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Government Production Statistics as Sources For Chemical Planning

MARGARET V. DONNELLY[1]

Hercules Powder Co., Wilmington, Del.

There are three major sources of chemical statistics: United States Tariff Commission, for productions and sales statistics on organic chemicals and plastic materials; Bureau of the Census, for production and shipments of inorganic chemicals; and Bureau of Mines, for coal chemicals. Selected chemicals are reported on a monthly basis, while hundreds are covered annually. Other sources of chemical statistics are such agencies as the Alcohol Tax Unit, Tennessee Valley Authority, and Bureau of Labor Statistics. The publications of these agencies are discussed in this paper.

Despite the complexity of the chemical industry and its problems of raw materials, diversified output, and marketing of products, there are numerous aids to management planning via government statistics. Chemical statistics is a broad subject, but this paper presents brief comments on the types of statistics made available to the industry by the major chemical statistics collection agencies. At the end of this paper, a representative listing of publications of these agencies is presented.

Types of data currently available on chemicals include production, consumption by producing plants, interplant transfers, sales, and stocks. Plant capacities are not usually reported and price data on manufactures are not covered although, in annual statistics, unit values can be calculated where quantity and value of sales are reported.

There are three major chemical statistics agencies in the Federal Government. The Bureau of the Census is the regular collection agency for inorganic chemicals; the Tariff Commission is responsible for production and sales figures on organic chemicals; and the Bureau of Mines collects figures on coke and coal chemicals and many other statistics of interest to the chemical industry. Other government agencies contribute also to varying degrees. For example, the Alcohol Tax Unit, Tennessee Valley Authority, Department of Agriculture, Bureau of Labor Statistics, Bureau of Transport Economics, Office of Business Economics, and Federal Reserve Board include some chemical reporting in their various individual functions.

Inorganic Chemicals

The various current services of the Bureau of the Census are helpful to chemical market researchers. The Census Bureau publishes 63 regular reports, on a monthly and quarterly basis, known as the "Facts for Industry" series. In the chemical classification, there are monthly reports covering glue, gelatin, paint, varnish and lacquer, and superphosphate, and one on inorganic chemicals which lists 80 basic inorganic chemicals and contains figures on primary production. A special Census Bureau report on "Inorganic Chemicals and Gases" contains 1950 data on more than 100 chemicals with comparative figures for earlier years wherever such figures were available. A similar summary was released for 1951.

Another monthly "Facts for Industry" containing statistics of value to the chemical industry is the *Fats and Oils* series. There are two of these reports: One contains figures on crushing, end-of-month stocks of raw materials, production, shipments and transfers for vegetable oils, animal fats, fish and marine mammal oils, and secondary products. The second report contains statistics on consumption of the foregoing materials by specific end uses, arranged by edible and inedible categories. The inedible classification separates uses into soap, chemicals, paint and varnish, lubricants and greases, and linoleum and oilcloth.

Of interest, also, to the chemical industry are such "Facts for Industry" reports as the monthly one on softwood plywood which, in addition to figures on production and consumption of plywood, contains data on consumption of glue by types of glue. The *Pulp, Paper and Board* reports which are also part of the "Facts for Industry" series should not be overlooked, particularly by researchers engaged in surveying markets for paper chemicals. *Glass Containers*, another monthly publication in the series, offers information of value to those engaged in a survey of sodium sulfate, for example.

It is readily apparent to users of the "Facts for Industry" reports of the Bureau of Census that the series is indeed well named. Exact titles and numerical identification of the reports are shown in the list presented at the end of this paper.

The Census Bureau has a series of "Cotton Ginning Reports" of special interest to agricultural chemical manufacturers. Included are figures on cotton ginned, yields of lint, and acreages; statistics are shown by counties and states. In some cases, the published data represent joint efforts of the Census Bureau and the Bureau of Agricultural Economics.

Foreign Trade Statistics

The Census Bureau has responsibility also for compilation and publication of United States foreign trade statistics. It is virtually impossible for a researcher studying domestic markets for a given chemical or group of chemicals to overlook the importance of imports and exports. Often, imports of a specific product may spell the difference between short supply and balance. And exports may be an important aspect of the total market for a chemical or chemical product. The Census Bureau publishes monthly export statistics on 2700 products, of which 276 are chemicals; the figures are arranged by commodities first, followed by countries of destination. The series on imports covers approximately 5300 items each month and figures are arranged by commodity and country of origin. These reports are available from the Bureau of Census at nominal subscription rates. To assist users of foreign trade statistics, the Census Bureau publishes import and export classification schedules, known as Schedules A and B, respectively. These schedules list numerical commodity classifications and reference to them is necessary to make fullest use of the monthly foreign trade reports, as items follow the schedules' numerical arrangement. In addition to the regularly published import and export statistics, the Bureau of the Census provides monthly reports on close to a hundred items upon special arrangements made with requesting companies and organizations. (Service consists usually of selecting individual items from within basket, or miscellaneous, groups.) The bureau charges for such special services are based on the time devoted to compiling the desired figures. During 1951, charges for special reports ranged from $21 to as much as $600 on an annual basis. However, when additional requests are received for an identical report, it is possible to reduce the cost to each subscriber.

One unable to locate individual items in either current manufacturers' reports or foreign trade statistics should ask; as a matter of fact, Census Bureau officials welcome interest and questions.

Organic Chemicals

Organic chemicals production statistics are collected, compiled, and published monthly and annually by the United States Tariff Commission. The monthly report is necessarily limited to the most significant and basic organic chemicals and, currently, includes data on 71 items, while the annual report lists thousands of organic chemicals and contains as well, in Part II, a directory of manufacturers of organic chemicals. The commission also reports, on a monthly basis, production of synthetic resins with statistics arranged by end-use classifications. These two monthly services are of great value to the chemical industry in watching production trends and in comparing current output of individual items with earlier periods.

Special studies on chemicals which are particularly helpful are released from time to time by the Tariff Commission. One, published in September 1951, is a summary of information on uses, production, trade, and supply of industrial alcohol. In the 50 pages of the report, there is a wealth of data; some of the figures go back to 1935 and 1937 and there is some information on alcohol in countries outside the United States. Another series of special reports, entitled "War Changes in Industry" was released a few years ago. While these do not come under the heading of current statistics, often the summaries contain official estimates on production and consumption of chemicals for which figures are not published generally. There are 10 publications in the series of interest to the chemical industry; among them are those on mercury, magnesium, petroleum, dyes, clay, and plastic products.

The Bureau of Mines is a source of many chemical statistics. The monthly *Coke and Coal Chemicals* report, part of the bureau's "Mineral Industry Surveys," contains, in addition to data on oven and beehive coke production, figures on production of ammonium sulfate, ammonia liquor, naphthalene, benzene, toluene, xylene, solvent naphtha, pyridine, crude coal tar, and cresote oil. Sales and end-of-month stock figures are also shown in the report. A useful feature of the report is the year-end supplement which gives year's totals by months.

It is not strictly current, but the mine of information in the annual *Minerals Yearbook* cannot be overlooked. The commodity reviews in the yearbook contain statistics on domestic production, foreign trade, consumption by end uses, prices, information on new mines and old ones and, often, historical data on a given mineral. The chemical market researcher will find many useful data in these commodity reviews; a casual check of commodities covered indicates that use of chemicals and related products is reported for at least 50 commodities. Helpful statistics are found on arsenic, barium chemicals, bismuth, chromium, clays and their consumption in chemicals, paints, insecticides, and fertilizers; there are figures on copper sulfate, feldspar and fluorspar, helium, lead and zinc pigments and mineral earth pigments, magnesium and mercury, potash, sulfur and pyrites, titanium, and even isotopes. There are many other items covered in the *Minerals Yearbook.* Because of the coverage involved, the yearbook is usually about 2 years late in being released, but the Bureau of Mines releases preprints of individual chapters in advance of the complete volume and there are also many monthly and quarterly reports released in the "Mineral Industry Surveys" series.

Various Sources of Chemical Statistics

The Alcohol and Tobacco Tax Division of the Bureau of Internal Revenue prepares and releases monthly and annually a report entitled *Comparative Statistics on Ethyl Alcohol* which contains statistical data on materials used at industrial alcohol plants, production of domestic undenatured alcohol, and end-of-month stocks, as well as figures on imported alcohol. State summaries of production, withdrawals, and stocks are also shown. At the end of each fiscal year, June 30, the division releases figures on specially denatured alcohol and its uses; the statistics are classified into uses falling within general categories (such as solvents, as in pharmaceutical products, cleaning and preserving, and flavoring preparations) and into uses as raw material in the production of chemicals, or use as a fluid or as a fuel.

The Tennessee Valley Authority publishes as a supplement to its annual reports a series of statistical tables which have value to chemical market researchers. One such table is a summary of agricultural materials distributed both inside and outside the valley and shows sales to governmental agencies as well as other sales of concentrated superphosphate, calcium metaphosphate, and fused tricalcium phosphate, ammonium nitrate fertilizer, calcium phosphates, etc. Figures on the disposition of chemical products are reported in tons.

The Bureau of Agricultural Economics of the Department of Agriculture has several statistical services which are useful to the chemical industry. Of special interest is the quarterly *Naval Stores Report,* which contains figures on production, distribution, consumption, and stocks of turpentine, both wood and gum types. Industrial consumption of both rosin and turpentine are shown by 15 specific industries, including quantities consumed by chemicals and pharmaceuticals, ester gums and synthetic resins, and paint, varnish, and lacquer. In addition, this quarterly report covers miscellaneous naval stores production, including products such as pine oil and resin oil.

The Production and Marketing Administration of the Department of Agriculture released a comprehensive report in the summer of 1950 entitled "World Trends in Supply, Distribution and Prices of Naval Stores, 1934–1949," which is a valuable addition to naval stores statistical material.

Another Bureau of Agricultural Economics report of interest to the chemical industry is the one published monthly, *Dry Casein.* This report contains figures on estimated production of casein as well as stocks held by driers at the end of each month.

The Bureau of Labor Statistics has just begun release of tables resulting from its interindustry relations study of 1947. Very generally, this study is concerned with the distribution of all output in the United States for 1947, by both industry of origin and industry of destination. The tabulations which have been prepared are the result of 2 years' work by the Bureau of Labor Statistics at the request of the National Security Resources Board and the Air Force. The purpose of the project is to improve industrial mobilization planning; and data were obtained from other government agencies as well as by direct survey of industries. Chemicals, of course, are covered in the survey and the total gross output of the industry is shown as somewhat over $14 billion in 1947, with 45 specific industries' total purchases of chemicals. Since the input-output analysis will benefit mostly those industries which supply other industries, it can be expected that the chemical industry will find considerable use for the statistics resulting from this study.

The Bureau of Labor Statistics reports monthly prices for chemicals in its wholesale price index series. The chemicals and allied products group is made up of chemicals, drug and pharmaceutical materials, fertilizer and mixed fertilizer materials, and oils and fats. The bureau has announced a revision of its wholesale price index beginning with January 1952 prices. The January report contains figures on the revised basis back to January 1947, with the revised series linked to that early month. In the revised index, the Bureau of Labor Statistics is using the 1947 to 1949 period as representing 100 instead of 1926 as had been the case. For the first time, plastics will be included in the Bureau of Labor Statistics wholesale price index. Other important items developed during or since the end of World War II are included in the new index.

The Bureau of Transport Economics and Statistics of the Interstate Commerce Commission is responsible for the freight statistics on commodities which can be used in various ways by the chemical industry. Since 1947, the bureau has had data, on a sample basis, of terminated traffic by commodity breakdowns. Issued quarterly, the Group V statistics titled *Manufactures and Miscellaneous* include numerous chemicals and chemical products. Number of carloads and tons are reported for Class I steam railways in the United States. Although no longer published, the state statistics by origination, destination, and commodity were useful data. Collection and publication of these figures were discontinued in January 1952.

The indexes of industrial production compiled by the Board of Governors of the Federal Reserve System provide an indication of the level of total industrial production as well as of individual industries and groups of industries. These indexes, which compare present output with average output during the 1935 to 1939 period, are published monthly in the *Federal Reserve Bulletin.* Indexes are compiled and published for the over-all chemical industry and for three separate segments: paints, rayon, and industrial chemicals. The indexes are useful in measuring growth trends and in making comparisons with other industries.

Interesting data on working capital of United States corporations, assets, liabilities, and net worth are included in the quarterly financial report series of the Federal Trade Commission and Securities and Exchange Commission. Chemicals and allied products are included as a group along with all other manufacturing firms. The Securities and Exchange Commission collects data for corporations registered with it, while information on nonregistered manufacturers is obtained from a carefully selected sample by the Federal Trade Commission. The series began with the first quarter of 1947 and is intended to meet general needs of Government and the public for current authoritative financial statistics.

The Office of Business Economics, Department of Commerce, obtains dollar sales figures each month from representative chemical companies as well as data on inventories. The individual company figures are classified into three groups: industrial chemicals, drugs and soaps, and other—which includes paints and fats and oils. From this information, it is possible to estimate total sales each month by the entire chemical industry. These estimates are published regularly in the *Survey of Current Business*, a monthly service of the Department of Commerce. Manufacturers are thus able to compare their individual sales performance with the industry as a whole. Similarly, inventories are reported. Unfilled orders data are somewhat difficult to obtain for the chemical industry, however.

Uses of Statistical Aids

The various statistical aids which have been discussed, when used intelligently, make it possible for chemical manufacturers to know more about raw material supplies, and to determine quantitatively how rapidly new industries are expanding or, conversely, others are contracting. Chemical statistics are useful in production scheduling; in studying markets for already existing or new products; and in establishing sales quotas and developing advertising programs and inventory policies. They enable the management of a company to compare the company's activity or position with that of the entire industry or segment of the industry.

Determination of market concentrations is possible. Statistics, particularly the general statistics of an industry, help the researcher measure performance. For example, it is believed that Census Bureau figures for "value added by manufacture" are almost synonymous with gross margin, since for many industries this is the difference between value of product shipped and cost of materials, fuel and electricity, and contract work.

Government chemical statistics generally can be used to advantage by both large and small manufacturers. They form the base for analysis of trends and survey of markets; without such a base, chemical market research would be much more difficult to accomplish and results much more open to question.

Numerous complaints are made by representatives of chemical companies as to the limitations and quality of some series of chemical statistics; at the same time, it is usually admitted that, despite shortcomings, the figures are better than none. Chemical companies often are not as careful as they might be in filling in statistical schedules on their products; many errors creep in. Some of these errors are discovered rather quickly when the reports are examined in Washington, but others may never come to light. The final total figures for a given product or group of products, therefore, are only as accurate as the respondent companies are accurate in their reporting to the collecting agencies. Another frequently voiced complaint concerns the lateness of published figures. Again, control of publication of figures is largely in the hands of chemical companies. A few slow-to-report chemical manufacturers can hold up publication for several days or weeks, especially if the delinquent companies are responsible for a sizable production of one or more chemicals. Tardiness in reporting not only delays publication of totals but adds to government expense in obtaining missing figures.

Government officials and statistical personnel, responsible for collection, compilation, and publication of statistics, are as anxious to do an accurate and worth-while reporting job as the industry is desirous of having such help available to it. Chemical statistics collection agencies in Washington give courteous attention and sincere cooperation with problems, and welcome suggestions for improvement of existing current statistics.

Selected Sources of Government Statistics on Chemicals

Bureau of the Census, Washington 25, D. C.

FACTS FOR INDUSTRY SERIES (monthly unless otherwise noted)

Animal Glue, Ser. **M19M.2a.**

"Animal and Vegetable Fats and Oils, 1950," *Ser.* **M17-1-00.** Annual data, 1949 and 1950.

Fats and Oils, Ser. **M17-1.**

Fats and Oils (Factory Consumption), *Ser.* **M-17-2.**

Gelatin, Ser. **M19M.1.**

Glass Containers, Ser. **M77C.**

Inorganic Chemicals, Ser. **M19A.**

"Inorganic Chemicals and Gases, 1950," *Ser.* **M19A-00** (1952). Annual data, 1947 through 1950.

Paint, Varnish, Lacquer and Filler, Ser. **M19J.**

Pulp, Paper and Board, Ser. **M14A.**

Softwood Plywood, Ser. **M13B.**

Superphosphate, Ser. **M19D.**

COTTON GINNING REPORTS

Cotton Ginning (preliminary reports). Eleven releases during season with an additional end-of-season report issued in March of the following year; shows number of bales of cotton ginned, by state.

Consolidated Cotton Report. 5 monthly reports each year, August to December; issued jointly by Bureau of the Census and Bureau of Agricultural Economics.

FOREIGN TRADE STATISTICS

United States Exports of Domestic and Foreign Merchandise (Commodity by Country of Destination), **FT 410,** monthly and annually.

United States Imports of Merchandise (for Consumption; Commodity by Country of Origin), **FT 110,** monthly and annually.

Statistical Classification of Commodities Imported into the United States, Schedule A (August 1, 1950).

Statistical Classification of Domestic and Foreign Commodities Exported from the United States, Schedule B (January 1, 1952).

United States Tariff Commission, Washington 25, D. C.

Preliminary Report on Production of Specified Synthetic Organic Chemicals in the United States, Ser. **6-2,** monthly.

Preliminary Report on Production and Sales of Synthetic Plastics and Resin Materials, Ser. **6-10,** monthly.

Synthetic Organic Chemicals, United States Production and Sales, annually. Latest covers 1951.

INDUSTRIAL MATERIALS SERIES

"Ethyl Alcohol" (Industrial Alcohol), *Rept.* **M-1** (September 1951).

WAR CHANGES IN INDUSTRY SERIES

"Aluminum," *Rept.* **14.**

"China Clay or Kaolin," *Rept.* **23** (1947).

"Dyes," *Rept.* **19** (1946).

"Industrial Alcohol," *Rept.* **2** (January 1944).

"Magnesium," *Rept.* **10.**

"Mercury," *Rept.* **4** (June 1944).

"Petroleum," *Rept.* **17** (1946).

"Plastic Products," *Rept.* **28** (1948).

"Refractory Magnesia" (Magnesite), *Rept.* **12** (1945).

"Rubber," *Rept.* **6** (1945).

United States Bureau of Mines, Washington 25, D. C.

MINERAL INDUSTRY SURVEYS (monthly unless otherwise noted)

Bauxite, quarterly.

Cadmium.

Coke and Coal Chemicals.

Copper Sulfate.

Lead Consumption.

Natural Gasoline and Allied Products.

Native Sulfur, monthly and annually.

Zinc Oxide.

Minerals Yearbook, annually.

Alcohol and Tobacco Tax Division of the Bureau of Internal Revenue, Treasury Department, Washington 25, D. C.

Comparative Statistics on Distilled Spirits, monthly and fiscal year.

Comparative Statistics on Ethyl Alcohol, monthly and fiscal year.

Comparative Statistics on Fermented Malt Liquors, monthly and fiscal year.

Comparative Statistics on Wines, monthly and fiscal year.

Statistics on the Use of Specially Denatured Alcohol, fiscal year.

Tennessee Valley Authority, Knoxville, Tenn.
Annual Report of the Tennessee Valley Authority.

Bureau of Agricultural Economics of the U. S. Department of Agriculture, Washington 25, D. C.
Dry Casein, monthly.
Naval Stores Report, quarterly.

Production and Marketing Administration of the U. S. Department of Agriculture, Washington 25, D. C.
"World Trends in Supply, Distribution, and Prices of Naval Stores, 1934–49" (July 1950).

Bureau of Labor Statistics of the U. S. Department of Labor, Washington 25, D. C.
Average Wholesale Prices and Index Numbers, monthly.

Bureau of Transport Economics and Statistics of the Interstate Commerce Commission, Washington 25, D. C.
"State to State Distribution of Carload Tonnage by Major Commodity Groups, 1950," processed (1952).

Board of Governors of the Federal Reserve System, Washington 25, D. C.
Federal Reserve Bulletin, monthly.

Federal Trade Commission, Washington 25, D. C.
Quarterly Financial Report on United States Manufacturing Corporations, published jointly with the Securities and Exchange Commission.

Office of Business Economics of the U. S. Department of Commerce, Washington 25, D. C.
Survey of Current Business, monthly.
Industry Survey: Manufacturers' Sales, Inventories, New and Unfilled Orders, monthly.

RECEIVED April 22, 1952. Presented before the Division of Chemical Literature, Symposium on Literature Sources for Chemical Market Research, at the 121st Meeting of the AMERICAN CHEMICAL SOCIETY, Buffalo, N. Y.

Chemical Statistics and Commerce's Chemical Division

F. M. HOFFHEINS and OSCAR A. COLTEN

Chemical and Rubber Division, Business and Defense Services Administration, U. S. Department of Commerce, Washington, D. C.

In programming chemical expansion and in studying supplies and requirements of chemicals, statistics are essential. Production statistics are obtainable through federal agencies, but data on plant capacities, uses, and raw material requirements are also necessary. Such data were developed by the Chemical Division of the National Production Authority on officially approved forms, which were sent to chemical producers. By the end of 1951, 92 specific chemicals were surveyed, analysis of data is in progress regularly, and results of such analyses are put to immediate use by the various chemical specialists.

During periods of national emergency, a system of priorities and allocations of materials and facilities based on supply and requirement studies of products and services is essential for national security. The basis of such studies is accurate and detailed statistical information.

Chemicals and allied products are so vital to national security that a control system must be ready for immediate use. This requires that the Government have at hand at all times up-to-date statistics on a variety of basic chemicals.

In recent years the nation has gone through two such emergencies: World War II and the Korean action. During World War II, a series of war agencies was established to assume responsibilities for priorities and allocations. The last and best known of these was the War Production Board. Regardless of the name, however, each of these agencies had a division which was responsible for chemicals.

In 1947, in enacting the National Security Act, Congress made provision for establishment of an agency which would be concerned with coordinating military, industrial, and civilian mobilization. The National Security Resources Board, as this agency was known, had both short- and long-range planning responsibilities in the areas of manpower; stabilization of civilian economy; production, procurement, and distribution of goods; supply-requirement statistics of manpower, resources, and productive facilities; stockpiles; and dispersion of industry and government.

In the period between World War II and the Korean action, the Chemical Division of the Commerce Department's Office of Domestic Commerce continued its long-standing function of compiling and disseminating statistics of concern to the chemical and chemical process industries.

Mobilization Program Required by Korean Action

The second emergency period started with the outbreak of the Korean action. The organizational setup of defense agencies during this emergency differed to some extent from that during World War II, but the basic objectives were the same.

In September 1950, for example, Congress passed the Defense Production Act which authorized the President to mobilize the economy. Under this act, NSRB remained a planning agency and several new agencies were set up to handle operating responsibilities in the fields of production and economic control.

The organization, as it finally shaped up, was headed by the Defense Production Administration (later Office of Defense Mobilization) which established policy and coordinated the activities of various operating units. Except for the Office of Price Stabilization, most mobilization agencies were set up within existing government agencies.

One of the most important of these and the one which controlled chemicals, was the National Production Authority (NPA) set up within the Department of Commerce. NPA had 33 divisions, including the Chemical Division. The nucleus of this unit was personnel from Office of Domestic Commerce's Chemical Division.

NPA's Chemical Division was responsible for promoting national defense and essential civilian economy by stimulating production of chemicals and providing production facilities as needed. Its duties also included restrictions on the use of critical materials for nonessential purposes, and taking measures to assure equitable distribution of critical materials for defense and civilian uses.

The NPA Chemical Division was organized into seven branches, five of which were concerned with commodities and two with program and requirements and facilities.

Statistics Vital in War Planning

The Chemical Division could not have performed its authorized function of stimulating defense production had it not been for industry and commodity statistics. Personnel had to know current production, consumption, and stocks of chemicals and related products. It had to be informed of existing demand and possible future demand for hundreds of inorganic and organic chemicals. Because of its functions concerned with processing applications for rapid tax amortization and loan assistance, the division also kept informed of planned chemical expansions.

One of the basic types of controls exercised over the nation's industry during the Korean action was the Controlled Materials Plan (CMP). Under CMP, steel, copper, and aluminum were allocated to industry. The Chemical Division was responsible for allocating these basic materials to manufacturers of 16 groups of chemical products such as paint, catalysts, and plastics. On July 1, 1953, CMP was replaced by the Defense Materials System (DMS).

To control use of critical chemicals, various types of regulations were used. The basic one (NPA order M-45) was designed to provide for distribution and use of limited supplies of chemicals so as best to serve the interests of national defense and civilian production. Approximately 10 chemicals were controlled by this order. These included: naphthenic acid, polyethylene, resorcinol, sebacic acid, methylene chloride, methyl chloride, Thiokol, Teflon, sulfuric acid, and plastic-type nylon.

Special orders were issued to control the sale and use of such chemicals as sulfur and chlorine.

Use and interpretation of chemical statistics were basic to all these operations.

Certificates of Necessity

Another major use of chemical statistics involved the handling of applications for certificates of necessity and loan applications.

Under the certificate of necessity program, "construction, reconstruction, erection, installation, or acquistion of facilities necessary in whole or in part in the interest of national defense during this emergency period" was allowed accelerated tax amortization on that portion of the amount applying to defense purposes. During the Korean action period some 1400 applications for certificates of necessity were processed by the Chemical Division. These certificates represented investments running over $3 billion.

To know when added capacity was needed, the Chemical Division had to obtain accurate and up-to-date supply-requirement data. Some statistics for this purpose were available in the form of published and unpublished figures of several government agencies which collect, compile, and distribute chemical statistics. During this period, organizations like the Bureau of the Census, Tariff Commission, and the Bureau of Mines expanded their monthly schedules at the request of the Chemical Division. They obtained current data on production, consumption, and stocks on an additional 100 or more chemicals. "Old-line" agencies were used to collect this material to avoid setting up duplicate or overlapping facilities.

In some cases, where it was necessary to obtain statistical data of a type not collected by old-line agencies, the NPA Chemical Division collected the data. Typical examples are information concerning plant capacity, proposed future production, raw material requirements, power consumption, and end-use patterns. During the war the capacity and end-use data were not made available publicly.

As was the case at the end of World War II when "wartime end-use patterns" for approximately 60 chemicals were made public, current end-use data are being released by the Chemical Division. Individual company figures are not disclosed.

In all of its operations, the Chemical Division utilized the services and advice of industry advisory committees. These committees, which totaled about 50, represented large, medium, and small producers of specific chemicals.

The practice of using industry-trained personnel on a rotating basis was adopted by the NPA commodity divisions, including the Chemical Division. Those men served on a full-time or consultant basis, usually without compensation (WOC).

By using industry advisory committees and industry trained men, the Chemical Division was able to get help in intelligent interpretation and analysis of the chemical statistics it compiled.

New Postwar Organization

The mobilization activities tapered off after the Korean action and controls on chemicals were taken off. NPA was dissolved and the Commerce Department reorganized its commodity divisions with the object of furnishing a service to industry on a more normal peacetime basis. Inherent in the reorganization planning, however, was the idea that the new setup should serve as the nucleus for any future mobilization programs. Business and Defense Services Administration, as the new organization is called, includes 25 commodity divisions. The Chemical and Rubber Division is one of these.

The Secretary of Commerce has continued the policy of utilizing the services of industry leaders on a rotating basis. These men serve as head of the Chemical and Rubber Division for periods of 6 months. To assure continued smooth operations, the deputy director is a career government employee.

The Chemical and Rubber Division is still carrying on certain activities called for by the Defense Production Act. One of these relates to certificates of necessity and loan applications. This program calls for extensive use of chemical statistics, as noted above.

Another activity relating to chemical statistics is the publication of end-use patterns of basic chemicals. Several of these have been issued, including benzene, toluene, sulfur, and sulfuric acid. New ones are planned and older ones are being updated.

Of interest to those who use statistics is the Chemical and Rubber Division's proposal to renew publication of regular reports on the chemical industry. These will be essentially analytical, showing trends in various phases of the industry.

The Chemical and Rubber Division of BDSA is interested in collecting and disseminating data and statistics concerning the chemical industry. Very often it has data, some of them unpublished, which are available for the asking, except for emergency periods when release of statistics could be a security problem.

Realizing full well that "to give is to get," the Chemical and Rubber Division, as a service organization to industry and government, welcomes requests, whether they be letters, phone calls, or personal visits.

Sources of Statistics

As noted above, the Chemical and Rubber Division is a secondary source of most chemical statistics data. It compiles and analyzes data collected by "old-line" government agencies.

From a chemical marketer's viewpoint, the Chemical and Rubber Division serves well as a point in Government where information can be obtained as to the availability and location of chemical statistics issued by government agencies.

The only statistical reports currently issued by the Chemical and Rubber Division are consumption and end-use patterns of various basic chemicals. These do not appear at any regular interval but when the data are available. To date reports on benzene, toluene, sulfur, and sulfuric acid have been issued.

Prior to the Korean action, the division issued monthly reports on the chemical industry. These were discontinued. Plans to resume publication of the report "Chemical and Rubber Monthly Industry Report" are still in the discussion stage. Similarly, the synopses of information on major commodities were discontinued but may be resumed. These would appear in the monthly report and possibly as separate reprints.

Principal sources of statistics of interest to the chemical and chemical process industries are cited in the "Chemical Statistics Directory." This publication was prepared by the Chemical and Rubber Division of the Commerce Department. The first edition of this appeared in 1947 and covered the year 1945. The second edition was printed in 1949 and covered the period 1946–47. No revised editions have appeared since that time. Copies of the first are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at $0.15. Copies of the second are available at the same address at a cost of $0.20.

The principal agencies cited in these directories and the areas which they cover are cited below: Bureau of the Census, inorganic chemicals, export-import data; Bureau of Internal Revenue, alcohol; Bureau of Labor Statistics, wages, hours, employment, payroll, and wholesale and retail prices and indexes; Bureau of Mines, metals and minerals; Bureau of Narcotics, narcotics; Department of Agriculture, chemicals from agricultural products, naval stores, fertilizer, agricultural chemicals; Department of the Interior, petroleum, gas, and coal; Federal Reserve System, business indexes; and Tariff Commission, synthetic organic chemicals, trade agreements data.

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State Sources of Market Information

JOHN D. McPHERSON and E. D. SIMPSON
American Cyanamid Co., New York, N. Y.

A survey was made of sources of market information limited geographically to one state. Directories of chemical manufacturers for three states are published separately. Directories of manufacturers for 45 states are available; in most cases, chemical manufacturers are grouped under a separate heading. Organizations, with addresses, which can supply information on the mineral, agricultural, or forestry resources are tabulated. State planning and development agencies for 38 states are listed.

The title of this symposium is "Literature Sources for Chemical Market Research." This is repeated here, because Webster's two most applicable definitions of literature are "The body of writings having to do with a given subject" and (colloquial) "Any kind of printed matter." Some of the sources covered by this paper are agencies which may supply information on request. The distinction is that such information does not now exist as literature.

By way of further definition, "state source" is intended to mean a source which gives information confined to the geographic limits of one state. Such sources are not necessarily functions of state government or of state, county, and city governments.

Obtaining Sources of Information

"Market Research Sources, 1950" (*62*), published by United States Department of Commerce, was used as the starting point for a mail survey upon which this paper is based. Paragraphs 126–280 of "Market Research Sources" list agencies of state and local governments. Each of the forty-eight states has a commission for collection and publication of information on employment; unemployment; employment by area, major industry, establishment; and earnings, wages, and hours. This information on employment and labor is the only item of market value which is exclusively furnished by state governments and is the only uniform type of data supplied by all forty-eight states.

Other commissions functioning under state governments, found in more than a majority of the states and having data which might be useful in some market studies, pertain to highways and motor vehicles; development, planning, and promotion; and agriculture and geology. Other parts of "Market Research Sources," which list some potential state sources, were Part III, Colleges and Universities; Part IV, Chambers of Commerce; Part VI, Commercial Organizations; and Part VII, Publishing Companies.

In preparing the mail questionnaire, some of the factors universally required in a market research study were kept in mind. These were producers and their locations, consumers and their locations, and raw materials used and their availability. Each questionnaire was prepared as an individually typed letter and was addressed to one agency within each state. The agency was selected from among the listings in "Market Research Sources."

The questions asked in each instance were:

Is there a published list of chemical manufacturers?
Available from? (name and address)
Price?
Does it give products manufactured?

If there is not a list of chemical manufacturers, are they included in a general directory of manufacturers?
If so,
Available from? (name and address)
Price?
Does it give a listing of products manufactured?

Is there a source of information on availability of raw materials in the state? (name and address)

Is there a state planning commission or similar bureau which can answer specific questions such as status of chemical industry in the state, availability of raw materials, location of markets, availability of plant sites, and transportation systems? (If so, name and address)

Directories of Chemical Manufacturers

Answers to the first question showed that a list of chemical manufacturers or an official directory of chemical manufacturers had been published separately for only three states. Several replies, however, referred to *Chemical Engineering* (*57*) for October 1948 in which there was published a directory of prime producers of chemicals in the western states. Reference was also given to "Principal Chemical and Metallurgical Industries of the Pacific Northwest—Information Circular No. 3" published by Raw Materials Survey, Portland, Ore. (*60*).

Forty-five states have published a directory of manufacturers. In each case, chemical manufacturers are included, and in most of these, they are grouped together under a separate heading. Although Washington and Oregon have not issued directories, the chemical manufacturers may be found in "Principal Chemical and Metallurgical Industries of the Pacific Northwest" compiled by the Industrial Division, Seattle Chamber of Commerce in January 1950 (*53*), and also in (*60*), mentioned previously.

Directories of manufacturers, as issued by various states, will be found to range in size from a mimeographed pamphlet to a very large bound volume. They will vary in make-up from a simple alphabetical listing of firm names to a combination listing alphabetically, geographically, and by-product grouping. Some of them list only firm names or firm names with general nature of business, whereas some include a detailed list of the products manufactured by each firm. Information taken from many of these directories will be found no more comprehensive than the same data taken from national or trade publications, such as "Thomas Register" (*61*), "*Moody's Industrials*" (*59*), and the Buyers Guide Issue of *Chemical Week* (*58*). However, they should be of value if a market study is to be made of a limited geographic region.

A list of directories of manufacturers, where they may be obtained, and their prices are given in the bibliography.

Information on Natural Resources

The third question was about natural resources. Agencies having this information were of various types. In most states there are one or more organizations which can supply information on the agricultural, forest, and mineral resources. In some cases, the names of individuals were given as sources. These have been eliminated from the sources of information on raw materials availability which are listed in Table I. The caliber of information available from the sources listed as being able to supply data has not been tested. The names were suggested in answer to our questionnaire, and it is hoped they may serve some useful purpose.

Table I. Sources of Information on Raw Materials Availability

ALABAMA
Agricultural: Agricultural Experiment Station, Alabama Polytechnic Institute, University, Ala.
Forest: State Department of Conservation, Montgomery, Ala.
Mineral: Geological Survey of Alabama, University, Ala. School of Chemistry, University of Alabama, University, Ala.

ARIZONA
Department of Mineral Resources, State Fairgrounds, Phoenix, Ariz.

ARKANSAS
Geology Division, Arkansas Resources and Development Commission, 446 State Capitol, Little Rock, Ark.

CALIFORNIA
Research Department, California State Chamber of Commerce, 350 Bush St., San Francisco 4, Calif.
State Division of Mines, Ferry Building, San Francisco 4, Calif.

COLORADO
Colorado State Chamber of Commerce, Chamber of Commerce Bldg., Denver, Colo.

CONNECTICUT
Connecticut Development Commission, State Office Building, Hartford, Conn.

DELAWARE
Delaware State Development Department, Dover, Del.

FLORIDA
Bureau of Business and Economic Research, University of Florida, Gainesville, Fla.
Agricultural: Agriculture Experiment Station, University of Florida, Gainesville, Fla.
Fishery: Marine Laboratory, Florida State University, Tallahassee, Fla.
Marine Laboratory, University of Miami, Coral Gables, Fla.
Forest: State Forester, Tallahassee, Fla.
Mineral: State Geologist, Tallahassee, Fla.

IDAHO
Idaho State Chamber of Commerce, Boise, Idaho

ILLINOIS
Agricultural Department, University of Illinois, Urbana, Ill.
State Geological Survey, Urbana, Ill.

INDIANA
Department of Chemical Engineering, Purdue University, Lafayette, Ind.
School of Agriculture, Purdue University, Lafayette, Ind.

KANSAS
Agricultural Experiment Station, Kansas State College, Manhattan, Kan.
Kansas Industrial Development Commission, 903 Harrison, Topeka, Kan.
Kansas State Geological Survey, Lawrence, Kan.

KENTUCKY
Agricultural & Industrial Development Board, Commonwealth of Kentucky, Frankfort, Ky.
Department of Geology, University of Kentucky, Lexington, Ky.
Department of Mining and Metallurgical Engineering, College of Engineering, University of Kentucky, Lexington, Ky.

LOUISIANA
State Department of Agriculture and Immigration, P. O. Box 951, Baton Rouge 1, La.
Louisiana Geological Survey, Geology Building, Louisiana State University, Baton Rouge 4, La.
Louisiana State Forestry Commission, P. O. Box 1269, Baton Rouge 2, La.
State Department of Commerce and Industry, Baton Rouge 4, La.
Statistician, State Department of Conservation, State Capitol, Baton Rouge 4, La.

MARYLAND
Department of Geology, Mines and Water Resources, Johns Hopkins University, Baltimore 18, Md.

MICHIGAN
Geological Survey Division, Michigan Department of Conservation, Lansing, Mich.

MINNESOTA
Minnesota Department of Business Research and Development, 117 University Ave., St. Paul 1, Minn.
Minnesota Geological Survey, University of Minnesota, Minneapolis, Minn.

MISSISSIPPI
Mississippi Agricultural and Industrial Board, Box 849, Jackson, Miss.

MISSOURI
Missouri Division of Resources and Development, State Office Building, Jefferson City, Mo.
Industrial Bureau, St. Louis Chamber of Commerce, St. Louis, Mo.
State Geologist, Rolla, Mo.

MONTANA
Montana Bureau of Mines and Geology, Butte, Mont.

NEBRASKA
Conservation and Survey Division, University of Nebraska, Lincoln, Neb.
Division of Nebraska Resources, State of Nebraska, Lincoln 9, Neb.

NEVADA
Colorado River Commission, 209 South Third St., Las Vagas, Nev.

NEW HAMPSHIRE
New Hampshire Forestry and Recreation Commission, State House Annex, Concord, N. H.
New Hampshire State Planning and Development Commission, State Office Building, Concord, N. H.
State Geologist, University of New Hampshire, Durham, N. H.

NEW MEXICO
Bureau of Mines and Mineral Resources, Socorro, N. M.
School of Agriculture, New Mexico College of Agriculture and Mechanical Arts, State College, N. M.

NEW YORK
New York State Department of Commerce, 112 State St., Albany 7, N. Y.

NORTH CAROLINA
Industrial Division, Department of Conservation and Development, Raleigh, N. C.

NORTH DAKOTA
North Dakota Research Foundation, State Capitol, Bismarck, N. D.

OHIO
State Geologist, Orton Hall, Ohio State University, Columbus 10, Ohio

OKLAHOMA
Oklahoma Geological Survey, University of Oklahoma, Norman, Okla.

OREGON
Raw Materials Survey, 701 Woodlark Building, Portland 5, Ore.

PENNSYLVANIA
Pennsylvania Grade Crude Oil Association, P. O. Box 96, Oil City, Pa.
Pennsylvania State Planning Board, Pennsylvania Department of Commerce, Harrisburg, Pa.

Table I. *(continued)*

RHODE ISLAND
Rhode Island State College, Agricultural Experiment Station, Kingston, R. I.
SOUTH CAROLINA
Geologist, State Research, Planning and Development Board, 234 Wade Hampton Building, Columbia. S. C.
SOUTH DAKOTA
South Dakota Natural Resources Commission, State Capitol, Pierre, S. D.
TENNESSEE
Tennessee Division of Geology, Nashville, Tenn.
Tennessee State Planning Commission, 517 Commerce Street, Nashville, Tenn.
Tennessee Valley Authority, Knoxville, Tenn.
TEXAS
Bureau of Business Research, College of Business Administration, The University of Texas, Austin 12, Tex.
UTAH
Utah State Department of Publicity and Industrial Development, 512 Atlas Building, Salt Lake City 1, Utah
VERMONT
Vermont Development Commission, Montpelier, Vt.
Vermont State Forestry Service, Montpelier, Vt.
VIRGINIA
Industrial Service Division and Department of Research, Virginia State Chamber of Commerce, 111 North Fifth St., Richmond 19, Va.
WASHINGTON
Raw Materials Survey, 701 Woodlark Building, Portland 5, Ore.
WEST VIRGINIA
West Virginia Industrial and Publicity Commission, Charleston 5, W. Va.
WISCONSIN
State Geologist, 115 Science Hall, University of Wisconsin, Madison 6, Wis.
WYOMING
Natural Resources Research Institute, The University of Wyoming, Laramie, Wyo.
State Geologist, The University of Wyoming, Laramie, Wyo.

State Planning and Development Agencies

The fourth question requested information on state planning or development agencies. Thirty-eight states have such agencies in one form or another; they are listed in Table II. Most of these are adjuncts of state government, but, in some cases, chambers of commerce or other organizations sponsor this activity. The function of planning and development agencies has been well expressed by one state—i.e., "to investigate, assemble, develop, and study information regarding the economic resources and industrial opportunities and possibilities of the state."

Development and planning agencies can be quite helpful in supplying answers to specific questions regarding industrial matters within the state. Most of these agencies have issued numerous publications which describe the state's resources, potentials, and opportunities. It should be remembered, however, that only thirty-eight states have such agencies. In some of these states, the development and planning agency is more concerned with governmental development than with industrial and economic progress. Here again, if a market study is to be confined to one or more states, these organizations should certainly be consulted.

Table II. State Planning and Development Agencies

ALABAMA
Alabama State Planning Board, Montgomery, Ala.
ARIZONA
Industrial Development Committee, Phoenix Chamber of Commerce, Phoenix, Ariz.
ARKANSAS
Arkansas Resources and Development Commission, State Capitol, Little Rock, Ark.
CALIFORNIA
Research Department, California State Chamber of Commerce, 350 Bush Street, San Francisco 4, Calif.
COLORADO
State Planning Commission, State Office Bldg., Denver, Colo.
CONNECTICUT
Connecticut Development Commission, State Office Bldg., Hartford, Conn.
DELAWARE
Delaware State Development Department, Dover, Del.
FLORIDA
Florida State Improvement Commission, Tallahassee, Fla.
IDAHO
Idaho State Board of Examiners, Boise, Idaho
INDIANA
Indiana Economic Council, 610 Board of Trade Bldg., Indianapolis, Ind.
IOWA
Iowa Development Commission, Central National Bldg., Des Moines 9, Iowa
KANSAS
Kansas Industrial Development Commission, 903 Harrison, Topeka, Kan.
KENTUCKY
Agricultural and Industrial Development Board, Commonwealth of Kentucky, Frankfort, Ky.

Table II. *(continued)*

LOUISIANA
  Planning Division, State Department of Public Works, State Capitol, Baton Rouge 4, La.
MAINE
  Maine Development Commission, State House, Augusta, Me.
MARYLAND
  Industrial Development Bureau, Baltimore Association of Commerce, 22 Light St., Baltimore 2, Md.
  The Maryland State Planning Commission, 100 Equitable Bldg., Baltimore 2, Md.
MASSACHUSETTS
  Massachusetts Development and Industrial Commission, 20 Somerset St., Boston, Mass.
  Massachusetts State Planning Board, 334 Boylston St., Boston, Mass.
MICHIGAN
  Department of Economic Development, 422 West Michigan Ave., Lansing 15, Mich.
MINNESOTA
  Department of Business Research and Development, 117 University Ave., St. Paul 1, Minn.
MISSOURI
  Missouri Division of Resources and Development, State Office Bldg., Jefferson City, Mo.
MONTANA
  Montana Resources Development Board, Helena, Mont.
NEVADA
  Nevada State Planning Commission, 319 North Carson St., Carson City, Nev.
NEW HAMPSHIRE
  New Hampshire State Planning and Development Commission, State Office Bldg., Concord, N. H.
NEW JERSEY
  Division of Planning and Development, Department of Conservation and Economic Development, 520 East State St., Trenton, N. J.
NEW MEXICO
  New Mexico Economic Development Commission, Sante Fe, N. M.
NORTH DAKOTA
  Greater North Dakota Association, Fargo, N. D.
  North Dakota Research Foundation, Bismarck, N. D.
OHIO
  Industrial Development Department, Ohio Chamber of Commerce, 820 Huntington Bank Bldg., Columbus 15, Ohio
OKLAHOMA
  Oklahoma Planning and Resources Board, 533 State Capitol, Oklahoma City 5, Okla.
PENNSYLVANIA
  Pennsylvania State Planning Board, Pennsylvania Department of Commerce, Harrisburg, Pa.
SOUTH CAROLINA
  Chief of Development, State Research, Planning and Development Board, 234 Wade Hampton Bldg., Columbia, S. C.
TENNESSEE
  Tennessee State Planning Commission, 517 Commerce St., Nashville, Tenn.
VERMONT
  Vermont Development Commission, Montpelier, Vt.
VIRGINIA
  State Planning Division, Department of Conservation and Development, Finance Bldg., Richmond, Va.
WASHINGTON
  Washington State Industrial Development Committee, 600 Ranke Bldg., Seattle, Wash.
WISCONSIN
  Wisconsin State Planning Board, State Office Bldg., Madison, Wis.
WYOMING
  Wyoming Natural Resource Board, Cheyenne, Wyo.

Additional Sources

There are also many other sources of information within the various states. Some of these furnish information as a public service. Some do specific surveys for a fee. These miscellaneous sources—state, city, and regional chambers of commerce; business and economic bureaus at state universities; trade associations; newspapers; banks; and consulting firms—are too numerous to list.

Another valuable source of state and regional information is the series of symposia on Resources for the Chemical Industry published in *Industrial and Engineering Chemistry*. These symposia, each covering one of the Federal Census Districts as established by the Bureau of the Census, have been a continuing series organized by the Division of Industrial and Engineering Chemistry of the ACS since the 119th National Meeting in 1951.

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Arizona
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Arkansas
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California
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Colorado
(8) Colorado Development Council, 522 Kettredge Bldg., Denver, Colo., "Directory of Manufacturers."
Connecticut
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Delaware
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Indiana
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Iowa
(18) Iowa Development Commission, Central National Bldg., Des Moines 9, Iowa, "Directory of Iowa Manufacturers," 1951.
Kansas
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Kentucky
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UTAH
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VERMONT
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VIRGINIA
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WASHINGTON

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Trade Associations as a Source Of Market Data

TERESA G. LABOV[1]

Sinclair Refining Co., 600 Fifth Ave., New York 20, N. Y.

