. Many of these will be described in the sections to follow.

Books serve a double purpose. They are useful not only for their original information but also for the many references to previous literature that they may contain. In "Sterilization in Food Technology," by Ball and Olson (*see* Technology, Processing, Preservation, Sanitation and Quality Control), the 93 references cited for Chapter 2, lean heavily on the journals—*Canning Age, The Canner, Food Industries, Food Manufacture*—but refer to Tanner's 1944 book, "The Microbiology of Foods," and go back to references published at least as early as 1897. Chapter 3 contains 19 references from such sources as *Food Technology, Nucleonics,* and *American Journal of Public Health.* The same is true for the other chapters, showing again the variety of information sources and pointing out the usefulness of books not only for their own information but for the references cited. Books, however helpful, tend to be storehouses of past developments. For more current disclosures the journal literature provides a fruitful source.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

As with books, journals and other primary source materials separate into areas of coverage for the industry as a whole or for segments. A number of the industries are represented by technical or trade associations, such as the American Meat Institute Foundation, The Milk Industry Foundation, the American Oil Chemists' Society, which publish journals, reports of research and/or proceedings of conferences and meetings.

Secondary Sources. The food industries lack a centralized food abstracting and/or documentation service to collect, condense, and present in an organized way all or even most of the information available. Despite this lack, however, there are a number of good abstracting services, indexes, bibliographies, and review publications available, which are useful for retrospective searching or for locating a particular article. Some of these, while not geared specifically to the industry, cover many publications of direct interest as well as those of peripheral interest.

While most users of the literature are aware of at least some of these services, such as *Chemical Abstracts,* the *Applied Science and Technology Index,* the *Engineering Index,* or the *Readers' Guide to Periodical Literature,* many do not realize the number of helpful government publications available. One such is *Technical Translations,* published by the U. S. Department of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., which contains a section on food handling and packaging equipment. (This publication ceased in 1967. Now available is *Translation Register Index.*) Another is the *Technical Abstract Bulletin,* available from Defense Documentation Center, Alexandria, Va. More familiar, perhaps, is *Nuclear Science Abstracts,* published by the Division of Technical Information, U. S. Atomic Energy Commission. In addition, a more recent publication is *Scientific and Technical Aerospace Reports* (STAR), published by U. S. National Aeronautics and Space Administration. Each covers food technology in at least a limited manner.

From France there is the *Bulletin de l'Institut Pasteur* which, abstracts journals of various countries in the area of microbiology and immunology. Pergamon Press offers the monthly *International Abstracts of Biological Sciences,* covering animal behavior, biochemistry, biophysics, experimental botany, microbiology, and several other subject areas.

Another abstracting source that receives more and more mention is the Russian *Referativnyi Zhurnal.* Of course, one must read Russian to use this source fully, although English translations of some sections are available. Also, its lack of a good, up-to-date index necessitates scanning abstract by abstract the chemical section, which covers food, and the section on food machinery.

Japan now offers the *Japanese Periodicals Index, Natural Sciences Section,* published in English. This index, issued monthly in two parts: Part I—Science and Technology and Part II—Medical Sciences, rapidly disseminates information in Japanese scientific periodicals. Titles are listed under an alphabetical subject index covering most food categories. Some Japanese journals also carry articles in the English, and others provide English summaries.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

In relation to foreign sources, Poland and other East European countries are beginning to publish abstracts of their own scientific endeavors. These are often in English as well as in Russian and the language of the country.

Unfortunately, the British publication, *Food Science Abstracts* suspended publication in 1957. Since then, the *Journal of the Science of Food and Agriculture* reports on the publications formerly described in *Food Science.*

For the individual concerned primarily with the more specific areas of the food industry, there are for particular segments of the industry, useful tools, such as *Dairy Science Abstracts, Nutrition Abstracts and Reviews,* and *World Fisheries Abstracts.* Certain journals also contain abstract sections that lead one more quickly to current information. A detailed discussion of the more pertinent of these secondary sources appears in the bibliography.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

Broad-Coverage Literature Sources

Food supply is a problem of major concern not only in the developing countries but also in the vastly industrialized United States and in the Soviet Union. In the United States for 1968 a 9% increase in research expenditures was planned; 80% of our food manufacturers expected to offer new products to the consumer. In 1967, about $1.41 billion was invested in new plants and equipment. The Soviet Union, recently forced to buy wheat from the United States, is investing in fertilizer and chemical plants as the first step in providing sufficient food for its people.

Information on foodstuffs is required not only by food scientists and technologists but by governments and the general public. For those whose interests are not confined to specific technical or economic aspects, publications using the broad-coverage approach will provide desired information. These "general" publications also make it possible for the specialist to keep up with developments in areas other than in his own specialty.

Books that fit into this general category have been limited to those concerned more with science or research. General-type books on food engineering are listed in the section discussing technology and processing.

The 40 journals listed in the bibliography either cover general technology in a broad sense, discuss a variety of products and industries, and/or present useful economic data.

Not to be overlooked, also, is the patent literature and, frequently, the theses written by candidates for masters or doctors degrees (*see: Dissertation Abstracts,* Secondary Sources section of the bibliography). In the *Official Gazette of the U. S. Patent Office,* Class 99 gives broad coverage of food and beverages. Its 450 subclasses deal with more specific areas, such as cereals, meats, preservation, apparatus, etc. Class 107 is concerned with bread, pastry, and confection making; Class 127 covers sugar, starch, and carbohydrates, and Class 195 covers fermentation, products and processes. Typical classes and subclasses are listed at the end of the bibliography.

History

As pointed out by Jacobs (2), there is actually "no good book on the history of the food industries." One, he claims, must consult books relating to specific fields of interest or seek information in books such as L. H. Meyer's "Food Chemistry" (*see:* Chemistry and Biology), which starts with a brief historical review of food chemistry and its development.

To a great extent, this is still true, although one contribution from the mid-fifties more closely approximates the historical approach. In the "History of American Industrial Science," Courtney Robert Hall traces through various industries the rise of the U.S. industrial science and strength. His coverage of the food industries starts with the application of science to agriculture and continues with a review of progress in the design and manufacture of food. Advances in nutrition, chemical engineering, bacteriology, packaging, refrig--eration, and manufacturing are described; the rise and growth of the food industry is illustrated by discussions on the meat industry, milk products, cereals and baked products, citrus fruits, food packaging, and several related industries.

Another concise history of the industry, "Food: America's Biggest Business," by Arnold and White, illustrates basic developments in the various food fields. In addition, packaging, marketing, and advertising are discussed.

More recently, M. S. Peterson reviewed the determinants that have shaped the history of the modern food industry. This discussion is Part II, "Technological History," in the first of a two-volume survey of food technologies and industries, "Food Technology the World Over."

A number of other recent texts that describe in varying detail the developments and changes in the food industry through the years are mentioned in the sections that follow, which describe the literature resources of the various industries. Moreover, older publications listed in the bibliography provide still valid reviews.

Technology, Processing, Preservation, Sanitation, and Quality Control

Modern thought on food technology and processing was perhaps first organized in the book, "Food Technology," by S. C. Prescott and B. E. Proctor. This was followed by other good publications, foremost being Jacobs' comprehensive, three-volume treatise, "Chemistry and Technology of Food and Food Products." More recently, Joslyn and Heid reviewed various aspects of this fast-developing area in their three volumes.