A survey of 2600 U. S. trade and allied organizations was undertaken in order to determine what information of chemical market interest was compiled by these groups. Associations were requested to list chemicals or commodities on which they collected statistical or other forms of information, indicating what particular aspect was covered—e.g., production, consumption, sales, prices, foreign tariffs, foreign trade, new products, new equipment, production facilities, labor, or others. For each aspect, answers to two questions—how often collected and to whom available—were requested. Information on journals, books, and other publications issued by the associations was also obtained. This paper summarizes the results of the findings of the survey, indicating various sources of data for several chemicals and commodities. A table listing specific information which is representative of the data obtained is included.

According to the book, "National Associations of the United States" (*1*), compiled by the Office of Domestic Commerce of the U. S. Department of Commerce, "A trade association may be defined as a nonprofit, cooperative, voluntarily-joined organization of business competitors, designed to assist its members and its industry in dealing with mutual business problems in several of the following areas: accounting practices, business ethics, commercial and industrial research, standardization, statistics, trade promotion, and relations with Government, employees, and the general public."

Many of the journals, bulletins, standards, and irregular publications of trade associations belong to a well-used segment of chemical literature. Among many others, the ASTM standards, the MCA safety regulations, the *Journal of the AGA*, the *NPVLA Abstract Bulletin*, and the *AMA Facts and Figures on Automobiles* come to mind.

Less well-known, except among the experts within the field involved, are the monthly, weekly, or even daily releases which many associations issue, in some cases containing a wealth of useful information, often in statistical form. To the writer's knowledge, no compilation of market research data of chemical interest that are available from trade and allied associations has recently been made.

It was felt that an inquiry into material issued by such societies would provide a source of data that would be of particular use to persons working in the field of chemical literature whose specialty was not necessarily market literature, but who were called upon to pinch-hit, or even, sometimes, to substitute for the market expert.

To this end a survey of 2600 U. S. trade and allied organizations was undertaken to determine what information of chemical market interest was compiled by each group. Questionnaires were sent to each organization, requesting a list of chemicals or commodities on which statistical or other forms of information was collected. Associations were

[1] Present address, 15 Cresent Way, Palisade, N. J.

asked to indicate what particular aspect was covered—e.g., production, consumption, sales, prices, foreign tariffs, foreign trade, new products, new equipment, production facilities, labor, or others. In addition, answers to two questions were requested: How often is this material collected and to whom is it available? Data on the purpose of the society, membership number and qualifications, as well as regular publications, including frequency, to whom available, and price, were also obtained.

A tabular report of all pertinent data obtained appears in the forthcoming "Chemical Business Handbook," edited by J. H. Perry, and published by McGraw-Hill Book Co. (*2*). The material included in this paper has been selected to illustrate the general types of data that are available within each of the following broad subject groups: metals and metal products; food and related industries; textile, apparel, and leather; lumber, furniture, paper; transportation and public utilities; chemicals and rubber; stone, clay, and glass; printing and publishing; petroleum, coal, and gas; drugs and hospital supplies; and miscellaneous. It should be emphasized that the material to be cited is merely representative of that which was received as a result of the questionnaire, and that the sources mentioned are not cited as being better than any others that might have been included.

Metals and Metal Products

The bulk of associations which fall under the category of metals and metal products deal with the products, rather than with the metals themselves.

The Lake Superior Iron Ore Association with headquarters in Cleveland is an association of producers and sellers of Lake Superior iron ores, as well as fee owners and lessees of iron ore lands. One of the purposes of this group is to compile and publish statistics and other information about the iron-ore industry. To this end, the following data on Lake Superior Iron Ores are collected: consumption, monthly; shipments, weekly; and analyses and flow maps, annually. This material is available to nonmembers. (Unless otherwise mentioned, all material discussed is available to nonmembers.)

For iron and steel, the American Iron and Steel Institute, of New York, collects monthly data on production, consumption, and labor, and annual information on production facilities. A comprehensive "Annual Statistical Report" (*3*) is issued.

The American Institute of Steel Construction, Inc., of New York, publishes *Steel Construction Digest* (*6*) quarterly which is available without charge to the public. Production and sales data on fabricated structural steel are collected monthly, but these are restricted to members.

Although named the American Bureau of Metal Statistics, this association, located in New York, is limited to producers of nonferrous metals, and its main function is the collection of statistical information on nonferrous metals. Production, consumption, price, and foreign-trade data are assembled monthly and annually.

Data on zinc and zinc products are available from the American Zinc Institute, Inc., of New York. Market development and promotion pamphlets relating to galvanized sheets, metallic zinc paint, and rolled zinc are available at no cost. Information on slab zinc production and shipments is collected monthly. Data on labor are also assembled, monthly, for the membership only.

Proceeding further into the field of metal products, there is The Wire Association, located in Stamford, Conn. Data on production, consumption, new equipment, and production facilities in the wire industry are collected, annually for the first two, and monthly for the latter two. An "Annual Buyers Guide and Year Book" (*7*) is also prepared, and a journal, *Wire and Wire Products* (*8*), is issued monthly.

The Scientific Apparatus Makers Association, whose main office is in Chicago, collects data on sales, foreign trade, foreign tariffs, foreign markets, new products, and labor in the fields of scientific instruments, laboratory apparatus, and reagent chemicals. This information is conditionally available to nonmembers.

Data on the monthly production of machine tools can be obtained from the National Machine Tool Builders' Association, in Cleveland. Occasional publications, such as "Machine Tools Today" and "Machines—Prices—Jobs," are issued once or twice a year to anyone interested.

The Collapsible Tube Manufacturers Association collects data on collapsible tubes for tooth paste, medicinal, pharmaceutical, cosmetic, household, and similar products. Tubes made of tin, lead, a combination of tin and lead, and aluminum are considered. Information on production, shipments, new orders, and exports is available monthly and annually. Periodically new products, new equipment, and production facilities are surveyed, as well as labor conditions, including job classifications, rate ranges, and wage-contract data.

Although issuing no statistical data as such, the Packaging Institute, Inc., of New York, offers its membership a newsletter, *The Packet*, (*5*), and the monthly, *Packaging Abstracts* (*4*).

The last association to be mentioned in this metals and metal products class is the National Association of Water Conditioning Equipment Manufacturers, located in Chicago. Annual production data on domestic and industrial water conditioning are collected.

Food and Related Industries

Associations in the food and related industries collect data on everything from soup to nuts, including potato chips, pineapples, sauerkraut, and a host of other products. For example, the Milk Industry Foundation, whose main office is in Washington, D. C., assembles data on production, consumption, and sales of milk, fluid milk products, and cottage cheese for its membership.

Data on the consumption, sales, and prices of grain and grain products are collected by the Milwaukee Grain Exchange. Monthly figures on the production of corn and its products are assembled by the Corn Industries Research Foundation, New York, but are available to members only.

Representative of agricultural equipment suppliers is the National Association of Silo Manufacturers in Norwich, N. Y. Data on production, sales, production facilities, labor, capital invested, and tonnage of critical materials used for silos are prepared annually.

Data on mineral feeds for livestock and poultry and sundry ingredients contained in such feeds are collected by the National Mineral Feeds Association, Inc., of Des Moines. Production and sales figures are available annually to members, and a survey of individual ingredients used has been initiated.

Information on fertilizers is available from three associations. The American Plant Food Council, Inc., of Washington, D. C., assembles data on fertilizer and fertilizer materials, using official government statistics. Reports on production, consumption, foreign trade and markets, new products and equipment, production facilities, and processes are compiled as they become available.

The American Potash Institute, Washington, D. C., compiles data on deliveries of potash for agricultural use by the principal American producers, and on imports of potash. Data are issued quarterly and annually. Tables of prices of farm commodities and fertilizer materials from published sources together with index figures on prices are published in the Institute's magazine, *Better Crops with Plant Food* (*9*).

Annual figures on fertilizer consumption are issued by the National Fertilizer Association, Inc., in Washington, D. C. In addition, data on the production of superphosphate are prepared monthly for the membership.

In the field of edible fats and oils, four associations provide data. The Institute of Shortening and Edible Oils, Inc., in Washington, D. C., issues a monthly report of statistics available on any of the following products: cottonseed oil, soybean oil, peanut oil, corn oil, federally inspected lard, and creamery butter. Data are compiled from various government sources and may indicate consumption, supplies, and disappearance, including exports and re-exports. In addition some price information, as well as some statistics on inedible oils, such as tung, linseed, animal fats, and greases, are assembled.

The National Cottonseed Products Association, Inc., whose main office is in Memphis, Tenn., assembles some statistics covering cost of processing cottonseed. A book of Rules Governing Transactions between Members of the National Cottonseed Products Association (*10*) is issued annually, and includes terms and definitions, and prescribes grades of cottonseed and cottonseed products, as well as chemical methods of determining these grades.

Another source for data on cotton products is the National Cotton Council of America Inc., whose main office is also in Memphis, Tenn. An annual report on "Cottonseed Oil, Uses and Consumption" is issued (*12*). In addition, data on foreign trade of cotton, cottonseed, and their products and by-products are occasionally assembled.

The American Soybean Association, of Hudson, Iowa, collects data on soybeans, soybean oil, soybean oil meal, lecithin, plywood glues, all livestock feeds, and any commodities using soybean products, for the following: production, sales, foreign trade and markets, new equipment, and production facilities, all annually; prices, daily; and new product surveys as needed. In addition it publishes a monthly magazine, *The Soybean Digest* (*14*).

Another field to be considered under foods and related industries is that of beverages, alcoholic and nonalcoholic. Five associations within this area will be considered.

The Malt Research Institute of Madison, Wis., assembles information on barley malt production, and utilization methods. No statistics are issued.

Data on hops are available to subscribers of "The Hopper," (*11*), a monthly journal published by the United States Hop Growers Association of San Francisco. Information on production, consumption, sales, prices, foreign trade, tariffs, and markets, as well as new products and equipment, and processes and labor concerned with hops is issued irregularly.

The American Society of Brewing Chemists, Inc., of Sturgeon Bay, Wis., collects annual data on production and processes concerned with brewing, malting, and related industries.

The Distilled Spirits Institute, Washington, D. C., prepares reports on public revenue from alcoholic beverages, apparent consumption of distilled spirits by states, the number of retail licenses for sale of distilled spirits, and analyses of the distribution of the population of the United States in relation to areas permitting or prohibiting the sale of distilled spirits. Some of these publications are available to the public.

Annual surveys of carbonated beverage costs and sales are prepared by the American Bottlers of Carbonated Beverages Association, in Washington, D. C., for its membership only. Bulletins on labor problems, law, and legislative matters of interest to the soft drink industry are compiled, and a monthly publication, *Recent Decisions* (*13*), covers the latest court decisions affecting taxes, labor, products liability, and so forth.

Textile, Apparel, and Leather

The Institute of Textile Technology of Charlottesville, Va., is mainly interested in cotton fibers, although information on all fibers is collected. Data on production, new products and new equipment, as well as processes and production facilities are accumulated. The information is mostly confidential, although some is released to the public.

The Textile Economics Bureau, Inc., a technical society of New York, collects monthly data on production, consumption, sales, foreign trade, and production facilities for rayon and other man-made fibers.

Although collecting no statistical data per se, the American Association of Textile Chemists and Colorists, of Lowell, Mass., publishes in their yearbook (*15*) a comprehensive list of dyes made in the United States as well as a list of textile chemical specialties.

Within the realm of apparel there is the American Knit Handwear Association, Inc., of Gloversville, N. Y. Monthly production and foreign trade information is assembled on knitted gloves and mittens, knit glove and mitten linings, and slipper sox. Annual sales data are issued to members.

The National Association of Hosiery Manufacturers, Inc., of New York, issues monthly data on production, shipments, and stocks of all types of hosiery. Special studies on imports and exports, based on Bureau of Census data, and special quarterly surveys on average hourly earnings are assembled for the membership. An annual bulletin, "Hosiery Statistics" (*16*) is available.

Information on leather belting, mechanical leather packings, and textile leathers is assembled by the American Leather Belting Association, of New York. Monthly production and price data on these commodities are assembled for members, as well as quarterly labor and production information.

Of interest to users of apparel, and also to chemists, are laundry techniques, on which data is assembled by the National Association of Institutional Laundry Managers, of Philadelphia. Information on new products and equipment, processes, labor, production facilities, and production of laundry techniques is available upon request.

Lumber, Furniture, Paper

As in the case of metals, the bulk of associations in the field of lumber, furniture, and paper are concerned with the products, rather than the raw material.

Data on lumber are available from two associations. The California Redwood Association, of San Francisco, assembles monthly statistics on redwood lumber production, stocks, and shipments. The Western Pine Association of Portland, Ore., issues weekly, monthly, and annual data on production, consumption, and sales of Western pine lumber. Statistics on prices, new products, equipment, facilities, and processes are assembled, but are usually available to members only.

The Northern Hemlock & Hardwood Manufacturers Association, of Oshkosh, Wis., issues weekly production, consumption, and sales figures on lumber, timber, and logs. Special studies on furniture, boxes, and wood chemicals are made from time to time. Some of this information is distributed regularly to nonmembers, while some requires special arrangement.

Data on wooden desks, chairs, and other office furniture are assembled by the Wood Office Furniture Institute, of Washington, D. C., for its membership. Information on production, sales, new equipment, and labor is included.

An association concerned with household furniture is the National Association of Furniture Manufacturers, of Chicago. Information on production, sales, and labor in the field of wooden, upholstered, and metal household furniture is assembled, but distribution is limited to membership.

Data on hardwood, plastics, glue, varnish, resin products, steel, and copper, including production, sales, prices, and new equipment and products, are collected by the National Association of Piano Tuners of Cleveland.

The United States Pulp Producers Association, Inc., of New York, issues annually "Wood Pulp Statistics" (*17*) which is available to anyone interested in the wood pulp industry. Data on the production, consumption, and sales of wood pulp are assembled monthly, and on production facilities, biennially. These are restricted to members.

Monthly data on newsprint paper, chemicals, and power generation, including production, consumption, foreign trade, foreign tariffs, foreign markets, and new products, processes and equipment, are assembled by the Newsprint Service Bureau, Inc., of New York. In addition, information on production facilities is issued annually.

The two associations which remain to be considered in this wood, furniture, and paper group concern packaging. The Laminated Bakery Package Research Council and the Paraffined Carton Research Council, both of Chicago, assemble monthly production and sales figures on laminated paperboard packages for baked goods and paraffined cartons, respectively. In both cases data are available to members only, although special reports are sometimes prepared for the public.

Transportation and Public Utilities

The Aircraft Industries Association of America, Inc., collects production, sales, and foreign-trade data on civil and personal aircraft, air frames, and aircraft engines. This information is restricted to members, as are data on labor turnover and the general financial situation.

As they are needed, the Aircraft Owners and Pilots Association, of Washington, D. C., assembles data on almost all phases of aircraft and related products such as fuels, lubricants, plastics, fabrics, and metals. Again this information is usually available to members only.

Information on automobiles and automotive parts is more readily obtainable. For example, the American Finance Conference, of Chicago, publishes in its monthly magazine *Time Sales Financing* (*23*), information on sales financing of automobiles and other consumer durable goods.

The Automotive Parts Rebuilders Association, of Chicago, collects data on the production, consumption, sales, prices, new products, new equipment, processes, and labor involved in automotive parts manufacture.

Monthly statistics on the production of cars, trucks, and buses are available from the Automobile Manufacturers Association, of Detroit. In addition, *Automobile Facts*, a monthly journal (*18*), "Automobile Facts and Figures," an annual yearbook (*19*), and "Motor Truck Facts," a biennial report (*20*), are published. All are available without charge.

Committee reports on highway design, construction, maintenance, finance, and operation are issued from time to time by the American Road Builders' Association, of Washington, D. C. Data on highways and streets are collected.

The Society of Industrial Realtors, whose main office is in Washington, D. C., publishes information on plant sites and plants purchased or sold in the chemical field by its members.

In the area of public utilities, the American Water Works Association, New York, collects data on water utilities, including production, consumption, sales, and prices. This information is available by purchase of the *Journal of the American Water Works Association* (*21*).

Data on quantities and characteristics of waste water, both sewage and industrial, are available in the journal *Sewage and Industrial Wastes* (*22*) published by the Federation of Sewage and Industrial Wastes Associations, Champaign, Illinois. No regular statistical services are carried on, although general service inquiries are handled for members and nonmembers.

Chemicals and Rubber

Associations in the chemicals field range from societies which include the whole field of chemistry to those which are concerned with one individual chemical. The most inclusive of such associations is, of course, the Manufacturing Chemists' Association, Inc., of Washington, D. C. Its publication, "Chemical Facts & Figures" (*32*) covers, in its third edition, the period 1946 to 1949, inclusive (the second edition covered the period 1940 to 1945). This series includes statistics from official sources on chemical production, sales, wholesale prices, foreign trade, and employment. The third edition is 420 pages long.

Industrial and Engineering Chemistry, an AMERICAN CHEMICAL SOCIETY publication, issues a special number every other June (even years) called *Facts and Figures for the Chemical Process Industries*. Production and consumption data is given for inorganic chemicals, organic chemicals, chemical specialties, and minerals and raw materials. A financial section gives data on one hundred of the principal companies in the chemical and process industries. Another section covers imports and exports of chemical and allied products. I&EC has also published over the last several years symposia on resources for the chemical industry. These symposia presented before national meetings of the ACS cover the major geographical divisions of the United States as defined by the Bureau of the Census. Typical resources reviewed are agricultural, wood, mineral, fuel, water, power, transportation, manpower, and education.

Data on prices of chemicals are published weekly by *Chemical and Engineering News* (*26*), another publication of the AMERICAN CHEMICAL SOCIETY.

In a slightly narrower field, the Synthetic Organic Chemical Manufacturers Association of the United States, located in New York, publishes *Lists of Chemical Imports* (*31*) weekly; *Reports on Competitive Status of Imports under Par. 27 & 28 of Tariff Act* (*35*) monthly; and *Chemical Patent Lists* (*27*) weekly. This information is available to members only.

Proceeding further from the universal to the particular, the field of photography is represented by three associations. The Master Photo Dealers' & Finishers' Association, of Jackson, Mich., collects data on all factors pertaining to the photographic business.

Data on motion picture and television film production and projection equipment are to be found in the *Journal of the Society of Motion Picture and Television Engineers* (*30*), published monthly by the Society of Motion Picture and Television Engineers, Inc., of New York. In addition, items on new products and new equipment and processes are included.

The National Microfilm Association, of Hingham, Mass., collects information on the production, consumption, processes, production facilities, and new equipment and products in the field of microfilming and microdocumentary reproduction. These data are generally not available to nonmembers. Much of the published data appear in the journal *American Documentation* (*24*), published by the American Documentation Institute.

Data on rubber tires and recapping materials are issued annually by the National Association of Independent Tire Dealers, Inc., of Washington, D. C. On a limited basis, information on consumption, sales, production facilities, and labor is supplied to nonmembers.

Two associations are concerned with paints. The National Paint, Varnish and Lacquer Association, of Washington, D. C., through its Statistical Division, compiles current data on domestic and Canadian sales, trends in hours and earnings, statistics on fats and oils, price indexes of prepared paints and paint materials, and other information. Such data are published in the weekly journal, *Coatings* (*28*), for its membership. The association issued in 1950 a "Statistical Handbook" (*33*) on the paint industry to its members. A supplement of this handbook will contain later statistics on production and sales, consumption of raw materials, exports, price data, and other information.

The Federation of Paint & Varnish Production Clubs of Philadelphia, Pa., does not gather statistics, but rather publishes papers and data of technical or production interest to members in its monthly journal (*34*).

Seven associations of interest in the fields of soap, perfumes, and related materials will be considered. The Toilet Goods Association, Inc., of New York, issues annually data on sales of perfumes, cosmetics, and other toilet preparations.

Information on sales, sales management, and inventories of sanitary chemicals, janitor supplies, maintenance equipment, and so forth is compiled by the National Sanitary Supply Association, Inc., of Chicago, for its membership.

The National Beauty & Barber Manufacturers' Association, of Washington, D. C., issues monthly data on sales of cosmetics and beauty- and barber-shop equipment. A buying guide and a dealers' directory are also published. For its membership, monthly consumption data and weekly foreign-trade and foreign-markets information on beauty- and barber-shop equipment, supplies, shampoos and soaps, cosmetics, packaging materials and containers, are assembled.

Data on glycerine, products used in the production of glycerine, and substitutes or competitives is available from the Glycerine Division of the Association of American Soap & Glycerine Producers, Inc., of New York. Monthly figures on production, consumption, prices, foreign trade, and stocks are issued. A quarterly journal, *Glycerine Facts* (*29*), is published.

The Fatty Acid Section of the Association of American Soap & Glycerine Producers, Inc., of New York, collects monthly data on the production, sales, and stocks of fatty acids and any products used in their production.

Data on the production and sales of tall oil are available to members of the Tall Oil Association. Specifications are also issued semiannually.

The Essential Oil Association of U. S. A., of New York, issues annually a list of trademarks and specialty names used in the industry and sponsors a compendium of standards and specifications for a number of essential oils and synthetic aromatics. Its basic trade association function is membership assistance in problems of import, export, credit, freight, and insurance.

Quarterly data on sales in dollars and tonnage of liquid and dry adhesives are available from the Adhesives Manufacturers Association of America, located in New York. In addition, annual labor statistics are compiled.

The Institute of Makers of Explosives, of New York, collects statistics on dynamite and blasting powder for use by the Bureau of Mines, U. S. Department of the Interior, in preparing its annual releases. Booklets to promote the safe handling and use of explosives are available.

Annual data on the consumption of agricultural limestone and other liming materials can be obtained from the Agricultural Limestone Institute, of Washington, D. C.

Technical data concerning applications, safe practices, handling, storing, and use of industrial gases, calcium carbide, and acetylene and its allied products are assembled by the International Acetylene Association, of New York, for its membership.

The main function of the Calcium Chloride Association, of Washington, D. C., is research and distribution of information on uses of calcium chloride. To this end, a bimonthly publication, *Calcium Chloride Association News* (*25*), is issued.

Stone, Clay, and Glass

The American Concrete Institute, of Detroit, collects information on concrete, accessory materials, and construction equipment. Within staff limitations, assistance is available in finding sources of needed information on concrete, especially that in the literature of the society, including its *Journal of the American Concrete Institute* (*36*).

The Marble Institute of America, Inc., of Mount Vernon, N. Y., issues, periodically, brochures on the technical and promotional phases of interior-building marble, of both foreign and domestic origin.

For its membership, the Porcelain Enamel Institute, Inc., of Washington, D. C., collects data on the production, consumption, processes, and new products of porcelain enamel and components.

Monthly data on the production of mineral wool used in housing is available to members of the National Mineral Wool Association, located in New York. Various reports, reprints, technical information, and charts concerning the scope of the industry are available at cost to the public.

The Acoustical Materials Associations of New York collects monthly sales data on acoustical materials for its membership.

Annual data on iron blast furnace slag production, sales, methods of transportation, and labor are available from the National Slag Association, of Washington, D. C. A publication, "Iron Blast Furnace Slag: Production, Processing, Properties and Uses," prepared by the group is available (*37*).

The Structural Clay Products, Inc., of Washington, D. C., collects data semiannually on brick and tile production for its membership.

The American Glassware Association, of New York, issues data annually on the foreign trade of pressed and blown glassware. Monthly figures on production and sales of glassware are prepared for the membership.

Printing and Publishing

The Printing Industry of America, in Washington, D. C., issues to its members monographs on employee-employer relations, as well as news of labor settlements.

The National Editorial Association, whose main office is in Chicago, collects annual data on markets and media concerning newspaper and commercial printing. Cost studies of production, market studies of consumption and sales, price studies of operation, and data on postal and other legislation pertaining to the industry are issued annually. In addition, information on new equipment, processes, and labor costs is assembled.

The American Booksellers Association, Inc., of New York, publishes annually for its membership the "ABA Book Buyer's Handbook" (*38*).

Table I. Selected List of Trade Associations Which Are Sources of Market Data

Acoustical Materials Association, 59 East 55th St., New York 22, N.Y.	Data on acoustical materials: sales[a], monthly; annual technical publications.
Adhesives Manufacturers Association of America, 441 Lexington Avenue, New York 17, N.Y.	Data on liquid and dry adhesives: sales in dollars and tonnage, quarterly; labor, annually.
Agricultural Limestone Institute, 1415 Elliot Place, N.W., Washington 7, D.C.	Data on agricultural limestone and other liming materials: consumption, annually.
Aircraft Industries Association of America, Inc., 610 Shoreham Bldg., Washington 5, D.C.	Data on complete aircraft, air frames, and aircraft engines (civil and personal): production[a], sales[a], foreign trade[a], financial situation[a], and labor turnover, hours, and earnings[a], monthly. *Planes*, bimonthly, free. "The Aircraft Year Book", annually.
American Bureau of Metal Statistics, 50 Broadway, New York, N.Y.	Data on nonferrous metals: production, consumption, prices, and foreign trade, all collected both monthly and annually.
American Gas Association, Inc., 420 Lexington Ave., New York 17, N.Y.	Data on manufactured, natural, and mixed gas: production, facilities, labor, accidents, and reserves, annually; consumption, sales, monthly; prices, quarterly. *A.G.A. Monthly* and numerous other publications.
American Glassware Association, 19 West 44th St., New York 18, N.Y.	Data on pressed and blown glassware: production[a] and sales[a], monthly; foreign trade, annually.
American Institute of Steel Construction, Inc., 101 Park Ave., New York 17, N.Y.	Data on fabricated structural steel: production[a], monthly; sales[a], monthly. *Steel Construction Digest*, quarterly, free.
American Leather Belting Association, 41 Park Row, New York 17, N.Y.	Data on leather belting, mechanical leather packings, and textile leathers: production[a] and labor[a], quarterly; sales[a] and prices[a], monthly. *Leather Belt Drive News*, free.
American Soybean Association, Hudson, Iowa.	Data on soybeans, soybean oil, soybean oil meal, lecithin, and other commodities using soybean products: production, sales, foreign trade, foreign markets, new equipment, and production facilities, annually; consumption, monthly; prices, daily; new products as needed. *The Soybean Digest*, monthly; "The Soybean Blue Book," annually.
American Zinc Institute, Inc., 60 East 42nd St., New York 17, N.Y.	Data on slab zinc: production and shipments, monthly; labor[a], monthly. "Annual Review of the Zinc Industry," free.
Association of American Soap & Glycerine Producers, Inc., Fatty Acid Section, 295 Madison Ave., New York 17, N.Y.	Data on fatty acid and any products in the production of the same: production, sales, and stocks, monthly.
Association of American Soap & Glycerine Producers, Inc., Glycerine Division, 295 Madison Ave., New York 17, N.Y.	Data on glycerine, products used in the production of glycerine, products employing glycerine and substitutes or competitives: production, consumption, prices, foreign trade, labor, and stocks, all monthly. *Glycerine Facts*, quarterly, free.
Automotive Parts Rebuilders Association, 1414 South Michigan Ave., Chicago 5, Ill.	Data on automotive parts: production, consumption, sales, prices, new product surveys, new equipment, processes, and labor. "Annual Trade Directory and Buyers Guide," free.
Bituminous Coal Institute, 320 Southern Bldg., Washington 5, D.C.	Data on bituminous coal: production, consumption, exports, fuel equipment, production facilities. "Bituminous Coal Annual."
Liquefied Petroleum Gas Association, Inc. 11 South LaSalle St., Chicago 3, Ill.	Data on liquefied petroleum gas and liquefied petroleum gas containers: production[a], consumption[a], sales[a]. Newsletter and bulletins[a].
Milwaukee Grain Exchange. 741 North Milwaukee St., Milwaukee, 2, Wis.	Data on grain and grain products: consumption, sales, prices. Annual report, free.
National Association of Independent Tire Dealers, Inc., 1302 18th St., N.W., Washington 6, D.C.	Data on rubber tires and recapping materials: consumption, sales, production facilities, labor, all annually. (Available on a limited basis to nonmembers.) *Dealer News*, weekly.

Table I (continued)

National Cotton Council of America, Inc., P.O. Box 18, Memphis 1, Tenn.	Data on cotton, cottonseed, and their products and by-products: production and consumption, annually; foreign trade, occasionally. "*Progress Bulletin*," monthly; "Cotton Counts Its Customers," annually; "Cottonseed Oil, Uses and Consumption," annually.
National Editorial Association, 222 North Michigan Ave., Chicago 1, Ill.	Data on newspapers and commercial printing, markets and media: price studies of operations, market studies of production and labor, new equipment studies, annually. *National Publisher*, monthly; *The Publishers Tab & Legislative Bulletin*, monthly.
National Fertilizer Association, Inc., 610 Investment Bldg., Washington 5, D.C.	Data on fertilizer consumption, annually: data on superphosphate production[a], monthly. *Fertilizer Review*, quarterly, free; *Fertilizer News*, bi-weekly[a].
National Foreign Trade Council, Inc., 111 Broadway, New York 6, N.Y.	Data on general foreign trade[a]. (Not listed by individual commodities.) Bulletins and memoranda[a].
National Mineral Wool Association, 2906 RKO Bldg., New York 20, N.Y.	Data on mineral wool used in housing: production[a], monthly; scope of industry. *The Reporter*, monthly, free. Various reports, reprints, technical information, maps, and charts.
National Slag Association, 644 Warner Bldg., Washington 4, D.C.	Data on iron blast furnace slag: production, sales, labor, method of transportation, annually. *The Slag Runner*, bimonthly[a]. "Iron Blast Furnace Slag: Production, Processing, Properties and Uses."
Newsprint Service Bureau, Inc. 342 Madison Ave., New York 17, N.Y.	Data on newsprint paper: production, consumption, foreign trade, foreign tariffs, foreign markets, new product surveys, new equipment, and processes, monthly; production facilities and labor, annually. *NSB Monthly Bulletin*.
Northern Hemlock & Hardwood Manufacturers Association, Washington Bldg., Oshkosh, Wis.	Data on lumber, timber, and logs: production, consumption, and sales, weekly. (Some distributed to nonmembers: others require special requests.)
Porcelain Enamel Institute, Inc., 1010 Vermont Ave., N.W., Washington 5, D.C.	Data on porcelain enamel and components: production[a], new products[a], new equipment[a], processes[a]. consumption[a], labor[a], all irregularly.
Structural Clay Products, Inc., 1520 18th Street, N.W., Washington 6, D.C.	Data on brick and tile: production[a], semiannually. *SCPI News*, monthly[a].
Synthetic Organic Chemical Manufacturers Association of the United States, 41 East 42nd St., New York 17, N.Y.	Data on chemicals: foreign trade[a], weekly, monthly; patents[a], weekly. *Lists of Chemical Imports*, weekly[a]; *Reports on Competitive Status of Imports Under Par. 27 & 28 of Tariff Act*, monthly[a]; *Chemical Patent Lists*, weekly[a].
Tall Oil Association, 122 East 42d St., New York 17, N.Y.	Data on tall oil: production[a], sales[a], monthly; specifications[a], semiannually. *Tall Oil In Industry*, quarterly, free to users or potential users of tall oil.
Textile Economics Bureau, Inc.[b], 10 East 40th Street, New York 16, N.Y.	Data on rayon and other man-made fibers: production, consumption, sales, foreign trade, and production facilities, all monthly. *Rayon Organon*, monthly.
United States Pulp Producers Association, Inc., 122 East 42d St., New York 17, N.Y.	Data on wood pulp: production[a], consumption[a], and sales, monthly; production facilities[a], biennially. "Wood Pulp Statistics", annually.
Western Petroleum Refiners Association, 1414 Hunt Bldg., Tulsa 3, Okla.	Data on refined petroleum products: production[a], consumption[a], monthly. Technical papers and bulletins[a].

[a] Available to members only.
[b] Not a trade association.

Petroleum, Coal, and Gas

The American Gas Association, Inc., whose main office is in New York, collects data on manufactured, natural, and mixed gas as follows: production, annually; consumption and sales, monthly, quarterly, and annually; prices, continuously; and construction, financing, accidents, and reserves, annually. Data on new equipment and processes are assembled for the membership.

Research bulletins on the production, processes, and new equipment dealing with utility gas are available from the Institute of Gas Technology in Chicago.

The Liquefied Petroleum Gas Association, Inc., of Chicago, assembles data on production, consumption, and sales of liquefied petroleum gas and liquefied petroleum gas containers. The information is available to members only.

The Natural Gasoline Association of America, in Tulsa, issues no regular statistical reports, but acts as a clearing house for information on natural gasoline and liquefied petroleum gas products and production.

Information on lubricants and lubrication devices is collected by the American Society of Lubrication Engineers, of Chicago, and is included in their bimonthly journal, *Lubrication Engineering* (*40*).

The National Lubricating Grease Institute, whose main office is in Kansas City, Mo., collects technical information regarding the manufacture or application of lubricating greases. In addition, monthly data on new products, new equipment, production facilities, and processes are available.

Monthly information on production and consumption of refined petroleum products is available to members of the Western Petroleum Refiners Association of Tulsa.

Information on the capacities and operations of refineries is available from the National Petroleum Association, of Washington, D. C. Bulletins are issued to members concerning legal aspects of the petroleum industry.

The Petroleum Equipment Suppliers Association, whose main office is in Houston, does not usually collect statistics, although at present it is working closely with the Petroleum Administration for Defense in compiling product statistics, including production, consumption, and sales, as needed.

Three associations furnish information on coal. Bituminous Coal Research, Inc., of Washington, D. C., collects data continuously on bituminous coal and coal-consuming equipment, including information on processes, equipment, and new products. Its technical staff is available to members and consumers on problems affecting coal preparation and consumption.

The statistical and research section of the Bituminous Coal Institute, of Washington, D. C., collects data from all available sources concerning production, consumption, and exports of coal; fuel equipment; and production facilities. These statistics are included in the "Bituminous Coal Annual" (*39*) and other publications of the society.

Monthly data on coal consumption and foreign trade, weekly information on coal production, and periodical new equipment surveys are assembled by the American Coal Sales Association, of Washington, D. C., for their membership only.

Hospital Supplies and Drugs

Data on sheets, paints, soaps, cleaning compounds, surgical dressings, drugs, thermometers, syringes, needles, and surgical instruments are assembled by the Hospital Bureau of Standards & Supplies, Inc., of New York. Periodically, information on prices, new equipment, and tests of qualities is made available to members.

The National Wholesale Druggists' Association conducts an annual survey of operations of member wholesalers which is restricted to members only. Research to develop specific commodity group-handling costs is being carried on for its members.

Miscellaneous

Three associations have functions so broad that it is difficult to place them in any of the above groups. The National Foreign Trade Council, of New York, assembles data on general foreign-trade tariffs and markets, not individual commodities, for its members.

The Twentieth Century Fund, of New York, which is not a membership organization, publishes reports, in book form, on a wide range of economic subjects. Examples of such publications include the following: "America's Needs and Resources" (*48*), "World Population and Production" (*51*), "Economic Effects of Technological Developments" (*50*), and "Cartels or Competition" (*49*).

The Chamber of Commerce of the United States, in Washington, D. C., publishes a weekly journal, *Business Action* (*41*), a monthly journal, *Nation's Business* (*47*), and *Governmental Affairs* (*46*), a daily release during sessions of Congress.

The association maintains the following departments: Agricultural, Commercial Organization, Construction and Civic Development, Domestic Distribution, Economic Research, Finance, Foreign Commerce, Governmental Affairs, Insurance, Manufacture, Natural Resources, Publicity, Trade Associations, and Transportation and Communication. The Economic Research Department of the Chamber of Commerce publishes a four-page monthly bulletin, *Economic Intelligence* (*45*), which covers new developments in international and domestic finance, labor economics, and so forth. Publications of the Foreign Commerce Department have included the following: "Trade Agreements and the United States Economy" (*44*); "Our 100 Leading Imports" (*43*); and "The International Trader and International Commercial Arbitration" (*42*). Numerous other bulletins and journals are published by this association.

Discussion

Over one hundred trade and allied associations have been discussed as examples of sources of market information. The specific data mentioned in each case have been limited to that which was, more or less, especially of interest in chemical market research. Table I lists certain of the associations mentioned above, showing in greater detail data that are available.

Some of the other activities of trade and allied associations, as, for example, the issuance of commodity specifications, the preparation of chemical safety data sheets, and the publication of journals that contain reports of original research investigations, may provide a valuable source of data within the context of specific problems. Space forbids their inclusion.

Policy does vary a great deal from one association to the next, but some trade associations have indicated on the questionnaire that they will attempt to answer legitimate inquiries from nonmembers. Such a service should not be overlooked.

A knowledge of the activities of the trade associations within a literature chemist's particular field or fields of interest would seem almost indispensible. An acquaintance with the associations in the related industries might well prove of equal or greater value. This paper has attempted to emphasize a source of market data that is perhaps not utilized as fully as it might be.

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Railroad Transportation Statistics for the Chemical and Allied Products Industry

H. Y. TURNER

Bureau of Railway Economics, Association of American Railroads, Washington, D. C.

It would be difficult, if not impossible, to visualize two industries which affect our daily lives to a greater degree than the chemical and allied products industry and the railroad industry. Practically everything we touch in our daily routine and even in our sleep requires the use of chemicals during some stage of its production. The railroad industry provides the transportation services essential to such production and distribution. It is only natural, therefore, that the chemical and allied products industry, with its many ramifications and requirements of rail transportation, is interested in statistics relating to the railroads, their facilities, and their services.

Few industries are more closely regulated than the railroad industry. The act to regulate commerce which became law April 5, 1887, created the Interstate Commerce Commission, and delegated many powers to it. Under that act, and subsequent acts extending the authority and scope of operations of the Interstate Commerce Commission, the railroad industry practically has come to live in a glass house. Its rates, fares, and charges are subject to regulation by the Interstate Commerce Commission and various state regulatory bodies. In many instances, the rates of pay for railroad employees have been set by government tribunals (Presidential Emergency Boards), and in emergencies organizations such as the Defense Transport Administration are given certain powers over railroad matters. In fact, practically every action of the industry comes within the purview of some government agency. Of these, the Interstate Commerce Commission is the most important.

In the exercise of its regulatory powers, it is but natural that the commission requires individual railroads to file numerous and voluminous statistical reports, which are summarized and published periodically by the Interstate Commerce Commission for the use of interested parties. A list of the regularly published reports relating to rail transportation is given in Table I.

This list enumerates 29 regularly published reports of the Interstate Commerce Commission which relate to railroad transportation. In most cases, the title of the report indicates the type of statistics covered. Two of the reports—Annual Report of Statistics of Railways in the United States, including selected data for the Pullman Co., Railway Express Agency, Inc., freight forwarders, and private car owners, and Preliminary Abstract of Railway Statistics (Steam Railways, Railway Express Agency, Inc., and the Pullman Co.)—are, generally speaking, all-inclusive, in that they show data (on a calendar year basis) relating to all phases of rail transportation with respect to:

Finances
- Investments
- Securities outstanding
- Balance sheet
- Income account
- Profit and loss account

Operations
- Mileage (road and tracks owned and operated)
- Revenues (by classes of service, freight, passenger, mail, express. etc.)
- Expenses (by general and primary accounts)

Employees and compensation
- Number of employees for each of 128 classes
- Service hours for each of 128 classes
- Compensation for each of 128 classes

Equipment in service
- Locomotives by class of service
- Freight-train cars by type
- Passenger-train cars by type

Train performance statistics
- Train-miles (freight and passenger service)
- Car-miles (freight and passenger service)
- Train-hours (freight and passenger service)
- Tons per train and per car (freight service), etc.

These data are shown for individual railroads, and summarized by geographic areas. The quarterly and monthly reports usually relate to some specific phase of railroad operations and provide interim statistics to indicate what results may be anticipated from operations for the current year.

All these reports are summaries of returns filed with the Interstate Commerce Commission by the individual railroads. Prior to 1916, annual returns were made on a fiscal basis (July 1 to June 30). The commission shifted to a calendar year basis beginning with the year 1916.

Groupings by Classes

Beginning with the year 1911, operating railroad companies were classified for statistical and accounting purposes with respect to their operating revenues by the Interstate Commerce Commission.

Line-Haul Operating Railroad Companies

Class I Railroads
- Roads having operating revenues above $1,000,000 annually

Class II Railroads
- Roads having operating revenues between $100,000 and $1,000,000 annually

Class III Railroads
- Roads having operating revenues below $100,000

Switching and Terminal Companies

Companies operate separately for joint account or for revenue, and performing switching and terminal services only, such as terminal trackage or facilities only, union passenger or freight stations, stock yards, operating bridges and ferries exclusively, etc. This category is also broken down into classes on the basis of operating revenues outlined for the line-haul companies.

Occasionally roads are reclassified—that is, shifted from one class to another. Such reclassifications, however, are not made on the basis of one year's operation alone, but only when the operating results of a road over a period of several years definitely indicate that that road does not belong to the class to which assigned.

Geographical Groupings

In addition to being classified according to operating revenues, railroads are also grouped geographically for statistical purposes into three districts and eight subdistricts or regions.

Eastern District. That portion of the United States bounded on the west by the northern and the

Table I. Publications Relating to Railroads

Prepared by the Bureau of Transport Economics and Statistics, Interstate Commerce Commission

Annual Reports

1. Accident Bulletin, Steam Railways
2. Annual Report on Statistics of Railways in the United States, including selected data for the Pullman Co., Railway Express Agency, Inc., freight forwarders, and private car owners
3. Comparative Statement of Railway Operating Statistics, Individual Class I Steam Railways in the United States
4. Freight Commodity Statistics, Class I Steam Railways
5. Preliminary Abstract of Railway Statistics (Steam Railways, Railway Express Agency, Inc., and the Pullman Co.)
6. Summary Tables of the Annual Report on Statistics of Railways in the United States
7. Tons of Revenue Freight Originated and Tons Terminated, in Carloads, by Groups of Commodities and by Geographic Areas, Class I Steam Railways (1940 to 1950 only)
8. Wage Statistics of Class I Steam Railways
9. Selected Statistics from Annual Reports of Private Car Owners

Quarterly Reports

10. Summary of Accidents Reported by Steam Railways
11. Freight Commodity Statistics of Class I Steam Railways
12. Tons of Revenue Freight Originated and Tons Terminated, in Carloads, by Groups of Commodities and by Geographic Areas, Class I Steam Railways (1940 to 1950 only)
13. Revenues, Expenses, and Statistics of Freight Forwarders
14. Summary of Quarterly Reports of Persons Furnishing Cars to or on Behalf of Carriers by Railroad or Express Companies

Monthly Reports

15. Freight Train Performance of Class I Steam Railways
16. Fuel and Power Statistics of Class I Steam Railways
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23. Revenue Traffic Statistics of Class I Steam Railways
24. Selected Income and Balance-Sheet Items of Class I Steam Railways
25. Summary of Accidents Reported by Steam Railways
26. Wage Statistics of Class I Steam Railways
27. Yard Service Performance of Class I Steam Railways
28. Monthly Comment on Transportation Statistics

Carload Waybill Analyses

29. The commission has issued a number of statements based on a 1% sample of terminated carload waybills filed by Class I steam railways showing, among other things, length of haul, average load, and revenue per ton-mile for various quarters and years, 1947 to 1951. The list is too lengthy to be shown here.

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western shore of Lake Michigan to Chicago, thence by a line to Peoria, thence to East St. Louis, thence down the Mississippi River to the mouth of the Ohio River, and on the south by the Ohio River from its mouth to Parkersburg, W. Va., thence by a line to the southwestern corner of Maryland, thence by the Potomac River to its mouth.

Southern District. That portion of the United States bounded on the north by the eastern district and on the west by the Mississippi River.

Western District. The remainder of the United States, exclusive of Alaska and the island possessions.

The general outlines of the eight territorial regions, embraced in the three so-called districts, are as follows:

Eastern District

New England Region. The New England States.

Great Lakes Region. The section of the Canadian boundary between New England and the westerly shore of Lake Michigan to Chicago, and north of a line from Chicago via Pittsburgh to New York.

Central Eastern Region. The section south of the Great Lakes region, east of a line from Chicago through Peoria to St. Louis and the Mississippi River to the mouth of the Ohio River, and north of the Ohio River to Parkersburg, W. Va., and a line thence to the southwestern corner of Maryland and by the Potomac River to its mouth.

Southern District

Pocahontas Region. The section north of the southern boundary of Virginia, east of Kentucky and the Ohio River north to Parkersburg, W. Va., and south of a line from Parkersburg to the southwestern corner of Maryland and thence by the Potomac River to its mouth.

Southern Region. The section east of the Mississippi River and south of the Ohio River to a point near Kenova, W. Va., and a line thence following the eastern boundary of Kentucky and the southern boundary of Virginia to the Atlantic.

Western District

Northwestern Region. The section adjoining Canada lying west of the Great Lakes region, north of a line from Chicago to Omaha and thence to Portland and by the Columbia River to the Pacific.

Central-Western Region. The section south of the northwestern region, west of a line from Chicago to Peoria and thence to St. Louis, and north of a line from St. Louis to Kansas City and thence to El Paso and by the Mexican boundary to the Pacific.

Southwestern Region. The section lying between the Mississippi River south of St. Louis and a line from St. Louis to Kansas City and thence to El Paso and by the Rio Grande to the Gulf of Mexico.

A railroad is usually assigned to that region (and district) in which the greater proportion of its mileage is located. A number of railroad companies operate in two or more regions or districts, but are classified in only one region and district.

The publications of the Interstate Commerce Commission showing statistical data have followed the above geographical grouping since 1926. This grouping had its origin in the rate case of 1920 and in the arrangement of the roads under regional directors during the federal control period, January 1, 1918, to February 28, 1920. Summarization of the statistical data for the regions produces data for the respective districts; summarization of the data for the three districts produces data for Class I railroads in the United States.

Many of the statistical data available, particularly those for individual railroads, are of primary interest to the roads themselves for comparison with other roads. They are also of interest to holders of railroad securities and the summaries by districts are frequently used in general rate cases before the Interstate Commerce Commission to indicate the rate of return for the districts, as well as for other purposes.

Definition of Chemical Industry

As Class I line-haul railroads account for about 97% of the total operating revenues and expenses of all steam railroads, and statistical data for those roads are more detailed, the following analysis of statistics relates to Class I line-haul railroads only.

Before outlining the railroad statistical data relating to the chemical and allied products industry, it seems desirable to define that industry. Table II lists the commodities produced by the industry (*2*), as defined by the Manufacturing Chemists' Association.