In the past decade advances have been made in such techniques as thermal processing, radiation sterilization, and in the automation of various processing methods. A brief review, "What's Ahead Technically," in *Food Engineering,* indicates progress in freeze-drying, freeze-concentration, puff-drying, foam-mat drying, tower drying, flash freezing of foods in liquid nitrogen, high-temperature short-time processing, aseptic processing, micro-filtration techniques, ionizing radiation, and automation.

The Division of Isotopes Development of the U.S. Atomic Energy Commission and the Department of the Army's facility at Natick, Mass. (both fruitful sources of published literature) have been conducting research on food preservation by radiation. The U. S. Department of Agriculture, a source of many useful, free publications, can provide information on various dehydration techniques and other food processes.

In *Food Technology,* Urbain reviews food engineering trends. This article is followed by five more specific reviews relating to food preservation by Seltzer, Cook, Stumbo, Hall, Goldblith, and Vaughn.

Just from this brief resumé, the reader must realize the importance of keeping informed about the types and varieties of current research in food technology and in the application of new discoveries in industry. Literature sources of help are described in the bibliography. The book list includes the more general or review-type books on technology and processing as well as those related more directly to specific processes such as preservation, freezing, drying, dehydration, and radiation. A few books on sanitation and quality control are included to guide those whose interests go beyond the technical aspects of food processing. Journals covering these areas are listed alphabetically, and selected articles are also given.

Related information is available in such sections as Broad-Coverage Literature Sources, Packaging and Canning, and in the several sections devoted to particular segments of the food industries, such as Baking and Milling Industries.

Chemistry and Biology

Although one can divorce studies of the chemistry of food constituents from their biological activity, the two disciplines are, in effect, sufficiently intertwined to warrant their discussion as a single topic.

Recent research has led to a more complete understanding of the composition and structure of such biologically active food constituents as the organic acids, carbohydrates, lipids, and proteins. Particular enzymes have been isolated, their composition and structure defined, and their role in metabolism and nutrition clarified. Concentrated studies on pectins have increased our knowledge of pectin substances and pectin enzymes and have changed our thoughts on their effect on the texture of fruits.

Recent developments and the possibility that chemistry will lead the way to producing in somewhat purer form the basic building blocks of food point toward the impending advent of synthetic foods. Plant or animal protein has been formed into filaments, pressed with edible binders through melted fat to produce "meat" products. Synthetic nuts have also been prepared from dried egg albumin, dried wheat germ filler, and an edible oil.

Texts pertaining to the chemistry of foods cover as broad a range as the discipline itself. Some concentrate on the chemical character of foods as carbohydrates, proteins, lipids, vitamins, coloring matters, flavors. Others approach the subject more from the standpoint of nutrition, stress adulteration of foods, or analytical chemistry of foods, or border on the biological aspects. Books in this section directed more to the chemical aspects are listed under the following authors: Anfinsen, Boyer, Braverman, Clayton, Colowick, Deuel, Em-

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

mett, Fox, Hanahan, Jacobs, Kersetz, McElroy, Meyer, Mitchell, Neilands, Nord, Scheraga, Schultz, Sherman, Williams, Witcoff, and Wolfrom. The reader should also check the literature of specific industries, such as Baking and Milling Industries.

Books more directly concerned with biological topics are listed in this section under these authors: Alexopoulous, Clifton, Enselme, Frazier, Prescott, Rose, Umbreit, and Weiser. In addition, items of interest can be found in many other sections of this paper. For instance, the microbiologist should check such sections as Meat and Meat Products, Packaging and Canning.

Many of the journals listed in the section Broad-Coverage Literature Sources contain articles relating to the chemistry of foods. Others are to be found in the section on Composition and Analysis; a few others covering both chemistry and biology are listed alphabetically for this section, immediately following the book listings.

The brief listing is intended to show the variety of texts and journals available. It is by no means exhaustive. A good general source is the *Annual Reviews of Microbiology,* published since 1948 by Annual Reviews, Inc., 231 Grant Ave., Palo Alto, Calif.

Composition and Analysis

From the day in 1743, when Marggraf discovered crystals of sugar in the red beet, leading to the possibility of extracting sugar on a commercial basis, the composition and analysis of foods have provided fertile grounds for writers.

Jacobs (*1*) referred to the U. S. Department of Agriculture Bulletin 28, first published by W. O. Atwater and A. Bryant in 1899 and revised several times, including a 1940 revision by C. Chatfield and G. Adams, as the classical work on the composition of foods.

Other treatises worth mentioning again are: "Structure and Composition of Food," in four volumes, by the late Andrew L. Winton and Kate Barber Winton; the 1945 book by the same authors, "Analysis of Foods"; and "Chemistry and Technology of Food and Food Products," Vol. II, edited by M. B. Jacobs.

The sources of information in this section emphasize analysis because so much information on the composition of foods is closely connected with the literature dealing with the chemistry of foods. Analytical techniques contribute to a better understanding of the composition and structure of foods, but they also provide the means of testing and controlling the quality of foods.

The past decade has witnessed great advances in analytical instrumentation and techniques and in the automation of established analytical methods.

Separation methods, such as filter paper chromatography, paper and column electrophoresis, electroosmosis, ion exchange resin chromatography, and vapor phase chromatography play an increasing role in the work of the food analyst in isolating and detecting constituents of foodstuffs. Mass spectroscopes, recording spectrophotometers, potentiometers, and polarographic instruments make it possible to obtain masses of useful data.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

As an example of automation, the Kjeldahl nitrogen analysis, automated by a wet-chemistry system, can be adapted to continuous on-stream analysis, recording, and control.

Such new methods and techniques have made it possible for the food analyst to define in reproducible physical and chemical terms the quality factors of color, consistency, and texture, and to a degree, nutritive value and flavor.

While contributing to the greater advance of food science, such discoveries and their applications are reported in a wide variety of publications. The literature sources that should be most useful in this area are listed in the bibliography.

Food Additives, Colorings, and Flavorings

The past decade has seen a tremendous rise in the use by industry and acceptance by the public of synthetic additives in foods. Deliberate adulteration of foods for quick profits is no longer feasible in the United States. Constantly revised and promptly enforced food and drug laws guide the industry and protect the public. Progressive food industries must keep abreast of these laws and their amendments, which cover not only the foodstuffs, but their packaging, labeling, and sales. In addition to the many publications covering particular additives and their effects, various publications alert the food researchers and producers to the new laws. In his review, L. A. Hall lists some commonly used additives, pointing out those chemical preservatives used for the first time during the past 25 years.

Food flavoring is not yet a science; quality control, for example, is possible only by tasting. This causes problems for the food flavor scientist, whose life is becoming steadily more complicated by spices, protein hydrolysates, and other additives in the increasing production of convenience foods and prepared meals. Unfortunately, literature dealing specifically with the use of flavorings and spices in foods is limited, but there are many useful general sources. Some of the more pertinent texts and journals are given in the bibliography under Food Additives; others appear in such sections as Broad-Coverage Literature Sources, Composition and Analysis, and Chemistry and Biology. Salt as a flavoring agent and preservative is discussed by M. A. Joslyn and A. Timmons in Chapter 42 of Joslyn and Heid's "Food Processing Operations," Vol. II (*see* Technology, Processing, Preservation, Sanitation and Quality Control).

Some progress has been made, however, in methods and techniques for measuring differences in food quality, and the literature describes such sensory techniques as difference testing, the flavor profile method, and dilution tests. A good review article by R. M. Pangborn appears in *Food Technology*.

Since 1950, the development of many new forms of food colors, the use of lakes as well as dyes, and new legislative rules have given rise to confusion regarding permissible colors. Noonan reviews, "Where We Stand on Food Colors." One of the latest books is by MacKinney and Little.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

Toxicity

An understanding of the causes of food poisoning and effective ways of preventing it is essential for the food industries. Continuous research, quickly paving the way to a more enlightened understanding of food infections, food intoxications, and the transmission of disease by food, emphasizes the need for the food workers to keep current. Their task is not easy, however. Desired information is often found in articles relating to plant sanitation, pests and pesticides, and waste product treatment.

Articles concerned with food poisoning, its causes, and prevention are scattered through the general journals, such as *Food Technology, Food Engineering, Journal of Food Science*, and through many of the publications devoted to the dairy industry, to wine making, canning, packaging, and the like. Pertinent articles are often found in journals such as the *American Journal of Public Health, Public Health Reports, Modern Sanitation.* Recently, Pergamon Press announced, *Food and Cosmetics Technology*, a bimonthly international journal, published for the British Industrial Biological Research Association. Starting September 1963, this journal contains informative abstracts on toxicology, summaries of toxicological data, and research reviews. Brochures from the U. S. Department of Agriculture are often helpful.

The earliest text to discuss chemical food poisoning systematically was "Chemical Analysis of Foods and Food Products," by M. B. Jacobs. A third edition appeared in 1959 (*see* Composition and Analysis). Other texts concerned with food poisoning and toxicology are listed in the bibliography; a few more appear in the section on Sanitation and Quality Control; others appear in the section on Chemistry and Biology.

Nutrition

Closely allied to the food industries is nutrition. Nutrition and the related problem of malnutrition in the developing countries is a topic of increased discussion and continuing research. Studies are underway to determine the influence of proteins on mental and psychomotor development, the ideal intakes of saturated and unsaturated fats, the use of fluorides in water, the need for retaining magnesium in human diets, the importance of well-balanced diets, and an understanding of the composition of natural foods. Impacts of these and other research studies will eventually be felt by the food industries. A detailed coverage of the literature in the field of nutrition would require a volume in itself, but the books and journals described in the bibliography should guide the food worker.

Frequently, interesting publications emanate from the Food and Agricultural Organization of the United Nations, from the U. S. Department of Agriculture, from the various Agricultural Experiment Stations in the United States, from the Ministry of Health in Great Britain, from the American Medical Association, Chicago, Ill., and from the medical societies in other countries. A useful, general reference is the annual publication, "Advances in Protein Chemistry," from Academic Press.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

As in other disciplines, symposia and conferences prove good sources of current reviews. An example is the "Symposium on Proteins." Two review articles worth reading are listed in the bibliography.

In "Milestones in Nutrition," editors Goldblith and Joslyn have collected some of the more important scientific papers and theories published in the past 150 years, providing a neat, historical review of nutritive science.

Packaging and Canning

Food packaging has received increased attention during the last decade. Factors contributing to this include the development of new flexible and semi-rigid packaging materials, the advent of convenience foods, and changing ideas in packaging techniques, including pressurized packaging and boil-in-bag foods. Food packages have improved in quality, and, often, have decreased in cost. Use of new packaging materials has, however, raised some safety problems, but continued research insures their solution. Since 1946, the food-container industry has co-sponsored a long-term study of staphylococcus food poisoning at the Food Research Institute of the University of Chicago. In this vastly competitive area, the food packer finds it increasingly necessary to keep in touch with the results of current research and with the latest government rules and regulations.

The food canner must be alert to advantages and drawbacks of new container components and to the latest developments in freezing, dehydration, and other processing techniques.

Although there is no dearth of literature on packaging and canning, relatively few books are devoted solely to these topics, and only a small number of journals treat the subject in a highly technical way. Much of the useful and necessary information must be sought through the books and journals covering specific industries and/or processing techniques. Because packaging and canning are so closely interrelated with all areas of the food industries, almost every section in this paper should be consulted. For example, many of the publications in Technology, Processing, Preservation, Sanitation and Quality Control; Chemistry and Biology (particularly publications on microbiology); Toxicity; Baking and Milling Industries; Beverage Industry; Fruits and Vegetables; Meat and Meat Products; and Fish and Fish Products contain pertinent information. Canning is considered by Ball and Olson in "Sterilization in Food Technology." Burton reviews protective packaging progress, and Anderson covers the past, present, and future of packaging processed foods.

Often, brochures covering processing methods, production statistics, nutritional aspects, labeling, are published by various government agencies, manufacturing companies, and technical and trade associations. Typical government sources in the United States are the Department of Agriculture; the Department of Commerce; the Department of the Interior, Fish and Wildlife Service (*see* Fish and Fish Products); and the Department of Labor, Bureau of Statistics. Examples of trade associations are: Can Manufacturing Institute (Washington, D. C.); Glass Container Manufacturers Institute, Inc. (New York, N. Y.); National Canners Association (Washington, D. C.).

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Baking and Milling Industries

Most reviews of baking and milling open with the statement that these are the oldest of industries, tracing their origin to the earliest days of recorded civilization. Many authors have traced the history of pounding, crushing, or grinding of grain and described the food and feed products resulting from these operations. Hilligan and Krause (*1*) summarized the developments in baking and milling concisely and precisely. More recently, in his paper on "Milling," (Chap. 9 in "The Chemistry and Technology of Cereals as Food and Feed," edited by S. A. Matz) Robert A. Larsen briefly traces the advances in the milling of cereal grains. He covers the milling of wheat, corn, rye and durum, and notes the comparatively recent development in the flour industry of turbomilling, a process involving the air classification of starch to separate starch from protein.

Larsen continues with a discussion of wheat selection and storage. Among other topics, he describes the cleaning house, tempering or conditioning, the grinding of wheat, the break rolls, the break sifting system, the reduction rolls, the reduction sifting systems, the scratch system, and the conveying system. Larsen cites 47 references, 37 of which are from the journal literature or are publications of the American Association of Cereal Chemists or other societies. Of the 10 books to which he refers, seven were published in 1952 or earlier.

This breakdown indicates the general situation relative to the literature of milling and baking. There are good books covering these areas, but many of them concentrate on specific aspects. The latest general book, is that by J. F. Lockwood.

Much of the literature on baking and milling is printed in various journals, many of which are not directly related to the industries. Another large body of useful information exists in the publications of the various associations and societies, such as the Association of Operative Millers, American Bakers Association, American Society of Bakery Engineers, American Association of Cereal Chemists, Millers National Federation, American Feed Manufacturers' Association, the Wheat Flour Institute, and societies in England, Italy, Germany, and other countries. Useful publications emanate also from the U. S. Department of Agriculture and from colleges and universities, such as Kansas State College, and the University of Florida.