Table II. Commodity Groups and Subgroups Comprising the Chemical and Allied Products Industry (2)

Heavy chemicals
Fine chemicals
Synthetic organics (including dyes and intermediates)
Plastics, except synthetic rubber
Explosives
Compressed and liquefied gases
Drugs and pharmaceuticals (excludes proprietary preparations)
Industrial alcohol
Solvents
Wood distillation products
Insecticides and fungicides (agricultural)
Coal-tar, crude and intermediates
Finished coal-tar products
Plastic materials and synthetic resins
Phenolic plastics
Casein and celluloid
Synthetic, organic, and inorganic chemicals
Industrial chemicals
Carbide
Sodium
Ferroalloys
Acids
Alkalies
Salts
Rayon and allied products
Fertilizers, fertilizer materials, and mixed fertilizers
Cottonseed oil
Cottonseed cake
Cottonseed meal
Cottonseed linters
Ammunition and small arms
Explosives and safety fuses
Soap and glycerol
Drugs
Medicines
Paints, varnishes, colors, and fillers
Other chemicals and allied products
Industrial inorganic chemicals
Industrial organic chemicals
Vegetable and animal oils and fats
Synthetic rubber
Synthetic fibers

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ICC Freight Commodity Statistics

The Interstate Commerce Commission's freight commodity statistics would appear to be of greatest interest to the chemical industry, in that they show, with certain limitations, the transportation service rendered by the railroads to the chemical and allied products industry (as defined), measuring that service in number of cars and tons of freight transported and the freight revenue the railroads receive for such transportation service.

The brief description of these freight commodity statistics, which follows, also indicates the changes (and effective dates) that have occurred since these statistics were inaugurated.

All Steam Railroads, 1888 to 1919. These statistics (in very abbreviated form as compared with present-day statistics) began in 1888, when only 38 classes or commodities were reported by all steam railroads. None of the 38 classes presented anything of interest to the chemical industry. The data reported were tons originated, and tons received from connections.

Class I Railroads, 1920 to 1927. Effective January 1, 1920, and continuing through 1927, the number of reporting classes was increased from 38 to 70. For each of these classes (except l.c.l., for which tonnage figures only are available) the following data were reported: Carloads and tons originated, carloads and tons received from connections, and total carloads and total tons carried.

These 70 commodity classes included only four individual commodities of interest to the chemical industry—chemicals and explosives, cottonseed and products, salt, and fertilizers. Generally speaking, the other commodities of particular interest to the chemical industry were submerged in the commodity class entitled "Other Manufactures and Miscellaneous." For the four commodities referred to, the number of carloads originated by the railroads and the freight revenue which the railroads received from the transportation of those commodities, are, by year, as follows:

Total Four Commodities

Year	Cars originated	Freight revenue
1920	944,998	$25,375,639
1921	745,489	18,495,281
1922	838,186	21,147,712
1923	912,454	23,635,272
1924	941,989	24,139,428
1925	1,052,399	27,293,591
1926	1,079,522	28,003,247
1927	1,075,274	28,877,157
Av.	948,789	24,620,916

An itemized list of the separate categories comprising each of these four commodity classes can be found in the 1927 issue of "Commodity Classification" (*1*).

Because of the growth in industry generally and to accord with such changed conditions, there have been two revisions of the commodity classifications—in 1928 and in 1947.

Class I Railroads, 1928 to 1946. Beginning with 1928 and continuing through 1946, the number of reporting classes was increased from the 70 to 157 classes. For the 157 commodity classes, the following data were reported.

Carloads and tons originated
  Terminating on line
  Delivered to connections
Carloads and tons received from connections
  Terminating on line
  Delivered to connections
Total carloads and total tons carried
Freight revenue

These 157 commodity classes included 18 classes which are of particular interest to the chemical industry as defined (Table III). From the reported data, it is possible to compute for those 18 classes the average tons per car, average revenue per car, and average revenue per ton, for the years 1928 to date.

Class I Railroads, 1947 to Present. Freight traffic during the years 1941 to 1945 reflected the effect of wartime production with its varying degrees of influence on certain particular commodities, as a result of which a revision of the commodity classification was again desirable. Effective with the January 1, 1947 revision, the number of commodity classes was increased again—this time from 157 to 262 classes. The data reported for each of the 262 classes are the same as shown for the period 1928 to 1946. Of the 105 new classes, some 17 additional classes are of interest to the chemical and allied products industry (Table III).

Among these 17 new commodity classes, chemicals not otherwise specified appear as a separate class. Not only has the number of separate classes been expanded, but the composition of each of these classes has been enlarged in order to reflect the increasing importance of the industry to the American economy. In the 1920 to 1927 period, chemicals and explosives combined represented only some 154 separate and identifiable types, classes, or grades of chemicals and explosives combined, while the 1947 classification of just chemicals not otherwise specified represents some 311 separate categories, not including the 65 separate categories of ammunition and explosives, which are included as a distinct class in the 1947 classification. Naturally, this makes for far better defined statistics.

Thus, there are now available statistics as to cars and tons transported, tons per car, and revenue per car and per ton, as well as total revenues for 34 major commodity groups, comprising some 376 individual commodities of particular interest to the industry.

Table III. Railroad Commodity Classes Related to Chemical and Allied Products Industry

New Number (1947 to Present)	Old Number (1928 to 1946)	Commodity Class Is of Particular Interest
35	91	Cotton linters, n.o.i.b.n.[a] and regins
37	100	Cottonseed
39	101	Cottonseed meal and cake
47	160	Vegetable oil cake and meal, except cottonseed
341	380	Salt
343	390	Phosphate rock, crude (ground or not ground)
345	391	Sulfur (brimstone)
417	440	Rosin
	441	Turpentine
511	460	Cottonseed oil
517	462	Vegetable oils, n.o.s.[b]
757	472	Molasses, blackstrap and edible molasses
539	640	Fertilizers, n.o.s.
535	660	Alcohol, denatured or wood
529	661	Sulfuric acid
631	662	Explosives, n.o.s.
547	691	Paints in oil and varnishes
769	698	Soap and washing compounds

1947 to Present	Other Commodity Classes
509	Gases, other than petroleum, n.o.s.
513	Linseed oil
523	Rubber, crude, natural and synthetic
525	Rubber goods, n.o.s.
527	Chemicals, n.o.s.
531	Acids, n.o.s.
533	Sodium (soda) products
537	Blacks, n.o.s.
541	Insecticides and fungicides, n.o.s.
543	Tar, pitch, and creosote
545	Tanning material, n.o.s.
549	Plastics
551	Cellulose articles, n.o.s.
553	Drugs, medicines, and toilet preparations
627	Tires and tubes, rubber
731	Synthetic fiber and yarns (rayon or nylon)
771	Matches

[a] Not otherwise indexed by name.
[b] Not otherwise specified.

In addition to the statistics thus far described data are also available for the years 1940 to 1950 by geographic areas. These data show tons originated and tons terminated for each of the commodity classes for 42 states separately, the New England states combined, and the District of Columbia and Canada. These geographic area statistics primarily provided data as to the principal states of origin for the 262 reporting commodity classes (1947) as well as data with respect to the consumption, by states, of those same commodities. However, the reports from which these data were compiled were discontinued as of January 1, 1951.

Carload Waybill Studies

Supplementing the freight commodity statistics, the Interstate Commerce Commission, in 1947, initiated a series of carload waybill studies. As a basis for these studies, Class I railroads were required to file copies of selected waybills covering carload shipments. The selection of waybills is based on a continuous sampling method, by which each railroad furnishes copies of its audited waybills whose serial numbers are "1" or with digits ending in "01". The plan is designed to produce a 1% sample of all carload traffic terminating on Class I railroads.

These waybills are processed by the commission to provide information for a continuing analysis of the flow of traffic by commodities, type of rate, average haul, and average revenue per ton-mile. Some 120 statements have been released by the commission's Bureau of Transport Economics and Statistics, based on the 1% sample of waybills covering the movements of carload freight. As illustrated, Table IV shows the kind of information that is available on commodity classes of interest to the chemical and allied products industry. Such data are, of course, subject to the infirmities inherent to any 1% sample.

Table IV. Carload Waybill Analyses, Terminations in 1950[a]

Classification No.	Commodity	Tons per Car	Average Short-Line Haul, Miles: Per ton	Average Short-Line Haul, Miles: Per car	Average Revenue: Per car	Average Revenue: Per short-line ton-mile, cents
35	Cotton linters	19	589	550	$212	1.91
37	Cottonseed	32	261	249	167	2.02
39	Cottonseed, meal, cake	34	393	408	201	1.52
47	Vegetable oil cake and meal, except cottonseed	28	336	331	156	1.65
341	Salt	39	377	403	226	1.55
343	Phosphate rock	57	285	296	163	1.01
345	Sulfur	65	316	346	209	1.02
415	Veneer, plywood	32	1554	1499	536	1.07
417	Rosin, turpentine	27	643	637	293	1.67
509	Gases not petroleum	29	419	421	348	2.89
511	Cottonseed oil	31	572	567	338	1.93
513	Linseed oil	28	735	742	412	1.97
517	Vegetable oils, n.o.s.	28	1092	1063	419	1.35
523	Rubber, crude	36	710	691	569	2.24
525	Rubber goods, n.o.s.	16	1173	940	499	2.65
527	Chemicals, n.o.s.	36	779	746	520	1.87
529	Sulfuric acid	55	161	164	210	2.38
531	Acids, n.o.s.	37	630	607	502	2.18
533	Sodium products	46	444	449	366	1.81
535	Alcohol, n.o.s.	27	626	621	382	2.27
537	Blacks, n.o.s.	30	1048	1022	695	2.21
539	Fertilizers, n.o.s.	41	300	296	180	1.48
541	Insecticides	24	818	849	465	2.41
543	Tar, pitch, creosote	43	342	357	290	1.98
545	Tanning materials, n.o.s.	33	441	437	387	2.65
547	Paint, putty, varnish	28	695	686	430	2.22
549	Plastics	19	594	527	397	3.58
551	Cellulose articles	11	1373	1304	424	2.87
553	Drugs, toilet preparations	21	1259	1338	665	2.53
627	Tires, tubes, rubber	16	667	635	305	2.94
631	Explosives	39	932	925	1919	5.32
731	Synthetic fiber	19	632	627	365	3.02
757	Molasses residual	48	537	546	373	1.46
769	Soap, cleaning compounds	23	773	742	387	2.22
771	Matches	16	748	734	352	3.02

[a] Statement 5131, June 1951, Interstate Commerce Commission.

Table V. Instructions and Definitions Applying to Reporting of Freight Commodity Statistics to Interstate Commerce Commission

A "carload" shall consist of a shipment of not less than 10,000 pounds of one commodity. A mixed carload shall be treated as a carload of that commodity which forms the major portion of the shipment in weight. If a single shipment is loaded into more than one car, each car used shall be reported as a carload. If more than one "carload" shipment is loaded into one car, each shipment shall be reported separately as a carload. All shipments weighing less than 10,000 pounds shall be included in less-carload freight.

"Originated on respondent's road" means: (*a*) shipments originated directly on respondent's road; (*b*) shipments received from water lines and highway motor truck lines, except when identified as having had previous rail transportation; (*c*) shipments which received first line-haul on respondent's road, but originated on switching lines connected directly or indirectly with respondent's road (*d*) import traffic received from water carriers; and traffic from outlying possessions of the United States; and (*e*) outbound freight which has been accorded transit privileges.

"Received from connecting rail carriers" means: (*a*) all shipments received directly from connecting rail carriers; (*b*) shipments received from water lines and highway motor truck lines, when identified from information on waybills or abstracts as having received previous rail transportation; (*c*) shipments received from connecting rail carriers operating in Canada or Mexico; (*d*) lake cargo coal received at upper lake ports; (*e*) iron ore received at lower lake and St. Lawrence River ports; (*f*) tidewater coal from Atlantic ports.

"Terminated on line" means: (*a*) shipments terminated directly on respondent's road; (*b*) shipments delivered to water lines and highway motor truck lines, except when identified as to receive further rail transportation; (*c*) shipments which receive last line-haul on respondent's road, but are delivered to switching roads connected directly or indirectly with respondent's road; (*d*) export traffic delivered to water carriers and shipments to outlying possessions of the United States.

"Delivered to connecting rail carriers" means: (*a*) all shipments delivered directly to connecting rail carriers; (*b*) shipments delivered to water lines and highway motor truck lines when identified from information on waybills or abstracts as to receive further rail transportation; (*c*) shipments delivered to connecting rail carriers operating in Canada and Mexico; (*d*) lake cargo coal delivered to Lower Lake and St. Lawrence River ports for transshipment by vessel; (*e*) iron ore delivered to Upper Lake ports for transshipment by vessel; and (*f*) tidewater coal to Atlantic ports.

"Gross freight revenue" means respondent's gross revenue from freight without adjustment for absorptions or corrections.

Utilization of Freight Commodity Statistics

In order properly to use and interpret the freight commodity statistics, certain instructions and definitions of the Interstate Commerce Commission should be kept in mind. These definitions are reproduced in Table V.

Certain tables in the annual tabulation of "Freight Commodity Statistics" published by the ICC are also recommended because they show such statistics as tons per car by commodities, revenue per ton by commodities, and relative importance of the various commodities. Table VI gives the titles of these tables.

Table VI. Tables Presented in Interstate Commerce Commission's Freight Commodity Statistics for 1950

Table 1. Tons originated and freight revenue, by groups of commodities and by districts
Table 2. Tons of revenue freight originated and tons terminated in carloads by classes of commodities and by geographic areas
Table 3. Freight traffic originated, freight traffic terminated, total traffic carried, and freight revenue, by individual classes of commodities and by regions
Table 4. Average load per car originated, by individual classes of commodities and by regions
Table 5. Average revenue per ton originated or per ton terminated, by classes of commodities
Table 6. Relative importance of various groups of commodities, ratios of group totals to grand total, tons carried, and freight revenue, by individual railways
Table 7. Tons of revenue freight and freight revenue for each Class I railroad by individual classes of commodities
Tables 4, 5, and 6 consist of computed averages derived from the basic statistics. These averages include tons per car originated, revenue per ton originated and terminated, by commodity classes, and also the ratio of tons carried and freight revenue in the major product groups to the grand totals for all traffic handled. The ratios serve to show the relative importance of the various major commodity classes.
Table 2 as issued for 1950 is the last statement of this series, the reporting of these data having been discontinued.

When commodity statistics of railroads in a particular area, district, or region are combined, they point up the peculiar production and traffic characteristics of areas which may have a bearing on such matters as freight car distribution. When the annual statistics of all railroads in the country are combined, a comprehensive picture of the producing and consuming areas is obtained as well as a clearer understanding of the vital part played by railroad transportation in the economic life of the nation.

These statistics are used extensively by the Interstate Commerce Commission in its general regulatory functions, particularly in connection with analyses of rate structures and related matters, and are also utilized in the commission's cost formulas in various ways. These statistics are also used by the United States Department of Commerce as source material in research problems in trade analyses and studies, as well as by industry and the public in rate cases and similar proceedings, and by other government agencies for a variety of purposes.

While the freight commodity statistics may sometimes be used in connection with national production figures, such uses should always be made with caution. Railroad freight commodity statistics are not intended to reflect commercial production, but only to show the tonnage of the specified commodity classes offered for rail transportation.

Keeping this important consideration in mind, Table VII shows for the 34 major commodity classes, of particular interest to the industry, the number of cars originated, tons originated, and the freight revenue as well as the tons per car, revenue per car, and revenue per ton, for 1950, the latest year for which complete data are available.

As shown on Table VII, 2,074,887 carloads were originated, representing 83,788,318 tons of freight. For transporting this freight, the railroads received $709,000,000. The average revenue per car ranged from a low of $157.52 for vegetable and nut cake and meal to a high of $2171.88 per car for ammunition and explosives, the average for the 34 classes as a whole being $341.72. For each ton of freight transported, the railroads received $8.46, as shown in the bottom line of the last column.

The transportation of many of the chemicals and/or chemical products involves

Table VII. Carloads and Tons Originated and Freight Revenue for Calendar Year 1950

(34 freight commodity classes of interest to the chemical and allied products industry)

No.	Commodity	Carloads Originated	Tons Originated	Freight Revenue	Tons per Car	Revenue per Car	Revenue per Ton
35	Cotton linters, oils, and resins	48,624	965,940	$11,600,946	19.9	$238.58	$12.01
37	Cottonseed	8,228	255,113	1,339,723	31.0	162.82	5.25
39	Cottonseed oil cake and meal	33,939	1,142,739	7,338,250	33.7	216.22	6.42
47	Vegetable and nut cake and meal, n.o.s.	24,430	692,743	3,848,304	28.4	157.52	5.56
341	Salt	98,547	3,712,145	31,140,674	37.7	316.0	8.39
343	Phosphate rock	357,460	20,513,437	58,402,463	57.4	163.38	2.85
345	Sulfur	81,798	5,296,566	18,563,366	64.8	226.94	3.50
417	Rosin and turpentine	25,624	690,918	8,836,833	27.0	344.87	12.79
509	Gases, other than petroleum, n.o.s.	58,278	1,696,125	20,160,916	29.1	345.94	11.89
511	Cottonseed oil	35,026	1,057,832	12,589,863	30.2	359.44	11.90
513	Linseed oil	10,965	314,258	4,507,193	28.7	411.05	14.34
517	Vegetable and nut oils, n.o.s.	19,782	566,441	8,586,953	28.5	434.08	15.16
523	Rubber, crude, natural, and synthetic	39,718	1,400,505	22,688,843	35.3	571.25	16.20
525	Rubber goods	3,603	62,436	2,040,159	17.3	566.24	32.68
527	Chemicals, n.o.s.	182,635	5,996,588	95,192,942	32.8	521.22	15.87
529	Sulfuric acid	64,282	3,462,975	13,686,548	53.9	212.91	3.95
531	Acids, n.o.s.	33,222	1,248,241	15,145,711	37.6	455.89	12.13
533	Sodium (soda) products	192,696	8,606,399	69,386,688	44.7	360.08	8.06
535	Alcohol, n.o.s.	29,095	779,211	11,234,673	26.8	386.14	14.42
537	Blacks, n.o.s.	18,469	557,118	13,794,210	30.2	746.88	24.76
539	Fertilizers	360,398	14,776,444	80,931,242	41.0	224.56	5.48
541	Insecticides and fungicides, n.o.s.	10,619	248,680	5,086,683	23.4	479.02	20.45
543	Tar, pitch, and creosote	57,591	2,443,351	15,947,075	42.4	276.90	6.53
545	Tanning materials, n.o.s.	7,268	230,015	2,631,513	31.6	362.07	11.44
547	Paint, paint material, putty, and varnish	46,187	1,275,905	21,331,953	27.6	461.86	16.72
549	Plastics	560	10,118	265,881	18.1	474.79	26.28
551	Cellulose articles, n.o.s.	2,455	34,384	985,648	14.0	401.49	28.67
553	Drugs, medicines, and toilet preparations	7,608	164,726	5,200,126	21.7	683,51	31.57
672	Tires and tubes, rubber	78,622	1,241,781	25,861,457	15.8	328.93	20.83
631	Ammunition and explosives	38,705	1,498,083	84,062,494	38.7	2171.88	56.11
731	Synthetic fiber and yarns (rayon or nylon)	8,123	157,728	2,813,042	19.4	346.31	17.83
757	Molasses, residual	28,293	1,321,379	9,897,611	46.7	349.83	7.49
769	Soap and cleaning and washing compounds	56,589	1,282,641	21,636,332	22.7	382.34	16.87
771	Matches	5,448	85,353	2,296,096	15.7	421.46	26.90
	Total	2,074,887	83,788,318	709,032,411	...	341.72	8.46

hazards to the railroads, in that some products are explosive, while others are flammable, corrosive, or contaminating. Many chemical companies own or lease their own special types of cars for the transportation of these products (both inbound and outbound). Details as to the number and kinds of these privately owned cars may be found in the quarterly publication *The Official Railway Equipment Register*. A quick check of the January 1951 issue indicates that more than 9000 freight cars are owned by chemical companies and possibly 25,000 privately owned cars are used in chemical service. These cars are predominantly tank cars, many of them of special construction to meet particular needs such as the handling of acids.

For the freight transported in these privately owned freight cars, the railroads collect the published tariff charges for the shipment, but pay the owners of the car a specified rate per mile for both the loaded and empty movement of the car.

For some industries, the freight commodity statistics provide some basis for estimating the amount of rail transportation requirements. But for an industry with ramifications as extensive as those of the chemical and allied products industry, such an estimate would be impossible. However, utilizing the 34 major commodity groups listed in Table VII as a minimum, the railroads in 1950 provided the industry with transportation service for 2,074,887 carloads of freight, containing 83,788,328 tons of freight, for which they received $709,032,411 in gross freight revenue. This amount represents more than 9% of the gross freight revenues collected by all Class I railroads on all carload freight handled.

If to these figures could be added the freight charges on that portion of the general or basic commodities used by the chemical industry, such as coal, petroleum products, iron and steel products, lumber and lumber products, glass and glass products, and paper and paper products, the gross freight revenue figure of $709,000,000 could well be raised to a billion dollars or more.

In short, the chemical and allied products industry makes much greater use of railroad transportation service, and depends upon such service to a much greater degree, than is indicated in the summary of the 34 major commodity classes.

Literature Cited

(1) Association of American Railroads, Washington 6, D. C., "Commodity Classification," 1947.
(2) Manufacturing Chemists' Association, Washington, D. C., "Chemical Facts and Figures. Useful Information and Statistics Relating to the Chemical and Allied Products Industries," 3rd ed., pp. 1, 290, 1950.

RECEIVED April 22, 1952. Accepted October 20, 1952. Presented before the Division of Chemical Literature Symposium on Literature Sources for Chemical Market Research, at the 121st Meeting of the AMERICAN CHEMICAL SOCIETY, Buffalo, N. Y.

Sources of Statistics on Chemicals In Latin America

PHYLLIS G. CARTER

Census Library Project, U. S. Library of Congress, Washington, D. C.

In January 1952, information on the sources of published statistics on chemicals of Latin American countries was collected. Addresses of some important agencies dealing with international statistics are listed. In the bibliography, the following are listed: publications in English which contain summary information extracted from official national statistics sources, addresses, and the most important current publications of the central statistical bureaus of the 20 Latin American republics, and bibliographies and accession lists of statistical publications of Latin America. The publications listed are located in the classified collection of the Library of Congress, the Government Publications Reading Room of the Library of Congress, the Inter American Statistical Institute, or the Bureau of Census.

A survey in January 1952, indicated that the basic published statistics on chemicals of the various Latin American countries are found in their industrial censuses, in yearbooks and bulletins of industrial production and mining production, in foreign trade yearbooks and bulletins, and in national yearbooks and bulletins of general statistics. These are usually compiled and published by the General Bureau of Statistics or its equivalent in the respective country, and of course are in the language of the country—i.e., Portuguese in Brazil, French in Haiti, and Spanish in the other 18 Latin American republics. Additional information is sometimes found in the annual reports of government departments and in bulletins and releases of their statistical sections, and in the publications of semiofficial and nonofficial organizations such as development corporations and trade associations. In practice and frequently by legal requirement the specialized agencies and associations usually send their statistical data to the General Bureau of Statistics for publication, so that most of the data to be found in the publications of the specialized agencies also appear in the publications of the General Bureau of Statistics.

More recent, as yet unpublished statistical data often can be obtained by writing directly to the Director General of the General Bureau of Statistics of the country concerned, who in most cases assumes the responsibility not only of answering questions relating to data compiled in the bureau under his direction but also of forwarding to the appropriate agency or institution those queries which can better be answered elsewhere. Letters receive prompter attention if they are in the language of the country, and should in all cases be sent by air mail.

Of particular interest to persons interested in chemical market research is the fact that many of the General Bureaus of Statistics maintain up-to-date registers of industrial establishments, for use in collecting their industrial statistics. Several other countries which had not done so in the past were in the process of establishing such registers as a preparation for industrial censuses planned for 1952 or 1953.

Certain international organizations and United States agencies with international programs prepare summaries and compilations, essentially of the data taken from the national official publications. The principal source of such information, specifically on chemicals in foreign nations, was for a number of years and until the end of 1950 the Office of International Trade of the Bureau of Foreign and Domestic Commerce; since the beginning of 1951 the major part of the program of commodities information has been in the National Production Authority.

Publications and Agencies

Table I contains the addresses of some important agencies dealing with international statistics.

Table I. Selected Sources for International Statistics

Caribbean Commission, Kent House, Port-of-Spain, Trinidad, B.W.I.
Publishes studies on various aspects of the development of the Caribbean area.
Census Library Project, Library of Congress, Washington 25, D. C.
Provides bibliographic and reference service in statistics.
Comisión Económica para América Latina, Avenida Providencia 871, 7° piso, Santiago, Chile
Economic Commission for Latin America of the United Nations. Prepares studies of industry and other phases of the economy of Latin America.
Consejo Interamericano de Comercio y Producción, Misiones 1400, Montevideo, Uruguay
Inter-American Council of Commerce and Production. Prepares studies on various phases of the economy and commerce of Latin American countries.
Division of Statistical Standards, Bureau of the Budget, Washington 25, D. C.
Maintains contact with United States and international statistical agencies and directs the inquirer on statistical matters to the appropriate agency or person.
Inter American Development Commission, 2400 16th Street, N.W., Washington, D. C.
Prepares studies on industry and other phases of the economy of Latin America.
Inter American Statistical Institute, c/o Pan American Union, Washington 6, D. C.
Does not collect data, but maintains a collection of statistical publications, a bibliographic program and reference service, and a directory of Latin American and international statistical agencies and statisticians.
Office of the Coordinator of International Statistics, Bureau of the Census, Washington 25, D. C.
Maintains a collection of statistical publications of all countries, and a reference service in international statistics.
Statistical Office, United Nations, New York, N. Y.
Collects official data from the countries and compiles and publishes them, frequently much sooner than the same data appear in the national publications.

The bibliography is divided into three sections. The first consists of lists of publications which contain summaries in English of information extracted from official national statistical sources. The second section includes addresses of the central statistical bureaus of the 20 Latin American republics as well as their most important pertinent current publications. The third section shows bibliographies and accession lists of statistical publications of Latin America.

In each reference there is a notation concerning the location of a copy of the publication. Location is indicated as follows: BC, Bureau of the Census; GPRR, Government Publications Reading Room, Library of Congress; IASI, Inter American Statistical Institute; and LC, classified collection of the Library of Congress.

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Publications of International and United States Agencies Including Statistics on Chemicals in Latin America

CARIBBEAN COMMISSION, PORT-OF-SPAIN
Caribbean Economic Review, 1949–. In GPRR.
Monthly Information Bulletin, 1947–. Articles and notes on new developments and scattered statistical data. In LC.
"Industrial Development of Puerto Rico and the Virgin Islands of the United States. Report of the United States Section," 1948. In LC.
"Yearbook of Caribbean Research," 1948–. Supplements for 1949 have been issued on agriculture, fisheries, and forestry; medicine and public health; social sciences; natural sciences; building, engineering, and technology. In LC.
GREAT BRITAIN. BOARD OF TRADE, LONDON
"Economic and Commercial Conditions in (countries listed)," Argentina, 1947; Brazil, 1948; Colombia, 1949; Costa Rica, 1950; Cuba, 1949; Ecuador, 1950; El Salvador, 1951; Honduras, 1951; Mexico, 1949; Panama, 1950; Peru, 1949; and Uraguay, 1950. Supersedes the prewar "Reports on Economic and Commercial Conditions." Brief reports on national economies, including finance, trade, industry, production, and

resources and containing information concerning the market possibilities for specific types of goods, with attention to factors affecting the export trade. In GPRR.

INTER-AMERICAN COUNCIL OF COMMERCE AND PRODUCTION, MONTEVIDEO

"El desarrollo industrial en América Latina," 1947. Industrial development in Latin America. In IASI.

"Encuesta continental sobre fomento y coordinación de industrias: respuesta referente a la República Argentina, 1945." Hemisphere-wide inquiry on promotion and coordination of industries: reply relating to Argentina. In LC.

"Encuesta continental sobre fomento y coordinación de industrias: respuesta referente a la República de Chile," 1945. Hemisphere-wide inquiry on promotion and coordination of industries: reply relating to Chile. In LC.

"Encuesta continental sobre fomento y coordinación de industrias: respuesta referente a la República del Perú," 1947. Hemisphere-wide inquiry on promotion and coordination of industries: reply relating to Peru. In IASI.

"Evolución industrial en América: motivaciones, características y condiciones," 1947. Industrial evolution in America: motives, characteristics, conditions. In IASI.

"Inquérito continental sobre fomento e coordenação de indústrias: resposta referente ao Brasil," 1946. Hemisphere-wide inquiry on promotion and coordination of industries: reply relating to Brazil. In IASI.

INTER-AMERICAN DEVELOPMENT COMMISSION, WASHINGTON, D. C.

"Industrial Report on the Republic of Guatemala," 1946. In LC.

"The Industries of Venezuela," 1948. In LC.

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT, WASHINGTON, D. C.

"The Basis of a Development Program in Colombia," 1950. Report of a mission headed by Lauchlin Currie and sponsored by the International Bank for Reconstruction and Development in collaboration with the Government of Colombia. In LC.

"The Economic Development of Guatemala," 1951. Report of a mission sponsored by the International Bank for Reconstruction and Development in collaboration with the Government of Guatemala. In LC.

"Report on Cuba," 1951. Findings and recommendations of an economic and technical mission organized by the International Bank for Reconstruction and Development in collaboration with the Government of Cuba in 1950. In LC.

UNITED NATIONS, NEW YORK.

"Non-self-governing Territories. Summaries of Information Transmitted to the Secretary-General," 1947–51. Summaries of the detailed annual reports on non-self-governing territories submitted to the United Nations by the governments responsible for their administration. Contain a survey of economic and social conditions in general and then separate reports on each territory. This publication, and the reports from which it is compiled, are the principal source of current information on the non-self-governing territories. Included for the Western Hemisphere are reports of Denmark on Greenland, Netherlands on Curaçāo and Surinam, the United Kingdom on the Bahamas, Barbados, Bermuda, British Guiana, British Honduras, Jamaica, Trinidad and Tobago, and Windward Islands, and of the United States on Alaska, Puerto Rico, and the Virgin Islands. In LC.

UNITED NATIONS. DEPARTMENT OF ECONOMIC AFFAIRS, NEW YORK.

"Estudio Económico de América Latina, 1949. Elaborado por la Secretaría de la Comisión Económica para América Latina," 1951. Edition for 1950 was expected to appear in January 1952. The first section is a study on various factors of the economy of Latin America, with some statistical tables on trade; the second consists of studies of the economic development of Argentina, Brazil, Chile, and Mexico, with statistical tables on various factors of the national economies including production, imports and exports, capitalization, energy, etc., usually with special paragraphs on the chemical industries; the third part, on recent changes in the economic situation of Latin America, covers prices, money, development plans, foreign trade, and commercial policy. In GPRR.

UNITED NATIONS. ECONOMIC COMMISSION FOR LATIN AMERICA, NEW YORK.

"Economic Development in Selected Latin American Countries," United Nations Documents, **E/CN.12/218** and addenda, 1951. In LC.

"Economic Developments in Selected Latin American Countries, (**E/CN.12/218**, 28 May 1951); "Recent Developments and Problems of Argentine Industry," (**E/CN.-12/218** Add.1, 20 April 1951); "Economic Development of Guatemala," (**E/CN.12/218** Add.4, 2 May 1951).

"Economic Survey of Latin America, 1950," United Nations Documents **E/CN.12/271** and addenda. 1951. In LC.

Series prepared for the Fourth Session of the Economic Commission for Latin America. The addenda which relate to the separate countries contain data on industrial, mining and agricultural production, money and prices, and foreign trade.

"General Introduction. Recent Developments and Trends in the Economy of Latin America," **E/CN.12/217**, 16 April 1951.

"Recent Events and Trends in the Economy of Argentina," **E/CN.12/217**/Add.1, 9 April 1951.

"Recent Developments and Trends in the Brazilian Economy," E/CN.12/217/Add.2, 26 March 1951.

"Recent Facts and Trends in the Economy of Chile," E/CN.12/217/Add.3, 6 April 1951.

"Recent Developments and Trends in the Mexican Economy," E/CN.12/217/Add.8, 26 March 1951.

"Recent Developments and Trends in the Economy of Venezuela," E/CN.12/217 Add.11, 6 April 1951.

"Recent Trends and Events in Mining in Latin America," E/CN.12/217/Add.12, 1 June 1951.

"Public Finance Developments in Latin America," E/CN.12/217/Add.13, 2 June 1951.

United Nations. Mission of Technical Assistance to Bolivia, New York.

"Report," 1951. Detailed presentation of the economic situation of Bolivia, with statistical tables. In IASI.

United Nations. Mission of Technical Assistance to Haiti, New York.

"Mission to Haiti. Report," 1949. Detailed presentation of the economic situation of Haiti, with statistical tables. In LC.

United Nations. Secretariat, Statistical Office, New York.

Monthly Bulletin of Statistics, 1947–. Data on industrial production, fuel and power, raw materials, manufactures, trade, finance, and wages and prices, as well as on population, employment and unemployment, and national income for each country for which it is available. In most of the tables only a few, and varying, Latin American countries appear. The scope of the *Bulletin* is revised to include new subjects and new statistical series for additional countries as they become available. In LC.

"Statistical Yearbook," 1948–. First issue for 1948, second for 1949–50. Basic compendium of international statistics, replacing the "Statistical Year-Book of the League of Nations," which was issued for years 1926–1942/44 (In LC), and including the available data for each country of the world on population, manpower, land, agriculture, forestry, foreign trade, industrial production, mining, etc. Latest issue includes tables on production, by country, of caustic soda, hydrochloric acid, nitric acid, nitrogen, soda ash, sulfuric acid, superphosphates, synthetic rubber, rayon filament yarn, rayon staple fiber, and woven rayon fabrics. Only a few, and varying, countries of the Western Hemisphere appear in each table. In LC.

"Yearbook of International Trade Statistics," 1950–. Supersedes the League of Nations. "International Trade Statistics" issued for the years 1931/32–38. Both in LC.

United States Bureau of Mines, Washington, D. C.

"Foreign Minerals Survey; a Regional Review of Mineral Resources, Production, and Trade," irregular, 1943–. Replaces *Foreign Minerals Quarterly*, 1938–41. In LC.

"Minerals Yearbook," 1932/33–. Includes a review of foreign minerals, by country, with emphasis on Latin America. Latest published is for 1945. In LC.

United States Office of International Trade, Washington, D. C.

"Foreign Commerce Yearbook," 1933, 1935–39, 1948–. Latest is for 1949, published 1951; most of the data brought forward through 1948. Published 1922–32 as "Commerce Yearbook," Vol. II. Highly condensed presentation of official data published by the 78 countries included, supplemented by publications of international agencies and by information supplied by other United States Government departments, generally derived from original foreign sources. For each country there is a brief statement on area and population, agriculture, mining, manufacturing, transportation and communications, and tables of imports and exports of principal commodities. Principal sources of the information are listed. In LC.

"International Reference Service," Vols. 1–7. 1941, 1945–50. No longer published. Before 1941, the same information was contained in the *Trade Information Bulletins* and *Trade Promotion Series*. Each volume issued as a series of approximately 125 releases. Releases cover such topics as "Economic Review of Canada, 1949," "Preparing Shipments to Haiti," and "Argentina—Summary of Basic Economic Information." In general, in the surveys of economic information on each country considerable attention is given to chemicals. As in the case of the *World Trade in Commodities* series, information in the releases is a summary of data taken from official publications of the countries concerned and from commercial consular reports. In LC.

World Trade in Commodities, Vols. 1–8, 1940, 1945–50. No longer published. From 1940 to 1947 inclusive, issued under title "Industrial Reference Service." Each volume issued in part, each part consisting of a series of releases on separate subjects. Most complete and detailed single source of information on chemicals in Latin America. The part devoted to chemicals (part 1 in earlier volumes, part 2 in later) includes each year approximately 50 releases of several pages each on a wide variety of topics, e.g., "Detergents in Ecuador, Peru, and Paraguay," "Digest of International Chemical Developments," and "Foreign Markets for United States Paints, Varnishes, and Lacquers, 1939–48." In addition to information gathered from official publications of the countries studied, these releases include information taken from commercial consular reports. Information from the commercial consular reports is also published regularly in the

Foreign Commerce Weekly of the Office of International Trade in the section "News by Commodities" and "News by Countries," but are neither indexed nor summarized in that publication. In LC.

UNITED STATES TARIFF COMMISSION, WASHINGTON, D. C.

"Agricultural, Pastoral, and Forestry Industries in (countries listed)." In LC.
Argentina, 1947.
Brazil, 1946.
Chile, 1949. Reissue of 1945 publication.
Colombia, 1949. Reissue of 1945 release.
Cuba, 1947.
Mexico, 1948.
Venezuela, 1949. Reissue of 1945 release.

"Economic Controls and Commercial Policy in (countries listed.)" In LC.
Argentina, 1948. Reissue of 1945 release.
Bolivia, 1946. Reissue of 1945 release.
Brazil, 1948. Reissue of 1945 release.
Chile, 1949. Reissue of 1945 release.
Colombia, 1948. Reissue of 1945 release.
Costa Rica, 1949. Reissue of 1945 release.
Cuba, 1946.
Dominican Republic, 1946.
Ecuador, 1946. Reissue of 1945 release.
El Salvador, 1947.
Guatemala, 1947.
Haiti, 1946.
Honduras, 1947.
Mexico, 1946.
Nicaragua, 1947.
Panama, 1946.
Paraguay, 1949. Reissue of 1945 release.
Peru, 1948. Reissue of 1945 release.
Uruguay, 1949. Reissue of 1945 release.
Venezuela, 1948. Reissue of 1945 release.

"Mining and Manufacturing Industries in (countries listed)." In LC.
Argentina, 1949. Reissue of 1945 release.
Bolivia, 1949. Reissue of 1945 release.
Brazil, 1949. Reissue of 1945 release.
Chile, 1949. Reissue of 1945 release.
Colombia, 1949. Reissue of 1945 release.
Costa Rica, 1949. Reissue of 1945 release.
Cuba, 1947.
Dominican Republic, 1948.
Ecuador, 1949. Reissue of 1945 release.
El Salvador, 1948.
Guatemala, 1949.
Haiti, 1949. Reissue of 1945 release.
Honduras, 1949.
Mexico, 1946.
Nicaragua, 1946. Reissue of 1945 release.
Panama, 1949. Reissue of 1945 release.
Paraguay, 1946. Reissue of 1945 release.
Peru, 1949. Reissue of 1945 release.
Uruguay, 1949. Reissue of 1945 release.
Venezuela, 1949. Reissue of 1945 release.

"Recent Developments in the Foreign Trade of (countries listed)." In LC. Argentina, 1950. Chile, 1945. Colombia, 1946. Venezuela, 1945.

Principal Current Statistical Publications of the 20 Latin American Nations

Argentina

DIRECCIÓN GENERAL DEL SERVICIO ESTADÍSTICO NACIONAL, MINISTERIO DE ASUNTOS TÉCNICOS, BUENOS AIRES.

"La actividad industrial argentina desde 1937 a 1949," 1950. In LC.

"Anuario estadístico de la República Argentina," Vol. 1, "Compendio," Vol. 2, "Comercio exterior," 1951–. "Compendio, 1948" is first general statistical yearbook since the "Anuario geográfico argentino, 1941," and its "Suplemento, 1942," published by the Comité Nacional de Geografía. "Compendio" includes sections on industry and foreign and domestic trade, as well as population, labor, prices, cost of living, etc. The agency sources of the data are shown. Volume 2, devoted to foreign trade, supersedes "El comercio exterior argentino," published 1915 to 1947. In LC.

"Estadística industrial," biennial, 1938–44. Results of three censuses of industry of 1935, 1937, and 1939. Not to be confused with the annual "Estadística industrial," published as part of the "Informe, Serie I" and "Informe, Serie E.I." Title varies; in 1936 called "Censo industrial de 1935." In LC.

"Informe, Serie E.I. Estadística industrial," 1950–. In IASI. Series of reports on industrial statistics superseding the "Informe, Serie I, Industria" (In LC), which was published for the years 1938–46, and which included the annual "Estadística industrial de la República Argentina."

Síntesis estadística mensual de la República Argentina, monthly, 1947–. Statistical summary with regular sections on industry (occupation and wages, production, indexes of volume of production), building, foreign and domestic commerce, transportation and communication, banking and capital, etc. In LC.

Síntesis estadística mensual de la República Argentina, 5, No. 5, 520–34 (1951). IV censo general de la nación. Censo industrial año 1946. Resultados generales de la República, clasificados por rama de industria. Fourth general census of the nation: industrial census of 1946, classified by branch of industry. In LC.

Bolivia

Dirección General de Estadística y Censos, Ministerio de Hacienda y Estiadstica, La Paz. (Dr. Jorge Pando Gutierrez, Director General).

"Comercio exterior, anuario," 1910–. Yearbook of foreign trade statistics. Latest, for 1945 was published in 1947. Title varies slightly. In LC.

"Industria fabril y manufacturera," 1936–. Yearbook of statistics of manufacturing industries. Latest, for 1943 was published in 1948. Title varies. In LC.

"Industria manufacturera, fabril y extractiva, 1938–1939." Mining data.

"Minería, 1940–1941–1942; transportes y comunicaciones, 1941–1942." Latest, 1943. Mining data.

Revista mensual, monthly, July, 1945–. Monthly statistical review with regular sections on industrial production, petroleum, exports, imports of machinery, etc. In LC.

Brazil

Conselho Nacional de Estatística, Instituto Brasileiro de Geografia e Estatistica, Rio de Janeiro. (Sr. Waldemar Lopes, Secretário Geral).

"Anuário estatísticó do Brasil," 1916–. Statistical yearbook. Volume 1 covered 1908–1912. Not published for 1913–1935. Latest, for 1950, published in 1951, has sections on industrial production, mining production, transportation, communication, money and banking, foreign and domestic trade, prices, wages, consumption, etc. In LC.

Boletim estatístico, quarterly, 1943–. Includes monthly economic statistical series on production, banking, commerce, cost of living, and annual series on a wide variety of subjects, as well as a section of special studies. In LC.

"Recenseamento geral do Brasil (1.° de setembro de 1940). Sinopse do censo industrial e do censo dos serviços, dados gerais," 1948. Summary of censuses of industry and services, Sept. 1, 1940. Detailed data for the 1940 census of industry have not appeared. In LC.

Serviço de Estatistica Econômica e Financeira. Ministério da Fazenda, Rio de Janeiro.

"Comercio exterior do Brasil," 18 –. Yearbook of foreign trade statistics giving exports and imports by country. Title varies. In LC.

"Comercio exterior do Brasil por mercadorias," 1900–. Annual summary of foreign trade of Brazil by commodities. In LC.

Mensário estatístico, monthly, July 1951–. Statistical bulletin includes data on public finance and money and banking as well as foreign trade.

Chile

Dirección General de Estad'stica, Ministerio de Economía y Comercio, Santiago. (Sr. Luis Cárcamo Cantín, Director General).

"Censo económico nacional, 1943," 1946–. 1 vol. for each state. National economic census. In LC. (It is not known when Chile will have the next industrial census.)

"Comercio exterior," 1844–. Annual foreign trade statistics. Some years issued as a numbered volume of the "Anuario estadístico." Latest is for 1949–50. In LC.

Estadística chilena, monthly, 1928–. Summary of national statistics, including mining, industry, building, prices, transportation, foreign trade, money and capital, public finance, etc. In LC.

"Minería e industrias," 1911–. Annual mining and manufacturing statistics. Title varies. Some years, including those from 1940 on, issued as two separate volumes. Some years issued as one or two volumes of the "Anuario estadístico." Latest: "Minería, año 1946," published 1949; "Industrias, año 1944," published 1947.

Colombia

Dirección Nacional de Estadística, Presidencia de la República, Bogotá, Colombia.

Anales de economía y estadística, monthly, 1938–. 2nd series, vol. 1, No. 1, 1945–. Economic and statistical review. Data on production, prices, cost of living, public finance, and other phases of the economy. In LC.

"Anuario de comercio exterior," 1914–. Yearbook of foreign trade statistics. Latest for 1949, published 1951. Title varies. 1918/22–35 issued as "Anuario general de estadística." In LC.

"Anuario general de estadística," 1905, 1915–. Statistical yearbook. Supersedes "Anuario estadístico," issued by the Oficina de Estadística Nacional. Latest is for 1948, published 1950; includes data on industrial production, foreign trade, prices, and consumption. In LC.

"Primer censo industrial de Colombia, 1945. Resumen general," 1947. First industrial census of Colombia, 1945: general summary. Separate volumes for each state also issued. In LC.

Costa Rica

Dirección General de Estadística y Censos, Secretaría de Hacienda y Comercio, San José, Costa Rica. (Sr. Wilburg Jiménez Castro, Director General.)

(No census of industry has been taken since 1907, one was planned for 1952.)

"Anuario," 1883, 1907–. Suspended publication 1894–1906. Title varies. Statistical yearbook. Latest is for 1949, published 1951; includes sections on foreign trade, transportation and communication, sale and production of liquors, construction, and price and cost of living indexes. In LC.

"Boletín de exportación," 1941–. Yearbook of export statistics. Latest, 1949. In LC.

Boletín, series estadísticas, July 1950–. Statistical bulletin, supersedes the *Boletín semestral de estadística*, 1934–?. Contents vary, with emphasis on prices, agriculture, and other economic topics. In GPRR.

"Estadísticas de comercio exterior," 1948–. Annual foreign trade statistics. Latest, 1949. In LC.

"Estadísticas del comercio exterior: resumen," 1947–. Summary of foreign trade statistics. Latest, 1948. In LC.

"Importación por artículos," 1940–. Yearbook of import statistics. Latest, 1950. In IASI.

Cuba

Dirección General de Estadística, Ministerio de Hacienda, Havana, Cuba. (Dr. Rodolfo Masferrer, Director General).

(No industrial census has been taken in Cuba; it is not known when one will be taken.)

Boletín de estadísticas, irregular, 1945–. Statistical bulletin, issued irregularly, usually for a 2 to 4 month period. Economic statistics, principally prices, money and banking, wages, and public finance. In LC.

"Comercio exterior," 1902–. Foreign trade yearbook. Latest for 1948–49, published 1950. Issued quarterly July 1902–December 1903, semiannually 1904–20, annual thereafter. In LC.

Dominican Republic

Dirección General de Estadistica, Ciudad Trujillo, República Dominicana. (Sr. Salvatore Aybar Mela, Director General).

(No census of industry has been taken in the Dominican Republic: it is not known when one will be taken.)

"Anuario estadístico de la República Dominicana," 1935–. Yearbook of statistics. Latest is for 1946–47, published 1951; includes sections on industry and commerce. In LC.

"Exportación de la República Dominica," 1936–. Statistics on exports of the Dominican Republic, issued irregularly. In LC.

"Importación de la República Dominicana," 1940–. Statistics on imports of the Dominican Republic, issued irregularly. In LC.

Ecuador

Direccion General de Estadística y Censos, Ministerio de Economía, Quito, Ecuador. (Sr. Luis F. Lopez Muñoz, Director General).

(No census of industry has been taken in Ecuador and it is not known when one will be taken.)

"Anuario de comercio exterior," 1891–. Yearbook of foreign trade statistics. Has been issued by various agencies and under various titles. In LC.

"Ecuador en cifras, 1938 a 1942," 1944. Only general compendium of statistics published in Ecuador. Includes industrial and mining production. In LC.