The bibliography lists several books covering various areas of interest and approximately 60 pertinent journals. The reader should also review the literature sources listed in other sections of this paper—*e.g.*, Beverage Industry in which items pertaining to barley and malt can be found; Sugar and Starch; and Candy, Confectionery, Cocoa and Chocolate.

The section on secondary sources, which carries descriptions of the various abstracting services, indexes, and bibliographies should also be checked. In addition, Broad-Coverage Literature Sources, contains a number of books and journals whose contents range broadly over the whole spectrum of the food industries, including baking and milling.

At least two books mentioned under Technology, Processing, and Preservation, should be mentioned here. These are 'Elements of Food Engineering," by Parker, Harvey, and Stateler; in Vol. I the authors cover the processing of wheat and corn flours, other cereal flours, rice and oats milling; and "Foodstuffs—Their Plasticity, Fluidity and Consistency," edited by G. W. Scott Blair, which takes up physical control methods, particularly for cereals.

In addition to the chapter by Larsen in Matz' book, the reader will be interested in Chap. 10, "Commercial Baking Procedures," by L. A. Rumsey; in the description of the corn wet-milling industry, which is Chap. 13, by John T. Goodwin; and in the chapters on feed manufacture, rice processing, and the manufacture of breakfast cereals.

Interestingly, from the standpoint of the literature searcher, of the 17 citations in Goodwin's, "Wet-milling" chapter, 10 are patents. The one book mentioned is "Chemistry and Industry of Starch," by R. W. Kerr, which is listed in the bibliography under Sugar and Starch.

The ATP Directory, 1960-61 edition, published by American Trade Press Clipping Bureau, lists 17 trade journals covering the baking industry.

Beverage Industries (Beer, Yeast, and Fermentation: Wines, Alcohol; Soft Drinks and Fruit Juices)

For this paper, beverages are defined as beer, wines, alcohols, and soft drinks. Tea and coffee warrant a separate section. Milk is under Dairy Products, and cocoa and chocolate are under Candy, Confectionery, Cocoa, and Chocolate.

Texts directly devoted to the beverage industries are fairly limited in number, but additional information is available in such books as "Elements of Engineering," by M. E. Parker *et al.* (*see* Technology, Processing, Preservation, Sanitation and Quality Control), and "Industrial Microbiology," by Prescott and Dunn (*see* Chemistry and Biology). On the other hand, there are more than 90 technical and trade journals providing useful information. Although a number of the trade journals cover the bottling and marketing of carbonated beverages, most of the more technical journals stress beer, wines, and alcohols, ignoring soft drinks. One exception is the *Canadian Beverage Review* which includes nonalcoholic beverages. Pertinent information can often be found in the general journals, such as the *Journal of the Science of Food and Agriculture* (*see* Broad-Coverage Literature Sources). Not to be overlooked also are publications listed in other sections, such as Food Additives, Colorings, and Flavorings; Packaging and Canning; and Edible Oils and Fats.

Often useful review articles appear not only in the beverage journals but also in the journals concerned with related disciplines or trades—*e.g.*, March 1964 issue of *Biotechnology and Bioengineering* is a review on fermentation. The 22 articles on fermentation operations and processes are well referenced.

An extremely prolific source, which has not perhaps been emphasized adequately in this paper, is the proceedings of conferences and symposia. One

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

such symposium of interest to the beverage industries was held in Prague. Those papers, were published in 1958 under the title, "Continuous Cultivation of Microorganisms—A Symposium." The papers from a similar symposium in Prague in 1962, also published in Czechoslovakia, are now available from Academic Press. Another symposium contributed to by 35 specialists was reported by Underkofler and Hickey in "Industrial Fermentations." Since 1947, the International Congress of the European Brewing Convention has met every two years. The proceedings of this Congress, covering all aspects of brewing and malting science and technology, are regularly published by Van Nostrand and/or American Elsevier. In the 1961 Congress, held in Vienna, discussions covered barley, malt and hops, yeast and fermentation, tannin, proteinous substances, and miscellaneous and novel ideas. The proceedings of the 1963 Brussels meeting are available from American Elsevier Publishing Company (52 Vanderbilt Ave., New York 10017). The Scandinavian Brewing Technical Meeting held every other year in Denmark, Norway or Sweden publishes about 20 papers in its "Proceedings" in Danish, Norwegian, or Swedish. The relatively new index, *Proceedings in Print* (*see* Secondary Sources), offers information on published proceedings in different fields.

In addition, the various scientific and trade associations connected with the industry offer many interesting publications. One of the more famous, perhaps, is the Institute of Brewing, in London, which has published its *Journal* since 1895. Some in the United States, whose publications may not be listed in the list of beverage journals, are:

American Bottled Water Association, 1 Gateway Center, Pittsburgh Pa. 15222, which publishes *Bottled Water Reporter*, bimonthly.

American Bottlers of Carbonated Beverages, 1128 16th St., N.W., Washington, D. C. 20036, which publishes *ABCB Bulletin*, monthly.

American Society of Brewing Chemists, 501 North Walnut St., Madison, Wis. 53705, which publishes *Brewing Chemists News Letter*, quarterly; *Proceedings* (1942) annual; and *Methods of Analysis of the ASBC*, irregular.

American Wine Association, 292 Madison Ave., New York, 10017.

Bourbon Institute, 711 Third Ave., New York, 10017, which publishes a cookbook, *The Bourbon Chef*, and *Bourbon Fact Book*.

Brewers Association of America, 541 W. Randolph St., Chicago, Ill. 60606, which publishes BAA Bulletin, weekly.

Brewing Industries Research Institute, 135 S. La Salle St., Chicago Ill. 60603, which publishes research notes on projects, bulletins on research programs and organizational structure.

Carbonated Beverage Institute, 122 West 30th St., New York, 10001.

Distilled Spirits Institute, 1132 Pennsylvania Bldg., Washington, D. C. 20004, which publishes *Distiller Bulletin*.

Independent American Whiskey Association, 12 South 12th St., Philadelphia, Pa. 19107.

International Union of United Brewery, Flour, Cereal, Soft Drink and Distillery Workers of America, 2347 Vine St., Cincinnati, Ohio 45219, which publishes *Brewery Worker*, monthly.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

In Literature of Chemical Technology; Smith, J.;
Advances in Chemistry; American Chemical Society: Washington, DC, 1968.

Master Brewers Association of America, 440 North Wells St., Chicago, Ill. 60610, which publishes *Master Brewers Communications*, bimonthly; *Technical Proceedings*, 1940, annual, and *Technical Quarterly*, quarterly.

National Alcoholic Beverage Control Association, 1000 Connecticut Ave., N.W., Washington, D. C. 20036, which publishes *NABCA News Bulletin*, bimonthly, and *Statistical Reports*, monthly and annual.

National Association of Alcoholic Beverage Importers, 6 East 79th St., New York, 10021, which publishes its *Bulletin*, irregular, and *Statistical Review*, annual.

National Association of Wine Bottlers, 250 W. Cambria St., Philadelphia, Pa. 19133, which publishes *NAWB Bulletin*, monthly.

National Beer Wholesalers' Association of America, 6310 N. Cicero Ave., Chicago, Ill. 60646, which publishes *Beer Wholesalers' News*, monthly.

National Brands Soft Drinks Institute, 79 West Monroe St., Chicago, Ill. 60603.

National Manufacturers of Beverage Flavors, 1051 First National Bank Building, Chicago, Ill. 60603, which publishes *Proceedings*, annual.

National Women's Association of Allied Beverage Industries, 155 East 44th St., New York, 10017, which publishes *Industry Information Guide*, 9/yr., and *Industry Woman*, 3/yr.

Puerto Rico Rum Producers Association, 508 Padin Bldg., San Juan, Puerto Rico, which publishes *Statistics of the Puerto Rican Rum Industry*, monthly.

Society of Soft Drink Technologists, 1128 16th St., N.W., Washington, D. C. 20036, which since 1955 has published its *Proceedings*.

United States Brewers Association, 535 Fifth Ave., New York, 10017.

Certain government agencies also publish items of interest. The U. S. Department of Commerce, Business and Defense Administration, published in October 1949, and again in May 1956, a pamphlet called "Basic Information Sources in the Bottled Soft Drinks Industry." The Internal Revenue Service, Alcohol and Tobacco Tax Division, offers such publications as, "Breweries Authorized to Operate," listing about 200 U.S. breweries, and "Distilled Spirits Plants Authorized to Operate," listing about 350 plants. The Division's annual report gives statistics on production of alcoholic beverages in the U.S.

In this country, as in others, various federal and local laws help regulate the industry. For the United States, state agencies in charge of administering alcohol beverage laws are listed in "The Brewing Industry in the United States. Brewers Almanac" (1956) published by the U. S. Brewers Foundation (535 Fifth Ave., New York City).

Individual states, such as Alaska, Arizona, California, Iowa, Nevada publish trade journals of interest. The Beverage Analyst Group, published by Bell Publications (2400 Curtis St., Denver, Colo. 80205) includes *Alaska Beverage Analyst, Colorado Beverage Analyst, Kansas Beverage Analyst, Nebraska Beverage Analyst, Western States Beverage Analyst* (Idaho, Montana, Oregon, Utah, Washington), and *Wyoming Beverage Analyst.* Iowa, Northwest, and Missouri Beverage Journals are published by the Mid-Continent Beverage Group (1210 Glenwood Ave., Minneapolis, Minn. 55405). A fairly complete list of journals of this type is given in "The Standard Periodical Directory," 1964-65, published by Oxbridge Publishing Co., Inc. (420 Lexington Ave., New York, 10017).

"Bottling, the Bottlers' Year Book," published by Bottlers' Year Book, Ltd. (Wallington, Surrey, England), is an informative directory-type publication. Others include:

"Brewery Age Blue Book," Modern Brewery Age, 80 Lincoln Ave., Stamford, Conn., annual (lists Western Hemisphere breweries, executives).

"Brewery Directory," Brewers Digest, 4049 West Peterson Ave., Chicago, Ill. 60626 (breweries in Western Hemisphere, executives, brewery associations, suppliers).

Brewing Industry Survey, Research Company of America, 185 Madison Ave., New York, 10016, annual (lists brewers, branch breweries in U.S., Canada, Mexico; executives, sales).

"Brewers Journal Directory," Gibson Publishing Co., 4717 North Broad St., Philadelphia, Pa. (Western Hemisphere breweries, personnel).

"Red Book Encyclopedia Directory of Wine and Liquor Industries," Liquor Publications, Inc., 6 West 57th St., New York, 10019, biennial (10,000 wines and spirit producers, brokers, wholesalers, executives).

"Wines and Vines Annual Directory," Wines and Vines, 690 Market St., San Francisco 4, Calif., annual (U.S. wineries, wine bottlers, personnel).

"World Directory of Breweries," 1964-65, American Brewer Publishing Corp., 33 Lyons Pl., Mt. Vernon, N. Y.

Candy, Confectionery, Cocoa, and Chocolate

In addition to the books and journals listed in the bibliography, other useful information concerning this section can be found in the more general food journals, such as *Food Engineering,* and *Industries Alimentaires et Agricoles* (*see* Broad-Coverage Literature Sources), or in the publications of allied industries (*see* Baking and Milling Industries, Sugar and Sugar Products). Related information may be found in the ADVANCES IN CHEMISTRY SERIES No. 12 (*see* Sugar and Starch). Also, Chapter 47, "Confectionery Manufacture," by Justin J. Alikonis and Chapter 41, "Corn Sweeteners," by William J. Hoover, in Joslyn and Heid's "Food Processing Operations," Vol. 3 (*see* Technology, Processing, Preservation, Sanitation, and Quality Control), should be helpful. Two older books by Stroud Jordan, still in use by some, are "Confectionery Problems" (1930), and "Confectionery Evaluation," both published by the National Confectioners Association.

A number of organizations and institutes often offer worthwhile contributions. Among these are the National Confectioners Association, Chicago; the American Association of Candy Technologists, New York; Pennsylvania Confectioners Association, Philadelphia; Chocolate Manufacturer's Association, Washington, D. C., and the British Food Manufacturing Industries Research Association, London. Other associations can be located in such directories as the "Encyclopedia of Associations," Vol. I; "National Organizations of the U.S." (3rd ed., 1961), Gale Research Co., Detroit, Mich., and "Scientific and Technical Societies of the United States," National Academy of Sciences—National

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Research Council, Washington, D. C. (Publication 1499, 1968); earlier editions included Canada.

Bulletins from various federal and state agencies and experimental stations are frequent and informative. These usually can be located by notices in such journals as *Food Technology*, through *Chemical Abstracts*, or, in some cases, by a direct request to be placed on the mailing list for notices and/or free publications.

The ATP Directory, American Trade Press Clipping Bureau, New York, lists 10 trade journals under the heading, Confectionery. Also of interest should be the "Candy Buyers' Directory" (W. Allured, Inc., 1031 South Blvd., Oak Park, Ill.), and the "Candy Industry Catalog and Formula Book" (Vol. 17, 1963) (Magazines for Industry, 660 Madison Ave., New York, 10021).

Coffee and Tea Industries

For information on coffee and tea, the two most promising journals are *Coffee and Tea Industries and the Flavor Field*, and *Tea and Coffee Trade Journal*. Information on these beverages is fairly voluminous, although much of it appears in publications from India, Russia, and Japan. The various publications from the last two countries are not listed in the bibliography because of the difficulty of reading the articles in their original languages. *Chemical Abstracts*, however, is a good source of review for items on tea and coffee, and it has steadily increased its coverage of foreign publications.

In an effort to be complete, the Soviet publications, *Biokhimiya* and the *Doklady Akademia Nauk SSSR*, and the Japanese journals, *Nippon Nogeikagaku Kaishi*, and the *Journal of the Agricultural Chemical Society, Japan* should be consulted, if available.

A review article by William H. Stahl, contains a bibliography of more than 200 references. J. H. Nair and P. P. Dahl present concisely recent technology of the manufacture of instant coffee and instant tea with a well-selected bibliography of patents in their paper, "Coffee and Tea" (Chap. 15), in Van Arsdel's, "Food Dehydration," Vol. II (*see* Technology, Processing, Preservation, Sanitation, and Quality Control).