El trimestre estadístico del Ecuador, quarterly, May 1945–. Includes data on industry and mining. In LC.

El Salvador

Dirección General de Estadística, Ministerio de Econom'a, San Salvador, El Salvador. (Tte. Cnal. Jorge Tenorio, Director General).

(First census of industry in El Salvador was planned for 1952.)

"Anuario estadístico," 1912–. Vol. 1, Sección demográfica y judicial; Vol. 2, Sección de comercio exterior y interior; Vol. 3, Sección de producción y consumo. Statistical yearbook. First part contains demographic and judicial statistics, second part consists of foreign and domestic trade statistics, and third part is data on production and consumption. In LC.

Boletín estadístico, irregular 193–. In LC.

Guatemala

Direccion General de Estadística, Ministerio de Economía y Trabajo, Guatemala, Guatemala. (Sr. Raúl Sierra Franco, Director General).

(An industrial census of Guatemala was planned for, and presumably taken, December 1951.)

Boletín, Dirección General de Estadística, bimonthly, May 1946–. Statistics of industrial production, prices, construction, and consumption. In LC.

"República de Guatemala: síntesis geográfico-estadística," 1948. Statistical-geographic summary. Includes data from the first industrial census of Guatemala taken in 1946. In LC.

Haiti

Bureau de Recensement, Département de l'Economie Nationale, Port-au-Prince, Haiti. (M. Robert Bazile, Directeur-Administrateur).

(The first industrial census of Haiti was planned for 1952. The Bureau de Recensement is a new office which to date has concerned itself almost exclusively with censuses, first the 1950 censuses of population, housing, and agriculture, then preparations for the economic census. Available economic statistics of Haiti are published at present by the National Bank of Haiti.)

National Bank of Haiti, Fiscal Department, Port-au-Prince, Haiti.

"Annual report of the Fiscal Department." Includes statistics of foreign trade and customs and public finance as well as banking data. In English. A separate edition also published in French. In LC.

Monthly Bulletin of the Fiscal Department, June 1924–. Includes statistics of foreign trade, customs, and public finance as well as banking data. In English. A separate edition also published in French. In LC.

Honduras

Dirección General de Censos y Estadísticas, Nacionales, Secretaría de Gobernación, Tegucigalpa, Honduras. (Prof. Carlos Zúñiga Figueroa, Director General).

(No census of industry has been taken in Honduras; it is not known when one will be taken.)

Annual report of the Dirección General de Estadística included as annex in "Informe de Gobernación, Justicia, Sanidad y Beneficencia" (Report of department of Government, Justice, Health, and Welfare), 1901/02–. Annual report constitutes the general statistical yearbook, and includes data on manufacturing and mining. In LC.

Additional data in "Informe de Hacienda, Crédito Público y Comercio" (Report of department of Finance, Public Credit, and Commerce) 1901/02–. In LC.

Mexico

Dirección General de Estadística, Secretaría de la Economía Nacional, México, D. F., México. (Lic. Gilberto Loyo, Director General).

(Fourth industrial census of Mexico was taken December 1951; no results have been published).

"Anuario estadístico de comercio exterior de los Estados Unidos Mexicanos," 1920–22–. Statistical yearbook of foreign commerce. Latest for 1948, published 1950. Title and name of agency have varied. In LC.

"Anuario estadístico de los Estados Unidos Mexicanos," 1893–1907, 1930, 1938–. Latest is for 1943–45, published 1950; includes data on mining, manufacturing, communication and transportation, foreign and domestic trade, finance. Data are more detailed than those in the "Compendio estadístico" but appear much later. In LC.

"Compendio estadístico," 1941, 1947–48, 1950–. Statistical compendium, includes data on mining, manufacturing, communication and transportation, foreign and domestic trade. In GPRR.

Revista de estadística, monthly, 1938–. Supersedes *Revista de economía y estadística*, 1933–36. Statistical review. Principal economic data on production (agricultural, mineral and metal, electrical energy, and industrial), prices and cost of living, foreign trade, finance, and transportation. In LC.

"Tercer censo industrial de los Estados Unidos Mexicanos, 1940," 1944–50?. Third industrial census of Mexico. A separate pamphlet for each industry. In LC.

Nicaragua

Dirección General de Estadística, Ministerio de Economía, Managua, Nicaragua. (Dr. Adolfo Lola Blen, Director General).

(First industrial census of Nicaragua is planned for 1955.)

"Anuario estadístico de la República de Nicaragua," Statistical yearbook of Nicaragua. Latest is for 1946, published 1949. Includes data on industry and mining, and foreign trade. In LC.

Boletín de estadística, quarterly (irregular), May 1944–. Title varies. Includes statistics on mining, industry, and foreign trade. In LC.

Panama

DIRECCIÓN DE ESTADÍSTICA Y CENSO, CONTRALORÍA GENERAL DE LA REPÚBLICA, PANAMÁ, PANAMÁ. (SRTA. CARMEN A. MIRÓ, DIRECTORA).

(First industrial census of Panama was planned for 1952 or 1953.)

Estadística panameña, monthly, October, 1941–. Statistical bulletin, includes data on industry, foreign trade, and other economic topics. In LC.

Boletín de trabajo, comercio, e industrias (Panamá), **No. 13,** 2–26 (April 1939). Análisis de los resultados del primer censo oficial de empresas industriales y comerciales radicadas en Panamá, ejecutado en el año de 1938. Includes results of an inquiry on selected industries in 1938. In IASI.

Paraguay

DIRECCIÓN GENERAL DE ESTADÍSTICA, MINISTERIO DE HACIENDA, ASUNCIÓN, PARAGUAY. (DR. CARLOS A. SOLER, DIRECTOR GENERAL).

(First industrial census of Paraguay was planned for 1952.)

"Anuario estadístico de la República del Paraguay," 1886–87, 1914–17, 1940–. Statistical yearbook. Latest is for 1946–47, published 1948; includes data on foreign trade, prices, finance, and industrialization of agricultural products. In LC.

Peru

DIRECCIÓN NACIONAL DE ESTADÍSTICA, MINISTERIO DE HACIENDA Y COMERCIO, LIMA, PERÚ. (DR. LEOPOLDO MIRÓ QUESADA, DIRECTOR NACIONAL).

(It is not known when an industrial census will be taken in Peru.)

"Anuario estadístico del Perú," 1944/45–. Statistical yearbook. (Supersedes the "Extracto estadístico del Perú, 19(?)–1943.) Latest is for 1947, published 1949; includes data on mining, industry, consumption, prices, and foreign trade. In LC.

Boletín de estadística peruana, quarterly, 1940–. Supersedes the monthly *Boletín de la Dirección General de Estadística* (title varies), 1928–193(?). Includes data on mining and industry, prices, and foreign trade. In LC.

Boletín de la Dirección de Industrias, **No. 3,** (August 1946) Estadística industrial, published by the Dirección de Industrias in the Ministerio de Fomento y Obras Públicas.

Uruguay

DIRECCIÓN NACIONAL DE ESTADÍSTICA, MINISTERIO DE HACIENDA, MONTEVIDEO, URUGUAY. (DR. EDUARDO FONTICELLI, DIRECTOR GENERAL).

(There were tentative plans for taking an industrial census in Uruguay in 1952 or 1953.)

"Anuario estadístico de la República Oriental del Uruguay," 2 vol., 1885–. Statistical yearbook. Vol. 1, general; Vol. 2, foreign trade. Vol. 1 has data on agriculture, banking and credit, public finance, communication and transportation, and demography, and other social statistics. In LC.

"Censo industrial de 1936," 1939. Industrial census of 1936. In IASI.

"Síntesis estadística, República Oriental del Uruguay," 18 –. Statistical synopsis, contains summary data on the same subjects as are found in the two volumes of the "Anuario estadístico." Earliest covers 1876–8, latest is for 1941–42. In LC.

Venezuela

DIRECCIÓN GENERAL DE ESTADÍSTICA Y DE CENSOS, MINISTERIO DE FOMENTO, CARACAS, VENEZUELA. (DR. MANUEL FELIPE RECAO, DIRECTOR GENERAL.)

(Census of industry in Venezuela was planned for 1952).

"Anuario estadístico de Venezuela," 1877–1912, 1938–. Statistical yearbook. Latest 1948, published 1950, includes data on production and consumption (industrial, energy, agricultural), prices and economic indexes, finance, and foreign trade. In LC.

Boletín de estadística, quarterly, 1941–. Includes data on production and consumption, prices, sales, finance, and foreign trade. In LC.

"Censos industrial, comercial y empresas que prestan servicios, 1936." 1937–41. 23 volumes, a separate volume for each state and 3 for the Federal District. Censuses of industry, commerce, and services. In LC.

Bibliographies on Statistical Publications in Latin America

GREAT BRITAIN. COLONIAL OFFICE. LIBRARY REFERENCE AND RESEARCH SECTION, LONDON.

Monthly List of Official Colonial Publications, 1948–. Brief listing of publications received, including those of the British colonies in the Western Hemisphere which are not systematically covered by the other sources mentioned. Each issue has a separate section on government gazettes, in which statistical supplements and sections in the gazettes are indicated by title or by notes. In GPRR.

INTER AMERICAN STATISTICAL INSTITUTE, WASHINGTON, D. C.

"Bibliography of Selected Statistical Sources of the American Nations," 1947. Guide to principal statistical materials of the 22 American nations, including data, analyses, methodology, and laws and organization of statistical agencies. Continued and maintained up to date by the bibliography in *Estadística*. In LC.

Estadística, quarterly, 1943–. Each issue contains a selected annotated bibliography of recent Latin American statistical publications, with special emphasis on census volumes and statistical yearbooks and other major compilations of data of the 22 American republics. The first issues of new bulletins and journals are listed, but no succeeding issues; however, articles, and sections of special interest are shown under their proper subject headings. A section of news notes immediately preceding the bibliography contains information on statistical studies and publications programs launched by statistical agencies. In LC.

Monthly Accession List of Publications Received. . . . 1948–. Brief entries, not annotated; principally of the statistical publications of the 22 American republics. The coverage is more comprehensive than in the bibliography published in *Estadística*, and new titles appear much sooner. Each new issue of each periodical received is listed. In IASI.

United States Bureau of the Census, Washington, D. C.

Publications on Foreign Countries, quarterly, 1948–. Annotated accession list of statistical publications received from all countries of the world, chiefly through exchange agreements with other national statistical offices. Brief entries, with a minimum of annotation or none, but listing separately titles of articles and sections of special interest. Each new issue received of each periodical is listed. In BC.

United States Library of Congress, Hispanic Foundation, Washington, D. C.

"Handbook of Latin American Studies." Annual, 1935–. Cambridge, Mass., Harvard University Press, 1936–51; Gainesville, Fla., Florida University Press, 1951–. Annotated bibliography of special studies in various fields. Official compilations of data are usually excluded, but special analytical statistical studies are included, especially in the section on economics. Latest is no. 14 for 1948, published 1951. In LC.

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Market Research in Western Europe

F. P. STEVENS

Imperial Chemical Industries, Ltd., Nobel House, Imperial Chemical House, Millbank, London S.W. 1, England

Information on chemical markets in western continental Europe is compiled from government or semiofficial statistical publications, from directories of manufacturers, and from trade journals and other publications which help to build up a background for a market investigation. A selected list of publications is presented; and their contents are described.

This is not a paper in the ordinary sense of the term. These preliminary remarks are intended to serve only as an introduction to the sources of information on chemical markets in western continental Europe. The majority of the sources will be familiar to most people working in this field, but there may be an occasional one or two of value which have been overlooked hitherto by some, and if this is so, the labor of compiling the list will not have been in vain. The sources chosen for inclusion are those generally familiar to the author and his colleagues. They are, in fact, those which are regularly or intermittently consulted for the provision of data for market research, or are being kept in mind for future eventualities. The list is by no means exhaustive, large as it is there must be many gaps, but there may be an advantage in selecting only those sources which are considered valuable for the purpose in question in the light of practical experience.

The sources mentioned are freely available to all. They consist mainly, of printed publications which can be purchased through the usual channels. For convenience, they may be classified as follows. Statistics generally appear in government or semiofficial publications and include figures on output, imports and exports, and on a host of economic factors such as public finance, labor conditions, price movements, and cost of living trends, which have a bearing on business and competitive conditions. Directories show the names of manufacturers or other suppliers of products, revealing the identity of competitors or potential customers. Other sources consists chiefly of trade journals and other organs of the press, which are the main regular sources of the innumerable scraps of information collected on a routine basis; these help to build up the background for a market investigation. In the author's experience, these public sources constitute the main channels for the data used in the kind of market research which is carried out at the headquarters of a company, the research with which he is himself concerned.

This is not to discount the importance of private sources of information, such as sales personnel actually in contact with a market, sales agents, and the like. The organization of a routine flow of information through the selling side is inclined to be difficult, however, since the salesman is quite naturally preoccupied with current problems and cannot be expected to have the almost academic detachment of the research worker.

A glance at the list will at once reveal an uneveness in the amount of material provided for the different countries. It is natural to expect a more highly evolved press in the more developed countries, but it must be confessed that the main reason for the difference in treatment is the language difficulty. The staffs of market research organizations in a private concern are necessarily on the small side, and it would be a matter of good fortune indeed if it should turn out to be possible to recruit a membership of economists and technical people who together could cover the majority of European languages. In practice it is necessary to hope that the news from countries whose languages are less known will be covered in the press of neighboring countries whose languages are more familiar.

Something should be said, perhaps, about the value, accuracy, credibility, and other characteristics of the sources listed, but it is practically impossible to generalize about such a mass of material. It is hoped that the discussion of each item, briefly indicating the contents, or otherwise commenting on the source, will provide some guide.

In any case, every worker in this market research field knows that the value or credibility of every single item of information, even when taken from the most respectable sources, must be weighed and tested in the light of experience and against the available knowledge around the subject. Even government statistics, although perfectly accurate, may not represent what they seem and require further explanation or interpretation.

Sources of Information

General. The statistical bulletin issued by the Organization for European Economic Co-operation (*1*) contains economic statistics for the countries participating in the organization—Austria, Belgium and Luxemburg, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Turkey, Sweden, Switzerland, United Kingdom, Canada, and the United States. All figures are given for individual countries.

Indices of total industrial output and of production in food, mining, textile, chemical, basic metal, and engineering industries are given on a monthly basis.

Production, by quantity, is given on a monthly or quarterly basis for the materials listed in Table I.

Table I. List of Materials and Industries for Which Production Figures Are Given in the O.E.E.C. *General Statistical Bulletin*

Aluminum, primary	Railway cars
Bricks, building	Rayon
Cement	Staple fiber
Coal	Yarn
Coke	Rubber, natural
Copper, primary	(consumption and stocks)
Cotton	Shipbuilding
Fabrics	Steel
Raw, consumption and stocks	Crude
Yarn	Finished
Electricity	Sulfur (also consumption)
Fertilizers, nitrogenous	Sulfuric acid
Iron	Textile machinery
Ferro-alloys	Timber (also consumption)
Ore	Tractors, agricultural
Pig	Wood pulp
Lead	Wool
Ore	Fabrics
Primary	Unmanufactured, consumption
Machine tools	Yarn
Motor cars	Zinc
Paper and paper board	Primary, and consumption thereof
(also consumption)	

Agricultural production and food supply figures are given on an annual basis. Population and man power figures, including employment and unemployment, are given on a monthly basis. Figures on foreign trade, given on a monthly basis, include total trade, distribution, trade balances, and changes in terms of trade. Prices--wholesale price, cost of living and earnings indexes, prices of major world trade commodities, and agricultural prices—are given on a monthly basis. Figures for finance, including gold and foreign exchange holdings, exchange rates, indexes of share prices, money supply, and European Payments Union settlements, are given monthly.

Tables for each country summarizing the principal statistics of general economic importance are given monthly.

The "United Nations Statistical Yearbook" (*2*) contains statistics for countries throughout the world on population, manpower, land use, agriculture, forestry, and fisheries, mining and quarrying, manufacture (for a selected group of important products such as foods and fuels), external trade, balance of payments, national income, currency and credits, public finance, social welfare, and education. Production statistic include data for sulfuric, hydrochloric, and nitric acid, caustic soda, superphosphates, nitrogenous fertilizers, "benzol," phosphate rock, potash, and sulfur.

Austria. The *Statistische Nachrichten* (*3*), issued monthly, gives statistics on population, labor conditions, production, foreign trade, and wholesale prices. Production figures are given for caustic soda, chlorine, carbon dioxide, calcium carbide, lime–ammonium nitrate, acetylene (dissolved), oxygen, soda crystals, soaps and detergents, cellulose, rayon, and magnesite.

Official returns of imports and exports are given in "Statistik des Aussenhandel Oesterreichs" (*4*).

Belgium. The *Bulletin de Statistique* (*5*) gives comprehensive statistical information on all aspects of the Belgian economy including descriptive analyses of economic developments. There is a limited section on chemical industry showing output and number of employees and hours worked for industries producing synthetic and by-product nitrogen, nitrogenous fertilizers and technical products, and tar and benzol products.

Official monthly returns of imports and exports are given in a bulletin (*6*). Two directories of value have been issued. The "Indicateur des Produits Belges" (*8*), a general directory of products and suppliers, contains an alphabetical list of products, showing suppliers, but it does not indicate which are manufacturers of the products in question and which are only merchants. This contains an English index of products.

A directory of Belgian chemical manufacturers and merchants (*7*) covers the more important producers, gives an alphabetical listing of chemical products, and indicates separately the manufacturers and merchants.

The Federation des Industries Chimiques de Belgique issues a monthly organ (*9*) containing articles mainly on strictly technical subjects. Branches of the Belgian chemical industry are described; there is a section of foreign news items; a table of Belgian chemical prices; and an index to advertisers of chemicals and chemical plants, classified by products.

Denmark. The government statistical department publishes annually statistics on population, weather, surface area, employment, housing, agriculture, industry (numbers employed in different branches), output of principal products (virtually no chemicals), fuel and power supplies, transport, consumption of food and staple commodities, cost of living, wholesale and retail prices, public finance, social insurance, and education. This publication (*11*) is in French as well as Danish.

There is a yearbook for the Danish industry (*12*) which gives general statistics for the various industries (number of works, number of workers, primary power machinery, electric motors, and fuel and electricity consumption); extensive tables for each new industry show output of products and consumption of raw and auxiliary materials. Among the industries dealt with are the explosives, soap, paint and chemicals industries. Among individual chemicals listed are soda crystals, synthetic detergents, baking powder, flavors, acetic acid, saccharin, gelatine, pharmaceuticals, polishes, dry colors, insecticides, weed killers, disinfectants, amyl and butyl alcohols, ethyl acetate, molding powders, synthetic resins, tanning extracts, and hydrochloric acid. There is some guidance in French.

Official annual returns of imports and exports are given in "Danmarks Vareinførsel og Udførsel" (*10*); official monthly returns are given in *Varomsaetningen med Udlandet* (*13*), but these are not by countries of origin or destination.

A directory of Danish exporters (*14*) gives a list of Danish products with names and addresses of suppliers. This gives reasonably good coverage of products including a few in the chemical field. There is an index of products in English.

Finland. A government statistical annual (*15*), contains statistics on area of country, population, health, agriculture, fisheries and forests, industries (including employment in the different branches, output value, wages and raw material costs, and production of more important products) transportation, foreign trade, currency and credit, social insurance, cost of living, wholesale price indexes, and retail prices. Chemical materials for which production figures are given include sulfuric acid, superphosphate, chlorine, caustic soda, wood tar, lime, paints and varnishes, rayon, and chemical pulps. The information is given in Finnish, Swedish, and French.

A statistical yearbook of the Finnish industries (*16*) includes general statistics for the various branches of industry (value of output, number of workers, wages, and motive power), and detailed tables of output and raw material consumption by the different industries. Chemicals for which output figures are given include paints, varnishes, and lacquers, superphosphate, turpentine, explosives, chlorine, caustic soda (solid and solution), hydrochloric acid, phosphates, trichlorethylene, chlorophenolates, calcium hypochlorite, carbon tetrachloride, calcium carbide, potassium chlorate, carbon dioxide (liquid), sulfuric acid, water glass, metasilicate, plastics and synthetic resins, dichloroethane, and chloral. For lacquers and varnishes, and plastics and synthetic resins, data are given for individual products.

Official annual returns of imports and exports are given in "Utrikeshandel Årspublikation" (*17*), and official monthly returns are given in *Utrikeshandel Månads-publikation* (*18*). Monthly figures are not very detailed; countries of origin or destination are not given.

A general directory of Finnish suppliers (*19*) has been issued in several languages, including English. About 40 chemicals are given in the classified list of products. The quarterly *Finnish Trade Review* (*20*) contains articles on industry, trade, and other matters affecting the Finnish economy, with a few statistics and news items. This is published in English.

France. An official bulletin (*21*), issued monthly, gives statistics on population, employment, industrial production, foreign trade, retail and wholesale prices, wages, and public finance. Production figures are given for the chemicals listed in Table II.

Statistics on industrial production are given in greater detail in another official publication (*22*) issued annually. This provides output data (in many cases also domestic delivery and foreign trade data) for the products of most of the main industries, including those listed in Table III, for the chemical industry.

Official import and exports are available monthly (*23*).

A directory of the French chemical industry (*24*) gives alphabetical lists of suppliers and products. There is no discrimination between manufacturers and merchants. A French newspaper (*25*) includes news items on developments in industries, markets, and individual companies in France, with valuable coverage, also, for other countries. Short articles on general developments of an economic and commercial nature, which are useful in throwing light on current trends, are also included.

Table II. Chemicals Listed in the *Bulletin Mensuelle de Statistique*

Ammonia	Nitric acid
Ammonium sulfate (synthetic and by-product)	Nitrogen fertilizers (synthetic)
Calcium carbide	Phenol
Calcium cyanamide	Phosphate, ground
Calcium nitrate	Potash salts
Carbon bisulfide	Resins, phenolic and urea-formaldehyde
Caustic soda (solid and solution)	Slag, basic
Chlorine	Sodium carbonate
Copper sulfate	Sodium nitrate (production and imports)
Dyestuffs, organic	Sodium sulfate
Fertilizers, mixed	Sulfur, refined
Formaldehyde	Sulfuric acid
Hydrochloric acid	Superphosphates
Methanol	Tanning extracts

Table III. Chemicals Listed in the "Annuaire de Statistique Industrielle"

Acetic acid
Acetone
Acetone cyanhydrin
Acetylene (dissolved)
Alkaloids
Alum
Aluminium chloride (anhydrous)
Aluminium fluoride
Aluminium sulfate (ordinary and pure)
Ammonium chloride
Ammonium phosphate
Ammonium sulfate (synthetic and by-product)
Anthracene
Antimony oxide
Arsenous oxide
Barium carbonate
Barium chloride
Barium sulfate
Basic slag
Benzene (motor, industrial, and pure)
Bleach (chloride of lime)
Bromine
Butyl acetate
Butyl phthalate
Butyric acid
Calcium carbide
Calcium cyanamide
Calcium hypochlorite
Calcium nitrate
Calcium potassium ferrocyanide (double salt)
Carbon bisulfide
Carbon black
Carbon tetrachloride
Caustic potash (solid and liquor)
Caustic soda (electrolytic and lime-soda)
Chiolite (calcined)
Chlorinated dielectric products
Chlorine (gaseous & liquefied)
Chromium sulfate
Coal tar (by sources)
Copper sulfate
Copper thiocyanate
Cream of tartar
Cresols
Cryolite (artificial)
Diacetone alcohol
Disodium phosphate
Dyestuffs
Ethyl acetate
Ethyl chloride
Ethylene glycol
Ethyl ether
Ethyl phthalate
Explosives (separate products)
Fatty acid condensation products
Fatty alcohols
Fertilizers
Formaldehyde
Formic acid
Gelatines
Glycerine
Hydrochloric acid
Hydrofluoric acid
Hydrogen (compressed)
Hydrogen peroxide
Lactic acid
Lead oxides
Lime
Lithopone
Metaldehyde
Methanol (synthetic)
Methyl acetate
Methylal
Methyl chloride
Monoethanolamine
Naphthalene (crude and refined)
Nitrogen (synthetic)
Olein
Oxalic acid
Oxygen (compressed)
Paints (separate products)
Pentaerythritol
Pharmaceuticals (separate products)
Phenol (synthetic and by-product)
Phosphoric acid
Phosphorus (yellow and red)
Phosphorus oxychloride
Phthalic anhydride
Plastics (in detail by chemical types)
Potassium bichromate
Potassium carbonate
Potassium chlorate
Potassium ferrocyanide
Potassium perchlorate
Potassium silicate (liquid)
Potassium-sodium tartrate
Pyridine
Rubber, synthetic (consumption)
Silver nitrate
Soaps (separate products)
Sodium (metal)
Sodium bicarbonate
Sodium bichromate
Sodium carbonate
Sodium chlorate
Sodium cyanide
Sodium ferrocyanide
Sodium fluoride
Sodium hypochlorate
Sodium nitrate
Sodium silicate (liquid and solid)
Sodium sulfide
Stearin
Sulfonated alkylnaphthalenes
Sulfonated fatty alcohols
Sulfur (crude & refined)
Sulfur chloride
Sulfuric acid
Superphosphate
Tanning materials
Tartaric acid
Tetrachloronaphthalene
Tin tetrachloride
Titanium white
Toluene
Triarylphosphates
Trichloroethylene
Trioxymethylene
Trisodium phosphate
Ultramarine
White lead
Xylene
Zinc oxide

A bimonthly publication (*27*) of the Institut Nationale de la Statistique et des Etudes Economiques is principally devoted to studies and analyses of various aspects of the French economy; it is of assistance in providing general economic data which have a bearing on production and competitive trends in the French market. *L'Industrie Chimique* (*28*) has a small commercial section with news on chemical manufacturing and other developments in France and in other countries. *Chimie & industrie* (*26*) has a commercial section with special articles on the French chemical industry and trade, news items, and some statistics.

Germany. The Statistisches Bundesamt, the federal West German statistical office, publishes statistics in *Die Industrie der Bundesrepublik* (*30*). Part I gives monthly statistics of employment and unemployment, hours and wages, and fuel and electricity supplies and consumption by individual industries. Part II gives monthly production statistics for mining, fuel and power, and the main industries. Chemicals included are sulfuric acid, hydrochloric acid, chlorine, caustic soda, synthetic ammonia, technical nitrogen, phosphate fertilizers (superphosphate, basic slag, etc.), calcium carbide, methanol, ethylene oxide, acetaldehyde, acetic acid, pharmaceuticals, mineral pigments, cellulose plastics, synthetic resins and plastics (phenolic, urea, polyvinyl chloride, polystyrene), paints and lacquers, and soaps. Part III gives quarterly statistics on industrial output, covering a range of products similar to that in Part II. In the chemical section there are statistics, in addition, for the following: phosphates, compounds of aluminum, lead, copper, and nickel, active carbon, hydrogen, oxygen, carbon dioxide, acetylene, and a further breakdown of pharmaceuticals. For most of the chemical products there are separate figures for production for sale, and for output for consumption in plant use. Part III appears much later than Part II, and contains revised figures.

Wirtschaft und Statistik (*31*), the official monthly statistical bulletin of West Germany, gives statistics on population, education, labor and unemployment, wages, cost of living, prices, welfare services, agriculture, forestry and fishery, industry (including products), electricity, gas and fuels, building, foreign trade, transportation, and public finance. There are special articles analyzing the implications of the statistics on one or more aspects of the country's economy. Chemical production figures are included for sulfuric acid, sodium carbonate, chlorine, caustic soda, nitrogenous fertilizers, phosphate fertilizers, potash salts, calcium carbide, synthetic resins, and plastics.

Official annual and monthly returns of imports and exports are published in *Der Aussenhandel der Bundesrepublik Deutschland* (*29*).

A general directory of commodity suppliers (*32*) lists products alphabetically and gives names of suppliers but does not discriminate between manufacturers and merchants. The list is inadequate for chemicals. The "Handbuch der Deutschen Aktiengesellschaften," a directory of German companies, gives detailed information on the finances, directorates, and industrial and other activities of the individual concerns. This is in five large volumes (*33*).

Three chemical journals (*36–38*) contain news items on chemical industries in Germany. *Die Chemische Industrie* (*38*) is one of the most useful periodicals in the chemical industry; it can be relied on, to a considerable degree, for particulars of development in other European countries. Lists of German prices for chemicals are published in *Chemie-Ingenieur-Technik* (*36*).

Handelsblatt (Deutsche Wirtschaftszeitung), a commercial newspaper, contains news on all usual commercial angles in Germany, and surveys of individual industries and overseas markets. This is useful for understanding current trends and policies (*39*).

Der Volkswirt, (*42*) a weekly economic, financial, and commercial journal, gives analyses of current economic events, trends, and policies; surveys of industries (nationally or by region, and in relation to the national or regional economy), status and activities of companies with full particulars on finances, history, current manufacturing facilities, and projects; and some economic statistics. This is possibly the best journal of its kind in Germany.

Bundesanzeiger (*35*) is the official daily gazette for government announcements. It contains information on government regulations affecting trade, currency dealings, and legal status of companies.

A weekly periodical (*34*) contains special articles on various problems affecting international trade and short surveys of current trade questions, including trade agreements.

Statistics and other information bearing on economic trends are published in *Schnelldienst* (*41*), a weekly economic review. This is useful for market prospects.

A monthly economic and financial periodical published by the Bank Deutscher Länder (*40*) contains factual analyses of economic conditions in Germany, with a separate statistical section. This is a high-quality publications.

Greece. Statistics on currency, banking, and other financial matters, indexes on cost of living and on output of the main industries are published in the *Monthly Bulletin of the Bank of Greece* (*43*). This is published in English as well as Greek. Official monthly returns of imports and exports are published in English (*44*).

Italy. There is an official statistical yearbook (*46*) covering area and climate, population, public finance, labor, building, industry (giving general statistics and production for various branches), mining, and transportation. Production data are given for the chemicals and related materials listed in Table IV.

Table IV. Chemicals Included in "Annuario Statistico Italiano"

Acetic acid
Acetone
Acetyl cellulose
Alumina
Aluminum sulfate
Ammonia (synthetic anhydrous)
Ammonium bromide
Ammonium carbonate
Ammonium sulfate (by-product)
Arsenous oxide
Barium chlorate
Borax
Boric acid
Bromine
Butanol
Calcium arsenate
Calcium bromide
Calcium carbide
Calcium chloride
Calcium hypochlorite
Camphor (synthetic)
Carbon (active)
Carbon dioxide (solid and liquid)
Carbon disulfide
Chlorine (gas and liquid)
Citric acid
Copper oxychloride
Copper sulfate
Cream of tartar
Dextrin
Dyestuffs
Ethanol
Ethyl bromide
Ethyl chloride
Ethyl ether
Ethylene bromide
Ferrous sulfate
Formaldehyde
Formic acid
Furfural
Glycerol (crude and refined)
Hydrochloric acid (by processes)
Hydrogen peroxide
Hydrosulfites (separate products)
Iodine
Lead arsenate
Magnesium chloride
Magnesium sulfate
Methanol
Nitrogenous fertilizers (separate products)
Nitric acid
Phenol
Phosphate fertilizers (separate products)
Phosphoric acid
Phosphorus (yellow and red)
Phosphorus sesquisulfide
Pigments
Plastics (separate products)
Polysulfides (barium, calcium, potassium, and sodium)
Potash, caustic, and intermediates (separate products)
Potassium aluminate
Potassium bichromate
Potassium bromide
Potassium carbonate
Potassium cyanide
Potassium chlorate
Potassium silicates
Sodium arsenite
Sodium bicarbonate
Sodium bichromate
Sodium bromide
Sodium carbonate
Sodium chloride
Sodium chlorate
Sodium hypochlorite
Sodium hydroxide (solid and solution)
Sodium nitrate
Sodium silicates
Sulfides (barium, calcium, potassium, and sodium)
Sulfur dioxide (liquefied)
Sulfuric acid (by processes)
Tar and tar products (separate products)
Tartaric acid
Trichlorethylene
Urea
Zinc phosphide
Zinc sulfate

The Instituto Centrale di Statistica issues annually the statistics for area and population, weather, education, armed forces, national income and expenditure, agriculture, fisheries and forests, industry (including output for the more important products), electricity and gas, housing, transportation, foreign trade, finance, prices, labor and wages, and food consumption. Output figures for industrial products include data for acetone, boric, citric, hydrochloric, nitric, sulfuric and tartaric acids, methyl and ethyl alcohols, aluminum oxide, synthetic ammonia, carbon dioxide (solid and liquid), borax, calcium carbide, synthetic organic colors (with separate figures for sulfur dyes), calcium cyanamide, ammonium nitrate, calcium nitrate, sodium nitrate, ammonium sulfate, iodine, compressed oxygen, superphosphates, synthetic perfumes, sodium carbonate, caustic soda, aluminum sulfate, copper sulfate, carbon disulfide, trichlorethylene, coal tar products and rayon (*47*).

An official monthly bulletin gives statistics on population, agriculture, forests and fisheries, industry (production indexes for main branches, output figures for salt, minerals, textiles, iron and steel, engineering, motor vehicles, cement, chemicals (including synthetic ammonia, sulfuric acid, dyes, caustic soda, and coal tar products), and fertilizer consumption including detailed figures by products and districts (*45*).

Official monthly returns of imports and exports are published in *Statistica del Commercio con l'Estero* (*48*).

There is a directory of Italian chemical manufacturers (*49*) arranged with alphabetical lists of companies and of products and their suppliers.

The Italian chemical journal, *Rassegna Chemica* (*50*), contains articles on technical and industrial developments and on chemical markets in Italy. Monthly statistics on Italian chemical production (quoted from the Ministry of Industry and Commerce) include the following: synthetic ammonia, nitric acid, sulfuric acid, sodium carbonate, caustic soda, alumina, trichlorethylene, calcium carbide, carbon disulfide, explosives, superphosphates, ammonium sulfate, calcium cyanamide, calcium nitrate, ammonium nitrate, copper sulfate, dyestuffs, ethyl alcohol, methanol, tanning extracts, tartaric acid, citric acid, wood pulp and cellulose, and sodium nitrate.

Netherlands. An official statistical yearbook (*51*) gives statistics on population, climate, health, employment and unemployment, wages, hours of work, social insurance, agriculture and fisheries, transportation, foreign trade, finance and credit, and public finance. Figures for industry include electricity and gas supply and consumption, number of manufacturing enterprises in main industries, and value of production. Output figures are given for the main products, including, in the chemical field, soaps, phosphate fertilizers, nitrogenous fertilizers, and sulfuric acid. The yearbook is printed in English and Dutch.

The official monthly publication (*52*) gives figures on population agriculture, finance and credit, and industrial output. This contains some English headings. Official monthly returns of imports and exports are available (*53*).

A directory of Netherlands chemical and pharmaceutical manufacturers (*54*) contains alphabetical lists of companies and products. There is an index in English to the products list.

The *Amsterdamsche Bank Quarterly Review* (*55*), in English, gives analyses of current economic conditions in the Netherlands, and relative factual data. Two trade journals (*56*, *58*) contain news on developments in the chemical industry. *Chemisch Weekblad,* (*57*) a technical journal, occasionally contains items of commercial interest.

Norway. Statistics on area and population, health, agriculture, fisheries, forestry and hunting, mines, industry (including output of more important products), electricity supply, building, foreign trade, transportation, finance, social insurance, price movements, labor and wages, housing and education are available annually (*62*). Production data are given for explosives and matches, paints and lacquers, calcium nitrate, sodium nitrate, lime–ammonium nitrate, mixed fertilizers, dolomite–ammonium nitrate, ammonium nitrate, nitric acid, calcium carbide, cyanamide, and chemical pulps. This annual is published in French and Norwegian.

The official statistics annual for Norwegian industry (*61*) gives general statistics for the different branches of the industry and detailed tables of output of products which include figures for the consumption of individual raw materials and auxiliary materials in the various industries. Figures are available for paints and lacquers (separate products), dry colors, tars, pharmaceuticals, polishes, baking powders, flavors, superphosphate, calcium nitrate, sodium bicarbonate, ammonium nitrate, ammonium bicarbonate, lime–ammonium nitrate, sodium nitrate, ammonia, sodium carbonate, nitric acid, carbide, cyanamide, explosives, ammunition and matches, and chemical pulps (separate products).

Official annual returns of imports and exports are published (*60*). Monthly returns (*59*) do not give countries of origin or destination.

A general directory of Norwegian exporters and export products (*63*) has classified lists of commodities with names and addresses of suppliers (manufacturers and merchants). Coverage of chemical products is moderate. Individual products are indexed in English.

Portugal. The official monthly statistical bulletin (*65*) includes figures on population, public finance, wages, agriculture, foreign trade (imports and exports of principal products including some chemicals), wholesale and retail price movements and transportation. This is published in French as well as Portuguese.

Official annual returns (*66*) and monthly returns (*64*) of imports and exports are available.

A directory of Portuguese products and their suppliers (*67*) has a products index in English.

Spain. Monthly official statistics on population, health, mining and industrial production, foreign trade, transportation, finance, labor, and cost of living are available (*68*). Chemical production statistics are given for the materials listed in Table V.

Table V. Materials Included in *Boletin de Estadistica*

Ammonia	Glycerol
Ammonium carbonate	Hydrochloric acid
Ammonium chloride	Hydrocyanic acid
Ammonium sulfate	Hydrofluoric acid
Barium carbonate	Hydrogen
Barium chloride	Nitric acid
Barium hydrate	Olein
Barium sulfate	Oxygen
Borax	Phosphate rock
Boric acid	Potassium chlorate
Calcium carbide	Potassium chloride
Calcium hypochlorite	Soda ash
Chrome alum	Sodium bicarbonate
Copper sulfate	Sodium chlorate
Carbon dioxide	Sodium hydrosulfite
Carbon disulfide	Sodium hypochlorite
Carbon tetrachloride	Stearin
Caustic potash	Sulfur
Caustic soda	Sulfuric acid and oleum
Chlorine	Superphosphate
Ferrous sulfate	Trichloroethylene

Official returns of imports and exports are available annually (*69*) and monthly (*70*). Current news on commercial and related matters, and on industrial developments may be obtained from a weekly news bulletin printed in English (*72*). There is a monthly chemical journal, *Ion* (*71*).

Sweden. A Swedish government statistical annual (*77*) covers area and population, agriculture, fisheries and forestry, mining, industry (including numbers employed in main branches, total value of production, output of the more important products) power supply, foreign trade, transportation, finance, cost of living, labor and wages, social insurance, health, education, housing, and retail and wholesale price movements. Production data are quoted for caustic soda, nitric acid, hydrochloric acid, sulfuric acid, chlorates and perchlorates, calcium carbide, superphosphates, medicinals and disinfectants, soaps, rayon, chemical pulps, tanning extracts, and explosives. This is available in French and Swedish.

An official statistical annual for industry (*75*) covers numbers employed in the different branches of industry, hours worked, and motive power employed, and includes extensive tables of production data for industrial products and detailed figures of raw material consumption by industries. The section on the chemical industry includes output figures for the products listed in Table VI.

Annual and monthly returns of imports and exports are reported (*74, 76*). There is a statistical annual for the mining industry (*73*).

An alphabetical list of industrial products, including a fair coverage of chemicals and their manufacturers, is included in a general directory of manufacturers (*79*). Names and addresses of exporters and export products classified by trades are available in the "Swedish Export Directory" (*78*).

The Swedish chemical journal (*82*) contains articles on current chemical developments in Sweden and elsewhere.

Table VI. Materials Included in "Industri"

Acetaldehyde	Hexamethylene tetramine
Acetanilide	Hydrochloric acid
Acetic acid	Hydrogen peroxide
Acetic anhydride	Iron oxide
Acetone	Lacquers and varnishes (separate products)
Acetone oil	Lead oxide
Acetyl salicylic acid	Methyl acetate
Aluminum sulfate	Monochloroacetic acid
Ammonia (liquid and solution)	Monochloroacetal
Ammonium sulfate (by-product)	Nickel sulfate
Amyl acetate	Nitric acid
Amyl alcohol	Nitrobenzene
Arsenic compounds	Olein
Butyl acetate	Paints (separate products)
Butyl alcohol	Paraldehyde
Calcium acetate	Pentaerythritol
Calcium carbide	Perchlorethylene
Calcium chloride	Perfumes (separate products)
Carbon bisulfide	Permanganates
Caustic potash (solid and solution)	Phenols
Caustic soda (solid and solution)	Phosphates, inorganic (separate products)
Celluloid	Phosphoric acid
Cellulose derivatives (separate products)	Phosphorus (yellow and red)
Chloramine	Phthalic anhydride
Chlorates and perchlorates	Phthalic esters
Chlorine	Plastics (polyvinyl acetate, alcohol, chloride, monovinyl acetate, phenolic, urea, and melamine resins, plastics in rods, sheet, and other forms)
Chlorine bleaching compounds (chloride of lime, hypochlorite solution)	Polyglycols
Chloroform	Potassium carbonate
Chlorosulfonic acid	Rosin
Chrome alum	Rubber, synthetic (chloroprene and thio types)
Colors, dry (separate products)	Saccharine
Copper oxide	Salicylic acid
Crotonaldehyde	Slag, basic
DDT	Soaps (separate products)
Diethylene glycol	Sodium carbonate (ash and crystals)
Diphenylamine	Sodium pentachlorphenate
Electroplating salts (including cyanides)	Sodium silicates (metasilicate, water glass, solids and solution)
Ethyl abietate	Stearin
Ethyl acetate	Sulfur
Ethyl diglycol	Sulfuric acid (oleum and other)
Ethyl ether	Superphosphate
Ethyl glycol	Tanning extracts
Ethylene chloride	Tar products
Ethylene glycol	Trichloroethylene
Ethylene oxide	Tricresyl phosphate
Explosives (separate products)	Triethanolamine
Furfural	Turpentine
Fertilizers (synthetic nitrogenous and others)	Zinc sulfate
Formaldehyde (solid and solution)	
Gases (separate products)	
Gelatine	
Glycerol (crude and refined)	

The *Anglo-Swedish Review*, issued by the Swedish Chamber of Commerce in London, contains articles on current economic developments in Sweden with reference to the effect of trade conditions (*80*). It also contains news items.

A quarterly economic review (*81*) published in Stockholm, includes articles on current economic developments and conditions in Sweden, with emphasis on monetary and financial aspects, and surveys of industries and important companies. This is in English.

Switzerland. Statistics on banking and finance, share price movements, employment and unemployment, foreign trade, wholesale price movements, cost of living indexes, agricultural prices, and balance of payments are published in (*84*). Official returns of imports and exports are published annually (*83*) and monthly (*85*).

A directory of Swiss Chemical manufacturers (*86*) gives particulars of companies and their products, classified only under broad headings such as heavy chemicals, pharmaceuticals, and so on. There is no index to individual products.

A monthly economic journal (*88*) contains concise statistical information on economic conditions in Switzerland, with short surveys of different aspects of Swiss economy (labor market, wage trends, credit conditions, and price trends).

The Swiss daily newspaper, *Neue Zürcher Zeitung* (*87*), has an economic section with articles on current problems and news items on industrial and other developments. This paper contains useful information on all European countries, as well as Switzerland.

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Unit Consumption Factors

R. NORRIS SHREVE

Purdue University, Lafayette, Ind.

Unit consumption factors are the quantitative data that enable calculations to be made in determining the amount of raw materials necessary to make, for instance, 1 pound of finished product. The conditions under which these unit consumption factors vary are discussed as is how they can be used, both in checking products and in planning for raw material supply and for the sale of chemicals. Nine functions wherein the unit consumption factors have been used are listed.

Quantitative data form the basis of the chemical industry. This has long been recognized in the design and implementation of factories, and in the supplying of the necessary raw materials. The quantitative aspect is just as important in sales planning and in marketing surveys. The difficulty is obtaining quantitative data in the marketing area. Though much has become available in recent years, more is needed. The retarding condition is the confidential nature of many of the basic figures.

Even in the area of marketing or sales, the application of the quantitative figures available requires technical training and understanding. The universities are giving such training as the backbone of the education imparted to chemical engineers wherein the emphasis is upon material balances, energy balances, flow sheets, and the yields and conversions of the chemical changes.

Definition of Unit Consumption Factors

As a foundation to the treatment of this subject, a frequent misunderstanding between yields and conversions must be clarified, because the unit consumption factors are based on the chemical yields and not on the conversions. The operational efficiency of chemical plants is interpreted in terms of the yield and conversion. These terms may be defined as follows:

$$\text{Percentage yield} = 100 \times \frac{\text{moles of main product}}{\text{moles of main product equivalent to net disappearance of chief reactant}}$$

$$\text{Percentage conversion} = 100 \times \frac{\text{moles of main product}}{\text{moles of main product equivalent to chief reactant charged}}$$

Based on the synthesis of ammonia at 300 atmospheres and 500° C., the yield is frequently above 98% while the conversion will be limited by the equilibrium figure of around 20%. This means that 80% of the hydrogen and nitrogen charged are not converted and must be recirculated after the removal of the ammonia. Somewhat higher figures prevail for the methanol synthesis. It is from the yields that the unit consumption factors are calculated.

The aim of the chemical engineer, concerned with the cost, is to arrange for such conditions of temperature, pressure, and proportions that the conversion figures approach the yields as closely as feasible. This is, of course, not possible for ammonia because of the low equilibrium of this reaction at practical temperatures and pressures. As a corollary of the low ammonia and methanol conversions, larger equipment is required than would be necessary were the conversion figures nearer to those of the yield.

When making any market study in the chemical field the unit consumption factors are needed because they are a measure of the average realized chemical change that takes place when a raw material is converted chemically into a salable finished product. This can be demonstrated most easily in conjunction with flow sheets (Figures 1, 2, 3, and 4) wherein the raw materials are put through a coordinated sequence of physical changes (unit operations) and chemical changes (unit processes) to convert them into products of enhanced value and usefulness. These latter products may enter directly into sales in the consumption areas or they may be consumed within the factory where they are manufactured in order to be turned into salable products of still further enhanced value and usefulness. It might also be pointed out here that the chemical industry is its own best customer, consuming much of its own products.