Dairy Industry (Including Milk, Cheese, Butter, and Ice Cream)

This industry is fortunate in having *Dairy Science Abstracts* (*see* Secondary Sources), which simplifies the task of locating and reviewing published information. In addition, a number of books help fulfill the need for scientific and engineering data and provide practical guides for laboratory and plant operations.

The approximately 40 journals listed in the bibliography make it possible for the varying levels of personnel in this industry to keep abreast of the technological and economic trends influencing their daily activities. Of the journals listed, perhaps the most significant are *American Milk Review and Milk Plant Monthly, Canadian Dairy and Ice Cream Journal, Dairy Industries, Journal of Dairy Science, Journal of Milk and Food Technology, Journal of the Society of Dairy Technology, Milchwissenschaft,* and *Milk Dealer*. In addition, a num-

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ber of the general journals serving the food industries often devote space to problems of and developments in the dairy field. The "ATP Directory" (American Trade Press Clipping Bureau, New York 10010), lists 24 trade journals under Dairy Products.

Occasionally, useful bulletins can be procured from such agencies as the U. S. Department of Agriculture, the American Public Health Association, and the U. S. Public Health Service. Another source of supply is the Dairy Industries Supply Association, Inc. (1145 19th Street, N.W., Washington, D. C. 20036). Dairy equipment manufacturers can also be called upon for brochures ranging from flyers describing specific items of equipment to brochures describing plant layouts. A representative listing of these manufacturers includes:

Cherry-Burrell Corp., 565 W. Washington St., Chicago, Ill. 60606
Chester-Jenson Co., 5th and Tilghman Sts., Chester, Pa. 19013
Creamery Package Mfg. Co., 1243 W. Washington Blvd., Chicago, Ill. 60607
DeLaval Separator Co., Poughkeepsie, N. Y.
Manton Gaulin, 44 Garden St., Everett, Mass. 02149
Majonnier Bros. Co., 4601 W. Ohio St., Chicago, Ill. 60604
Paul Mueller Co., P.O. Box 150, Springfield, Mo. 65801

Other manufacturers can be located in directories, such as "Thomas Register of American Manufacturers (Thomas Publishing Co., 461 Eighth Ave., New York, 10001).

A number of trade organizations provide bulletins, periodicals, and other types of information services. Typical of these are:

American Butter Institute, 110 North Franklin St., Chicago, Ill. 60606
American Dairy Association, 20 North Wacker Dr., Chicago, Ill. 60606
American Dry Milk Institute, Inc., 221 North LaSalle St., Chicago, Ill. 60601
Evaporated Milk Association, 228 North LaSalle St., Chicago, Ill. 60601
Milk Industry Foundation, 910 17th St., N.W., Washington, D. C. 20036
National Cheese Institute, Inc., 110 North Franklin St., Chicago, Ill. 60606
National Dairy Council, 111 N. Canal St., Chicago, Ill. 60606

Because the dairy industry is one of the most highly regulated segments of the food processing industry, various federal, state, and trade standards applicable to milk, cheese, butter, and ice cream assume importance. These standards are published by government agencies and by some trade associations. A few typical ones are listed in the book section; specifications for standards are published in the *Journal of Milk and Food Technology*.

A review chapter on dairy products by B. L. Herrington appears in Joslyn and Heid's, "Food Processing Operations," Vol. I (*see* Technology, Processing, Preservation, Sanitation, and Quality Control).

Edible Oils and Fats

In addition to the literature dealing specifically with edible oils and fats much pertinent information is interwoven with the literature of inedible fats; some appears in the literature dealing with chemistry, biochemistry, analysis, dairy products, and nutrition, and, frequently, articles concerned with the

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edible oils and fats appear in the general literature sources available to the food industry on the whole (*see* Broad-Coverage Literature Sources).

In Chapter 26 of Heid and Joslyn's, "Food Processing Operations," Vol. 2, Theodore J. Weiss summarizes information on fats and oils, covering sources of supply, composition, processing, stability, analysis, and fat and oil products (*see* Technology, Processing, Preservation, Sanitation, and Quality Control). Some of the publications in the sections on Chemistry and Biology, such as Deûel's books on lipids, as well as items in Composition and Analysis are of direct interest. Examples in the latter section are Mehlenbacher's book on methods of analysis used commercially in the fat and oil industry, and publications of the Association of Official Agricultural Chemists.

The American Oil Chemists' Society can be depended upon for useful information beyond that which appears in its regularly published journal. Other associations offering publications include the National Institute of Oilseed Products (1026 17th St., N.W., Washington, D. C. 20036); National Cottonseed Products Association (3116 Commerce St., Dallas, Tex.); National Peanut Council (Suffolk, Va.); American Soybean Association (Hudson, Iowa); National Association of Margarine Manufacturers (545 Munsey Building, Washington, D. C. 20004); Institute of Shortening and Edible Oils (2000 K St., Washington, D. C. 20036).

Trade journals, not listed in the bibliography, but which are often useful include *Butterfat* (425 Eighth Ave., W., Vancouver 10, B. C.); *Journal of Milk and Food Technology* (Shelbyville, Ind.); the *National Provisioner* (15 W. Huron St., Chicago, Ill.).

In this industry, as with so many of the other food industries, helpful and informative publications are available from the U.S. government agencies, state agricultural experiment stations, and agricultural colleges.

Fish and Fish Products

Although its contents are less voluminous than those of *Dairy Science Abstracts,* the major abstracting service covering the fishery industries, *World Fisheries Abstracts,* performs a competent job. In addition, it is supplemented by *Commercial Fisheries Abstracts.* Recently, several excellent books, described in the bibliography, have been published, which touch upon the handling and processing of fish and which cover chemical, biological and nutritional aspects.

Two chapters in Vol. I of the recent book by Joslyn and Heid, "Food Processing Operations" (*see* Technology, Processing, Preservation, Sanitation and Quality Control), detail commercial fishery methods and the processing of seafoods. An interesting point made is that the fishing industry generally carries out its operations in many medium-to-small plants, a direct contrast to operations in the meat industry. In the latter industry, a few large plants handle completely a large proportion of the animals processed.

Seekers of information pertaining to fish will find fruitful sources in the publications of the Fish and Wildlife Service of the U. S. Department of the Interior and the Food and Agriculture Organization of the United Nations.

About a dozen journals are concerned directly with problems of fish and fisheries and useful articles appear in the various general journals (*see* Broad-Coverage Literature Sources).

Fruits and Vegetables

The cultivation, handling, processing, and distribution of foodstuffs may well be the most important industry of any country. Perhaps more than any other business, the food industry embraces most disciplines, touches almost every other industry, and affects all facets of society. When we think of fruits and vegetables, we are reminded immediately of the farmer, whom history has labeled the revolutionary element of a country since it is true that most revolutions have been based on the dissatisfaction of the farmers. Indeed, the farmer can serve as the index to a country's prosperity. Food production and distribution in this country has kept abreast of a growing urban civilization by improvement of farming techniques and equipment, and through the development and proper use of pesticides and other agricultural chemicals. Following these developments, new and better methods of plant cultivation and food processing and distribution have led to a food industry that in the U.S. alone has reached an annual volume of more than $75 billion. From the farm we follow through such areas as transport of food to the consumer; ways of keeping foods fresh, flavorful, and attractive as well as improving their nutritional value; and the marketing of new products from food ingredients.