Variations in Unit Consumption Factors

The literature sometimes uses the words unit conversion factors when they really mean unit yield factors. The latter, as explained above, represents the net change of a given raw material into the main product. As a corollary to this consideration, the actual yields should be compared to the theoretically possible yields. While it is not the function of the market investigator to endeavor to change conditions in the factory in order to make the realized yield approach as closely as possible to the theoretical yield, yet in case of wide discrepancy between these, he should recognize that, with advancing knowl-

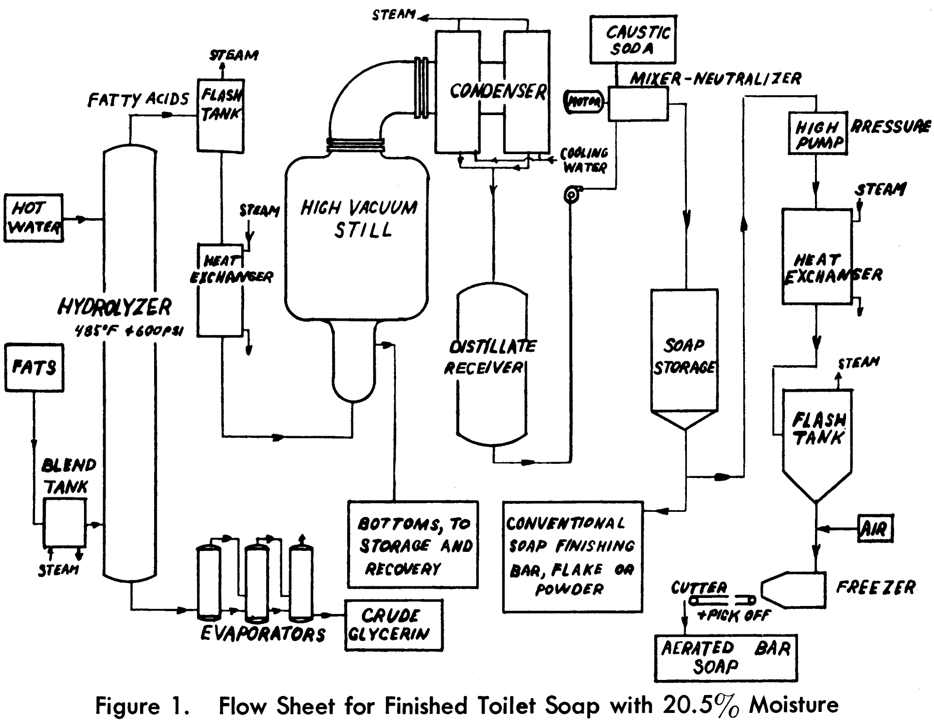

Figure 1. Flow Sheet for Finished Toilet Soap with 20.5% Moisture

Pounds per pound of soap

Fat	0.85	Make-up water	0.833
Lye (as 50° B´ caustic soda)	0.236	Steam (150-lb.)	1.2
Salt	0.0067	Electricity (kw.-hr.)	0.025
Sodium silicate (49° Bé. solution)	0.005		

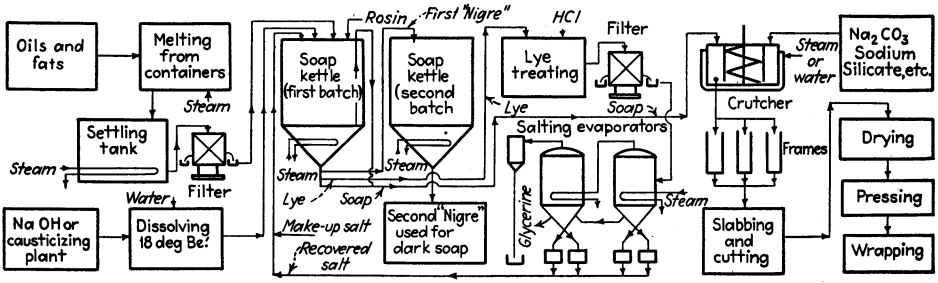

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Figure 2. Flow Sheet for Laundry Soap

Per ton of a typical laundry soap (plus 70 pounds of 80% glycerol)

Oil, fats	653 pounds	Steam	2 tons
Sodium hydroxide (76% Na_2O)	111 pounds	Water	230 gallons
Rosin	90 pounds	Soda ash (58% Na_2O)	37 pounds
Salt (make-up)	4 pounds	Sodium silicate (18° Bé.)	822 pounds

edge, the actual yields tend to approach theoretical ones. In the parlance of the factory superintendent this happens when the chemical yield of the process is improved. Throughout the entire chemical field a certain proportion of the funds assigned to research are devoted to the improvement of chemical yields. When this occurs the principal unit consumption factor will decrease.

Published unit consumption factors are subject to variations with advances in the chemical industry. This industry is characterized by change; in its entirety it spends the largest percentage of sales dollars and probably the largest actual number of dollars in research and development. While much of this goes into developing new chemicals and chemical products like DDT, Dacron, Dynel and many others, a certain proportion of research expenditures are employed for improvement of processes. The improvement of these processes proceeds along three general lines. First is the enhancement of yields with elimination of wastes and consequent decrease of unit consumption factors. This is fairly simple and is illustrated by the great improvements in the sulfonation process for making phenol wherein the consumption factor for sulfuric acid (66° Bé.) has been much decreased to 1.4 pound per pound of phenol.

The second approach involves a change of products or their proportionate conversions and may be illustrated by chlorination of benzene. Although monochlorobenzene was the product commercially needed, some *o*- and *p*-dichlorobenzene were always formed in the process. These were stored by the wise manufacturer until excellent markets for these products were developed. At present certain manufacturers conduct the chlorination of benzene to make the maximum amount of the dichloro derivatives. Here the unit consumption factor of chlorine, for example, varies with the proportion of the polychloro derivatives made. When benzene is chlorinated in this fashion, there will be not one conversion factor but two series, giving for each the conversion factor of benzene or of chlorine to chlorobenzene, *p*-dichlorobenzene, and *o*-dichlorobenzene. For this multiple-product manufacture the over-all picture can be obtained only by the summation of the individual product conversion factors.

The third aspect of improvement may mean an entirely different process for making an old substance. For many decades soap has been manufactured by caustic soda saponification of fats in the batch process. In recent years plants have been installed for the high pressure, high temperature rapid hydrolysis of fats in the countercurrent liquid mixed phase using water and a catalyst. In this case the sodium fatty acid or the soap may be prepared by neutralizing the free fatty acid hydrolysis product with caustic soda or soda ash depending upon convenience and the market. Naturally the unit consumption factors changed when the improved process was used.

Figure 1 gives the unit consumption factors for one pound of a finished toilet soap with 20.5% moisture. Figure 2 represents a flow sheet for laundry soap wherein chemical reactions and physical changes (unit processes and unit operations) are involved in the manufacture. Note the change in the unit conversion factors between the two different kinds of soap. Figure 3 represents a flow sheet for the concentration to suitable purity of glycerol obtained from the preceding flow sheet, together with the recovery of the cyclical salt (unit operations).

Judgment and technical experience will enable an approximation of a unit consumption factor to be made in certain areas. The approximation will be nearer to the actuality, the more experienced the calculator is in the particular field. For instance, a man versed in the manufacture of chlorinated insecticides with knowledge of yields can calculate the unit consumption factor for chlorine consumption for an analogous new chlorine-containing product with fair accuracy.

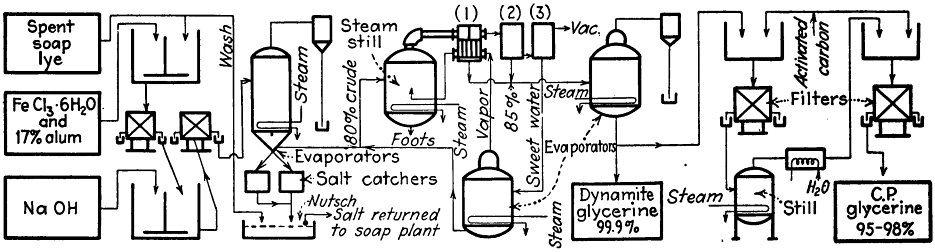

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Figure 3. Flow Sheet for Glycerol Manufacture

To produce 1 ton of glycerol and 2.2 tons of salt

Spent lye (glycerol, 5%)	22 tons	Direct labor	4 man-hr.
Sodium hydroxide	200 pounds	Activated carbon	5–10 pounds
Aluminum sulfate	22 pounds	Steam still condensers 1, 2, and 3 are, respectively, a vapor superheater, an air or warm-water partial condenser for 85% glycerol, and a cold-water final condenser for sweet water.	
Ferric chloride	110 pounds		
Steam	8000 pounds		
Electricity	10 kw.-hr.		

Where no chemical change is involved, the unit conversion factor is the measure of the average realized extraction or crystallization or other physical change. This is illustrated by Figure 4 wherein a salable product is extracted out of a mixture. This may be done by solvents, by crystallization, or by distillation. Figure 4 typifies this type of extractive procedure as applied in sugar refining. The principal unit consumption factor is greater than unity, or 1.06 pounds of raw sugar to furnish one pound of refined sugar. Many other flow sheets with the data for the unit consumption factors, are available in the references described.

Evaluation

Unit consumption factors enable the caustic soda manufacturer to determine how much caustic soda is going to be needed for a million or a billion pounds of soap of the quality and type for which the unit consumption factors are available. The composition of soaps vary greatly according to their use and market areas, and as these and the quality change, the unit consumption factors must change. This illustrates how a technical understanding is required for the evaluation of unit consumption factors.

Another example is the determination of sulfur needed for sulfuric acid on the basis of the equivalent of 1 ton of 100% sulfuric acid. The consumption figure for sulfur will vary from 677 pounds to make 93% sulfuric acid to 688 pounds to furnish 20% oleum. Plants for chamber acid, concentrated acid, or oleum vary greatly in the costs and slightly so for the yields, and hence for the unit consumption factors. The Government in their statistical reports reduces the various strengths of sulfuric acid to 50° Bé. acid (62.18%) in order to have the same yardstick for statistical reports. In marketing surveys, an investigation should be made between different grades of a chemical because their costs vary.

Many chemicals, other than the sulfuric acid, are sold in different purities and forms. Solid chemicals like soda ash and sodium sulfate may be anhydrous or crystalline; and even the number of molecules of crystal water may vary as illustrated by sodium carbonate monohydrate ($Na_2CO_3.H_2O$) and decahydrate or sal soda ($Na_2CO_3.10H_2O$). Other chemicals are sold in solutions of different strengths as sodium silicate (water glass) or even with different ratios of constituents (Na_2O to SiO_2). Because of great variations in the active constituents: nitrogen (N_2), potash (K_2O), and phosphoric acid anhydride (P_2O_5), fertilizers are commonly evaluated by the percentages of these constituents in the single, more or less pure, salt; or by the percentages of the three in a mixed fertilizer (e. g., $N_2:P_2O_5:K_2O = 10:6:4$). Here and elsewhere, solutions such as ammonium nitrate solutions or "U.A.L." (urea-ammonia liquors), are articles of commerce. All of the variations in purity or composition effect the unit consumption factors, so the purity or composition of products must be specifically stated.

Preparation

The writer has participated in obtaining and publishing unit consumption factors; it seems worthwhile to record how these have been made available. The procedure was to work up a flow sheet of a selected process and material and energy balances including, when possible, hours of labor and kilowatt hours of electricity used in the process. If the data, from which the flow sheet and unit consumption factor calculations were made, were reliable and based upon wide experience, the result was satisfactory.

If the data for material, energy, and labor balances were not deemed reliable, improved data were frequently obtained by sending tentative figures to be checked to certain individual factories whose cost and production figures embodied the data needed. As some requested data was considered confidential, some companies rightly did not consider it good business to release such figures. This confidential aspect largely pertains to new processes, and as the competitive picture widens and more plants use the same process, the figures become more readily available.

Sources

References from which unit consumption factors can be obtained are listed. The books that are most usable are those in which the unit consumption factors are given with a flow sheet, since these factors cannot be used properly without a knowledge of the technical procedures concerned. Earlier flow sheets published several decades ago did not, as a rule, contain data for the calculation of the factors of material, energy, or labor. In recent years there have appeared a number of books and publications containing annotated and enlarged flow sheets. It seems to the writer that the most useful way of presenting these data are as tabulations underneath the technical flow sheets as shown in Figures 1, 2, 3 and 4. The books by Shreve (*15*), Olive and Shreve (*11*), Lee (*8*), Perry (*12*), and Faith, Keyes, and Clark (*2*) have the quantitative data arranged in the most convenient manner. In certain books these quantitative data are included in the text descriptive of the accompanying flow sheet.

The "Chemical Process Industries" by Shreve (*15*) contains many flow sheets with quantitative data. That book was published in 1945 and a revision is underway. There is now being written, for 1953 publication, the "Chemical Business Handbook" (*12*) in which one of the co-editors, J. R. Skeen, has very carefully recalculated and arranged in tabular form all the available unit consumption factors that he can find. For many years *Chemical and Metallurgical Engineering*, now called *Chemical Engineering*, has published separately a book of flow sheets. The last edition was revised by Olive and Shreve (*11*). Nine-tenths of these flow sheets with comments are in "Chemical Process Industries" (*15*).

"Industrial Chemicals" by Faith, Keyes and Clark (*2*) is extremely valuable for its flow sheets with quantities, but no further references to the literature are given. Currently there is being published under the editorship of Kirk and Othmer (*7*) the "Encyclopedia of Chemical Technology." This very excellent encyclopedia has numerous flow sheets, and occasionally these flow sheets or the adjacent text contain the data necessary to calculate unit consumption factors. It will be very helpful to have this encyclo-

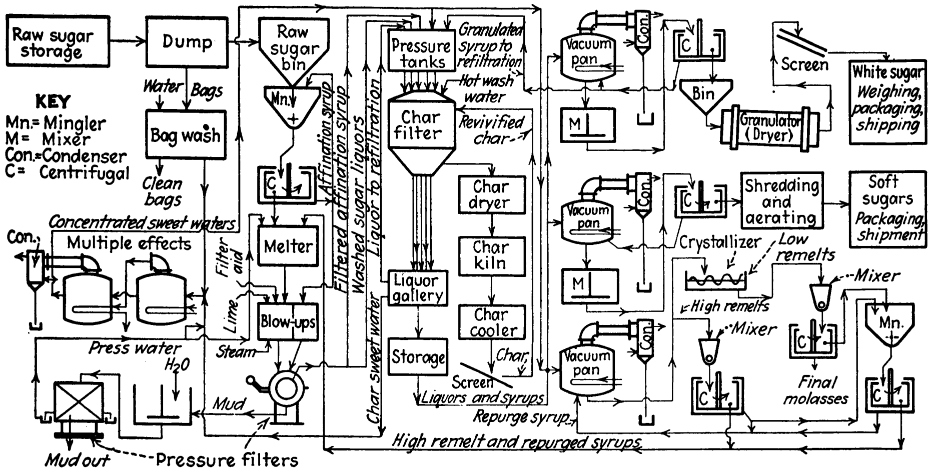

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Figure 4. Flow Sheet for Refined Cane Sugar

Per 100 pounds of refined sugar (about 4 pounds of residual sirup also produced)

Raw sugar (97 Pol.)	106	pounds	Condensing water	2000–3500	pounds
Hydrated lime	0.05	pounds	Pure water	600	pounds
Kieselguhr	0.25	pounds	Process steam and power steam	175	pounds
Bone char (in process)	150–250	pounds	Char kiln fuel	20,000–25,000	B.t.u.
Bone char (revivified)	35–75	pounds	Employees (total)	0.3	man-hr.
Bone char (new)	0.25–0.3	pounds			

pedia in English to supplement Ullmann's "Enzyklopaedie der technischen Chemie" (*17*). It is surprising how much data the Germans have been able to obtain. A third edition of Ullmann is to appear very shortly.

Groggins and his coauthors in the fourth edition of "Unit Processes in Organic Synthesis" (*4*) have brought together many flow sheets, with quantities. This is also true of "Industrial Chemistry" by Riegel (*14*) and "Chemical Engineers' Handbook" by Perry (*12*). In the electrochemical field Mantell (*9*) in his third edition of "Industrial Electrochemistry" has a large amount of data, both in tabular form and in flow sheets. Nelson (*10*) in the third edition of "Petroleum Refinery Engineering" has many flow sheets and much material data for the petroleum industry. Furnas (*3*) in the sixth edition of "Rogers' Manual of Industrial Chemistry" was able to include many flow sheets and an occasional compilation of data. "Chemical Engineering Plant Design" in the third edition by Vilbrandt (*16*) uses a flow sheet for making hexachlorobenzene to illustrate in great detail various principles of plant design. It is doubtful whether any process is described as quantitatively as this one. This book also has a few other flow sheets with some quantitative data. The first volume of the series on "Chemical Process Principles" by Hougen and Watson (*5*) includes an excellent description of the data and calculations necessary for the determination of energy and material balances on which unit conversion factors are based. Certain of our chemical journals have been extraordinarily valuable in recent years in supplying flow sheets and quantities for material and energy balances. This has been particularly true of the monthly pictured flow sheets in *Chemical Engineering* (*1*) and in the Staff Industry Reports appearing monthly in *Industrial and Engineering Chemistry* (*6*).

With technical development, the unit consumption factors change, both for materials and energy and labor—in most cases decreasing with the advances in technology. For this reason, any published unit consumption factors should be checked from time to time.

Applications

A rather interesting use of unit consumption factors was related to the writer by Albert B. Newman. Immediately following World War II, Professor Newman was technical advisor to the American occupation group in Germany. One of the important planning jobs was to determine just how much sulfuric acid, caustic soda, and nitric acid or other chemical would be needed to supply the peace time demands of the German nation for fertilizers, soap, insecticides, medicines, dyes, and all the other products required for making explosives or other war chemicals. Professor Newman told the writer that without the data that were available in the American literature on unit consumption factors it would have been impossible for him to have checked the tonnages of the various chemical raw materials that the Germans said they needed in order to make the finished materials which everyone acknowledged they must have to carry on their technical civilization.

The applications of unit consumption factors are varied. A tabulation of these figures serves to check production and yields in any process, whether batch or continuous. Indeed in many plants the quantities of materials consumed to produce a given quantity of a finished chemical, are charted from day to day, from week to week, and from year to year. If these charts for materials are extended to include energy, labor, and other factors entering into the cost of a product, there is presented the best series of comparisons for cost control of manufacturing operations. A further comparison of such figures for the different procedures for making the chemical will indicate the relative position in the economic picture of different processes and point out the cheapest one. This may lead to the abandonment of a high cost process.

The use of unit consumption factors in sales and marketing development is just as important as in production. This may be looked at from two viewpoints—i.e., markets for new products and markets for old products. In the consideration of the advisability of undertaking the manufacture of any product, the unit consumption factors will enable a prospective manufacturer to determine how much raw material he is going to consume and, therefore, he will be able to investigate properly the avenues for obtaining that raw material. Also, the unit consumption factors will enable a prospective supplier of this raw material to ascertain the quantities that will be consumed in a given area if he can obtain the tonnages of the sales. Turning to new products the unit consumption factors will permit exact calculations to be made for raw materials for specified areas and facilitate proper planning for managements' decision regarding the risk involved in introducing new products. Certainly such calculations should precede the expenditure of any considerable amount of money in research and development and should be continued as the process reaches the pilot plant and before any large sum is spent for plant and equipment. Finally the unit consumption factors can be employed from year to year to check and to compare sales, both from the consumption and the production viewpoints for a given area.

In summary unit consumption factors have been used to carry out the following functions:

Reduce the costs in manufacturing processes.
Eliminate obsolete processing.
Stimulate research for new and better processes.
Enable management to make wiser decisions regarding both processing and marketing.
Point out quantitatively declining markets in given areas.
Point out quantitatively advancing markets in a given area.
Enable markets for new products to be studied more quantitatively.
Guide research and development in a profitable direction by studying markets quantitatively at the time research and development is being carried on.
Enable sales to be predicted more certainly for those products for which these factors are available.

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Sources of Chemical End-Use Data

RICHARD F. WARREN

Market Research Section, New Product Development Department, American Cyanamid Co., New York, N. Y.

Quantitative data on the end uses of about 200 chemicals have been published in recent years. Discussions have varied from single sentences to full scale reports. This discussion shows where published data has appeared in the past and where it is likely to be found in the future.

In the past few years, uses for almost 200 chemicals have been discussed in the various standard publications. These discussions have ranged from small paragraphs to full scale reports. In general, data on uses of a specific chemical are not as widely discussed on a quantitative basis as are production data of individual products. Before World War II, very little information on quantities of major chemicals consumed in various markets was available in published form.

To set up its allocation program during the last war, the U. S. Government collected a great deal of information on the chemical requirements of various industries. At the end of the war a sizable amount of this material was published. Unfortunately, this snapshot of industry's chemical requirements was sometimes distorted by the war. However, it did a great deal to stimulate publication of chemical consumption data.

Then too, the chemical market researcher was coming into his own at the war's end— and several magazines in the chemical process industries responded to the requests for more detailed statistics flowing into their offices. They published articles that gave data on the commercial interrelationship of chemicals and their ultimate markets.

Publications

For many years the Bureau of Mines has published very detailed statistics on nonmetallic minerals (*7*, *8*), but it relied in part on data published in *Chemical and Engineering News*, *Industrial and Engineering Chemistry*, *Chemical Engineering*, and *Chemical Week's* parent, *Chemical Industries*, as well as a number of papers appearing in publications on related process industries.

Harry Stenerson's "Markets" page in *Chemical and Engineering News* became a spot to watch for odd numbers that might help fill in missing information which could complete an end-use pattern.

Chemical & Metallurgical Engineering has done its part in developing data on chemical uses. Their pioneer work, in 1937 and 1939, was the result of Henry Batter's following, for many years, the status of chemicals and their markets. Data were published in "Chemical Facts & Figures" issues, which were followed by an annual statistical review in *Chemical Engineering*, published every February.

In 1948 John Skeen contributed a number of statistical reviews of individual commodities to *Chemical and Engineering News*. These reviews gave a complete supply-demand-price story of the chemical for several years and included considerable information that had not been published previously.

About the same time *Chemical Engineering* began its "Commodity Survey" series that covered 36 chemicals. This series was designed to show for a single chemical,

Table I. Sources of Statistics on Consumption of Chemicals[a]

Chemical	Publication	Date	Page
Acetic anhydride	*Chem. Met. Eng.*	8-49	303
	Chem. Eng. News	9-26-49	2806
	Food Eng.	4-51	130
Acetic acid	*Chem. Eng.*	2-48	312
	Chem. Inds.	8-48	217
Acetone	*Chem. Met. Eng.*	7-48	313
	FI-6-8-13	5-29-46	
Acetylene	*Chem. Eng. News*	4-4-49	977
	Chem. Eng. News	12-4-50	4247
	Chem. Inds.	4-28-51	17
	Oil Gas J.	5-17-51	122
Acrylonitrile	*Chem. Met. Eng.*	3-50	114
	Chem. Inds.	3-50	345
Aldrin	*Agr. Chemicals*	9-50	7
	Oil, Paint, Drug Reptr.	2-19-51	11
Aluminum chloride	JC	2-24-49	13
Aluminum sulfate	*Oil, Paint, Drug Reptr.*	2-21-49	38
	Tappi	12-49	26 and 27A
	Agr. Chemicals	2-50	26
Ammonia	JC	8-9-48	13
	Chem. Eng. News	11-15-48	3410
	Agr. Chemicals	6-49	39
	JC	12-12-49	2 and 18
	Hearings-1949 Fert. Sup.		
	Ind. Eng. Chem.	6-50	989
Ammonium nitrate	*Agr. Chemicals*	6-49	39
	Agr. Chemicals	9-49	32
	Hearings—1949 Fert. Sup.		
	Agr. Chemicals	2-50	26
	Agr. Chemicals	6-50	36
Ammonium phosphate	*Agr. Chemicals*	6-49	39
Ammonium phosphate (di-)	Hearings—1949 Fert. Sup.		
Ammonium sulfate	JC	12-21-48	13
	Agr. Chemicals	6-49	39
	Chem. Met. Eng.	11-49	268
	Hearings—1949 Fert. Sup.		
	Agr. Chemicals	2-50	26
	Min. Yrbk., Coke & Coal Chemicals		
	Agr. Chemicals	6-50	36
	Chem. Eng.	9-49	268
Aniline	*Chem. Eng. News*	12-27-48	3827
	Chem. Inds.	4-14-51	39
Anisic aldehyde	*Drug & Cosmetic Ind.*	1-50	91
Antimony	*Oil, Paint, Drug Reptr.*	12-4-50	45
	Min. Yrbk., Antimony		
Arsenic	Min. Yrbk., Arsenic		
Barium salts (carbonate, chloride, etc.)	Min. Yrbk., Barite		
Bauxite	Min. Yrbk., Bauxite		
Benzene	*Chem. Met. Eng.*	2-49	119
	Chem. Eng. News	10-24-49	3154
	JC	11-30-49	1
	Chem. Met. Eng.	2-50	100
	Chem. Inds.	3-50	348
	Chem. Eng. News	11-6-50	3866
	Chemist	7-51	298
	Can. Chem. Process Inds.	7-51	573
	Chem. Eng. News	3-26-51	1260
	Chem. Eng.	1-50	271

Table I. *(continued)*

Chemical	Publication	Date	Page
Benzene hexachloride	*Agr. Chemicals*	10-48	22
	Ind. Rept.	10-49	19
	Oil, Paint, Drug Reptr.	2-26-51	3
	Chem. Inds.	3-24-51	24
Beryllium	Min. Yrbk., Minor Metals		
Borax	*Agr. Chemicals*	6-49	39
	Chem. Met. Eng.	2-50	269
Boron minerals	MMS 1983		
Bromine	MMS 1791		
	Min. Yrbk., Salines-Misc.		
Butane	Min. Yrbk., Natural Gasoline		
2,3-Butanedione	IRB	7-24-50	11
Butylene	*Oil Gas J.*	7-6-50	54
	Chem. Eng.	8-50	117
Cadmium oxide	Min. Yrbk., Cadmium		
Calcium arsenate	Ind. Rept.	10-49	19
Calcium carbide	*Chem. Eng. News*	7-18-49	2062
	Chem. Inds.	7-49	30
Calcium carbonate	*Oil, Paint, Drug Reptr.*	2-21-49	38
	Chem. Met. Eng.	7-50	104
Calcium chloride	MMS 1793		
Calcium cyanamide	*Agr. Chemicals*	6-49	39
	Agr. Chemicals	6-50	36
Calcium hydroxide (lime)	*Oil, Paint, Drug Reptr.*	2-21-49	38
	Rubber Age (N.Y.)	9-49	714
	Oil, Paint, Drug Reptr.	10-24-49	38
	MMS 1796		
	Min. Yrbk., Lime		
Calcium hypochlorite	Ind. Rept.	7-49	50
Calcium magnesium phosphate	*Agr. Chemicals*	6-49	39
Calcium nitrate	*Agr. Chemicals*	6-49	39
Calcium phosphate (phosphate rock)	Min. Yrbk., Phosphate Rock		
Calcium metaphosphate	*Agr. Chemicals*	6-49	39
Tricalcium phosphate	*Agr. Chemicals*	6-49	39
Calcium sulfate (gypsum)	*Tappi*	12-49	24A
	JC	9-20-50	11
	Min. Yrbk., Gypsum		
Camphor	STI 3		105
Carbon (graphite)	*Chem. Inds.*	10-48	609
	Min. Yrbk., Minor Non-Metals		
Carbon bisulfide	*Chem. Week*	8-4-51	36
	Chem. Met. Eng.	1-49	317
Carbon black	*Oil, Paint, Drug Reptr.*	7-25-49	66
	Rubber Age (N.Y.)	8-49	556
	Rubber Age (N.Y.)	9-49	714
	MMS 1754 and 1971		
	India Rubber World	4-51	66
	Min. Yrbk., Carbon Black		
	Rubber Age (N. Y.)	6-51	346
Carbon tetrachloride	*Soap, Sanit. Chemicals*	4-49	45
	Chem. Eng.	5-50	361

Table I. *(continued)*

Chemical	Publication	Date	Page
Casein	*Chem. Eng. News*	9-12-49	2650
Cellulose acetate	*Modern Plastics*	1-49	
	Ind. Rept.	2-49	27
Chlordane	*Oil, Paint, Drug Reptr.*	2-26-51	3
	Chem. Inds.	3-24-51	24
Chlorine	*Chem. Inds.*	12-48	938
	Oil, Paint, Drug Reptr.	2-21-49	38
	Chem. Met. Eng.	2-49	115
	Chem. Met. Eng.	7-49	315
	Ind. Eng. Chem.	10-49	2155
	Tappi	1-50	38A
	Ind. Eng. Chem.	6-50	989
Chlorobenzene	*Chem. Met. Eng.*	1-50	272
Chromic acid	*Chem. Inds.*	12-50	877
Citric acid	HR 309		7066
Columbium	Min. Yrbk., Minor Metals		
Copper	Min. Yrbk., Copper		
	MMS 1985		
Copper acetate	STI		230
Copper naphthenate	*Chem. Inds.*	2-49	219
Copper sulfate	*Agr. Chemicals*	7-48	
	STI		226
	Agr. Chemicals	6-49	
	Ind. Rept.	10-49	19
	Oil, Paint, Drug Reptr.	4-16-51	3
	Chem. Week	6-23-51	43
Cresylic acid	*Oil, Paint, Drug Reptr.*	9-6-48	50
	Chem. Eng. News	1-30-50	316
Cryolite	*Agr. Chemicals*	10-48	22
	Min. Yrbk., Fluorspar		
Cupric acetoarsenite	*Agr. Chemicals*	10-48	22
Cupric chromate	*Chem. Inds.*	2-49	219
Cuprous oxide	STI		75
DDT	*Oil, Paint, Drug Reptr*	2-26-51	3
	Chem. Inds.	3-24-51	24
	Ind. Rept.	10-49	19
Diacetyl	*Oil, Paint, Drug Reptr.*	3-6-50	70
2,4-D	*Agr. Chemicals*	9-49	40 & 82
	Ind. Rept.	10-49	19
Ethanolamines	*Chem. Inds.*	4-12-51	36
Ethyl alcohol	ATU, Year End Statistics		
	Chem. Eng.	10-49	314
Ethyl cellulose	*Chem. Eng.*	3-51	279
Ethylene	*Chem. Met. Eng.*	8-50	116
	ATU, Year End Statistics		
Ethylene glycol	*Chem. Inds.*	3-48	381
	JC	10-6-48	8
	JC	4-12-49	19
	Chem. Met. Eng	5-49	357
	Chem. Inds.	7-50	41
	Chem. Eng. News	2-19-51	712
	Chem. Inds.	2-24-51	16
Ethylenediamine	*Chem. Eng. News*	3-14-49	748

Table I. *(continued)*

Chemical	Publication	Date	Page
Ethylene oxide	*Chem. Met. Eng.*	7-50	331
	Chem. Inds.	7-50	41
Ethylene sulfate	ATU, Year End Statistics		
Feldspar	Min. Yrbk., Feldspar		
Ferric sulfate	Agr. Chemicals	6-49	39
Fluorspar	MMS 1716		
Formaldehyde	*Modern Plastics*	9-49	176
	Chemical Industries	2-10-51	11
	Modern Plastics	3-51	bulletin
	Chem. Met. Eng.	8-50	249
	Modern Plastics	7-51	88
Furfural	*Chem. Eng. Progr.*	9-48	669
	Chem.	10-17-49	20
Gelatin	FI M19M.1a		
Geraniol	STI 4		153
Glycerin		9-20-48	2771
	FI M17-7-07		
	FI M17-1-08,09		
	Ind. Rept.	4-49	12
	STI 3		51
	Chem. Eng. News	9-11-50	3168
	DNR	2-1-51	28
Graphite. *See* Carbon.			
Gypsum. *See* Calcium sulfate.			
Hexamethylene tetramine			
	STI 3		20
Hydrochloric acid	*Chem. Met. Eng.*	8-49	299
	Ind. Eng. Chem.	3-50	22A
	Chem. Inds.	3-17-51	7
	Ind. Eng. Chem.	6-50	989
Hydrofluoric acid	MMS 1596		
	Chem. Met. Eng.	12-48	313
Hydrofluoric acid	*Chem. Inds.*	1-49	53
	Fluorine		30
	MMS 1716		
Hydrogen	Ind. Rept.	8-48	7
Hydrogen cyanide	*Chem. Inds.*	5-12-51	41
Hydrogen peroxide	*Chem. Eng. News*	7-25-49	2174
Hydrogen sulfide	*Chem. Met. Eng.*	2-50	97
Iodine	STI 3		60
	Ind. Eng. Chem.	8-49	1547
	Min. Yrbk., Salines-Misc.		
Iron ore	Min. Yrbk., Iron Ore		
Iron oxide	STI		56
Isobutylene	*Chem. Met. Eng.*	8-50	116
	Ind. Eng. Chem.	9-49	1872
Lactic acid	*Chem. Eng. News*	10-3-49	2870
Lauryl alcohol	JC	2-11-49	9
Lead	MMS 1900		
	Min. Yrbk., Lead		
Lead acetate	STI 3		69

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Table I. *(continued)*

Chemical	Publication	Date	Page
Lead arsenate	JC	2-10-49	9
	STI 3		72
	Ind. Rept.	10-49	19
Lead oxide (white & red lead)	*Am. Paint J.*	7-2-51	39
	Min. Yrbk., Lead and Zinc Pigments		
	Rubber Age (N.Y.)	9-49	714
	MMS 1956, 1979		
Lead sulfate	*Rubber Age (N.Y.)*	9-49	714
	MMS 1979		
Lime. *See* Calcium hydroxide.			
Litharge	Min. Yrbk., Lead and Zinc Pigments		
	MMS 1609, 1834, 1956, 1979		
Lithopone	Min. Yrbk., Barite		
	Min. Yrbk., Lead and Zinc Pigments		
	MMS 1956, 1979		
	Am. Paint J.	7-2-51	39
Magnesium carbonate	Min. Yrbk., Magnesium Compounds		
Magnesium compounds	Min. Yrbk., Magnesium Compounds		
Magnesium oxide	Min. Yrbk., Magnesium Compounds		
	MMS 1792		
Magnesium silicate	*Rubber Age (N.Y.)*	9-49	714
Magnesium sulfate	Min. Yrbk., Magnesium Compounds		
	Agr. Chemicals	6-49	39
	Min. Yrbk., Gypsum		
Maleic anhydride	*Chem. Eng. News*	12-13-48	3684
Manganese	Min. Yrbk., Manganese		
	Manganese Rept. #51	9-48	
Manganese sulfate	*Agr. Chemicals*	6-49	39
Melamine	*Chem. Ind.*	2-10-51	12
Menthol	JC	4-8-49	14
Mercury	Min. Yrbk., Mercury		
	MMS 1820, 1975		
Methanol	*Chem. Eng.*	6-51	285
	Chem. Eng. News	10-11-48	3024
	Modern Plastics	3-51	bulletin
Methyl ethyl ketone	*Chem. Eng.*	12-50	286
Naphthalene	*Chem. Eng. News*	8-30-48	2555
	Chem. Eng. News	9-27-48	2894
	Soap, Sanit. Chemicals	5-49	133
	Am. Paint J.	7-9-51	76
Nickel oxide	Min. Yrbk., Nickel		
Nitric acid	*Chem. Met. Eng.*	3-49	351
	Ind. Eng. Chem.	6-50	989
Olefins	*Oil Gas J.*	7-6-50	54
Oleic acid	*Soap, Sanit. Chemicals*	8-48	45
	FI M17-7-07		
	FI M17-1-08,09		
Oxygen	*Chem. Met. Eng.*	8-48	113
Pentaerythrito	*Chem. Eng. News*	2-19-51	712
	Chem. Inds.	2-24-51	16
Petroleum waxes	*Chem. Trade J.*	3-9-51	581

Table I. *(continued)*

Chemical	Publication	Date	Page
Phenol	*Modern Plastics*	5-51	bulletin
	Rubber Age (N.Y.)	6-51	335
	Modern Plastics	7-51	bulletin
	Modern Plastics	8-51	bulletin
Pyrethrum	*Soap, Sanit. Chemicals*	10-50	127
Radium	Min. Yrbk., Uranium, Radium and Thorium		
Resorcinol	*Chem. Eng.*	6-51	71
Rosin	Naval Stores Rept., Annual		
	Tappi	1-50	14A
	Review and Outlook, Naval Stores	4-51	
Rotenone	Ind. Rept.	10-49	19
Selenium	Min. Yrbk., Minor Metals		
Silicone carbide	Min. Yrbk., Abrasive Materials		
Sodium	Min. Yrbk.		
Sodium aluminate	Wood, Water, Work—*Paper Trade J.*		
Sodium antimonate	Min. Yrbk., Antimony		
Sodium benzoate	FOS 132		
Sodium carbonate	*Chem. Met. Eng.*	2-49	114
	Min. Yrbk., Salines-Misc.		
	MMS 1795		
	Wood, Water, Work—*Paper Trade J.*		
	Chem. Eng.	3-51	275
	Ind. Eng. Chem.	6-50	989
	Chem. Eng.	11-50	325
Sodium chloride	FOS 132	7-49	
	MMS 1848, 1739		
Sodium fluorosilicate	*Chem. Eng. News*	8-22-49	2420
Sodium hydroxide	*Chem. Met. Eng.*	2-48	115
	Chem. Met. Eng.	1-50	267
	Wood, Water, Work—*Paper Trade J.*		
	Ind. Eng. Chem.	6-50	989
	Chem. Eng.	1-51	
Sodium nitrate	*Agr. Chemicals*	6-49	39
	Hearings—1949 Fert. Sup.		40
	Agr. Chemicals	6-50	36
Sodium phosphate, (di)	STI		149
Sodium phosphate, (tri)	*Soap, Sanit. Chemicals*	11-48	46
	STI		149
Sodium sulfate (salt cake)	STI		156
	MMS 1795		
	Wood, Water, Work—*Paper Trade J.*		
	Min. Yrbk., Salines, Misc.		
	Ind. Eng. Chem.	6-50	989
Sodium sulpho acetate	HR 309		7067
Sorbitol	*Chem. Eng. News*	2-19-51	712
	Chem. Inds.	2-24-51	16
Stearic acid	FI M17-7-07		
	FI M17-1-08,09		
Streptomycin	Ind. Rept.	11-48	39
Styrene	*Chem. Eng.*	6-50	327
	Chem. Eng. News	4-16-51	1549
	Modern Plastics	10-51	bulletin
Sulfanilamide	*Drug & Cosmetic Ind.*	3-49	285

Table I. *(continued)*

Chemical	Publication	Date	Page
Sulfur	*Agr. Chemicals*	6-49	39 Agr C,7-51
	Chem. Week	6-23-51	13 p. 63 India
	Rubber Age (N.Y.)	9-49	714 Rub. Wld, 7-51 p. 458
	Wood, Water, Work—*Paper Trade J.*		
	Chem. Eng. News	5-28-51	2162
	Agr. Chemicals	2-50	26
	Min Yrbk., Sulfur and Pyrites		
	Tappi	7-51	70A
	Chem. Eng. News	4-2-51	1310 & 1360
	Com. Fertilizer	3-51	20
	Chem. Eng.	4-51	267
	Can. Chem. Process Inds.	6-51	496
Sulfuric acid	*Chem. Met. Eng.*	2-49	112
	Chem. Met. Eng.	2-50	97
	Chem. Eng. News	4-2-51	1312
	Std & Poor's	5–52	
	Ind. Eng. Chem.	6-50	989
	Min. Yrbk., Sulfur and Pyrites		
	Chem. Eng.	4-50	337
Superphosphate	FI M19D-19		
	NFA Serv. Letter #40	2-10-50	
	NFA Serv. Letter #32	2–19-51	
Tall oil	FI M17-7-07		
	FI M17-1-08,09		
Tantalum	Min. Yrbk., Minor Metals		
Tellurium	Min. Yrbk., Minor Metals		
Tetrachloroethane	*Chem. Met. Eng.*	7-49	315
Tetraethyllead	MMS 1805		
	Mo Lead Rept #24		
Thorium	Min. Yrbk., Uranium, Radium, and Thorium		
Tin	*Paint, Oil, Chem. Rev.*	2-15-51	18
	Min. Yrbk., Tin		
Titanium dioxide	Wood, Water, Work—*Paper Trade J.*		
	Am. Paint J.	7–2–51	39
	Chem. Eng.	3–48	322
Toxaphene	*Chem. Week*	6-16-51	13
	Oil, Paint, Drug Reptr.	2-26-51	3
Tricresyl phosphate	*Modern Plastics*	4-49	101
	FI-6-8-25		
Turpentine	Naval Stores Rept., Annual Review and Outlook, Naval Stores	4-51	
Uranium	Min. Yrbk., Uranium, Thorium and Radium		
Urea	*Agr. Chemicals*	6-49	39
	Modern Plastics	7-51	88
	Chem. Eng.	3-51	111
	Chem. Eng.	8-51	274
Xylene	FI-6-8-12		
Zinc	Min. Yrbk., Zinc		
Zinc chloride	*Chem. Inds.*	2-49	219
	MMS 1956, 1979		
Zinc oxide	MMS 1609, 1736, 1834, 1956, 1979		
	Rubber Age (N.Y.)	9-49	714
	Min. Yrbk., Lead and Zinc Pigments		
	Am. Paint J.	7-2-51	39

Table I. *(continued)*

Chemical	Publication	Date	Page
Zinc sulfate	MMS 1609, 1736, 1956, 1979		
	Agr. Chemicals	6-49	39
	Min. Yrbk., Lead and Zinc Pigments		
Zinc sulfide	*Tappi*	12-49	24A
Zirconium	Min. Yrbk., Minor Metals		
Zirconium silicate	*Chem. Inds.*	11-49	728

[a] Authorized abbreviations from the *Chemical Abstracts* "List of Periodicals" have been used. A key to other abbreviations follows.

Ann. Pet. St.	Annual Petroleum Statement, Bureau of Mines
ATU	Alcohol Tax Unit, Treasury Dept., Bureau of Internal Revenue
Chem.	*The Chementator*
Crops	Better Crops with Plant Food, American Potash Institute
DNR	*Daily News Record*
FI 6-8	Facts for Industry, Wartime End Uses, Dept. of Commerce
FI M14A	Facts for Industry, Pulp and Paper Board, Dept. of Commerce
FI M17-1	Facts for Industry, Fats & Oils, Dept. of Commerce
FI M17-7	Facts for Industry, Fats & Oils, Dept. of Commerce
FI M19D	Facts for Industry, Superphosphate, Dept. of Commerce
FI M19M.1a	Facts for Industry, Gelatin, Dept. of Commerce
Fluorine	Fluorspar and Fluorine Chemicals-Report of Investigations #141, Illinois State Geological Survey, Urbana, Ill.
FOS	Fats and Oils Situation, Dept. of Agriculture
Hearings—1949 Fert. Sup.	Hearings before subcommittee of the Committee of Agriculture—House of Representatives, 81st Congress, "1949 Fertilizer Supplies."
HR 309	House Joint Resolutions 309 & 331, Hearings to permit use of oleomargarine by armed forces
Ind. Operations Bur.	Industry Operations Bureau, Dept. of Commerce, Rubber Statistics
Ind. Rept.	*Chemicals & Drugs—Industry Reports*, Dept. of Commerce
IRB	Internal Revenue Bulletin, Treasury Dept.
JC	*Journal of Commerce*
Manganese Rept. #51	Manganese in 2nd quarter of 1948, Bureau of Mines
Min. Yr. Bk.	"Minerals Yearbook," Bureau of Mines
MMS	*Mineral Market Surveys*, Bureau of Mines
Nat'l Rub. News	Natural Rubber News, Natural Rubber Bureau
Naval Stores Rept.	Naval Stores Report, Dept. of Agriculture
NFA Serv. Letter	National Fertilizer Association Service Letter
Oilways	Oilways, Esso Standard Oil Co.
Review & Outlook, Naval Stores	Review and Outlook, Naval Stores, Dept. of Agriculture
STI	"Summaries of Tariff Information," Dept. of Commerce
Std & Poor's	Standard & Poor's "Basic Industry Survey, Chemical"

"Who makes it? Where is it made? How much is made? How is it made? How much does it cost? Where is it used? John Skeen did a great deal for the advancement of the chemical industry by supplying several articles in this series.

Chemical Industries approached the problem a little differently. It published, at odd intervals, a series of very detailed commercial studies of the more important chemicals.

In the *Industry Reports* series on chemicals and drugs (*9*), the Department of Commerce published a synopsis of information for each of a number of major chemicals and antibiotics.

Many magazine articles also have given information on chemical consumption in the past few years.

However, magazines are not the only sources of information on chemical consumption. A book on sources of chemical market information, by R. M. Lawrence of the Monsanto Chemical Co., has been published (*3*).

The author, in preparing a chapter for the "Chemical Business Handbook," edited by John H. Perry (*4*), examined most of the data published since 1948. It became apparent that data comes from a wide variety of sources. Using F. D. Snell's *Chemical Market Report*, which is published monthly (*1*), it was easy to check the material which was listed as containing consumption data. This was supplemented by the "Minerals Yearbook" (*8*) and "Summaries of Tariff Information" (*10*).

More than 50 different sources—government publications, magazines, and newspapers—were found to contain data on chemical consumption. Of course, some of it was duplicated, but each source supplied some valuable information.

Of all the sources studies, the most valuable single source of consumption data was *Chemical Market Report.* It gives abstracts of articles appearing in other publications in sufficient detail to allow the reader to decide whether or not the original article is worth further investigation.

In addition, "Industrial Chemicals," by Faith, Keys, and Clark, (*2*) contains data on consumption of chemicals by markets for 1948. One-hundred-four chemicals are included. Another valuable source of chemical consumption data is "Chemical Economics Handbook," edited by Raymond Ewell (*6*).

Collecting Data

In collecting data on chemical end uses, there are sources which should be checked regularly. Starting with the daily papers, there is the *New York Times, Wall Street Journal, Journal of Commerce,* and *New York Herald Tribune.*

Chemical data is occasionally found in general weekly magazines, such as *Newsweek, Time,* and *U.S. News and World Report.*

Among business publications chemical use data may be found in *Business Week, Chemical Week, Chemical and Engineering News, Oil & Gas Journal,* and last, but not least, the *Oil, Paint & Drug Reporter.*

Monthly magazines that frequently carry end-use data are *Industrial and Engineering Chemistry, Chemical Engineering, Modern Plastics, Soap and Sanitary Chemicals, Fortune, Tappi, Canadian Chemistry and Process Industries, The Chemist, Chemical Engineering Progress, Rubber Age, Agricultural Chemicals,* and *Rayon Organon.*

Further information on these magazines can be obtained in any library by looking up their listing in *Standard Rate and Data,* which lists all reputable commercial publications (*5*).

Consumption data for chemicals can also be obtained regularly in the various government releases put out by Department of Commerce, Tariff Commission, Bureau of Mines, and Department of Agriculture, as well as the chemical sections of NPA and DPA.

For those interested in actual data, sources of information which contain figures on consumption of individual chemicals are listed in Table I. This list was prepared with the assistance of Dr. Skeen and associates.

Uses

Of course, the primary use of chemical end-use data is in chemical market research. The chemical market researcher has to have a technical background to correlate data that has appeared in the literature or information that he has collected outside of the literature. To the technically trained man, the data on production of carbon bisulfide can be related to the consumption of sulfur in a consuming industry. Similarly, the production rates of viscose rayon can be directly related to the use of carbon bisulfide in the rayon industry.

Therefore, the more specialized form of chemical end-use data—such as conversion factors—can be related to total tonnage of a known chemical to provide total tonnage of another product or use.