This thought again serves to illustrate that the task of the individual looking for information on food products is not an easy one, especially if his major concern is fruits and vegetables. Much information useful to the processor of fruits and vegetables or to the scientist interested in their chemistry appears in publications concerned with other aspects of food technology. The reader will find pertinent information in such other sections of this paper as: Technology, Processing, Preservation, Sanitation and Quality Control; Chemistry and Biology; Packaging and Canning; Beverage Industries.

The U. S. Department of Agriculture, the various state agricultural experiment stations, and societies, such as the United Fresh Fruit and Vegetable Association (Washington, D. C.) contribute profusely to the published literature. They cover a wide variety of aspects, including consumption statistics, processing, and transport. In the bibliography a few miscellaneous publications are offered merely as an indication of this variety.

Books dealing with the growing of fruits and vegetables are not included in this paper, but some of the journals listed do cover this aspect. Of the books, perhaps Cruess' gives the most comprehensive review of the many interrelated topics of interest. Others deal with specific fruits and vegetables; some are included because they provide related background information.

"Tree Fruit Crops for Processing," by Robert C. Pearl (Chap. 17) in Joslyn and Heid's "Food Processing Operations," Vol. I, and "Receiving and Preparing Fruits and Vegetables for Processing," by J. G. Woodruff, Chapter 18 in that volume, plus Chapter 46 in Vol. III, "Raw Products: Small Fruits," by Ralph Garren, Jr., and H. B. Lagerstedt contain interesting information and useful references, most of which are miscellaneous publications (*see* Technology, Processing, Preservation, Sanitation and Quality Control).

Meat and Meat Products

The literature of meat, meat packing, and the allied by-products industry is scattered in books, technical and trade journals, and the publications of various research organizations. The books and journals itemized in the bibliography by no means comprise full coverage of the available literature; the miscellaneous publications noted merely indicate the kinds of information offered by various government agencies, institutes, trade and professional associations, meat companies, and suppliers.

Much useful information appears in the general literature and in publications listed in such other sections of this paper as Broad-Coverage Literature Sources; Technology, Processing, Preservation, Sanitation and Quality Control; Chemistry and Biology; Packaging and Canning; Edible Oils and Fats; and Poultry and Eggs.

For example, G. E. Brissey and P. A. Goeser contributed "Aging, Curing and Smoking of Meats" (Chap. 22) in Joslyn and Heid's, "Food Processing Operations," Vol. I (*see* Technology, Processing, Preservation, Sanitation, and Quality Control). In Vol. II of that same publication, Goeser and Walter M. Urbain discuss "Cattle, Hogs and Sheep" (Chap. 24). From time to time, the "Advances in Food Research" (*see* Broad-Coverage Literature Sources) offers excellent reviews of certain phases of meat biochemistry.

Items of interest appear also in such journals as *Food Technology, Journal of Agricultural and Food Chemistry, Journal of Food Science, Journal of the Science of Food and Agriculture*, and *Zeitschrift für Lebensmittel-Untersuchung und- Forschung* (*see* Broad-Coverage Literature Sources), in the *Journal of the American Oil Chemists' Society* (*see* Food Additives, Colorings, and Flavorings), and in some of the journals on bacteriology. Of the journals listed in this section, the most important may be *Fleischwirtschaft* and the *Journal of Animal Science*. Among the abstracting services, *Biological Abstracts* and the *Chemical Abstracts* are useful. *BASIC*, the Biological Abstracts information dissemination system, like KWIC (the Key Words in Context Index) from *Chemical Abstracts*, provides the user with current titles.

Among the many useful sources of information in the U.S. are the Institute of Meat Packing (University of Chicago, Chicago, Ill.), the American Meat Institute Foundation (Chicago), National Meat Canners Association (727 National Press Building, Washington, D. C.), National Livestock and Meat Board (Chicago, Ill.), National Independent Meat Packers Association (1820 Massachusetts Ave., N.W., Washington, D. C.), and Western States Meat Packers Association (604 Mission St., San Francisco, Calif.).

In 1961 the Institute of Meat Packing published a brochure, "Books and Pamphlets on the Meat Packing Industry." Typical publications of the Institute include, "Sausage and Ready-to-Serve Meats," and "Pork Operations." The American Meat Institute Foundation offers the proceedings of symposia

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and publications such as the 1960, "The Science of Meat and Meat Products." The proceedings of the Reciprocal Meat Conferences, sponsored by the National Livestock and Meat Board, is another excellent source of information on meat and meat products.

Many publications from the U. S. Department of Agriculture, Washington, D. C., relate to meat, as do those from the U. S. Army Natick Laboratories, Natick, Mass., formerly Quartermaster Food and Container Institute for the Armed Forces.

Representative foreign research institutes which publish extensively are the Low Temperature Station, Cambridge, England, the Danish Meat Research Institute, Roskilde, Denmark, the German Meat Research Institute, Kulmbach, Germany, the Central Institute for Nutrition Research T.N.O., Utrecht, the Netherlands, and the Japanese Meat Research Institute.

Poultry and Eggs

For the most part, published literature specific to this area deals with the raising of chickens and turkeys and with the marketing of poultry and eggs. The most important journals from the standpoint of science and technology are *Poultry Science*, the *World's Poultry Science Journal,* and *Poultry Meat* (combining *Poultry Processing and Marketing, Turkey World,* and *Broiler Business*). Many good articles about poultry meat and poultry processing appear in such journals as *Food Technology, Food Engineering, Journal of Agricultural and Food Chemistry,* and in such publications as the "Advances in Food Research" (*see* Broad-Coverage Literature Sources). Textbooks on food processing, microbiology, nutrition, and meat often contain useful information. For instance, in Chapter 25 of Joslyn and Heid's, "Food Processing Operations," Vol. 2, Eldon J. Strandine reviews "Poultry Production and Processing" (*see* Technology, Processing, Preservation, Sanitation and Quality Control; *see also* Chemistry and Biology, Nutrition, Meat and Meat Products).

In his review, Strandine cites approximately 70 references, many of which are publications of the U. S. Department of Agriculture. Other U.S. government agencies and state agricultural departments often publish in the interests of the poultry and egg industry, as does the American Poultry Association (P.O. Box 337, Great Falls, Mont.). Among the abstracting and indexing services, the best source is *Agricultural Index,* followed by *Biological Abstracts* and *Nutrition Abstracts and Reviews.*

Sugar and Starch

The literature on the chemistry, production, and processing of sugar is not only voluminous, but at least 50% of it appears in non-English publications. These are primarily German, French, and Spanish; some are Swedish, Italian, and Hungarian; and slightly more than 10% are in the less familiar Russian, Polish, Czech, Dutch, Chinese, Japanese, and Portuguese. By comparison, the sources of information relating to the chemistry, sources, produc-

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

tion, and uses of starch may seem less voluminous. Nevertheless, the literature is rich also with material on this carbohydrate.