Quality of Published Data

Published data on chemical end use are incomplete in many cases. Some major chemicals are still closely controlled by one or two companies, and data on them is not published.

The professional market researcher uses published data as a starting point in any market study. He does not consider it the final answer. As a matter of fact, as an ex-editor let me state that the mere fact that a number finds its way into print does not mean the figure is correct. It is considered reliable at the time of publication, but sometimes even reliable sources can be wrong. There have been cases where one man gave another a guess on the size of a particular market, the second man passed the number on to a third, and eventually it wound up in print. The first man saw it and immediately rejoiced to see how closely he had guessed the true size of that market. These instances are not common, because editors are generally a bit skeptical and check closely on these stray figures. However, slips occur. So use any published figure with the same discretion that you would apply to an unpublished number.

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The Statistics of the Plastics Materials Industry

R. W. CRAWFORD
Monsanto Chemical Co., Springfield, Mass.

The rapid growth of the plastics industry makes it necessary to analyze the statistics of the industry with care. This industry, entitled "Plastics Materials and Elastomers, Except Synthetic Rubber," Standard Industrial Classification Code #2823, includes cellulosic materials excluding protective coatings on a plasticized basis, and synthetic resins including protective coating resins on an unplasticized basis (approximately). Care must be taken to make sure that materials are comparable as to basis, as to type, and as to classification. They may be shown on a wet basis, a dry basis, or a net resin basis. Types of figures are production, sales, shipments and consumption, and shipments and inter-plant transfers. Resins which contain materials from two or more classes must be handled consistently as regards class. The paper describes the figures available for each commodity listed in the Seven Digit Census Code as shown in the "NPA Product Assignment Directory of 1951" and includes a copy of the code.

The statistics of the plastics materials industry must be considered in the light of the characteristics of the industry itself. The industry has grown rapidly. Except for a few materials, figures on individual commodities are available for only a short period. New products are continually appearing. There are a large number of commodities. For example, in the code (Table I) showing the breakdown by class and end use, there are 50 commodities. In the latest Tariff Commission report showing the breakdown by class, by chemical composition, there are over 90 commodities. No one company is an expert in all. Not only are there large numbers of commodities, but the analysis is further complicated by the combinations and mixtures of these commodities. Units are different in the sense that weights of commodities can be classified on wet, dry, or net resin weight. On these conditions there is superimposed the question of what is the definition of the industry and what commodities should be included.

In measuring the output of commodities under these circumstances it is impossible to set up permament categories for all statistical series, over a long period. These series must be dynamic. The proper approach in setting up statistics for this type of industry is to forecast what the industry will be like in 20 years and build gradually, year by year, towards this over-all model.

Under these circumstances, certain problems in the statistics of the plastics material industry are important, and others, which are problems in other fields, are relatively unimportant. Of the important problems, the obvious basic one is: Are the figures for the particular commodity published or are they lumped into a class to prevent disclosure? The most important thing in published data is that the series be comparable over a period of years. To be comparable, the basis must be consistent or it must be possible to convert to obtain consistency. There is the problem of shifting from production to sales. There is the problem of the consistency of the definition of classes of commodities at different times when the particular commodity contains materials from two or more classes. There is the problem that end-use figures may not be available for particular commodities.

The problems of imports and, to a lesser degree, exports are unimportant.

The plastics figures are an excellent example of the continual dilemma that exists in statistics—whether it is more important to have complete coverage or to have the figures consistent over a period of time. In other words, is it more important to have the magnitude 90% right and the figures comparable than it is to have the magnitude 100% right and have the comparability poor or the direction wrong? It is better in some cases to sacrifice a magnitude to maintain comparability.

Definition of the Industry

Industry 2823 entitled "Plastics Materials and Elastomers, except Synthetic Rubber" is in industry group #282, entitled "Industrial Organic Chemicals." This group is a part of major group 28, "Chemicals and Allied Products." It is in part 1, "The Manufacturing Industry Section" of the Standard Industrial Classification Code (*7*).

As the figures are now reported, the industry really includes the plastics materials and resins for elastomers, rather than the elastomers themselves. In the Tariff Commission's annual figures, elastomers, including synthetic rubber, are in a separate schedule. The cellulosic segment of the industry includes cellulosic plastic materials but excludes cellulosics for surface coatings. The entire lacquer industry is excluded as well as the cellulosic flake for the lacquer industry. In the synthetic resin segment, resins for both plastics and protective coatings are included.

The cellulosic materials are on a dry basis which is the same as an "as shipped" basis, which includes the weight of the plasticizer. The synthetic resins segment is on a dry basis except for the large plasticizer-consuming vinyl resin class which is on a "net resin" basis. Generally speaking, the cellulosic segment then includes the weight of plasticizers, although the synthetic resin segment excludes the weight of plasticizers.

In addition to cellulosic and synthetic resins, the present scope of the industry includes vulcanized fiber, casein plastics, and regenerated cellulose. This definition has evolved over a period of years.

All Plastic Materials

The primary sources for data on the plastics industry are cited.

Annual Data. Total plastics industry figures are shown only in the "Census of Manufacturers" (*3*), available as a biennial from 1919 to 1939, and as an annual for 1947. For 1919 to 1939, it shows total production in pounds and production for sale and for consumption in the producing plant in pounds and dollars. In 1947, it shows production in pounds and shipments and interplant transfers in pounds and dollars. The basis for the unit figures given for the earlier years is not certain; these figures are seldom used except for cellulosics, which are obviously on an "as shipped" basis.

The "Annual Survey of Manufacturers, 1949–1950" (*1*), shows the total value of shipments of the industry for these two years. There is no detail by commodity.

The annual Tariff Commission's report has been published since 1919 (*11*). From 1919 to 1942 it shows production in pounds, sales in pounds, and sales in dollars. From 1943 to 1947 it shows production in pounds, and sales and interplant transfers in pounds and dollars. From 1948 to 1950, it shows production in pounds, and sales in pounds and dollars. The figures from 1919 to 1947 are on a net resin basis. The figures from 1948 to 1950 are on a dry basis, with the exception of vinyl resins which are on a net resin basis in the breakdown by chemical composition. Vinyl sheeting and film is also shown on a dry basis in 1949 and 1950, as well as on a net resin basis in the breakdown by classes. The shift in these figures in 1948 from a net resin basis to a dry basis is a serious one in affecting comparability. All figures for thermosetting molding compounds, for example, must be adjusted either entirely onto a net resin basis or onto a dry basis over the complete time span.

A Tariff Commission publication, "Synthetic Resins and Their Raw Materials," was published in 1938 (*12*). It summarizes the annual synthetic resin figures for all years prior to and including 1937.

Monthly Data. From January 1933 through June 1945, the Bureau of Census collected monthly figures on cellulose plastics products and released them in *Cellulose Plastic Products* (*2*). From January 1933 to December 1934, they showed production in pounds and shipments in pounds. From January 1935 to June 1945, they showed production in pounds, shipments in pounds, and consumption in pounds. The data is on a "pounds as shipped" basis; the comparability is good.

The Bureau of Census published monthly data from June 1945 to June 1948, which includes both cellulosic and synthetic resins (*4*). The figures show shipments and consumption in pounds. They are on a dry basis with the exception of vinyls. Vinyl sheeting and film is on a plasticized basis. Vinyls for all other uses are on a net resin basis.

The U. S. Tariff Commission published the monthly plastics figures (*9*) from July 1948 to the present. The figures from July 1948 to December 1948 were maintained comparable to the census figures. In January 1949, the figures for shipments and consumption in pounds were shifted to two sets of figures—production in pounds, and sales in pounds. The production figure is roughly comparable to the shipments and consumption figure except for changes in inventory in the sense that both include the captive market. The figures are shown on a dry basis similar to the census figures except for vinyl resins. Vinyl resin figures remain comparable to the census figures through December 1950. In January 1951, vinyl sheeting and film was changed to a net resin basis.

The biggest change in the Tariff Commission figures was made in January 1949. Prior to that time the figures excluded all protective coatings and were comparable to the census figures. From January 1949 to the present they include all protective coatings with the exception of the cellulosic protective coatings as covered in the definition of the industry.

Imports and Exports. It is desirable to have data on imports and exports colected according to the same commodity breakdown as domestic sales. In this way it is possible to add imports and U. S. sales and subtract exports to obtain domestic U. S. sales figures, but not as much detail is given on imports and exports as on U. S. sales.

Imports and exports are found in the Tariff Commission's "Imports of Coal Tar Products" (*8*), in the Bureau of Census "U. S. Exports in Domestic and Foreign Merchandise" (*5*), and in the summaries of tariff information (*10*).

Imports and exports of cellulosics are sometimes hard to explain. Scrap is reported as well as virgin material. Washed film is shown. It is difficult to isolate exactly the pounds shipped on a basis comparable with the figures on United States production and sales.

In synthetic resins the figures should be scrutinized very carefully. Figures for resins should be on an "as shipped" basis and may include water or solvents. They may include, as well as the resins themselves, exports of monomers for that particular type of resin and exports of finished products made from that particular type of resin. The figures just must be scrutinized carefully.

The difficulty in the figures is not as important in plastics as it might be in other materials because imports and exports are not as important in this field as they are in other fields.

Evaluation of Figures. In general for the entire industry over the last 30 years, the best procedure is to use the cellulose figures from the Bureau of Census and the synthetic resin figures from the Tariff Commission rather than the census total industry figures. The tariff figures available each year have probably more complete coverage and have considerably more detail.

In showing the sales or production for the plastics industry as a whole over a period of years, obviously total plastics will reflect any comparability or lack of comparability in the figures of each individual class of commodity. In looking at total figures, differences pertaining to all plastics materials plus differences in individual commodities must be considered.

Because of the comparability problem, in a number of cases the people in the industry have used the monthly figures in preference to the annual figures in spite of the fact that the annual figures have better coverage. In reporting figures, month after month, the accounting department doing the reporting, does it so frequently that the figures go in on a comparable basis. In reporting annually, the monthly uninterrupted sequence in reporting is not maintained, and the breakdowns required change from year to year, and comparability may be lost.

Commodities Made of Resins Found in Two Classes

With the rapid growth of the plastics industry in the last ten to fifteen years, a problem in the comparability of figures in each class of plastic material has developed. For example, with a plastic material made of a phenolic resin and rosin, the problem is whether to classify this combination as phenolic or as rosin. It is important for each specific class of material that these mixed commodities be considered consistently in one class or in another. In the published figures this particular combination is handled in a number of different ways. How they should be handled is an arbitrary matter; the most important thing is to handle them consistently.

Plastic Materials, Class by Class

The statements made in the section on All Plastic Materials concerning comparability in terms of production, consumption, and sales and in terms of wet, dry, or net resin basis, will not be repeated. However, they apply.

Plastic materials are discussed in the following paragraphs in the same order as they are shown in the latest government code—i.e., the Seven Digit Census Code as shown in the "NPA Product Assignment Directory of 1951" (*6*). A few modifications have been incorporated. The main change has been to add a protective coating end use under each class, and to add three classes—i.e., 250, alkyds; 260, rosin esters and adducts; and 270, coumarone indene and petroleum polymer resins. The modified code is presented in Table I; modifications by Monsanto are so designated.

Evolution of the code will be summarized briefly. In 1947, the Bureau of Census converted the code in the "Standard Industrial Classification Manual" (*7*) to a seven digit code for the "Census of Manufacturers" (*3*) following generally the arrangement of the monthly census publication of plastic figures (*4*). This commodity code for the industry breaks the commodities down by class and by end use. The first four digits of this code (discussed under Definition of the Industry) are identical to the Standard Industrial Classification Industry Code, and the last three digits are commodity digits. The Bureau of Census calls the first commodity digit a class of commodity, and the three commodity digits represent an individual commodity. The Tariff Commission has followed this breakdown roughly in recent years. In Tariff Commission terminology, the first two digits identify class of commodity, and the three-commodity digits identify class of commodity by end use in their second table; in their first table, they have broken down synthetic resins by classes and then by chemical composition rather than by end use. In the Seven Digit Census Code, the first four digits of each commodity represent the industry number, 2823; followed by the three commodity digits. Only the three commodity digits will be used in this discussion.

110 and 120, Cellulose Acetate and Mixed Ester Plastics. Cellulose acetate plastics are totalled in the biennial census data for 1935 and 1937 (*3*), and in other years the total is available merely by adding the components.

111, CELLULOSE ACETATE AND MIXED ESTER PLASTICS: CONTINUOUS SHEETS UNDER .003″. Figures on this classification are available on a monthly basis since June 1945 (*4, 9*). They are also available in the annual census of 1947 (*3*).

113, CELLULOSE ACETATE AND MIXED ESTER PLASTICS: CONTINUOUS SHEETS EQUAL

Table I. Seven-Digit Census as Shown in "NPA Product Assignment Directory of 1951"

(Industry Digits 2823)

100		Cellulose plastic materials (include fillers, plasticizers, and extenders)
110 & 120		Cellulose acetate and mixed ester (include acetate butyrate and propionate plastics)
	111	Continuous sheets (under .003 gauge)
	113	Continuous sheets (.003 gauge and upward)
	119	All other sheets
	121	Rods and tubes
	123	Molding and extrusion materials
	125	Other uses
130		Nitrocellulose
	131	Sheets
	135	Rods and tubes
	139	Other uses
	198	Other cellulose plastics (include methyl and ethyl cellulose and related plastics)
200		Synthetic resins
210		Phenolic and other tar acid resins (include mixtures):
	211	Casting
	213	Laminating
	215	Adhesives
	217	Molding materials (include fillers, plasticizers, and extenders)
	218[a]	Protective coatings
	219	Other uses
220		Urea and melamine resins (including dimethylol urea)
	221	Adhesives
	223	Textile and paper treating resins
	225	Laminating
	227	Molding materials (include fillers, plasticizers, and extenders)
	228[a]	Protective coatings
	229	Other uses
230		Vinyl resins
	231	Safety glass sheeting
	232	Other sheeting and film
	233	Textile and paper coating resins
	234	Adhesives
	235	Molding and extrusion material
	237[a]	Protective coatings
	239	Other uses
240		Styrene resins
	241	Molding materials (include fillers, plasticizers, and coloring material)
	243[a]	Protective coatings
	245	Other uses
250[a]		Alkyd resins
260[a]		Rosin modifications
270[a]		Coumarone indene and petroleum polymer resins
290[a]		Plastics and synthetic resins not listed above (except synthetic rubbers, photographic film, rayon, or nitro-explosives)
	291[a]	Molding materials (include fillers, plasticizers, and extenders)
	295[a]	Protective coatings
	299[a]	Other uses
300		Vulcanized Fiber
	311	Sheets
	351	Rods, tubes, and hollow ware
	398	Other forms (specify kind)
400		Plastic and resin material, not elsewhere classified
410		Casein
	411	Sheets, rods, and tubes
	431	Regenerated cellulose, except rayon

[a] Monsanto Code.

TO OR GREATER THAN .003". On this class figures are available since June 1945 on a monthly basis (*4*, *9*). They are also available in the annual census of 1947 (*3*).

119, 121, 111, AND 113, CELLULOSE ACETATE AND MIXED ESTER PLASTICS: SHEETS, RODS, AND TUBES. Monthly data are available from 1933 to May 1945 (*2*). From February 1941 to the end of the period, cellulose acetate safety glass plastic was excluded. Since that time this total class can be computed by adding together the acetate sheet classifications, rods, and tubes.

119 AND 121, CELLULOSE ACETATE AND MIXED ESTER PLASTICS: ALL OTHER SHEETS, RODS, AND TUBES. Data for this class are available on a monthly basis since June of 1945 (*4*, *9*), and on an annual basis in 1947 (*3*).

110 AND 120, IMPORTS AND EXPORTS, CELLULOSE ACETATE SHEETS, RODS, AND TUBES. Imports for consumption for cellulose acetate are available for 1937, 1938, 1939, 1943, 1946, and 1947 (*10*). Exports are available since 1944 (*5*).

123, CELLULOSE ACETATE AND MIXED ESTER PLASTICS: MOLDING. Annual figures are available for 1939 (*3*). Monthly figures are available from 1938 to the present (*2*, *4*, *9*).

123, CELLULOSE ACETATE AND MIXED ESTER PLASTICS: MOLDING EXPORTS. Export figures are available from 1944 to the present (*5*).

130, Nitrocellulose Total. Biennial figures are available from 1923 to 1939 (*3*). Monthly figures are available from 1935 to 1944 (*2*) and may be computed since then by adding the component segments.

131, NITROCELLULOSE SHEETS. Annual figures are available for 1947 (*3*). Monthly figures are available from 1933 to the present (*2*).

135, NITROCELLULOSE: RODS AND TUBES. Monthly data are available from 1933 to the present (*2*). Annual data are available for 1947 (*3*).

130, NITROCELLULOSE: IMPORTS AND EXPORTS. Imports of cellulose compounds are given from 1937 through 1947 (*10*). They are primarily cellulose nitrate. Exports are available from 1946 through 1951 (*5*).

200, Total Synthetic Resins. In the Tariff Commission annual figures (*11*) the total is broken down by end use in some years. In other years the benzenoid and nonbenzenoid segments are broken down separately. The total of the two would give the breakdown of all synthetic resins by end use. In this breakdown of all resins, protective coatings, molding and casting, and laminating resins are broken out from 1941 through 1947. Adhesives are broken out for 1942 to 1947. Textile paper and leather are broken out for 1943 to 1947. Ion exchange is shown separately in 1946 and 1947.

210, Phenolic and Other Tar Acid Resins. This class includes modifications with vinyls, styrene, coumarone indene, aniline formaldehyde, and polyhydric alcohols. This class excludes modifications with phthalic alkyds, maleic alkyds, and rosin. Phenolic resins in total are shown in the Tariff Commission's annual figures from 1927 on (*11*). In 1927 and 1928, it is assumed that the entire coal tar reported figure is tar acid resins.

The total Phenolic and Other Tar Acid Resins class is broken down by chemical composition. In breaking down tar acid total resins by chemical composition, the Tariff Commission's annual figures from 1937 to 1948 (*11*) originally made the first breakdown phenolic resins other than mixed phenolics, and the second breakdown mixed phenolics. For 1949 and 1950, the breakdown is first by phenolic resins, unmodified, and secondly phenolic resins, modified. During 1948, it is possible to bridge the gap between these two breakdowns because both are given for that particular year. The first breakdown now, however, is between unmodified and modified resins, and each breakdown is followed by a more detailed breakdown by chemical composition.

211, Phenolic and Other Tar Acid Resins: Casting. Phenolic and other tar acid resins for casting are disclosed from 1934 to 1937, and phenol-formaldehyde for casting is disclosed from 1938 to 1941 and for 1943 (*11*).

213, Phenolic and Other Tar Acid Resins: Laminating. Monthly phenolic resins for laminating are disclosed from June 1945 through 1951 on a monthly basis (*4, 9*). In this industry, there is a large captive market. Care must be taken to distinguish between shipments and consumption, 1945 through 1948, and sales, 1949 through 1951. Annual figures are available in 1947 (*3*). Laminating totals are broken down between phenol-formaldehyde and cresol-formaldehyde (cresylic acid–formaldehyde) over the period from 1941 to 1946; phenol- and cresol-aldehydes for laminating are shown from 1941 to 1943 (*11*).

215, Phenolic and Other Tar Acid Resins: Adhesives. Annual figures for phenolic adhesives are disclosed in 1947 (*3*) and in 1949 and 1950 (*11*). Figures for phenol-formaldehyde adhesives are disclosed from 1943 through 1946 and annual resorcinol-formaldehyde adhesives are disclosed in 1945 and 1946 (*11*). Monthly figures on phenolic adhesives are available from June 1945 to the present (*4, 9*).

217, Phenolic and Other Tar Acid Resins: Molding Materials. Annual figures for phenolic molding materials are disclosed in 1947 (*3*) and in 1949 and 1950 (*11*). Phenol-formaldehyde for molding is disclosed from 1938 to 1945; phenol-formaldehyde for molding and casting is disclosed in 1946. Monthly phenolic molding figures are disclosed from June 1945 to December 1950 (*4, 9*). Phenolic resins for molding and casting are disclosed in 1951 (*9*). In this market there are captive producers, and shipments and consumption must be differentiated from sales. It is very important that figures in units on a net resin basis be differentiated from shipments on a dry basis.

218, Phenolic and Other Tar Acid Resins: Protective Coatings. Figures on phenolic protective coating resins are given on an annual basis for 1947 (*3*) and on an annual basis from 1949 through 1951 (*11*). Unmodified phenolic resins are broken out from 1948 to 1950 (*11*).

In the breakdown by chemical composition, phenol-formaldehyde protective coating resins are broken out from 1941 through 1946. Cresol-formaldehyde (cresylic acid–formaldehyde) protective coating resins are broken out for 1941 through 1943. *p-tert*-Amylphenol–formaldehyde is shown separately for 1945 and 1946. Phenol and cresol-aldehyde resins are shown in 1941 and 1952. Mixed phenolic resins are shown for protective coatings in 1945 and 1946 (*11*).

Monthly phenolic and other tar acid resins figures for protective coatings are available in 1949 and 1950. They are classed as 100% types containing less than 10% modifiers. In 1951 the class was changed to protective coating resins modified and unmodified except by rosin (*9*).

210, PHENOLIC AND OTHER TAR ACID RESINS: IMPORTS AND EXPORTS. Imports are quite small and are relatively unimportant. Figures are given for 1939, 1946, and 1947 on imports (*10*). Exports of tar acid resins are available from 1945 through 1951 (*5*).

220, Urea and Melamine Resins. In the urea class, modifications with melamine are excluded. In the melamine class, modifications with urea are included. Annual figures on total urea and melamine resins are shown specifically from 1994 on (*11*). Prior to 1944, figures for melamine are small, and the urea figure is really most of the total.

In annual figures urea-type resins are split out separately for the entire period, 1933 to date, with the exception of 1936 and 1937, where they are not available (*11*). Butyl urea–formaldehyde is shown for 1950; urea-formaldehyde as such is shown separately for 1948 through 1950. A class headed melamine-formaldehyde type is shown from 1948 through 1950. Melamine-formaldehyde, unmodified is shown for 1945 and 1947. Melamine-formaldehyde, modified is shown for 1945. Melamine-formaldehyde type, others, is shown for 1947.

221, UREA AND MELAMINE RESINS: ADHESIVES. Annual tariff figures are available for 1946, 1947, 1949, and 1950 (*11*). Annual census figures are available for 1947 (*3*). Urea-formaldehyde for adhesives is shown separately from 1943 through 1945 (*11*). Because melamine is such a small proportion of the total, the comparability of the figures is not a factor, and either urea or urea and melamine can be used almost equivalently. Monthly urea and melamine figures are given from June 1945 to the present (*4, 9*).

223, UREA AND MELAMINE RESINS: TEXTILE AND PAPER TREATING RESINS. The monthly urea and melamine resins for textile and paper treating are shown from 1946 through 1950 (*4, 9*). In 1951, resin for textile treating is shown separate from paper treating (*9*). Annual figures are shown for 1946, 1947, 1949, and 1950 (*11*). In 1944 urea-formaldehyde alone is shown for textile, paper, and leather treating (*11*).

225, UREA AND MELAMINE RESINS: LAMINATING. Urea-formaldehyde for laminating is disclosed in 1941.

227, UREA AND MELAMINE RESINS: MOLDING MATERIALS. In the annual data urea-formaldehyde for molding and casting is disclosed from 1941 through 1944 (*11*). In the monthly data from 1949 through 1951, molding figures are lumped in with laminating to show a total for laminating and molding (*9*).

228, UREA AND MELAMINE RESINS: PROTECTIVE COATINGS. Urea and melamine resins for protective coatings are disclosed on a monthly basis from 1949 through 1951 (*9*). Annual figures are shown for 1948 to 1950 (*11*). The urea-formaldehyde figures for protective coatings are disclosed in 1941, 1942, and 1945 (*11*).

220, UREA AND MELAMINE RESINS: IMPORTS AND EXPORTS. Urea resin exports are disclosed for 1944 through 1948. Urea and melamine exports are disclosed for 1949 and 1950. Urea and melamine adhesives exports are shown separately for 1949 and 1950. Urea and melamine protective coatings exports are shown separately for 1949 and 1950 (*5*).

230, Vinyl Resins. This class excludes mixtures of vinyls and phenolics. Total vinyl resins are disclosed as such for 1945 through 1950. Prior to 1945, individual segments are disclosed. Polyvinyl alcohol ester and halide resins are disclosed for 1941 through 1943. Polyvinyl alcohol, ester, and ether and halide resins are disclosed in 1944. Polyvinyl halide resins alone are disclosed 1945 through 1950 (*11*). Vinyl acetate production has been estimated for 1937, 1938, 1939, 1943, 1946, and 1947 (*10*), and has been published for 1948 through 1950 (*11*). Polyvinyl alcohol and halide has been published for 1942 through 1944; polyvinyl alcohol acetate and ether figures are published in 1945; and polyvinyl-aldehyde resins were published from 1942 to 1946 (*11*).

231 AND 232, VINYL RESINS: SAFETY GLASS SHEETING, PLUS OTHER SHEETING AND FILM. Monthly figures on this class are disclosed from June 1945 through 1951 (*4, 9*).

Care must be taken in analyzing this class to differentiate between figures on an "as shipped" basis (1945 to 1950) and figures on a net resin basis (1951). Annual figures on a net resin basis are available for 1946 and 1947 and on a dry basis for 1947, 1949 and 1950 (*11*). In 1942 polyvinyl alcohol–aldehyde resins are shown for laminating.

233, VINYL RESINS: TEXTILE AND PAPER COATING RESINS. Monthly figures on this class are disclosed from June 1945 through 1951 (*4, 9*). Annual figures are available for 1946, 1947, 1949, and 1950 (*11*).

234, VINYL RESINS: ADHESIVES. The figures for adhesives separately are disclosed in the annual census of 1947 (*3*) and in the monthly (*9*) and annual tariff data (*11*) for 1949 through 1951. From June 1945 through 1948 vinyl resin adhesives are included in all other vinyl resins in the monthly figures (*4, 9*).

235, VINYL RESINS: MOLDING AND EXTRUSION. The monthly figures are disclosed from June 1945 through 1951 (*4, 9*). Annual figures are shown for 1946, 1947, 1949, and 1950 (*11*).

237, VINYL RESINS: PROTECTIVE COATINGS. Vinyl resins for the protective coatings are disclosed the first time in 1951 on a monthly basis. In 1949 and 1950, they are included under miscellaneous synthetic plastics and resin materials for protective coatings (*9*).

230, VINYL RESINS: IMPORTS AND EXPORTS. Imports of vinyl acetate monomer and polymer were disclosed from 1937 to 1947. Vinyl acetate polymer is shown separately for 1937 and for 1946 and 1947 (*10*). Exports of vinyl resin are disclosed from 1949 through 1951, and are broken down between vinyl chloride and all other vinyl resins in 1950. From 1945 through 1948 the vinyls, styrene, and other resins were all lumped together and not disclosed separately (*5*).

240, Styrene Resins. This class includes modifications with phthalic alkyds, maleic alkyds, and other monomers, and excludes modifications with phenolics. In the monthly figures, total styrene resins are shown from 1945 to the present date (*4, 9*). They are now headed "Styrene Resins." Originally they were called "Styrene and Styrene Derivative Polymer and Copolymer Resins." From July 1945 through 1948, the monthly figures were shown for polystyrene and excluded protective coating resins. Since that time surface coatings are included.

In the annual figures (*11*) polystyrene resins are disclosed from 1942 through 1950. Styrene-acrylonitrile copolymers are disclosed in 1950. Care must be exercised in using these figures to see where styrenated alkyds are classified. Polystyrene polyesters are disclosed in 1945; polystyrene–maleic anhydride resins are disclosed in 1946; styrene-alkyd polyesters are disclosed in 1949 and 1950; polystyrene-butadiene copolymers are disclosed in 1949 and 1950.

241, STYRENE RESINS: MOLDING. Styrene resins for molding are disclosed in the monthly (*9*) and annual reports (*11*) from 1949 to the present. Prior to this time molding was not broken out. Polystyrene alone for molding and casting was disclosed in 1943, 1944, and 1947 (*11*).

243, STYRENE RESINS: PROTECTIVE COATINGS. The annual tariff figures disclose styrene resins for protective coatings in 1949 and in 1950 (*11*). The monthly figures in these two years (*9*) lumped styrene protective coating resins in with miscellaneous synthetic plastic and resin materials. The monthly figures disclose styrene protective coating resins in 1951.

245, STYRENE RESINS: OTHER USES. This miscellaneous class has been shown on the tariff report since 1949 on a monthly basis (*9*). Prior to that time polystyrene was not broken down by end use.

240, STYRENE RESINS: IMPORTS AND EXPORTS. Styrene imports are disclosed from 1947 through 1950 (*8*). Styrene exports are disclosed separately from 1949 on (*5*); prior to that time they were lumped in with vinyl export resins.

250, Alkyd Resins. The phthalic alkyds class includes modifications with phenolics, maleic alkyds, adipic acid, and oils and fatty acids, and excludes modifications with styrene and rosin. The nonbenzenoid alkyd resins (maleic) class includes modifications with phenolics and oils and fatty acids and excludes modifications with styrene, phthalic alkyds, and rosin.

An entire paper could be presented on alkyd resins alone. There is a great deal of detail available in the annual Tariff Commission breakdowns (*11*). The breakdowns are principally by chemical composition with very little in terms of information on breakdown by end use. In general, most alkyd resins are used for protective coatings. The primary breakdown in the Tariff Commission is the breakdown between phthalic alkyd resins, and alkyd resins non-benzenoid.

The phthalic alkyd class is broken down into resins which are unmodified, resins which are modified, except with rosin and rosin ester, and finally resins which are modified with rosin and rosin ester. Under each class various chemical compositions are broken out for purposes of analysis. The alkyd resins modified with rosin and rosin ester are going to be considered in the rosin ester class of materials rather than the phthalic alkyd class of materials. Figures on phthalic alkyds have been available since 1933 (*11*). The Tariff Commission has used more than one type of breakdown over this period. In 1946 they broke down total alkyds into two classes: oil-type alkyds as compared with other than oil-type alkyds. Before and after that year, this breakdown was not made.

For alkyd resins, non-benzenoid (maleic type) care must be taken to see that comparability is maintained over a period of years. Styrene alkyds are included in the total for some years. Maleic alkyds, modified with rosin and rosin ester, are included in the annual figures and in the monthly figures. Figures on maleic alkyds are available from 1938 on (*11*).

In the annual data (*11*) alkyd resins are specifically broken out into protective coatings and all other uses from 1941 to the present. Phthalic alkyd resins for adhesives were broken out in 1943. Phthalic alkyd resins for textiles were broken out in 1943. Phthalic alkyd resins for molding and casting were broken out in 1943. Phthalic anhydride–glycerol resins for molding and casting were broken out in 1944. Care must be used also in analyzing the alkyd monthly figures in 1950. For example, the breakdowns were first by chemical composition in phthalic and maleic types and then into unmodified and modified types, under these headings. In 1951 it was shifted to a breakdown first by end use—i.e., alkyd resins for protective coatings and then alkyd resins for all other uses. Then under the protective coatings end use it was broken down into phthalic and maleic types and under each one of these types it was broken down into unmodified and modified.

250, ALKYD RESINS: IMPORTS AND EXPORTS. Figures on alkyd resins imports have not been located; alkyd resin exports are given from 1944 to the present time (*5*).

260, Rosin Modifications. This class includes modifications with phenolics, phthalic alkyds, maleic alkyds, and fatty acids and oils. Rosin modifications can be broken out roughly into rosin and rosin esters, unmodified, and rosin and rosin esters, modified. The unmodified classification can be broken down into esters esterified with glycerol and esters esterified with other alcohols. The rosin and rosin esters, modified can then be broken down to those modified with phenolic and other tar acid condensates, those modified with phthalic alkyds, and those modified with maleic or fumaric alkyds. This is a very complicated classification and great care must be exercised in order to keep the classes consistent and comparable over a period of years.

270, Coumarone Indene and Petroleum Polymer Resins. The coumarone indene class excludes modification with phenolics. The data on these two classes of resins are usually lumped in with miscellaneous resins and are not disclosed. The coumarone indene figures were disclosed in the annual Tariff Commission figures in 1940 (*11*). Coumarone-indene and petroleum polymer combined are disclosed in the annual Tariff Commission figures in 1950 (*11*) and are disclosed in the monthly figures starting in 1951 (*9*).

290, Miscellaneous Resins. Under this classification the aniline-formaldehyde class excludes modifications with phenolics. The polyamide class excludes modifications of phthalic alkyds by adipic acid.

In the miscellaneous classifications a number of resins, having production and sales figures which cannot be disclosed, are lumped together. These resins, broken down by chemical composition, are aniline-formaldehyde, petroleum condensation resins, coumarone indene, petroleum polymer resins, toluene-sulfonamide, epichlorohydrin, acrylates, polyamide resins, polyethylene, polyterpene resins, polyacrylonitrile resins, furfural resins, and silicone resins.

The aniline-formaldehyde class excludes aniline-formaldehyde modified with phenol-formaldehyde. The polyacrylonitrile class excludes styrene-acrylonitrile copolymers; the polyterpene class excludes maleic anhydride terpene resins.

Because the miscellaneous class includes a large number of resins and the exact composition of the class may vary from year to year and certainly varies from monthly figures to annual figures and from census to tariff figures, it is quite difficult to analyze these figures with any degree of comparability.

291, Miscellaneous Resins: Molding Materials. The molding materials segment of the miscellaneous resins is broken out from June 1945 to the present time in the monthly data (*4, 9*), and it is also broken out in the annual data. It is difficult to arrange these figures in comparable order, however.

295, Miscellaneous Resins: Protective Coatings. Miscellaneous resins broken out into protective coatings and uses have been disclosed in the annual Tariff Commission figures since 1945 (*11*). They have been disclosed on the monthly Tariff Commission figures since 1949 (*9*). Again, all the qualifications that apply to miscellaneous resins in general apply to this class.

299, Miscellaneous Resins: Other Uses. In essence this class represents miscellaneous uses of miscellaneous resins, and comparability is very difficult because of the changes in composition and uses of resins included.

300, Vulcanized Fiber; and 400, Casein and Regenerated Cellulose. The authors are not acquainted with all the sources of information for these classes. Vulcanized fiber figures are available in the "Census of Manufacturers" of 1947. Vulcanized fiber exports and imports are available for 1937 through 1947. The figures on regenerated cellulose (cellophane) are not disclosed separately in published figures because of the number of manufacturers at present. When there are three or fewer manufacturers, the disclosure of industry totals would reveal the operation of individual companies.

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Marketing Maps, Their Sources and Uses

ARCH C. GERLACH

Map Division, Library of Congress, Washington, D. C.

Maps are now accepted as tools in organizing area concepts and displaying propaganda effectively. Statesmen have long used maps to plead a cause by emphasizing on them some particular concept. Business men are now using specialty maps with comparable effectiveness. From an annotated bibliography of 428 marketing maps of the U. S., fourteen are described and analysed to show their value in delineating sales areas for individual commodities, general trading areas, and complex concepts of marketing regions.

Maps are among the most effective tools for organizing area concepts beyond the ordinary scope of human observations and for displaying propaganda effectively. Both functions are served by marketing maps. Let us consider their organizational value first and turn to the propaganda factor later.

An ant crawling over a large Persian rug may be tickled by its fibers, but probably gains no concept of, or aesthetic pleasure from, its complex and beautiful pattern. Likewise, men have difficulty in seeing and understanding the world's complex surface unless they reduce it, by means of a map, to a scale they can observe. The resultant pattern may focus attention upon the distribution of topographic features, political boundaries, transportation facilities, human activities, resources, manufactured commodities, or even ideas.

Displaying Propaganda. The concept of maps as tools for propaganda has developed more recently. This term propaganda is not necessarily a bad word, but it does connote influence, which is another word that is poorly received these days. A skillful cartographer can, by the selection of appropriate scales, projections, symbols, and colors, focus attention on certain facts to the virtual exclusion of others without detracting from the technical accuracy of a map. Politicians and statesmen long ago learned to use maps not only to organize information but also to plead a cause, and this discussion of marketing maps is prefaced by a few examples of political propaganda maps from a war atlas published by German geopoliticians in 1940 and 1941.

One excellent example (Figure 1) is entitled "England's Predatory Campaign." On a world map all parts of the British Empire are shown in vivid yellow and the rest of the world is sharply contrasting black. If each country appeared in a different color on this map, the British Empire would be far less conspicuous, but this presentation appears to set the British Empire against the rest of the world.

Another example which makes even more effective use of color and lines on a map is entitled "India: Divide and Rule." Unrest and friction within India are emphasized by showing the various minor divisions in sharply contrasting colors such as black, orange, green, yellow, and red. The adjacent parts of Asia are uniformly light gray, giving an impression of relative peace and tranquility beyond the boundaries of British domination. Furthermore, broken, barbed lines are used to focus more attention on the internal boundaries of India, while smooth, continuous lines delineate only the international boundaries of surrounding countries.

The Germans also published a classic map to show the German population of Lithuania in 1940. On that map human figures are distributed so that 15 of them cover Lithuania completely. This gives an impression that Lithuania was full of Germans in 1940. The map is technically accurate with a legend which indicates that each figure represents 5,000 Germans, but a little study reveals that 15 figures represent only 75,000 Germans, or 3% of the total Lithuanian population in 1940.

Marketing Maps

During the past 2 decades, businessmen have come to use specialty maps with comparable effectiveness. They have applied cartographic techniques to help administrators and salesmen in delineating operational territories, in plotting the sources and distribution of products, and in selling ideas to the public. For example, here are four different methods of mapping facts about marketing medical products.

The first is an odd looking map of the United States (Figure 2) on which state areas are proportional to the volume of drug sales within them (*5*). It badly distorts the shape, size, and position of states in relation to each other, but it should be worth a lot of money to certain Chambers of Commerce groups in Florida who would, for once, look with favor upon this portrayal of their state as a shrunken appendage of the United States in sharp contrast of the conspicuous enlargement of California, where there is a far larger demand for medical remedies.

The second map shows drug sales by counties on an outline of the United States (*12*). Those few counties which appear in solid black sell 50% of the drugs sold in the United States. This gives a far different picture than the first, highly generalized map, based on state-wide statistics. A table in the corner of this map is an opportunistic insert by *This Week Magazine* in which the map was published. The table shows that in the counties which sell 50% of the drugs in the United States, *This Week Magazine* has several times the circulation of other popular magazines such as *Life*, *Time*, and *The Saturday Evening Post.*

A third map of drug sales is even more precise in locating sales centers (*4*). Each center is shown by a black dot and the city is named. Around each center is a yellow circle whose size is proportional to the total drug sales in that city. Consequently, the map pinpoints the sales centers and at the same times gives an impressionistic concept, with reasonable mathematical accuracy, of the relative importance of those sales centers.

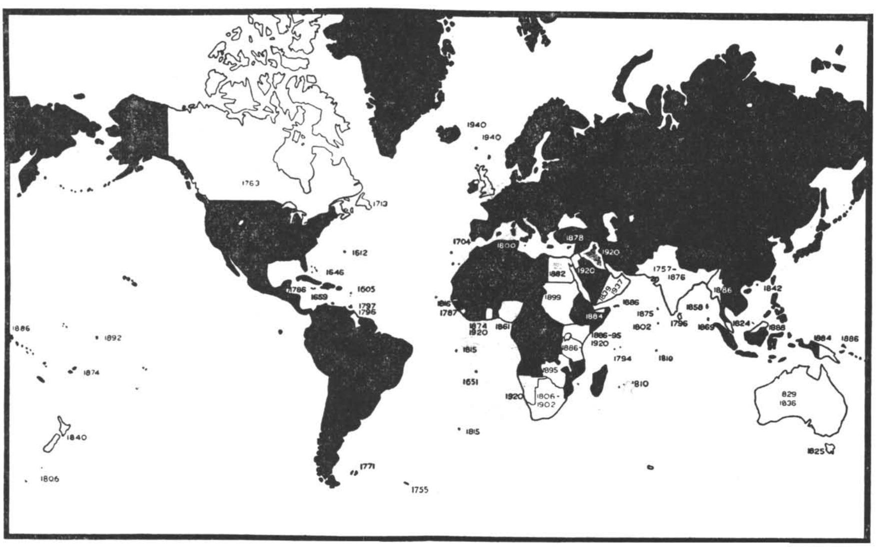


Figure 1. England's Predatory Campaign in Five Continents; 1605–1940

A fourth map (Figure 3) shows wholesale distribution centers for drugs in a highly impressionistic fashion (*11*). Fifteen to eighteen centers become exceedingly conspicuous because colored lines are drawn toward those centers from the surrounding trade areas, but the lines overlap in marginal areas, so that the flow of trade there cannot be determined precisely.

From the Library of Congress collections of some 428 marketing maps, a few others have been selected to demonstrate contrasting ways to show market centers or market sales areas for individual commodities.

One map shows the distribution of steel warehouses in several categories (*1*). The map is a real source of information but requires considerable study because so many meaningless, geometric symbols are used to designate the various types of steel warehouses that one has to refer constantly to the legend in order to interpret the symbols correctly.

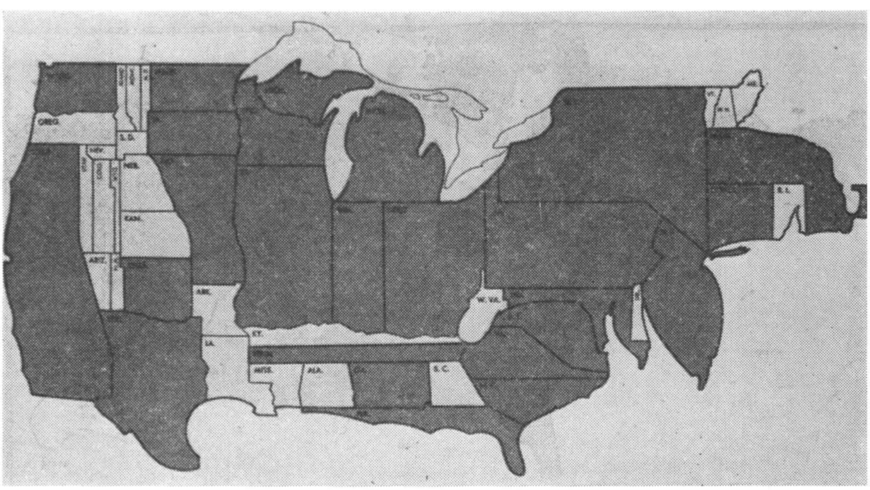
Another is a motor marketing map showing the density of automobiles in various parts of the United States (*9*). Statistics have been collected on a county basis and it is easy for an observer of the map to determine where the greatest sales prospects exist. It would be more effective to use red for the highest density because it is more conspicuous than yellow, which indicates greater density than the red areas on this map.

A map (Figure 4) showing the distribution of Penney's Department Stores gives a clear impression that Penney stores are widely distributed throughout all parts of the United States except the Southeast (*13*). A sales manager for Penney's marketing organization could not possibly overlook the void in coverage south of the Ohio and East of the Mississippi.

Another map shows the sales of *This Week Magazine* in various parts of the United States (*14*). Large white circles indicate cities with the highest sales density. Large black sections surrounding them show areas of secondary density and make the city center symbols disproportionately conspicuous. Other color shades are used to designate regions of decreasing sales density. Such a map would be useful both to impress advertisers and to organize sales efforts.

Plotting Trade Areas. The next series of maps demonstrates three ways of plotting trading areas on maps. Unlike marketing maps for individual commodities such as drugs, autos, steel, stores, and magazines, these are designed for planning and organizing marketing activities.

The first, by Brooke, Smith, and French (Figure 5) shows trading areas by counties



COURTESY CROWELL-COLLIER PUBLISHING CO.

Figure 2. Drug Store Sales Map

States as they would appear if area were proportional to drug stores sales; 24 leading states

(*2*). Counties with several common denominators for marketing activities are grouped within heavy lines that delineate marketing regions. There are many such maps but various firms draw the lines in different patterns and it is important to know the basis on which the regions were established. This is usually explained in the legend of such maps.

COURTESY THIS WEEK MAGAZINE

Figure 3. Western Half of the F.W.D.A. Distribution Map

Instead of separating trading regions from each other by boundary lines, another type of map ties towns to trading centers by means of arrows (*8*). For this type of map, precise studies are required to determine the extent of both retail and wholesale deliveries, the frequency of long distance phone calls, the distribution of newspapers, the sale of bus and rail tickets, and possibly a score of other factors that businessmen consider in determining the relationships of subsidiary marketing centers to the larger trade centers.

A fine little propaganda map entitled "The 11 Western States Viewed from Los

Angeles," shows the United States at such an angle that Los Angeles appears to be at the center of the map instead of in the southwest corner of the country (*7*). Buying power of various regions is shown in colors that gradually fade out toward the northeast so that more attention is focused upon Los Angeles as the hub of trade for the 11 Western States and Texas.

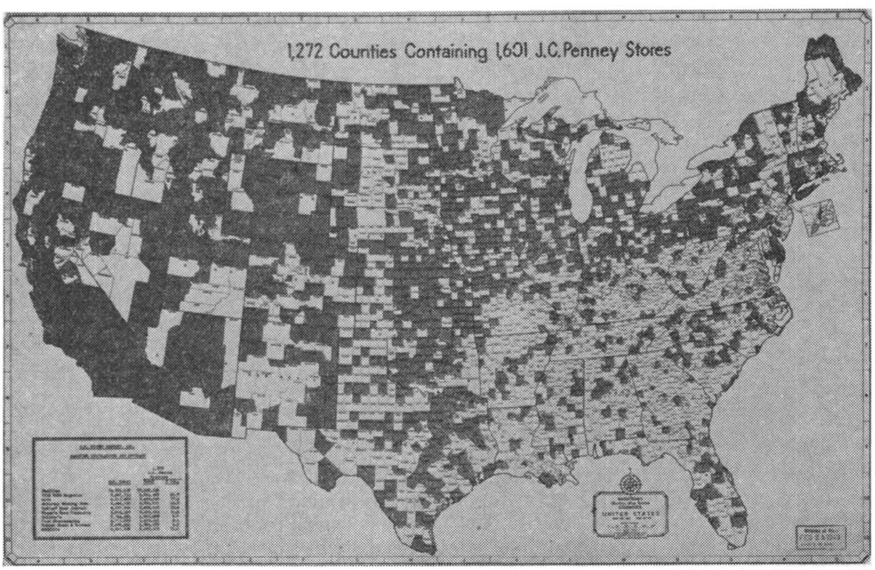
Some of the more directly analytical maps of marketing regions are of even greater business interest.