Books and journals covering the various aspects of sugar and starch are listed in the bibliography. As with other areas of the food industries, much useful information on sugar and starch often appears in the general publications. For instance, *Chemical Abstracts* contains pertinent information under such sections as carbohydrates, industrial carbohydrates, and foods. Fruitful sources are such journals as *Industrial and Engineering Chemistry, Journal of Agriculture and Food Chemistry,* and *Journal of Science of Food and Agriculture* (*see* Broad-Coverage Literature Sources), *Journal of the Association of Official Agricultural Chemists* (*see* Composition and Analysis), and *Cereal Chemistry* (*see* Baking and Milling Industries).

"Starches in Food Processing" are described by R. L. Lloyd in (Chap. 43) Joslyn and Heid's, "Food Processing Operations," Vol. III (*see* Technology, Processing, Preservation, Sanitation, and Quality Control).

Other useful sources include the research societies, and trade and technical associations in the United States and other countries. The U. S. Department of Agriculture makes pertinent contributions, as does the Sugar Research Foundation (New York), the American Society of Sugar Beet Technologists (Fort Collins, Colo.), and the Tropical Plant Research Foundation (Yonkers, N. Y.). Other representative organizations are the Division of Carbohydrate Chemistry of the American Chemical Society (Washington, D. C.), the Association of Official Agricultural Chemists (Washington, D. C.), the National Bureau of Standards of the Department of Commerce, the Corn Industries Research Foundation (Washington, D. C.), the American Association of Cereal Chemists (St. Paul, Minn.), Sugar Industry Technicians, Inc. (P.O. Box 47, Medford, Mass. 02155), and the U. S. National Committee on Sugar Analysis (affiliated with the International Commission for Uniform Methods of Sugar Analysis, Tate & Lyle Research Laboratories, Keston, Kent, England). In connection with the last, the ICUMSA Proceedings, available from the Sugar Research Foundation (52 Wall St., New York, 10005), should be mentioned. These are more formally identified as "International Commission for Uniform Methods of Sugar Analysis, Report of the 11th Session, 1954 (12th Session, 1958; 13th Session, 1962), ICUMSA, Tate & Lyle, Ltd., Research Laboratories, Keston, Kent, England.

Also useful are the publications of the Hawaiian Sugar Planters' Association, the Association of the Hawaiian Sugar Technologists, and the Agricultural Experiment Station of the University of Hawaii. The Agricultural Experiment Station of the University of Puerto Rico, the Asociacion de Tecnicos Azucareros de Puerto Rico, and the Sugar Technology Division, Public Service Commission of Puerto Rico also publish reports and bulletins.

Similarly, other countries have such associations. In Cuba, there are Colegio Nacional de Ingenieros Agronomos y Azucareros, Havana; Asociacion de Tecnicos Azucareros de Cuba; Colegio Nacional de Maestros Quimicos Azucareros, Havana; Estacion Experimental Agronomica, Santiago de las Vegas; and Secretaria de Agricultura, Havana. Sources in the British West Indies include Barbados Department of Science and Agriculture; Cane Breed-

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

ing Station, Barbados; Department of Agriculture, British Guiana; Agricultural Society of Trinidad and Tobago; British West Indies Sugar Technologists; and the British West Indies Sugar Association, Barbados. The last publishes the B.W.I.S.A. Handbook, which is a report of the Proceedings of Meetings of the B.W.I. Sugar Technologists. Then, there is the Jamaican Association of Sugar Technologists in Jamaica.

Others include: Union Nacional de Productores de Azuca, Mexico; Estacion Agricola de Tucuman, Tucuman, Argentina; Instituto do Acucar e do Alcool, Rio de Janeiro, Brazil; Asociacion Peruana de Tecnologos Azucareros, Lima, Peru; and Estacion Experimental de Occidente, Division de la Cana de Azuca, Ministerior de Agricultura y Cria, Yaracuy, Venezuela.

From other parts of the world can be included Taiwan Sugar Experiment Station, Tainan, Taiwan; Department of Agriculture, Federation of Malaya; Indian Institute of Sugar Technology, Cawnpore; Deccan Sugar Technologists' Association, Walchandnagar; Sugar Technologists Association of India, in Cawnpore; Sugar Industry Research Institute, Mauritius; Bureau of Sugar Experiment Stations, Brisbane; and the Department of Agriculture, Brisbane, Australia.

In Europe, there are the Insituut voor Suikerbietenteelt, Bergen op Zoom, Netherlands; Centre d'Etudes, Recherches et Information Sucrieres, Marseille; Bureau du Journal des Fabricants de Sucre, Paris, France; Society of Chemical Industry on the Progress of Applied Chemistry (its *Annual Reports* contain an annual review on progress in sugar chemistry and technology), London; British Sugar Corporation, Peterborough; International Sugar Council, London; and the Central Laboratory of the Polish Sugar Industry and the Principal Institute of the Agriculture and Food Industries, both in Warsaw, Poland.

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

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Year	*Section*
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1962	64. Foods
1963	70. Foods

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

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U.S. Patent Classes and Subclasses

	Class	*Subclass*
Beverages	99	
Carbonated	99	79
Carbonater	261	
Carbonating and flavoring	99	275
	62	389+
Canning		
Cooking and subsequent	99	356
Cooking filled receptacles	99	359+
Filling and closing	53	266+
Food preserving apparatus	99	234+
Food preserving processes	99	150+
Hermetic	99	182+
Coffee	99	65+
Preservation	99	152
Substitutes	99	72+

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

	Class	*Subclass*
Seeding and stoning	146	17+
Sorting machines	209	71+
Stemmer	146	55
Meat	99	107+
Butchering	17	
Choppers hand	30	
Cleaning	17	
Brushing or wiping machines	15	3.1+
Liquid contact apparatus	134	
Cutter and comminutor	146	
Tenderer	17	25+
Preservation	99	157+
Canning	99	187+
Coating	99	169
Dehydration	99	208+
Packaging	99	174+
Refrigeration	99	194+
Tenderers	17	25
Pounders	17	30
Poultry		
Butchering	17	11+
Husbandry	119	
Sugar	127	
Cane plant	PLT	89
Crystals washing out	127	63+
Cutting and shaping	107	
Design	d82	
Fermentative liberation or purification	195	11
Foods containing	99	
Grape	127	36+
Invert	127	41
Syrups	99	142
	260	398+
Milk	31	
Artificial	99	63+
Chocolate	99	24+
Condensing	159	
Evaporating	159	
Filter	210	348+
Modification	99	54+
Preservation	99	151
Canning	99	183+
Dehydration	99	200+
Sterilization and pasteurization	99	212+
Protein foods from	99	19+
Separating	233	
Testing	23	258
Processes	23	231
Sediment	73	61
Vegetable		
Cleaning		
Apparatus brushing or wiping	15	3.1+
Apparatus liquid treatment	134	
Processes	99	103+
Coffee substitutes from	99	74
Comminuting machines	146	
Cutting comminuting peeling	146	
Grating	146	177+
Jellies	99	131
Juices	99	105+
Peeling	146	43+

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ch040

	Class	Subclass
Pit stem or core removal	146	
Preservation	99	154+
Canning	99	186
Coating	99	168
Dehydration	99	204+
Refrigeration	99	193
Protein foods	99	17
Baking	99, 107, 117, 126, 220	
Confectionary	107	
Candy	99, 107	

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INDEX

Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ix001

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ix001

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Publication Date: January 1, 1968 | doi: 10.1021/ba-1968-0078.ix001