One shows county character according to the predominant occupation of the populace (*3*). The counties in red have a majority of the adults occupied in business; those in green are primarily industrial areas; and the remaining, white counties are fundamentally agricultural. This type of map has been in considerable demand for legislative reference service during election year because politicians take a genuine interest in the predominant occupations of their constituents. The map appears to be broken in a north-south direction in the Mississippi Valley because the smaller counties in the Eastern United States would not be legible if reproduced at the same scale as the larger counties in the Western United States. Consequently, there is a break in the map and the eastern third of the country is shown at a larger scale.

Another map of the United States represents buying activity in various regions of the country (*10*). Green sections in the Far West and the Northeast are the most fluorishing. Yellow sections of the Middle West and Southeast are considered healthy in their buying activities. The Rocky Mountains, Great Plains, and Missouri Basin had relatively poor buying health at the time this map was compiled. Colored rings within each of the major regions bear numbers to show the relative standing among all 12 districts and also contain index figures which represent the actual ratio to buying activity within the district the previous year.

One of the most complex marketing maps is published in black and white by the Department of Agriculture to show migratory routes of agricultural labor (*15*). This map requires considerable study and interpretation. Numbers scattered over the United States are interpreted in an extensive legend which names the crops produced and indicates the harvest season for each of the numbered areas. Lines across the map indicate routes used by migratory farm laborers as they follow the crops north from summer to autumn.

Library of Congress Collection. These maps are only a few of those available in the Library's collection of some 2,225,000 maps, 18,000 atlases, and several



COURTESY THIS WEEK MAGAZINE

Figure 4. Distribution of Penney's Department Stores

COURTESY BROOKE, SMITH, FRENCH & DORRANCE, INC.

Figure 5. Trading Areas by Counties

hundred globes. Most of the maps are not cataloged, but they are filed by area, subject, and date. To facilitate their use the Map Division has compiled annotated lists such as the one titled "Marketing Maps of the United States," by Marie C. Goodman and Walter W. Ristow (*6*). It is a bibliography of some 428 marketing maps published by both government and commercial sources and ranges in subject coverage from the sale of brassieres to the distribution of wholesale plants for heavy industries. The first 253 maps are pertinent to all or major parts of the United States; the last 174 entries pertain mainly to individual states or metropolitan districts and are arranged alphabetically by States. The entire volume is indexed to show both the author and the subject entries. The first edition ran out of print within 3 months, but a revised and enlarged edition is now for sale by the Card Division for 70 cents. Maps described in the bibliography are not sold or distributed by the Library of Congress. Copies may be obtained from the publishers in most instances or borrowed on interlibrary loan through a local library for the cost of postage.

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date includes listings, by cities, of stores operated by leading drug chains; also analysis of the chain store drug market and the market outlook. Four inset maps for metropolitan areas.

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(8) International Magazine Co., Inc., Marketing Division, New York, "New Marketing Map of the United States," c. 1935. Drawn by Rand McNally & Co. Colored. 41 × 58 in. No scale given. Has 10 insets of multiple trading center maps. The purpose of this map is to give manufacturers who are striving for national distribution, the simplest means for directing their sales and advertising efforts on a practical and economical basis. This map shows the normal flow of trade by the logical grouping of communities into consumer trading areas, and it also shows the national market in its three broad divisions. Nineteen business factors, studied comparatively, enter in the determination of these consumer trading areas.

(9) *Motor Age.* "Automotive Marketing Map (United States)," Philadelphia, Chilton Co., c. 1949 Base map copyrighted by Hagstrom Co., Inc. Colored. 29 × 47 in. ca. 1:4,000,000. Seven enlarged insets of areas of dense population. Indicates the total vehicle registration (cars, trucks, buses) of each county, by color. Also indicated are the 359 leading automotive wholesale centers and cities of 20,000 population or over. Total vehicle registrations used as a basis for this map are compiled by the Chilton Co. automotive headquarters, and represent a total as of the end of the 1948 registration year.

(10) Sales Traffic Digest, Inc., New York, "Buying Health Map (United States)." c. 1941. Colored. 28 × 33 in. No scale given. Report for March 1941, issued April 22: Financial Stability and Sales Information. Includes color scheme for comparison with "average month 1936" and "same month, year ago." 14 graphs for large cities at bottom of map.

(11) *This Week Magazine*, New York, The F. W. D. A. Distribution Map of 1948, Showing Areas Served by Members of the Federal Wholesale Druggists' Association," c. 1948. Base map copyrighted by Hagstrom Co., Inc. Colored. 30 × 47 in. ca. 1:4,000,000. Names and addresses of 56 members of F.W.D.A. are listed at bottom of the map.

(12) *This Week Magazine*, New York, "Leading Counties: Retail Drug Store Sales (United States)," 1948. Colored. 14 × 23 in. 1:12,500,000. 67 counties having 50% of U. S. total are colored red.

(13) *This Week Magazine*, New York, "1,272 Counties Containing 1,601 J. C. Penney Stores (United States)," 1948. Colored. 14 × 21 in. 1:12,500,000. (Hagstrom's outline map series). Penney counties shown in red. Includes table: "J. C. Penney Co., Inc.; Magazine Circulation and Coverage."

(14) *This Week Magazine*, New York, "The *This Week Magazine* Market, 1,129 Counties with Effective Coverage of Families (United States)," 1948. Colored. 14 × 22 in. 1:12,500,000. (Hagstrom's outline map series). 24 cities with 54% coverage shown with large black dots; 37% coverage (retail trading zones outside cities) in green; 359 counties with 10 to 20 per cent coverage in blue.

(15) U. S. Department of Agriculture, Washington, D. C., "Major Migratory Routes in the Agricultural Labor Market," (crop areas, seasonal work charts, state employment service headquarters offices, U. S. Department of Labor, U. S. Employment Service and Affiliated State Agencies, Farm Placement Service) 1951. 1:6,000,000 approx., 30 × 40 inches. As the title indicates a mass of material on migratory labor is presented. The omission of arrows to show the movement of labor is regrettable. Some of the charts are difficult to read. The use of color and an alphabetical arrangement by states or a numerical listing of crop areas would improve the map.

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Congressional Committee Hearings

W. C. GILBERT

Legislative Reference Service, Library of Congress, Washington, D. C.

The establishment of the committee system in Congress and the gradually increasing importance of committees, both legislative and investigating, were traced. Though there has been difference of opinion as to the proper scope of committee jurisdiction and the best methods of obtaining witnesses, the value of the hearings, in general, is undisputed as a source of information. The hearings have not been used fully, due to methods of distribution, which traditionally were controlled by the individual committees. Even now, the committee is the primary source, but its supply is determined largely by its guess as to demand. The market for such literature, which is extremely specialized, is quite uncertain, and this uncertainty has militated against regular printing for sale. At present, distribution is made automatically to the several hundred depository libraries, and hearings will be available from the Superintendent of Documents, upon advance notice.

The modern spell-binder committee hearing, that vies with Hopalong Cassidy and Bob Hope for the attention of radio and TV fans, is a brother of that first Congressional investigation of 1792, established when Congress felt there was something "fishy" about a U. S. Army under General St. Clair being beaten by an inferior army of Indians on the Wabash River. The essentials are the same. In each case a select committee of one of the Houses of Congress was exercising the power of Congress to look into a particular subject within the purview of Congress.

If the hearings that are most in the public eye happen to be investigating committee hearings rather than the more prosaic legislative variety, it is of little moment here. The style or powers of the committee are not of so much interest as the subject of their consideration, and the form and availability of their printed proceedings. The significance of crime investigations, for example, would be relatively slight in comparison with hearings of the standing legislative committees considering legislation on tariff or fair trade or interstate commerce.

Development of Congressional Committees

It may seem odd to us, with whom the idea of standing committees seems as sturdy as the Constitution itself, but actually the development of committees with their present power was slow and against strong opposition. In the earliest Congresses the general procedure was to thresh out the principles of legislation in Committee of the Whole House on the State of the Union, and then, having settled the broad principles and purposes, to refer the matter to a select committee to work out the details. "Strict constructionists" argued that the Constitution granted the legislative power to Congress, and it would be an unconstitutional delegation of power to authorize a body less than the membership of either House to initiate a bill. In the Second Congress, Representative Livermore of

New Hampshire raised such an objection to a standing committee of elections, and when the committee was set up notwithstanding, he was appointed chairman! Perhaps that converted him.

In the Fourth Congress, the House set up a standing committee of ways and means, another of claims, and still another of commerce and manufactures. But when Representative Ezekiel Gilbert tried to have referred to this committee a resolution to restrict the carrying trade to American vessels (which would seem a pretty obvious and logical reference), his motion was defeated largely through the efforts of James Madison. And as late as 1806 a matter which had been referred to the Ways and Means Committee was recalled by the House and re-referred to the Committee of the Whole.

By 1817, the idea of committee responsibility was so well established that the individual member didn't get far when he ran up against one. Representative Johnson spoke with considerable feeling on the point in the debate on a resolution to repeal the internal revenue law (*11*).

Mr. Speaker, How long, Sir, has it been settled that the rights and the interests of the American people shall be exclusively confided to a few members of this House who compose its standing committees, or more peculiarly to the still smaller number who preside over those committees? Is it presumptuous or criminal in any other member of this body, to submit a proposition which he believes calculated to promote the interest, the prosperity and the happiness of the nation? Are the laws imposing taxes to remain fixed and unalterable, except by the will and pleasure of the Chairman of the Committee of Ways and Means and by the will and pleasure of the chairman of some other important standing committee? Shall no other Member dare to propose the repeal of any revenue law, lest he be denounced as a miserable timeserving trimmer and hunter after popularity? (*5*).

In 1827 the House Committee on Manufactures requested authority from the House "to send for persons and papers," and this proposal was amended so as to authorize the committee "to send for and examine persons on oath, concerning the present condition of our manufactures, and to report the minutes of such examination to the House."

In the long and acrimonious debate touched off by this resolution, the proposal that the committee report the minutes of its examination to the House went largely unnoticed; most of the argument turned on the authority demanded by this, a legislative committee, to summon and examine witnesses. The committee had many conflicting statements from interested persons. One of the strongest speeches in favor of the resolution was made by Mr. Livingston of Louisiana.

Shall we reverse the rule of business in this House, and instead of employing a committee to state facts, and give us their deductions from them, shall we oblige them to bring in a bill without any knowledge of the subject, and supply the gross deficiency with our superior knowledge? But before we take this course, it is worth inquiry whether we ourselves possess the knowledge, and to what extent? We will take this from the gentlemen who oppose the resolution, if any member in this House possess the information. They have it, and they have not left us in doubt as to the kind of evidence on which they rest their belief. What more, say those gentlemen, can be desired? Have we not memorials from all the manufacturers? Do not our tables groan from the weight of their complaints? What more can be desired? Something more in my opinion; and if this is the best evidence—and it must be supposed to be such, for it has been relied on, by all who spoke against the resolution—it is the strongest argument that could be used in favor of the measure proposed. I will believe that many of these memorialists are very respectable people; but are they disinterested? . . . A long professional practice has taught me the danger of relying on the testimony of interested witnesses, and has also shown me the great utility of cross examination. From disinterested witnesses it is calculated to elicit truth; but it is invaluable for the detection of those subterfuges to which interest resorts, in order to hide the truth, or give a false color to a true statement (*14*).

The discussion in this early case sounds remarkably modern. The questions raised are persistent.

Sixty years later, the House Ways and Means Committee created quite a furore by refusing to hold hearings on a tariff bill, and C. P. Breckenridge came to their defense in the *North American Review* (*6*).

No one has a right to demand as a matter of right that he shall be heard by a Committee of the House. The constitutitional right of petition to Congress has nothing whatever to do with the claim to be heard in argument before a committee. It is a matter of discretion with a Committee as to the mode in which it will seek information concerning subjects referred to its consideration.

Mr. Breckenridge argued that not only was there abundant material for every member to inform himself as to the facts necessary to reach an intelligent conclusion, but if the committee had heard one party, it felt it would have had to hear all, and finally "the gentlemen who wanted to be heard were not to come as witnesses under oath, subject to cross-examination, but to present arguments prepared for the purpose of influencing the Committe to legislate in their particular interests."

Fifty years later, that astute legislator and parliamentarian, Robert Luce, again took issue with the idea that appearance before a committee was a matter of right (*13*).

> To get information is one of the chief purposes of hearings; it does not follow that the committee should necessarily expose itself to the time-consuming process of acquiring information through indiscriminate volunteering on the part of whatever citizens choose to present themselves. Only by accident will it happen that the men best qualified to inform will be in attendance.

In his view, a committee seeking information should pick its witnesses from experts and invite or even require their attendance. "The few volunteer truth" he said, "where the many volunteer wisdom."

Value of Published Hearings

There seems to be some difference of opinion as to the intrinsic value of the published hearing. Mr. Schmeckebier calls them "the most important publications originating in Congress, but the most elusive." Writing in 1923, Roger Hawson of Columbia (*9*) gave his opinion.

> From the point of view of the future historian, there is probably nothing that could shed more light on vexed questions—and he will find them in plenty—than the published records of hearings before Committees. They give the contemporary reasons for current political action and are essential documents. Presumably they comprise the considered advice of the best minds on a particular subject, and at any rate they chronicle the conviction of those whose interest in a particular subject is, for one reason or another, most earnest. They are not books that one would expect to find on the shelves of a private library, but they are material that historical students should find on the shelves of the greater libraries.

This is perhaps an overly optimistic statement for a generalization on the caliber of committee hearings; however, hearings are valuable documents. They are valuable not only to the future historian of political affairs, but in limited degree, to the chemists and others whose fields of activity are touched by the broadening scope of Federal legislation. The industry at large would, no doubt, be interested in hearings before the Committees on Finance and Ways and Means, the Committees on Agriculture and Armed Services, the Committees on Interstate and Foreign Commerce, the special committees set up from time to time, and certainly the Joint Committee on the Economic Report.

A list of hearings selected from the thousands which have been printed in recent years, with the idea of pointing out the richness of the materials available is given in Table I. To keep it from being unnecessarily long, most hearings of general interest, and all the annual appropriation hearings have been omitted. However, the latter group should definitely be examined in any study involving the research activities of a government agency, such as the Department of Agriculture or the National Bureau of Standards. The place of publication and publisher are not given in the bibliography, since all are published by the Government Printing Office, Washington, D.C.

Availability of Published Hearings

The question is, how, when, and where are any such hearings available? Are they found on the shelves of the greater libraries? If they are of considerable importance, why are they not more generally available?

Publication Control. The basic fact in the whole matter is the extent of committee control of publication. The rules of the two Houses do not require the printing of the hearings. In early years, the House setting up a committee sometimes ordered its testimony printed as a House or Senate document. But, in general, the committee is the sole judge of whether its hearing shall be printed or not. In some situations there is a consensus against it.

Contested elections have been subjects of committee examination from 1789 on, and the uniform practice is not to print the testimony, for political reasons. Sometimes the subject matter may be such that it cannot properly be made public.

There is great variation between committees. The House Armed Services Committee has had all hearings published; the House Rules Committee has had none published since 1945.

In rare cases, a committee may feel that the expense of printing is not warranted. A recent example was the hearing on the nomination of Mr. Pauley as Under Secretary of the Navy, in the Seventy-ninth Congress. The testimony ran to over 2400 pages, which would have cost about $6,000 to print. When the nomination was withdrawn subsequent to the hearing, the Chairman, Senator Walsh, would not agree to publication.

Volume of Published Hearings. The very first hearings were printed by Congress just 125 years ago, in 1827. That was nearly 40 years after Congress was organized under the Constitution. Although it took many years to get the first hearing printed, the annual report of the Government Printing Office for 1947 (the latest report printed) shows that hearings were second only to the *Congressional Record* in cost of printing for Congress—$1,062,377 (106,738 pages) compared to $1,239,865. Appropriation hearings alone, for the Eightieth Congress, ran to 37,729 pages; the hearings of the two houses on the National Labor Board Act totaled 6,356 pages. In fiscal 1950, the cost of the printing of hearings had jumped to $1,744,083 for a grand total of 149,038 pages; and the estimate for 1951 showed a still rising trend—$1,915,000 for 152,600 pages.

A study recently made in the Legislative Reference Service of the Library of Congress shows that in the Eightieth Congress (1947-48) the 19 House committees printed 766 hearings, and the 15 Senate committees, 338 hearings—a total of 1104 of over 2500 hearings held. These figures represent all the separate sessions each of which, technically, is a hearing, rather than the groups of sessions devoted to a particular subject or bill.

Distribution. Hearings have not had adequate distribution, considering their potential value. This has long been recognized. If hearings are printed, it is for the use of the committee. Just where the use of the committee stops and the use of the public begins is, perhaps, doubtful.

The committee is not required to print by the Rules; it is, therefore, in control of both printing and distribution. To achieve a fair distribution, based on the importance of and general interest in the hearing, with as few copies as possible left over is a problem. It is difficult to gauge popular demand, especially where the product is low-cost or free, and this is especially true where the potential market is the whole American people.

A single illustration will point this up. Forty years ago, the House was concerned about storage space for Congressional documents, and Rep. James Mann of Illinois stated (*8*):

> There are two million and a half documents in the folding room now, and I dare say that of that number there are at least a million which have been in the folding room for years, not one of which has been called for or one like it sent out for years.

There are two angles to the problem—public distribution and private distribution. What facilities are available for finding out what has been printed and how may hearings be obtained?

Some of the pertinent laws will be mentioned. In 1846, (*10*) after many shifts in policy, Congress decided that the printing for the two Houses should be done on two-year contracts, to be let by the Secretary of the Senate and Clerk of the House, each acting for his own House. There would be separate contracts for each of the following: bills and resolutions, reports of committees, journals, executive documents, and all other. Hearings presumably were in the "all other" class. In 1852 (*2*) the system was changed. An appointed superintendent supervised the work of printers elected by each House. The work was classified as bills and resolutions, reports of committees, and journals and executive documents of either House. Again, there was no specific mention of hearings.

In 1860 (*11*) the Government Printing Office was established—the outcome, by the way, of the operation of a Congressional investigating committee. Difficulties with the public printing were not entirely solved, but remedial legislation was long a-borning. In 1892 a comprehensive bill was reported in the Senate, §59 of which would have required the Public Printer to send one copy of every document not bearing a congressional number, and not of a confidential character, to the Senate and House libraries and document rooms. The report on the bill (*15*) explained that the purpose of the section was "to preserve for reference copies of reports and papers printed for the use of committees, which, being given no document number, soon became lost and inaccessible, although they may contain much valuable information that will be sought for both by legislators and the public."

The Printing Act of 1895 (*3*) along with a great many other amendments, attempted to assure a file copy of hearings by providing (§62) that "the Public Printer shall, immediately upon its publication, deliver to him (the Superintendent of Documents) a copy of each and every document printed at the Government Printing Office, not confidential in character." So strong, however, was tradition that in the face of this statute, the Public Printer continued to send all copies of hearings to the issuing committee. So many hearings were closed and not reported that he considered all of them confidential. As a rather ludicrous result, the Public Documents library in the office of the Superintendent of Documents (a subordinate of the Public Printer) often found itself without a single copy of some printed hearings. The Public Printer's customary rule was to fill requisitions of the publishing agency first, and, since no notice was published of the holding of hearings, the library would not be aware of them until the hearings were over, and the supply of printed reports was exhausted. It did its best to keep track of hearings by following the newspapers and magazines for casual notices.

The Librarian of Congress, writing in the same vein to the Printing Investigation Commission in 1905 stated, "The Public Printer acts on the assumption that all documents printed for use of Congressional Committees are confidential. Our only method of obtaining these documents at present is to visit the various committees and collect such publications as they are willing to furnish."

Distribution of hearings was thus one of many defects which was considered in the revision of the printing law proposed in 1911 and again in 1914. George Carter, Clerk of the Joint Committee on Printing, explained the revision on this point (*7*). Committee hearings were to have a regular distribution, including distribution to depository libraries. "Hearings" he said, "are coming to occupy a more and more important part in the proceedings of Congress; in fact, substantially all important legislation is now based upon such hearings, and it has been decided that they ought to be ensured proper publicity and preservation by regular distribution to the libraries of the country. All except 'confidential' hearings, of which there probably will be few in the future, are included in the distribution." The bill would also have provided a bulletin of committee hearings, to be issued daily during sessions.

This proposed revision did not materialize, and things ran along about as usual until the Sixty-seventh Congress. Then, in 1922 (*12*) Congress authorized the Superintendent of Documents to extend his book selling activities to include "any Government publication not confidential in character." Under this authority, committee hearings were regularly listed in the *Monthly Catalog* and offered for sale. On the whole, they were somewhat less than best sellers. Starting with a blanket order for 25 copies, the Superintendent of Documents found himself stuck with a good share of them. As he had to pay for the copies supplied him, and wanted to show a profit, the order was cut, until finally it was down to 15. Even then, the situation was so uncertain that in the Eightieth Congress, the project was virtually abandoned. Since then, only three hearings have been priced—the monopoly hearings before the House Judiciary Committee, the Kefauver crime investigations, and the MacArthur hearings.

The Superintendent of Documents, though he dislikes to estimate the demand himself, is very glad to cooperate, and will order copies for sale if application is made in advance of publication in any particular case.

In the Sixty-seventh Congress, the appropriation for the office of the Superintendent of Documents, fiscal 1924, carried a proviso in the following terms: Provided, no part of this sum shall be used to supply to depository libraries any documents, books or other printed matter not requested by such libraries. On these last words was based the selective plan under which depository libraries may make their choice of the public documents they will receive. They may either enter a blanket order for the hearings of all committees, or for all hearings of a given committee; or order individual hearings from the Government Printing office *Monthly Catalog*.

The depository libraries got a break in 1938 when Congress amended the law (*4*) to require the Public Printer to furnish to the Superintendent of Documents enough copies so that he could distribute to each library one copy "of all publications not confidential in character printed upon the requisition of any Congressional committee."

Table I. Selected List of Hearings

Joint Committee on the Economic Report
- Allocation of grain for production of ethyl alcohol. Hearings, Eightieth Congress, 1948.
- Current price developments and the problem of economic stabilization. Hearings, Eightieth Congress, 1947.
- Corporate profits. Hearings, Eightieth Congress, 1949.

House Committee on Agriculture
- Disposal of Government-owned alcohol plants. Hearings, Eightieth Congress, 1948.
- Federal Insecticide, Fungicide, and Rodenticide Act. Hearings, Eightieth Congress, 1947.
- 1948 Fertilizer supplies. Hearings, Eightieth Congress, 1948.
- 2,4-D weed killer. Hearings, Eightieth Congress, 1948.

House Committee on Armed Services
- Stockpiling of strategic and critical materials. Hearings, Eighty-first Congress, 1950.
- Synthetic rubber. Hearings, Eighty-first Congress, 1950.

House Committee on Banking and Currency
- Price-control bill. Hearings, Seventy-seventh Congress, 1941.

House Committee on Interstate and Foreign Commerce
- Inflammable textiles. Hearings, Eightieth Congress, 1947.
- Iodized salt. Hearing, Eightieth Congress, 1948.
- National Science Foundation. Hearings, Eighty-first Congress, 1949.
- Petroleum study. Hearings, Eighty-first Congress, 1950.
- Synthetic liquid fuels. Hearing, Eightieth Congress, 1948.

House Committee on Mines and Mining
- Production of gasoline from coal and other products. Hearings, Seventy-seventh Congress, 1942.

House Committee on Post Office and Civil Service
- Collection and publication of statistical information by the Bureau of the Census. Hearings, Eightieth Congress, 1947.

House Committee on Public Works
- St. Lawrence seaway. Hearings, Eighty-second Congress, 1951.

House Committee on Ways and Means
- Control of narcotics, marihuana and barbiturates. Hearings, Eighty-second Congress, 1951.
- Percentage depletion. Hearing, Eightieth Congress, 1947.
- Simplification of customs administration. Hearings, Eighty-second Congress, 1951.

House Select Committee on Small Business
- Inedible fats, oils, grease and tallow. Hearings, Eightieth Congress, 1948.
- Problems of small business related to the national emergency. Hearings, Eighty-second Congress, 1951.

House Select Committee to Investigate the Use of Chemicals in Food Products
- Chemicals in food products. Hearings, Eighty-second Congress, 1951.

Senate Committee on Agriculture and Forestry
- Fertilizer, farm machinery, pesticides. Hearings, Eighty-second Congress, 1951.
- Government-owned industrial alcohol plants. Hearings, Eightieth Congress, 1948.
- National fertilizer program. Hearings, Eightieth Congress, 1947.
- Utilization of farm crops. Hearings, Eighty-first Congress, 1949–51.

Senate Committee on Armed Forces
- Stockpiling of tin and rubber. Hearing, Eighty-second Congress, 1951.

Senate Committee on Banking and Currency
- Diversification of tin recovery facilities. Hearings, Eighty-first Congress, 1949.

Senate Committee on Expenditures in the Executive Departments
- Basic Magnesium Plant, Henderson, Nev. Hearings, Eightieth Congress, 1947–48.

Senate Committee on Finance
- Processing tax on coconut oil. Hearing, Seventy-seventh Congress, 1942.

Senate Committee on Interior and Insular Affairs
- Defense minerals. Hearings, Eighty-second Congress, 1951.
- National fuel reserves and fuel policy. Hearings, Eighty-second Congress, 1951.
- Research laboratory in North Dakota lignite-consuming region. Hearing, Eightieth Congress, 1948.
- Synthetic liquid fuels. Hearings, Eightieth Congress, 1948.

Senate Committee on Interstate and Foreign Commerce
- Study of pricing methods. Hearings, Eightieth Congress, 1948.

Senate Committee on Military Affairs
- Scientific and technical mobilization. Hearing, Seventy-eighth Congress, 1943–44.
- Stockpiling. Hearing, Seventy-ninth Congress, 1945.
- War plants disposal—synthetic rubber. Hearing, Seventy-ninth Congress, 1946.

Senate Committee on Mines and Mining
- Stock piles of strategic minerals. Hearings, Seventy-eighth Congress, 1943.

Senate Committee on Small Business
- Rubber survey. Hearings, Eighty-second Congress, 1951.

Senate Special Committee to Investigate the Centralization of Heavy Industry in the United States
- Centralization of heavy industry in the United States. Hearing, Seventy-eighth Congress, 1944.

Finally in 1946 the Legislative Reorganization Act (*1*) restated the Senate and House Rules on the subject of standing committees, and made some interesting new regulations on the subject of hearings. Each standing committee, for one thing, shall require, so far as practicable, all witnesses to submit a written statement of their proposed testimony in advance; their oral testimony is to be limited to a brief summary. All hearings (except executive sessions for voting or marking up a bill) are to be open, unless otherwise directed by a majority vote. Each committee, (except Appropriations) is to fix regular meeting days, and a list of all meetings and hearings is carried in the daily *Congressional Record.*

So far as the depository libraries are concerned, then, the law has finally made it possible for them to secure copies of all printed hearings not specifically restricted by the committee as confidential. It is possible, but only about 20% probable. In 1947 only 125 of approximately 600 depository libraries were actually receiving the entire quota of Government documents. Doubtless some more were getting a complete coverage of all hearings.

How does the interested individual secure copies? Primarily by applying to the issuing committee. And this presupposes that the applicant knows what committee has jurisdiction of the subject matter in interest, that he follows events closely enough to get in his bid before the supply is exhausted. Under the law, a committee may print 1000 copies irrespective of cost. After that, it may apply to its own House for printing up to \$500—i.e., by simple resolution. If the amount is over \$500, it requires concurrence of both Houses; if it doesn't run over \$200, the Joint Committee on Printing may authorize additional printing without further reference.

Committee jurisdiction is conveniently set out in the Legislative Reorganization Act of 1946 (*1*). However for up-to-the-minute information, the current Manuals of Senate and House reflect the latest changes in Rules. All of the committees except Appropriations regularly publish a calendar at stated intervals, indicating matters under consideration. And the daily *Congressional Record*—not to mention the press—will keep one advised of current hearings. The figures seem to show that any particular hearing stands a little less than an even chance of being printed. For a person who does not care to take that chance, but prefers to know that a document is in print before trying to get it, the *Monthly Catalog* issued by the Government Printing Office lists all hearings issued, under the name of the committee only. The annual index to the *Monthly Catalog*, however, gives references under both committee and subject matter.

Though hearings are not currently printed in abundance, they are available to those who really want them and make their wants known in time.

Acknowledgment

The list of hearings in Table I is as prepared by Harold O. Thomen, Library of Congress, Washington, D. C.

Literature Cited

(1) Act of August 2, 1946, 60 Stat. 812, Title I.
(2) Act of August 26, 1852, 10 Stat. 30.
(3) Act of January 12, 1895, 28 Stat. 601.
(4) Act of June 25, 1938, 52 Stat. 1206.
(5) Annals of Congress, 14th Congress, 2d Session, p. 963.
(6) Breckenridge, C. P., *North American Review*, **146**, 520 (May 1888).
(7) Carter, G. H., *Library Journal*, **39**, 815, 818 (1914).
(8) *Congressional Record*, **45**, 198 (December 16, 1909).
(9) Hawson, Roger, *A.L.A. Bulletin*, 17, 250 (1923).
(10) Joint Resolution 16, August 3, 1846, 9 Stat. 113.
(11) Joint Resolution 25, June 23, 1860, 12 Stat. 117.
(12) Joint Resolution 57, May 11, 1922, 42 Stat. 541.
(13) Luce, Robert, "Legislative Procedure," p. 144, Boston, Houghton Mifflin, 1922.
(14) Register of Debates, 20th Congress, 1st Session, p. 871.
(15) S. Report 18, 52d Congress.

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Information on the Chemical Industry Developed by Antitrust Cases

HALDOR R. MOHAT

Antitrust Division, Department of Justice, Washington, D. C.

The kinds of information regarding the chemical industry developed in the course of investigations, trials, consent decrees, the obtaining of judgments, and the arrangement of relief in connection with antitrust cases brought by the Antitrust Division of the Department of Justice are outlined. What part of this information is available to the public, how access to it may be obtained, and the limitations on its availability and use are discussed. A list of some major chemical antitrust cases, indicating the type of case, the date when brought, the products involved, and the disposition or present status is presented.

How antitrust cases may originate; how they are developed, the pertinent pretrial and trial procedures of the court, the prosecution, and the defendants; how consent decrees are sometimes negotiated; and the process of the arrangement of relief where granted, are outlined in the first part of this paper.

Operation of Antitrust Division

How Antitrust Cases Originate. Antitrust cases usually originate as a result of complaints received by the Antitrust Division, surveys made by the division on its own initiative, the existence of conditions, discovered by the Federal Trade Commission, which fall within the province of the Antitrust Division, and complaints or conditions called to the division's attention by Congress or brought to light by hearings before Congressional committees. Any case may result from an accumulation of grievances, flowing from one, several, or even all of these various sources over a period of time, making action by the division necessary.

Complaints. A great many complaints regarding practices or conditions believed to violate the antitrust laws come to the Antitrust Division directly from a section of an industry concerned, from consumers, wholesalers or jobbers, retailers, and other groups or individuals. These complaints, which are treated as confidential by the division, are investigated in order to determine whether the conditions complained of really exist and, if found to be a fact, whether they constitute an offense falling within the jurisdiction of the antitrust laws and thus make prosecution mandatory, with the object of convicting guilty parties and obtaining economic and legal relief. In the course of checking complaints, complainants often volunteer important information concerning the industry and its operations, or they may be called upon to do so by the division. The same is true of those who are accused; frequently, they are asked to explain certain things or to furnish information bearing upon the conditions or practices about which complaint has been made.

Antitrust Division Surveys. Antitrust violations involve economic problems as well as legal questions, therefore, the Antitrust Division has been devoting more time to surveying the national economy for symptoms or conditions likely to contribute to antitrust violations. In this connection the division attempts to keep a running check on such developments as increasing concentration, particularly in industries already dominated to a substantial degree by a relatively few large companies; the building up of power or control through major accumulations of patents; market behavior that "smacks" of artificial price influences; and parallel action by competitors under suspicious circumstances.

FEDERAL TRADE COMMISSION INVESTIGATIONS. Although the specialized work and duties of the Federal Trade Commission and the Antitrust Division tend to cover different aspects of the monopoly and trade-restraint fields, there is a certain amount of overlapping in their investigations, with the result that each agency at times discovers situations which are within the other's province and are therefore relinquished to the other agency for more appropriate handling. In this way the Antitrust Division sometimes obtains useful information from the Federal Trade Commission regarding a given branch of industry, such as its organization, the companies in it, trade and marketing practices, and complaints relative to alleged violations of the antitrust laws.

CONGRESSIONAL COMMITTEE HEARINGS. Regular or special Congressional committees frequently investigate certain industries, conditions, or practices in such a manner as to bring out much information significant in antitrust enforcement. Sometimes the Congressional committees call upon the Antitrust Division to aid them or to work with them in conducting hearings and otherwise developing information. The Congressional committees may also call upon other departments or bureaus of the government to assist them in developing basic information needed, and these data then become public information, or at least available for the use of other governmental agencies. The studies and reports of the Temporary National Economic Committee are good examples on a large scale of the type of information with antitrust implications that Congressional committees may develop.

Preliminary Investigations. During the preliminary stages of antitrust investigations (including the period of checking of complaints, obtaining the basic background information on the industry and the companies directly involved, and learning the business methods and practices), the Antitrust Division has to depend primarily upon public sources of information plus the voluntary cooperation of the members of the industry.

PUBLIC SOURCES. Sources of information freely available to the public include trade journals, certain types of magazines which frequently publish detailed descriptions of important industries or companies, books and monographs on industrial and commercial subjects, reports of hearings before Congressional committees, transcripts of the records of previous trials involving the same industries or companies, proceedings before the Federal Trade Commission, and publications of other governmental agencies, such as the Department of Commerce, and the Department of Agriculture.

In connection with information available from governmental agencies, there are definite limitations on the kinds of information which can be made available to the public and other agencies. As an example, the Bureau of the Census is prohibited by legislation from disclosing information regarding the production or sales of any individual company. Totals for the particular branch of industry or for a particular geographical area, such as a state, are, of course, available to the public, provided the company set up in the industry or the geographical area is not such that even the total might disclose some information regarding the individual company or companies involved.

INDUSTRY SOURCES. The Antitrust Division often obtains factual data directly from the industry involved on a voluntary basis. In such instances the information may come from complainants in the industry as producers adversely affected by the conditions or practices objected to, from distributors of the products of the industry, the consumers of these products, or others who feel that all is not right with that particular branch of industry. In many cases the companies under investigation voluntarily furnish a great deal of pertinent information at the request of the division.

Grand Jury Proceedings. When the information obtainable from public sources and through voluntary industrial channels is sufficient to indicate that criminal action is warranted, a grand jury proceeding may be instituted in order to investigate conditions more thoroughly.

The status of the information developed by a grand jury proceeding varies according to the procedure and with the nature of the information; documents may be released and returned to those furnishing them after they have served the purposes of the grand jury or they may be impounded by the court.

Filing of Complaints or Informations. A formal antitrust suit may be launched either through a grand jury indictment or by the filing of a formal document known as an "information" or a "complaint." Indictments and informations pertain to criminal cases, while complaints are used in civil cases.

In a representative information or complaint, the general information set forth is ordinarily organized under the following sections: jurisdiction and venue, description of the defendants, nature of the trade and commerce involved, violations of law charged, effects of the violations of law, and prayer for relief, if the case is a civil one.

Defendants' Answers to Government's Charges. In civil cases the defendants file an answer to the charges with the court. This answer may be brief or it may be lengthy, depending partly upon the nature of the charges to be met and partly upon the character of the defense planned. Ordinarily, such a document can be thought of as comprising three main parts—denials and admissions of the charges, or neither position due to alleged lack of knowledge necessary to state a belief one way or the other; affirmative defense; and prayer for a dismissal of the action by the court.

Pretrial Proceedings Before the Court. Under modern rules governing trials, particularly long and complicated ones, certain pretrial proceedings aimed at simplifying the trial are frequently utilized. These will be discussed.

BILLS OF PARTICULARS. The filing of a request for a court order for a bill of particulars is most commonly used by defendants to force the government to detail or otherwise clarify the charges made against the defendants before the trial proceeds or fairly early in the course of the trial.

PRETRIAL CONFERENCES. The court may, particularly in civil cases, direct the attorneys for the parties concerned to appear before it for pretrial conferences to consider simplification of the issues, the desirability or necessity of amending the pleadings, the possibility of avoiding unnecessary proof by obtaining admissions of fact and of the authenticity of documents, limitation of the number of expert witnesses, and any other matters. In civil cases, the court then issues an order which recites the action taken at the pretrial conferences and limits the issues for trial to those not thereby disposed of and which thus control the subsequent course of the action, unless later modified by the court to prevent mainfest injustice.

STIPULATIONS. The attorneys for the prosecution and the defendants in an action may agree as to the correctness or authenticity of certain documents or other sets of facts and, when approved by the court, this information may then become a part of the evidence. Such agreements are usually known as stipulations and are not necessarily limited to the pretrial phases of an action but may be agreed upon at most any stage of the trial.

DEPOSITIONS. By permission of the court after jurisdiction has been obtained over any defendant in a civil case, or without such permission after an answer has been served, the testimony of any person, whether a party to the action or not, may be taken at the instance of any party by deposition upon oral examination or written interrogatories for the purpose of discovery, or for use as evidence in the action, or for both purposes.

ADMISSIONS. At any time after the pleadings are closed in a civil case, one party may serve upon any other party a written request for the admission, by the latter, of the genuineness of any relevant documents described in and exhibited with the request, or of any relevant matters of fact therein set forth. An admission made by a party in response to such a request is solely for the purpose of the pending action, does not constitute an admission for any other purpose, and cannot be used against the respondent in any other proceeding without his permission.

INTERROGATORIES. In civil cases, one party may serve written interrogatories upon any adverse party to be answered by the latter or, if the party served is a public or private corporation, a partnership, or an association, by any officer thereof, competent to testify in its behalf. Objections to interrogatories served may, of course, be made to the court, with notice as in the case of a motion, and answers are then deferred until the objections are determined. Interrogatories are used quite extensively in antitrust cases and are frequently one of the main sources of information developed during the case.

SUBPOENAS DUCES TECUM. The clerk of the court may, upon the request of one of the parties and under the seal of the court, issue a subpoena commanding persons to attend and give testimony or to produce the books, papers, or other documents designed therein. The court, however, may, upon proper motion by the party served, squash the subpoena if it is unreasonable or unduly oppressive, or condition or modify its effect. Subpoenas constitute one of the principal instruments of the government in the prosecution of criminal antitrust cases. They are usually served prior to the start of the trial or very early therein, in order to allow the respondents ample time to comply.

PRODUCTION FOR INSPECTION. Upon motion of one of the parties showing good cause and with notice to all other parties to the action, the court may order any party to produce and permit the inspection and copying or photographing, by or on behalf of the requesting party, of any designated documents, papers, books, accounts, letters, etc., not privileged, which constitute evidentiary material to any matter involved in the action and which are in the possession, custody, or control of the party ordered to produce them. Such orders are commonly used in obtaining needed information in civil antitrust cases.

Trial of Antitrust Cases. The opening statements of a trial customarily outline the prosecution's theory of the case against the defendants, developed in detail, and the defense's detailed denials and answers to the prosecution's charges. Following completion of the opening statements, the government proceeds with the presentation of its side of the case. The evidence relied upon to establish the charges made usually falls under two main categories: (1) documentary evidence including such materials as correspondence and telegrams, contracts, minutes of corporate or association meetings, accounting books and records, etc., obtained through voluntary action or by subpoena from the defendants; and (2) testimony of witnesses, including those persons known to have relevant first-hand knowledge of matters at issue, those acquainted with, responsible for, or having custody of important documents or records, and, in some instances, expert witnesses. Accountants, economists, or statisticians are frequently used as expert witnesses in introducing or analyzing books, records, and basic statistics of the industry, for the purpose of pointing up or summarizing pertinent information or evidence.

The outline of the defense evidence is rather definitely determined by the theory and presentation of the government's side of the case—that is, the primary task of the defense counsel is to refute or modify the evidence presented by the government in support of its theory of the case. In attempting to do so, the defense ordinarily has to resort to much the same general types of evidence—documentary, oral, and expert—that is used by the prosecution.

At the close of the defense, the prosecution may produce a limited amount of evidence bearing upon any point raised and presented in the trial by the defense, but may not introduce any new issue into the action or present any evidence which should have been part of the presentation of its main case during this rebuttal.

In much the same manner as the opening statements outlined the evidence that each side would present and explained what each side expected to prove, the closing arguments summarize and highlight the evidence presented, and set forth what each side claims to have actually proved thereby, during the progress of the trial.

Upon completion of the closing arguments, the verdict of the jury, or the finding of the court in actions tried without a jury, is rendered, and the court then directs the entry of what it believes to be the appropriate judgment under the law.

In criminal cases, defendants may decide not to contest the case, while at the same time not admitting their guilt. This is effected by their entering a plea of *nolo contendere*. Thereupon the court usually levies fines in antitrust cases.

Judgments: Punishment and Relief. Judgments as a result of trial and conviction primarily involve punitive measures if the action is a criminal case, and relief measures designed to remedy the conditions complained of if the action is a civil one. Punitive judgments in antitrust cases ordinarily involve the levying of fines upon the defendants. Judgments in civil cases ordinarily result in some injunctive form of relief prohibiting the defendants from continuing the practices complained about or ordering them to take certain positive steps to correct the illegal conditions found to exist. In some cases, particularly in instances of monopolization, these steps may involve the divestiture of certain plants or other properties by the defendants or even the dissolution of large defendant corporations into a number of smaller firms in order to break up a monopoly and induce increased competition. Obviously, these latter types of positive action require an exceedingly careful examination of the industry and its members; to work out a satisfactory and practical readjustment these examinations naturally bring out much interesting information regarding the particular branch of industry and the companies involved.

Consent decrees are negotiated between the prosecution and the defendants with the approval of the court, rather than by trial. In negotiating consent decrees, considerable factual information regarding the industry and the defendant companies is usually furnished to the Judgment and Judgment Enforcement Section of the Antitrust Division by the defendants. Sometimes this information is submitted with the understanding that it is not to be made public but is solely for the use of the government and the court for the purpose of formulating the decree. This is particularly true of data regarding the operations of individual defendant companies.

Once a satisfactory decree has been negotiated, it is reviewed by the court and, if approved, it becomes a formal decree binding the defendants party to it.

Type and Availability of Information Developed

Nature of Information. The kinds of information likely to be pulled together by the Antitrust Division in the preliminary investigation, trial, and completion of an antitrust action are outlined.

- Background information
  - Present organization of the industry
    - Companies in it and their descriptions
    - How the business is carried on—methods, business customs, and practices
    - Raw materials
    - Degree of integration
    - Systems of distribution
    - Financing
    - Relation to other industries
  - Historical development of the industry and companies
    - Trends in the industry
    - General history of the development of each important company
- Detailed information regarding recent operations in the industry
  - Relative size and power of member companies
    - Assets
    - Production (absolute and as a percentage of the industry total)
    - Sales or shipments
    - Patent resources and control
    - Manufacturing processes

Control over the distributive flow of products
Relative efficiency and costs
Any other factors indicative of importance or power
Price data
Price trends
Comparative prices as between companies
General price behavior (rigidity or flexibility, uniformity, the timing of changes, etc.)
History of income and profits
How have consumers fared?
Pricewise
As to quality
Service factors

Naturally, the information developed will vary widely in nature and amount from case to case; the outline must be applied to any given case merely as a suggestive check list.

Availability of Antitrust Information. The location of the information developed as a result of antitrust cases varies according to the type of information. Copies of complaints, informations, briefs, and similar documents are in the custody of the Legal Procedures Unit of the Antitrust Division, Washington, D. C., while economic and statistical data will be found mainly in the files of the Economic Section or of the General Records Section. The Antitrust Library may also have duplicate copies of many of the printed documents but not of the statistical material unless it has been printed or mimeographed as part of a proceeding record.

The court of trial also has a complete set of records of the evidence admitted in any given case, as well as all the legal documents pertaining to the action, and this information, being in the public domain, may be available upon proper request to the clerk of the court, unless by legal agreement it has been made subject to restrictions as explained elsewhere.

To obtain access to information in the Antitrust Division, inquiry should be made of the Legislation and Clearance Section of the Division, either by letter or by personal application. As a rule, the latter method is much more satisfactory.

There are some very definite limitations on the availability of certain antitrust information to the public. The division cannot disclose the identity of or information about any complainant. Likewise, it cannot make public any information it may use in an antitrust action until that information has been admitted to the public record of the trial. Even then, the court may keep such information secret by admitting it under seal. In much the same manner, certain confidential information necessary to the division in negotiating consent decrees may be supplied by each of the companies involved with the understanding that it will be seen and used only by the consent-decree personnel of the division, and later returned to the company or companies involved. Information furnished the division on a voluntary basis during the preliminary stages of an antitrust investigation or case may also be held on a confidential basis under some circumstances.

In some instances, supervision of records which include confidential information can become a decided burden on the limited staff of the Antitrust Division, due to the difficulty of segregating and protecting the confidential material while still granting access to the unrestricted portions of the records.

Another limitation in many instances is the limited number of copies of documents, such as transcript records of trials, complaints, informations, briefs, tabulations, and charts, available. Quite often access to such documents may be limited to inspection, in the division offices, of its file copies.

Antitrust Cases Involving Chemical Industries. Table I is a condensation of a list of cases brought by the Antitrust Division in the chemical industries, compiled from the following sources: (1) the "Blue Book" (*1*), the publication formally entitled, "The Federal Antitrust Laws, With Summary of Cases Instituted by the

United States," which summarizes each of the cases brought prior to July 1, 1948; (2) the Supplement to the "Blue Book," mimeographed by the Department of Justice, and covering cases instituted during the period July 1, 1948, through June 30, 1951, in the same summary fashion; and (3) the files of the Legal Procedure Unit of the Antitrust Division, Department of Justice, from which information regarding very recent cases has been compiled.

Table I. Antitrust Cases Brought by the Department of Justice in the Chemical Industries

	Identification[a]	Date Filed	Status
Acrylic plastics	D. C., N. J. Cr. 878-C	8-10-42	Not guilty
Alkalis	S. D., N. Y. Civ. 24-462	3-16-44	Judgement
Borates, borax, etc.	N. D., Cal. Civ. 23690-G	9-14-44	Consent[b]
Borates, borax, etc.	N. D., Cal. Cr. 28900-S	9-14-44	Nolo[c]
Bichromates, Na and K	N. D., Ind. Cr. 1270	6-26-42	Nolo
Chromic acid	N. D., Ind. Cr. 1266	6-26-42	Nolo
Carbon dioxide	E. D., N. Y. Civ. 9179	6-24-48	Pending
Chemicals, paints, ethyl, etc	N. D., Ill. Civ. 493-1071	6-30-49	Awaiting trial
Chemical rust-proofing, etc.	E. D., Mich. Civ. 3653	2- 1-43	Judgement
Chemical or pharmaceutical products	D. C., N. J. Civ. 3159	10-28-43	Consent
Chemical products, ammunition	S. D., N. J. Civ. 24-13	1- 6-44	Opinion
Chlorine compounds, etc.	D. C., R. I. Cr. 6070	5- 1-47	Nolo
Concrete curing solutions	S. D., Cal. Cr. 21729	3-28-51	Nolo
Dyestuffs, etc.	S. D., N. Y. Cr. 111-135	12-19-41	Trial, 1952
Dyestuffs	D. C., N. J. Cr. 753-C	5-14-42	Nolo
Formic acid	N. D., Ind. Cr. 1268	6-26-42	Nolo
Luxene 44 (dentures)	S. D., N. Y. Civ. 66124	4-27-51	Awaiting trial
Laminates (plastic)	E. D., Pa. Cr. 14607	4-20-48	Nolo
Methanol, wood	S. D., N. Y. Civ. 27-145	8-29-44	Consent
Methanol, wood	S. D., N. Y. Cr. 117-66	4- 5-44	Nolo
Methyl methacrylate	D. C., N. J. Cr. 877-C	8-10-42	Dismissed
Muriatic acid	N. D., Ind. Cr. 1269	6-26-42	Nolo
Oxalic acid	N. D., Ind. Cr. 1267	6-26-42	Nolo
Plastic materials	E. D., Pa. Civ. 9068	11-18-48	Consent
Phenolic resins	D. C., N. J. Civ. 7742	4- 2-46	Dismissed
Phenolic resins	D. C., N. J. Civ. 7743	4- 2-46	Dismissed
Soda ash	D. C., Kan. Civ. 2046	6-24-42	Consent
Sulfuric acid	N. D., Ind. Cr. 1265	6-26-42	Nolo
Titanium compounds	S. D., N. Y. Cr. 114-455	6-28-43	Nolo
Titanium compounds	S. D., N. Y. Civ. 26-258	6-24-44	Judgement

[a] D. C., district court; S. D., southern district; N. D., northern district; E. D., eastern district of states; civ., civil case and number in court; cr., criminal case and number.
[b] Consent decree, about the same as a judgement—no admission of guilt and settlement is negotiated.
[c] Nolo contendere—not contested.

The "Blue Book" consists of two parts; Part I sets forth the several statutes pertaining to the antitrust laws; Part II presents in chronological order a summary of all cases which have been instituted by the Department of Justice under those laws from 1890 to the closing date of the particular edition of the "Blue Book." Each summary contains a statement of the charges made in the case, the result of court proceedings, and the status of pending cases. The cases are comprehensively indexed both by case name and by subject matter.

The first edition of the "Blue Book" was published in 1947. A later edition bears the date January 15, 1949 (*1*). A new edition covering the period 1890 to 1951 is now available.

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Basic Science in the Literature of Plastics

H. F. MARK, *Brooklyn Polytechnic Institute, Brooklyn 2, N. Y.*

E. S. PROSKAUER, *Interscience Publishers, Inc., New York 1, N. Y.*

Basic science in the general field of macromolecules includes the principles of their synthesis, the investigation of the size and structure of individual molecules in solution, and the relationship between structure and properties in the bulk phase. Approximately 450 scientists in 90 laboratories all over the world devote the major portion of their time to basic science in the subject field. The results of their work are published in about 150 technical journals which include literature on plastics. Reviewing the literature at present is difficult. The author suggests services which include a weekly news letter, monthly journal for papers, semiannual journal for review articles, and formula and data sheets in addition to regularly appearing monographs, textbooks, and handbooks.

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Considering basic science in the general field of plastics there are essentially three divisions—synthesis, molecular structure, and structure and properties of bulk polymers.

Definition of the Field

Synthesis of macromolecules which are of interest and importance for the production of plastics comprises mainly the mechanism of polymerization and polycondensation, the use of various techniques such as polymerization in bulk solution, suspension, emulsion, in the gas phase, in the gel phase, and on interfaces. It also includes the application of different types of catalysts, initiators, activators, promotors, modifiers, retarders, and inhibitors; and the phenomena of copolymerization including "graft" and "block" copolymerization and second-stage cross linking. It comprises studies on the degradation of macromolecules by heat, light, chemical reagents, mechanical action, and micro-organisms and the fundamental aspects of the methods of counteracting these deteriorating influences.

Molecular structures of macromolecules are revealed by experiments carried out in the dissolved state. A large class of contributions of this kind deals with the elucidation of details in the molecular structure by organic chemical methods, such as the establishment of head-to-tail or head-to-head, tail-to-tail sequence, cis-trans isomerism of double bonds in the chain, existence and structure of cyclic systems, analytical determinations of end groups, and the study of the chemical composition of copolymers. Another equally large and significant group of studies is concerned with the physicochemical behavior of macromolecules in solution, their molecular weight, molecular weight distribution, solubility, fractional precipitation and specific intermolecular aggregation in certain solvents as elucidated by the measurements of osmotic pressure, light scattering, sedimentation, diffusion, and electrophoresis. It also comprises the phenomena of viscosity and flow birefringence in solutions of macromolecules and their evaluation in terms of structural details of the solute.

Investigation of the structure and properties of polymers in the bulk phase includes many important papers describing the use of x-ray and electron diffraction, ultraviolet and infrared absorption, and microwave spectroscopy to establish the degree of crystallinity and the orientation of the crystalline domains in a given sample as the consequence of mechanical deformation such as stretching, rolling, or extruding. Other articles deal with the rheology of polymer melts or of concentrated macromolecular solutions; again others focus their attention on the mechanical, electrical, and optical properties of plastics dependent on the molecular structure, the temperature, and the presence of auxiliary materials such as softeners, plasticizers, antistatic agents, and reinforcing fillers. Phenomena such as adhesion, cohesion, plasticity, brittleness, abrasion resistance, electrical resistivity, and optical refractivity belong to this group and are of considerable importance for practical problems in plastics application.

All publications containing information of these types fall into the subject field of literature on the basic science of plastics if they deal with macromolecules important for the synthesis of plastics or if they describe methods which could be applied to such materials. Evidently a new method of measuring molecular weight or of fractionating a macromolecular system is of interest even if it has not been applied to technologically useful material. Papers which contain only qualitative or general remarks connected with fundamental work on macromolecules have been omitted but, in general, in case of doubt, borderline publications have been included because it was felt that it would be a smaller mistake to have a few articles of lesser significance included than to have something really important missing.

Origin of Information

All experimental methods and data, all compilations and correlations, and all theoretical interpretations emerge from a number of laboratories in which scientists devote their efforts to work on basic science in the general field of macromolecules. The Commission on Macromolecules of the International Union of Pure and Applied Chemistry is just now completing a world-wide survey of such laboratories as to their location, number of scientific and technical workers, equipment, field of special interests, and yearly scientific output. The tables in this paper are part of this survey, which will be presented in full at the meeting of the International Union in July 1953, in Stockholm.

Table I. Laboratories Engaged in Basic Work on Macromolecules

	No. of Laboratories	No. of Workers		No. of Laboratories	No. of Workers
Australia	2	10	Italy	2	10
Austria	3	10	Japan	3	10
Belgium	3	15	Netherlands	5	20
Canada	4	20	Russia	..	..
England	12	60	Scandinavia	6	20
France	4	20	Slavic Countries	..	..
Germany	8	60	South America	2	5
Hungary	..	..	Spain	1	5
India	3	10	Switzerland	5	20
Israel	1	5	United States	25	150

It appears that about 90 laboratories with a total of 450 scientists are devoting the major part of their time to expanding the knowledge in the field of basic science of macromolecules. Table I lists the number of laboratories and number of workers in each laboratory according to geographic distribution. Lack of information made it impossible to fill in definitive data for Hungary, Russia, and the Slavic countries (Czechoslovakia, Poland, Romania, and Yugoslavia) but it is fair to assume that there are about 10 to 15 laboratories in these countries. In order to show how the number of workers who spend essentially all of their time in the subject field was estimated, Table II is added, which contains the estimated number of workers in a few well-known laboratories that for many years have been making regular contributions to fundamental research in the plastics field. Of course, the total number of scientific and technical employees in these organizations is much larger than the figure given in Table II, but most of them work either preponderantly on practical problems or on basic science not directly connected with the preparation, properties, and application of plastic materials. It is probably fair to estimate that 80 to 85% of all new results and ideas on basic science in the plastics field emerge from the laboratories listed in Table I. There are, of course, outsiders who do not work in direct connection with any of them and who contribute significant new material, but their number and location vary too much to be assessed in a reliable way in this preliminary survey.

Quantity and Distribution of Information

As soon as work on a certain problem in the laboratories has reached a sufficiently advanced stage, the authors will want to make their results known. The first step is to present a paper at one of the many scientific meetings, which are held in a more or less regular manner all over the world. It appears that more than 80% of all new facts and ideas are first presented orally and only later appear as printed papers. For anyone who is interested in current developments, a quick and regular report on the events at the scientific meetings will be of special interest. A survey on the number, character, and size of congresses in the various countries led to Table III, which contains the number of large

Table II. Some Important Laboratories with Number of Workers in Macromolecule Field

National Bureau of Standards, Washington, D. C.	8
Harvard University, Cambridge, Mass.	5
Du Pont Experimental Station, Wilmington, Del.	12
Dow Chemical Co., Midland, Mich.	5
University of Manchester, England	6
Research Laboratory of the ICI, Welwyn Garden City, England	4
University of Strasbourg, France	5
University of Freiburg, Germany	4
Research Laboratory of the BASF, Ludwigshafen, Germany	7
University of Basel, Switzerland	4

scientific meetings held in the specified area at which papers on fundamental research in the polymer field were presented and discussed, together with the number of these papers and an estimated figure on total average attendance. In the case of the 122nd meeting of the AMERICAN CHEMICAL SOCIETY it was evident that such a large congress could not be counted as a single event. Considering the program of the various divisions, it was felt that this meeting was equivalent to six separate conferences presenting new information in the subject field because the Divisions of Cellulose Chemistry, Colloid Chemistry, Organic Chemistry, Paint, Varnish and Plastics Chemistry, Physical and Inorganic Chemistry, and Polymer Chemistry each had a number of papers contributing to basic science in the subject field. The number of these papers was about 100, and the total number of chemists who attended the sessions was probably 2500 to 3000. Comparing the total number of papers presented in 1951 (1200 to 1300) with the total number of scientists working in the field (450 to 500), it was concluded that, on the average, each producing worker reports between two and three times a year on the results of his investigations. This is a proportion which seems to agree well with the actual conditions.

Table III. Conferences and Meetings

(Above 100 attendants)

	Western Hemisphere			Europe, Asia, and Australia		
	1949	1950	1951	1949	1950	1951
Meetings	40	50	60	...	32	35
Papers presented	400	450	650	...	400	600
Chemists attending	8000	10,000	15,000	...	4000	6000

The next step in the dissemination of new results is to publish them in one of the technical journals which regularly carry articles in the general field of macromolecules. Table IV gives the number of such journals published in the various countries; their

Table IV. Journals, Published in Various Countries, Containing Papers in the General Field of Macromolecules

	Papers Appear			Papers Appear	
	Regularly	Two or more in each issue		Regularly	Two or more in each issue
Australia	3	0	Italy	5	2
Austria	6	2	Japan	4	2
Belgium	4	2	Netherlands	4	2
Canada	4	1	Russia	6	4
England	11	6	Scandinavia	10	2
France	6	3	Slavic Countries	8	0
Germany	18	7	South America	5	0
Hungary	2	0	Spain	2	0
India	4	0	Switzerland	4	1
Israel	2	1	United States	35	10
			Total	143	45

total is about 150. This is a very large number to review, and it is therefore important to determine how much useful material the individual journals carry. Therefore essential journals—those which publish in every issue at least two articles containing new information on basic science in the polymer field—were selected. The numbers of these journals with originating countries is listed in Table IV. A list of the essential journals is given in Table V, and a list of lesser known journals occasionally containing scientific articles on plastics is presented in Table VI. Table VII shows the total number of publications on fundamental research in the plastics field for the past three years, specified as original articles, review articles, and comprehensive books. The number approaches 1000 per year, which indicates that every active worker in the field publishes, on the average, about two papers per year.

Services to Facilitate Literature Reviewing

In considering an adequate way to reach the existing information, one might propose the following set of services:

News Letter, a weekly, containing, in condensed form, the announcement of new work done and new results obtained. The individual items of this advanced information service should not be longer than four or five lines and should essentially cover all

Table V. Selection of Journals Containing Two or More Papers on Macromolecules in Each Issue

England
- *Chemistry and Industry*
- *Journal of the Chemical Society (London)*
- *Journal of the Textile Institute*
- *Nature*
- *Proceedings of the Royal Society (London)*
- *Transactions of the Faraday Society (London)*

France
- *Annales de chimie (Paris)*
- *Bulletin de la société chimique de France*
- *Comptes rendus hebdomadaires des séances de l'academie des sciences*

German
- *Angewandte Chemie*
- *Annalen der Chemie, Justus Liebigs*
- *Chemische Berichte (Berichte der deutschen chemischen Gesellschaft)*
- *Makromolekulare Chemie*
- *Zeitschrift für Elektrochemie und angewandte physikalische Chemie*
- *Zeitschrift für Naturforschung*
- *Zeitschrift für physikalische Chemie*

Russia
- *Doklady Akad. Nauk S.S.S.R.*
- *Isvest. Akad. Nauk S.S.S.R.*
- *Journal of Applied Chemistry (U.S.S.R.) (Zhurnal Prikladnoĭ Khimii)*
- *Journal of General Chemistry (U.S.S.R.) (Zhurnal Obshcheĭ Khimii)*

United States
- *Industrial and Engineering Chemistry*
- *Journal of the American Chemical Society*
- *Journal of Applied Physics*
- *Journal of Chemical Physics*
- *Journal of Colloid Science*
- *Journal of Physical Chemistry*
- *Journal of Polymer Science*
- *Science*
- *Tappi*
- *Textile Research Journal*

lectures given at scientific meetings immediately after they have been delivered, and letters to the editors of the essential journals when they deal with basic science in the plastics field. According to Table III about 1200 individual news items will be available per year; therefore about 25 items will appear in each weekly issue of the news letter. With an average length of five lines for each item, it follows that the news will consists of four pages per issue and can therefore be distributed easily and conveniently scanned even by very busy people. Information services of this type are common in technical and industrial fields. *Chemical and Engineering News* carries many

Table VI. Lesser Known Journals Containing Papers on Plastics

Australian Journal of Applied Science	*Metallurgia*
Bulletin of the Research Council of Israel	*Physica*
Busseiron Kenkyu	*Svensk Kemisk Tidskrift*
Gazetta chimica italiana	*Zeitschrift für analytische Chemie*
Materials & Methods	*Zhurnal Fizicheskoi Khimii*

announcements of this character for the entire field of chemistry, whereas *Rayon Organon and Natural Rubber News* cover the more specialized fields of production, consumption, and technical progress in rayon and natural rubber. The news service proposed here would be focused exclusively on fundamental research in the polymer field. In order to illustrate the type of condensed information which this service should offer a few sample items on lectures and on articles which appeared in the spring of 1952 are presented. These appeared in lesser known journals, so they could be considered as being difficultly available information.

R. S. Rivlin and D. W. Saunders, British Rubber Prod. Res. Ass.; *Trans. Faraday Soc.*, **48**, 200 (1952). Free energy of deformation for cured rubbers. Load-deformation data on vulcanization covering a wide range of hardness are reported. The mean segment lengths as determined from swelling can be correlated with the deformation data.

C. Pinte, P. Rochas, and J. Henno, Centre Rech. Ind. Text., *Bull. inst. textile France*, **30**, 141 (1952). Influence of stretching on the structure of swollen cellulose xanthate gels. X-ray diffraction and swelling measurements are used to study the molecular structure of cellulose fibers at different degrees of stretching.

B. G. Ranby, Inst. Phys. Chem., Univ. Uppsala, *Arkiv Kemi*, **4**, 241 (1952). Fine structure and reactions of native cellulose. Electron microscope study of morphology of celluloses from wood, cotton, bacteria, tunicates, and algae; behavior of samples on swelling in sodium hydroxide and hydrolytic degradation.

E. Treiber, G. Porod, and W. Lang, University Graz, Austria, *Osterr. Chem. Ztg.*, **53**, 162 (1952). On the existence of orthoxanthates. Spectroscopic, ebullioscopic, and analytical data on isopropylxanthate indicate that there exists no ortho form of the xanthates of this alcohol. It is concluded that the less stable xanthates of cellulose cannot be explained by ortho-xanthate formation.

Standard Journal, appearing semimonthly and containing original articles, short notes, and letters to the editor. With 500 papers per year such a journal could take care of about 50% of all articles and would represent a considerable concentration of information. Right now two magazines exist that are exclusively devoted to papers on basic science in the polymer field: the *Journal of Polymer Science* and *Makromolekulare Chemie.* Together they have about 1600 pages per year and contain about 18% of all articles written in the field.

Table VII. Total Number of Publications on Plastics

Type of Publication	1949	1950	1951
Original articles	750	810	890
Review articles	45	51	56
Comprehensive books	14	10	16

Review Magazine, appearing quarterly and containing only review articles. Planning 400 pages per year it could publish 10 review articles in each issue and could take care adequately of the condensation, documentation, and correlation of new results in the subject field. This magazine would be very similar in character to *Chemical Reviews* or *Quarterly Reviews*.

Formulas and Data Sheets, issued yearly, containing all newly established fundamental equations and numerical data on basic properties of polymers. These would include new equations to express viscosity as a function of temperature, concentration, or shear rate; new relations between intrinsic viscosity and molecular weight; new formulas on the kinetics of polymerization and copolymerization; data on second-order transition points of new polymers or copolymers; heat and entropy of solution, dilution, melting, and swelling of macromolecules; and similar fundamental data as they are contained in the articles appearing during the reference year. They would be similar in purpose to the Technical Data Sheets and complement them in regard to fundamental information.

In addition there will be monographs, textbooks, and handbooks written by specialists in the field as the progress in polymer science and the demand for comprehensive documentation and information justify their publication.

The ideal system of information in the subject field presents only two new features, the news letter and the data sheets. They do not exist as yet in the domain of basic science on plastics and would probably assist the individual worker in the field to find existing information and to keep the permanent and significant results of the scientific progress on file.

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Literature Searching for Plastics Engineering

M. H. NICKERSON and K. T. BARKER

DeBell & Richardson, Inc., Hazardville, Conn.

Scanning the journals will acquaint the searcher with those carrying digests of patents and news. Knowing the names of outstanding workers in the field is helpful in locating papers which often contain bibliographies leading to additional information. Maintaining a patent file is helpful. The application of information obtained from literature searching to the design of a plant is described.

The plastics industry today is so fast moving that anyone who wishes to keep abreast must continually scan the literature. This can be likened to a "warming up" process, since it keeps one aware of new developments and the available sources of information even though the memory may not be relied upon to bring back specific details at any given moment. At least when the job of tackling a specific project arises, the fragments of information recalled from the scanning process give one a place to hang one's hat when digging in earnest begins.

The need for scanning, for which little time can usually be allotted from regular duties, seems to be pretty widely recognized in these days of a veritable deluge of literature of all sorts. Many of the better journals or magazines now feature a page or two in which the important events are brought together in brief, concise news items. *Chemical and Engineering News* does this neatly in various departments such as "conCENTrates," and *Industrial and Engineering Chemistry* features "Headlines." *Modern Plastics* presents each month an excellent digest of newly issued patents in the plastics and rubber field, and *Plastics World* also presents highlights of the more recent developments in brief paragraphs. *India Rubber World* and *Plastics News Letter* perform a similar valuable function. There are many other journals doing excellent jobs in this respect, and one is not recommended over the other, but the importance of picking out such sections from favorite technical publications and reading them regularly should be emphasized. With this as a background, literature searches on specific subjects can be less tedious. It is a tremendous help to know who is working on what and what degree of success is being attained. Subject matter is sometimes indexed under a variety of headings, but the publications of a given author can always be found by consulting the author index.

In any fast-moving field of development such as plastics there is frequently a substantial lag between the successful operation of a chemical process and the publication of a description of that process either in the patent literature or in a technical journal. No description of a process can possibly do justice to all the details of design and operation which have to be "sweated out" by the engineers involved. With these two things in mind, the engineer's approach to the literature should be one of assembling all known data for a firm foundation on which to base the new process and plant and to confirm pilot plant results. The new plant must be better than any described in order to be at least as good as any being put into operation. It is most distressing to find that a new plant is obsolete before it gets off the drawing board.

Getting started on a literature search is sometimes the hardest part, and there are a few rules which are useful in breaking the ice. Knowing the names of a few of the outstanding men in the subject field is a great help, since by using indexes to *Chemical Abstracts* their publications can be located quickly. Also, when using the "author" method of search, it becomes unnecessary to wait for the annual subject index of the current volume to be published, since each issue of *Chemical Abstracts* contains an author index. *Chemical Abstracts* lists as authors for patents the names of the companies to which the patent is assigned, so that the patent situation of a company can be easily reviewed. In many fields reviews of past work are published. These are extremely valuable in picking up much essential literature. Most authors, in writing an article for publication, usually give some sort of a review of previous work and furnish references. For this reason it is a good idea, at an early stage, to pick out a few of the articles and read them for the benefit of their bibliography. Often a chain reaction results; each noted reference leads to an article which in turn has other references.

Last, but by no means least, information indexed by subject matter must be examined. This operation is postponed because the above-mentioned procedures can be run through so quickly and are often very productive. Subject searching is used as a sweeping operation to catch references that have been missed. Here a certain amount of imagination and shrewd guessing has to be done since the desired subject matter may be indexed in a variety of ways. For example, a particular piece of process equipment may be perfectly described in an article dealing with a basically similar but subjectively different process. The ideal drier for polyvinyl chloride may have been described most fully in an article on processing of wheat flour. There are no particular rules to follow except those of common sense guided by a general knowledge of the usefulness of certain basic operations.

A general scheme for obtaining specific information from the literature, along with comments on the utility of the various sources, is presented. The literature may be divided rather arbitrarily into two main categories based largely on the sequence in which they are to be examined. Primary sources are those publications which are examined first in order to pick out the highlights and establish a picture of what the proposed development work involves. Secondary sources really provide the fundamental engineering and process data for the detail work. Often primary sources guide the searcher to secondary sources.

Primary Sources

Chemical Abstracts. This should be consulted for a thorough coverage of all the literature.

Patents. Maintaining a complete list of all patents under the various subclass numbers, especially the polymer subclasses of Class 260, with a brief abstract of each patent, is helpful. Periodically this may be brought up to date in the Patent Office search room. When a project in a particular line becomes active, the important patents may be purchased and filed. In this manner a very complete patent file can be built up over a period of time, without excessive expense. The patent literature may be invaluable, not only for pointing out interferences, but also for indicating, in many cases, that there must be a better way. It must also be remembered that a patent is not issued until about two years after the application is made. This lag must be made up from other sources of information, such as consultants.

Government Reports. The Office of Technical Services of the Department of Commerce has reports from the Office of the Publication Board (OPB), British Intelligence Objectives Subcommittee (BIOS), Combined Intelligence Objectives Subcommittee (CIOS), and Field Information Agency, Technical (FIAT). A file and index of these reports form a valuable addition to any research library. Discretion is required in using this information, and it must be realized that there have been many advances since these reports were written. In spite of this, much information of value can be obtained from these sources.

Original Research Reports. This source of information, which includes reports from both the laboratory and consultants, is frequently the most fruitful, since the work done was aimed toward a specific objective. Government bureaus can often furnish good background reports for projects in which they are interested.

Secondary Sources

Engineering Publications. Journals of value are *Chemical Engineering Progress, Transactions of the American Institute of Chemical Engineers, Chemical Engineering,* and *Industrial and Engineering Chemistry.*

Trade Publications. *Modern Plastics, Plastics World, British Plastics, Chemical Week, Chemical and Engineering News,* and *India Rubber World* often contain useful information.

These represent some of the principal sources of engineering information, and all are good, at various times. It is not possible to rank these journals in order of desirability or utility, since at any time any one of them may have part or all of the information sought, or none.

One very valuable source of information lies in the advertisements in the magazines. Scanning is recommended in order to pick up this type of information. One must screen a fairly large tonnage in order to separate out a few gems, but the results usually justify the effort.

Handbooks and Indexes. Handbooks of value are listed in the bibliography (*8, 12, 13, 15*). The "Industrial Arts Index" (*9*) and the "Engineering Index" (*7*) may also prove to be of value.

Manufacturer's Literature. Frequently considerable information can be obtained from this source, particularly on applications and properties of materials. Information of this type also is helpful in rounding out a complete picture of a process or industry. Much of the output of such literature is of no utility, and is consigned to the circular file after a cursory reading.

Business Directories and Catalog Collections. These sources have their principal value rather late in the picture. Very little technical information is obtainable from such publications. However, directories such as Thomas Register, Chemical Engineering Catalog, and the Refinery Catalog (*3, 19, 20*) are invaluable as timesavers when the time comes to execute a project. One can readily locate the companies who supply the equipment desired, by reference to such directories. It pays also to maintain a complete and up-to-date-catalog file to supplement the condensed information given in the catalog collections.

Application to Plant Design

The use of this mass of literature may be illustrated best by a specific example. A plant for the polymerization of vinyl chloride was selected because there is much published information available, and no confidences will be betrayed in presenting such a case. In planning the literature search the process should be broken down into its basic steps, and a certain amount of time allocated for each of these steps. It is rare that a complete description of a chemical operation from start to finish will be found, but a good engineer will often take the best features of a variety of different operations and put them together to make a well-integrated plant.

Flowsheet. In accordance with good practice, a flowsheet must be made. This is of particular value in demonstrating to the board of directors that a great deal has been accomplished on the project. Here the following sources would be consulted. Government reports will indicate how the German plants operated. This will show two methods: the emulsion polymerization and the suspension polymerization. Most of the information available is for emulsion polymerization, which is usually the least desirable. This fills out the background and provides a starting point. *Chemical Abstracts,* original journals, and patents are sources of information which will enable the engineer to fill in the suspension polymerization picture up to the present time (remember to allow a 2-year lag in patent information). Very little concrete information will be obtained from this search, but bits and pieces of the puzzle will begin to fall in place. By

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the time this information has been digested, it should be possible to construct a very attractive pictorial flowsheet.

Material Balance. The next step is the material balance. Here it is necessary to specify the end use of the product. If it is to be electrical, that automatically fixes the catalyst which can be used. The Sales Department's prognostication as to the demand for the product will fix the over-all production. (It is wise for the engineer to get this in writing.) At this point, some laboratory work should be done in order to determine a satisfactory formulation. In this particular case, suspension polymerization of vinyl chloride is rather simple, if the correct formulation is used, so the time consumed need not be great. It will now be possible to settle on a material balance.

Economic Evaluation. Contrary to the belief of some business men, it is necessary to go through at least the two preceding steps before making a complete economic evaluation of the process, including a construction cost estimate accurate to $\pm$ 10%. It should now be possible, however, to rough out the economics of the process, provided the engineer has imagination, and some knowledge of the cost of comparable plants. If it is assumed that the economic hurdle has been taken, the next job is to design the plant. From this point on, the primary literature wanes in importance, and the secondary sources wax.

Process. The process is examined from the unit standpoint, to give a breakdown something as follows: storage of raw materials, polymerization, graining, separation and washing, drying and size classification, and packaging. Later these may be split into subgroups, and some steps may be eliminated—i.e., graining, which depends on the method of polymerization. The literature which may be consulted during this stage of writing out design sheets and specifications, consists primarily of handbooks, manufacturer's catalogs, and tables of corrosion-resistant materials.

Design. The mechanical design of the various kettles, tanks, and other equipment is usually carried out with reference to the American Petroleum Institute and American Society of Mechanical Engineers codes, local ordinances, and fire insurance company recommendations.

Design Book. The final step, which leads to operation of the plant, requires compilation of a digest of all of the preceding information in a design book, so that the start-up and operating personnel will have at their finger tips all the accumulated knowledge culled from the many sources.

If the literature searching and pilot experimentation have been conscientious, and if a large measure of common sense has been employed in using it in the design, there is reason to expect the plant to operate with a minimum of grief and a low incidence of complaints from the production department.

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Literature Searching for Plastics Fabricating Methods and Machinery

HENRY W. WEHR, JR., and GORDON B. THAYER
Plastics Technical Service, Dow Chemical Co., Midland, Mich.

Searching the mechanical engineering literature for information on fabricating methods and machinery should include consideration of periodicals, manufacturers' technical data, institutional publications, patents, textbooks, proceedings of various professional societies, bibliographies, unpublished data, foreign literature, dissertations, and abstracts. This paper has been prepared to guide people in the fields of plastics fabrication as well as outsiders interested in plastics to the available information. A bibliography is included with suggestions for obtaining some types of information which are not widely available.

Sources of information are discussed as groups in this paper; the bibliography is subdivided into the same groups.

Periodicals

A rather sizable list of periodicals on fabricating methods and equipment for plastics is available to the searcher. Unfortunately, not all of these periodicals reach libraries because they are published in the interest of a specialized group of advertisers and are distributed to a carefully selected list of prospective buyers. The editorial and advertising material in these periodicals is a rich source of immensely practical information. The advertisers demand results from their expenditures, and the editors usually have close and frequent contact with them. There is much pressure to provide information which is useful at once rather than background material.

Periodicals which are specialized in product design and engineering are sources of information on methods and equipment. Foreign periodicals present information which often is not given much space in United States literature. One of the reasons for this difference in emphasis is adaptability to mass production markets. Production methods employed by foreign people may be too expensive for use here. However, there are many principles of technology which have been adapted to United States economy, and there will be many more. Some people have substituted ingenuity and hard work for natural resources and mass buying power. It is not practical to discount foreign technology merely because it is not like that in the United States.

The present status of plastics fabrication is such that physicists and high polymer specialists are reporting behavior of plastics which has not been widely adapted to fabrication techniques. For this reason the searcher may find information of value concerning fabrication in periodicals not ordinarily considered in the field.

The bibliography contains a list of periodicals compiled with the foregoing ideas in mind. Articles on the technology of molding, extruding, compounding, calendaring, laminating, and tooling are to be found in these publications.

Manufacturers' Technical Data

Plastic material manufacturers, machinery builders, specialty item distributors, and fabricators of plastics supply information concerning the use of their products as well as other information pertaining to fabrication of plastics. Some of the publications are extensive essays on various phases of plastics fabrication, while others are little more than descriptions of the products. Nevertheless, these sources of information are extremely important because of the lack of more formal presentations in standard textbooks and references.

A bibliography of some of the technical data (*24*) supplied by one manufacturer has been prepared as an example. Such publications are revised frequently because of the ever-changing conditions for which they are produced.

It is impossible to list all the information which is available, because of limited space and the fact that the compilers of this list cannot possibly be acquainted with everything which is currently published. Sweet's Catalog Service (*25*) publishes a catalog file which covers literature issued by the major manufacturers in the United States.

Editors of trade publications and scientific journals are acquainted with many of the manufacturers' publications, and the editors may be a source of considerable current information. Also, the advertising pages of trade papers carry announcements of new technical data bulletins. Most of the large manufacturers and many small ones have established technical service organizations which prepare publications and may be consulted in specific cases in which general data are not sufficient.

Institutional and Governmental Publications

Institutional publications are not likely to provide readily usable information for the engineer in manufacturing fabrication equipment for plastics. However, universities which maintain engineering research institutes and private engineering research institutes often supply extremely useful information concerning machine design and process principles on the theoretical level. Such institutions usually do research work on a contract basis for industrial clients. Some of their findings are, therefore, restricted as far as distribution is concerned. Other information is often made available generally.

Typical engineering research institutes are Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, and the University of Michigan Engineering Research Institute, East Engineering Bldg., Ann Arbor, Mich. These may suggest other institutes for specific information.

The United States Government Office of Technical Services supplies information on government research documents. Some of these services have been described previously (*26*) and they are not discussed at this time.

Patents

Patents contain much information concerning fabricating methods and machinery. The United States Patent Office has established classifications for various kinds of equipment. This classification list is available in most libraries and can be obtained from the United States Patent Office.

One of the best methods of keeping up with new patents is to establish a standing order with the Patent Office for all patents as they are issued within the classifications desired.

The *Patent Gazette* (*29*) is issued weekly by the United States Patent Office, and it may be studied for abstracts of new patents. Also, various current magazines publish patent digests in their editorial pages; (*27*) and (*28*) list new patents as a regular editorial feature. These digests are often several weeks old, but they are a good source of information.

Foreign patents may be found at the United States Patent Office, although they are not classified in the same fashion as the United States patents are.

Two references on searching United States (*30*) and foreign (*31*) patent literature are included, as they have been found of considerable help in searching patent literature.

Textbooks

Engineers who have been engaged in building and designing fabrication equipment for plastics have been much too busy to write textbooks which cover such equipment in detail. Much of the equipment is specialized, and some of it is kept secret. Some features, of course, have been patented. In general, the principles of mechanical engineering design have been applied to processing equipment; therefore, the standard engineering textbooks and handbooks are recommended for useful information concerning design of equipment. There are a number of books about plastic fabricating and machinery available, and these have been listed in a bibliography.

Proceedings of Various Professional Societies

Several professional societies have been extremely active in promoting the publication of information concerning fabricating methods and machinery for plastics. The official publications of these organizations have carried the new papers to a considerable extent in the past. A bibliography listing publications of the principal societies which are likely to have information is given, with the location of the society headquarters.

Bibliographies

The field of fabricating methods and machinery for plastics has not been covered extensively by bibliographies published as such. The main source of bibliographies lies in reading the literature and obtaining the information from the various articles which have been prepared carefully enough to contain their own bibliographies.

Some trade publications publish bibliographies of articles of recent origin on an annual basis. Also, the Rubber and Plastics Division of the American Society of Mechanical Engineers makes an annual review of papers of interest to mechanical engineers on articles concerning rubber and plastics. The reviews are published in *Mechanical Engineering* (*53*.)

Unpublished Data

Industrial concerns engaged in the manufacture of plastic materials or equipment for processing such materials have many unpublished data in their files. A considerable amount of this information is available. It is something of a problem to be able to find it, but there are several places to begin looking.

Most manufacturers of plastic materials have technical service departments which are in contact with the various laboratories in the organization. These technical service groups are able to be of assistance in many cases to uncover unpublished information which is of interest to the searcher.

Editors of trade journals have wide contacts industrially and can often steer the searcher to the information he wishes to obtain. Professional societies can also guide the searcher to various individual members who may know of data which have not been published but which can be made available.

Foreign Literature

Many industrial concerns subscribe to foreign periodicals and abstracts. Industrial libraries are an excellent source of foreign literature references. In general, foreign literature on fabrication methods and equipment for plastics comes largely from European countries. This is because the industry is well established there and is not highly organized in other countries. It has become generally true in most cases that people look to the United States for new ideas in fabrication technology for plastics. The searcher, therefore, is likely to find a considerable amount of United States technology described in foreign literature. This does not mean, however, that other people are not making new developments of interest.

Since the end of World War II, many American industrial organizations have

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searched European technology for new equipment and materials. A number of new items of equipment have been introduced in the American market either through agents of foreign manufacturers or through American manufacturers who have adapted foreign equipment. A study of the advertisements of domestic manufacturers of equipment will serve to keep the searcher up to date in this regard.

Dissertations

Very little information concerning fabrication methods and machinery directly is available in the form of dissertations. Equipment for fabricating plastics is expensive and is difficult for research institutions to obtain and maintain with the latest design features. Also, the needs of industry are considerably more specific than the work which can be handled by students of basic technology. For this reason the development of equipment and methods on the manufacturing level usually is done in industrial plants rather than in educational institutions. Dissertations are not likely to prove to be a fertile field for fabrication equipment development ideas.

Abstracts

At the present time abstracts in the field of fabrication methods and equipment for plastics are not a very important source of information. No formal abstracting service in this field is known to the authors, although possibly some abstracts cover fabricating methods and equipment when such information appears in other classifications of literature. *Chemical Abstracts* deals mainly with the chemical nature of the materials being fabricated and not with the fabrication processes and machinery. It does not appear likely that an abstract service would be able to pay its own way because of the relatively few engineers who are engaged in development of fabrication methods and equipment for plastics. Some of the trade magazines do abstract each others' articles as well as recently received manufacturers' technical data bulletins. This information is not usually classified nor is it selected by any systematic method.

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The Literature on Properties and Applications of Modern Plastics

THOMAS HAZEN and ARCHIE J. WEITH

Bakelite Co., Division of Union Carbide and Carbon Corp., 230 Grove St., Bloomfield, N. J.

The more significant sources of information concerning the properties and applications of plastics were determined by a breakdown and analysis of two plastics literature reviews covering the years 1950 and 1951—viz., the literature review published annually in the technical section of *Modern Plastics,* and the chapter on synthetic plastic insulation in the National Research Council's annual "Digest of the Literature on Dielectrics." An appended bibliography lists the major sources of information. Searching for highly specialized types of information is discussed briefly.

This paper is not a discussion of the properties and applications of plastics as such, a very broad subject indeed, but rather an attempt to indicate to technical personnel the most likely sources in the literature from which significant information concerning the properties and applications of plastics may be obtained.

Properties and applications naturally go together, the latter usually being determined to a large extent by the former. At the risk of seeming to state the obvious, it is important to point out that the possession by a given plastic material of the desired specific property for a particular application does not necessarily mean that the material will best serve in the application in question. The chemical engineer seeking an acid-resistant plastic material for a construction job in a chemical plant will need to know something of the mechanical strength, heat resistance, and fabricating qualities, in addition to the chemical resistance of the material. Most electrical applications of plastics are also structural ones, more often than not requiring that good heat resistance, cold resistance, aging and weathering properties, moisture resistance, mechanical strength, and proper rigidity go along with the low dielectric loss, high insulation resistance, high dielectric strength, and other desired electrical properties in the material chosen. In the use of a foamed plastic resin as thermal insulation, the engineer must generally know much more about the material than merely that it possesses a low thermal conductivity. In short, the searcher for information about plastics should learn to look for as complete information as possible, even when the major concern may be with some very specific property or application.

Standard Sources of Information

Much information about the properties and applications of commercial plastics is readily available in the more or less obvious standard sources, such as books, treatises, handbooks, and technical society specifications. Several of these (exclusive of books and treatises) are listed in the appended bibliography (*4, 5, 23, 37, 42, 48*).

The problem of determining which literature sources give the maximum coverage of information concerning the properties and applications of plastics is a difficult one.

However, a practical approach to the solution of this problem has presented itself through an analysis of two recent plastics literature reviews known to be reasonably complete, although limited principally to coverage of the literature in English. These literature reviews were the annual review published under the editorship of Gordon M. Kline in the technical section of the trade journal *Modern Plastics;* and the chapter on synthetic plastic insulation appearing in the National Research Council's annual "Digest of the Literature on Dielectrics." Each of these two reviews was analyzed for the years 1950 and 1951. In addition to the advantage of being based on recent practical experience, this solution of the problem of naming the literature sources most useful in supplying information about plastics tends to eliminate prejudice and guesswork. It also makes possible the listing of these sources in the approximate order of their importance, even though this be only by the quantitative measure of the number rather than the quality of the references in each. Table I illustrates the extent of the literature coverage by these two reviews. It indicates the number of references specifically classified as dealing with properties and applications, and also gives the number of different literature sources that are referenced in this connection.

Table I. Plastics Literature Coverage by *Modern Plastics* and N.R.C. Digest Reviews of 1950 and 1951 Literature

References	*Modern Plastics*		*N.R.C. Digest*	
	1950	1951	1950	1951
Total	496	573	573	356
Number on properties and applications	243	275	300	201
Sources for information on properties and applications	40	36	64	47

It is interesting to observe from Table I that both the *Modern Plastics* and N.R.C. digest reviews show approximately half of the total references as having to do with properties and applications. Plastics literature references listed in the N.R.C. digest for 1950 and 1951 are not limited to electrical properties and applications; general coverage is given.

Table II. Reference Sources, with Number and Percentage of References Dealing with Properties and Applications of Plastics, in *Modern Plastics* Reviews for 1950 and 1951

1950 Literature

Source	No. of References	% of Total
Modern Plastics	59	24.3
Brit. Plastics	21	8.6
Ind. Eng. Chem.	17	7.0
ASTM Bull.	13	5.4
J. Appl. Phys.	13	5.4
J. Polymer Sci.	12	4.9
Plastics (London)	12	4.9
Anal. Chem.	11	4.5
ASTM Proc.	11	4.5
J. Chem. Phys.	11	4.5
J. Am. Chem. Soc.	7	2.9
Elec. Mfg.	6	2.5
J. Research Natl. Bur. Standards	6	2.5
Nature (London)	4	1.6
Trans. Faraday Soc.	4	1.6
Trans. Am. Soc. Mech. Engrs.	3	1.2
Chem. Ind.	3	1.2
Proc. Phys. Soc. (London)	3	1.2
SPE Journal	3	1.2

1951 Literature

Source	No. of References	% of Total
Modern Plastics	72	26.2
J. Polymer Sci.	25	9.1
ASTM Bull.	18	6.5
Brit. Plastics	17	6.2
Ind. Eng. Chem.	14	5.1
Plastics (London)	12	4.4
J. Colloid Sci.	11	4.0
Modern Packaging	11	4.0
Anal. Chem.	9	3.3
J. Appl. Chem. (London)	8	2.9
J. Am. Chem. Soc.	7	2.5
J. Appl. Phys.	7	2.5
J. Chem. Phys.	7	2.5
J. Phys. & Colloid Chem.	7	2.5
Elec. Mfg.	6	2.2
Trans. Faraday Soc.	6	2.2
Materials & Methods	4	1.4
SPE Journal	4	1.4
Trans. Am. Soc. Mech. Engrs.	3	1.1
Australian J. Appl. Sci.	3	1.1
Chemistry & Industry	3	1.1

The sources from which three or more references dealing with properties and applications of plastics were obtained in the 1950 and 1951 literature were tabulated in the order of decreasing numbers of references, with a notation of the number of references as well as the approximate percentage of the total of those relating to properties and applications, appearing in each of these sources. Table II gives such a tabulation for references in the

Table III. Reference Sources, with Number and Percentage of References Dealing with Properties and Applications of Plastics, in N.R.C. Digests for 1950 and 1951

1950 Literature

Source	No. of References	% of Total
Modern Plastics	33	11.0
Ind. Eng. Chem.	25	8.3
N.R.C. Conf. Papers	20	6.7
J. Appl. Phys.	18	6.0
Plastics (London)	18	6.0
Brit. Plastics	17	5.7
ASTM Bull.	14	4.7
Elec. Eng.	10	3.3
India Rubber World	10	3.3
Elec. Mfg.	8	2.7
Materials & Methods	8	2.7
Nature (London)	8	2.7
Gen. Elec. Review	7	2.3
Kunststoffe	6	2.0
Proc. Phys. Soc. (London)	6	2.0
Product Eng.	6	2.0
British J. Appl. Phys.	5	1.7
Offic. Digest, Federation Paint & Varnish Production Clubs	5	1.7
ASTM Proc.	4	1.3
Electronics	4	1.3
J. Colloid Sci.	4	1.3
SPE Journal	4	1.3
Trans. Faraday Soc.	4	1.3
Trans. Am. Soc. Mech. Engrs.	3	1.0
E.R.A. Reports (British)	3	1.0
J. Sci. Instr.	3	1.0
Natl. Advisory Comm. Aeronautics, Tech. Notes	3	1.0
Rev. Sci. Instr.	3	1.0

1951 Literature

Source	No. of References	% of Total
Kunststoffe	18	9.0
Brit. Plastics	17	8.5
J. Appl. Phys.	15	7.5
Modern Plastics	15	7.5
ASTM Bull.	13	6.5
Elec. Mfg.	9	4.5
J. Polymer Sci.	7	3.5
Materials & Methods	7	3.5
N.R.C. Conf. Papers	7	3.5
Plastics (London)	7	3.5
Ind. Eng. Chem.	6	3.0
Offic. Digest, Federation Paint & Varnish Production Clubs	6	3.0
SPE Journal	6	3.0
Elec. Eng.	5	2.5
India Rubber World	5	2.5
Proc. Inst. Elec. Engrs. (London)	5	2.5
Trans. Am. Soc. Mech. Engrs.	4	2.0
Prod. Eng.	4	2.0
ASTM Proc.	3	1.5
Bell Syst. Tech. J.	3	1.5
Chemistry & Industry	3	1.5
Rev. Sci. Instr.	3	1.5

Modern Plastics reviews; Table III gives similar information for references in the chapters on plastics in the N.R.C. digests.

By combining all the referenced literature sources given in Tables II and III and adding all the references to each of these sources, a list is obtained consisting of 41 literature sources to which at least three citations relating to the properties and applications of plastics were made in the reviews for 1950 and 1951. The number of references to each of these sources, although many duplications obviously are included, will give the searcher some idea of the relative significance of each journal or publication. Table IV summarizes the final results of this analysis, and the 41 reference literature sources are given in alphabetical order in the appended bibliography, with the names and addresses of the publishers.

Table IV. Sources Containing Three or More References to Properties and Applications of Plastics Cited in the 1950 and 1951 Plastics Reviews

Total number of references cited, including duplications, is 903.

Reference Source	No. of References, 1950 and/or 1951	Reference Source	No. of References, 1950 and/or 1951
Modern Plastics	179	*Nature (London)*	12
Brit. Plastics	72	*Proc. Phys. Soc. (London)*	12
Ind. Eng. Chem.	62	*Modern Packaging*	11
ASTM Bull.	58	*Offic. Digest, Federation Paint & Varnish Production Clubs*	11
J. Appl. Phys.	53	*Product Eng.*	10
Plastics (London)	49	*J. Appl. Chem.*	8
J. Polymer Sci.	44	*Gen. Elec. Review*	7
Elec. Mfg.	29	*J. Phys. & Colloid Chem.*	7
N.R.C. Conf. Paper	27	*Chemitrsy & Industry*	6
Kunststoffe	24	*J. Research Natl. Bur. Standards*	6
Anal. Chem.	20	*Rev. Sci. Instr.*	6
Materials & Methods	19	*British J. Appl. Phys.*	5
ASTM Proc.	18	*Proc. Inst. Elec. Engrs. (London)*	5
J. Chem. Phys.	18	*Electronics*	4
SPE Journal	17	*Australian J. Appl. Sci.*	3
Elec. Eng.	15	*Bell Syst. Tech. J.*	3
India Rubber World	15	*Chem. Ind.*	3
J. Colloid Sci.	15	*E.R.A. Reports (British)*	3
J. Am. Chem. Soc.	14	*J. Sci. Instr. (London)*	3
Trans. Faraday Soc.	14	*Natl. Advisory Comm. Aeronautics, Tech. Notes*	3
Trans. Am. Soc. Mech. Engrs	13		

Number Versus Quality of References

Thus far more emphasis has been put upon the number than upon the quality of the references. The frequency with which a given source is referred to does not necessarily give a true measure of the amount of reliable information that may be obtained from it. The searcher will have to depend upon his own judgment and technical background in deciding where to look first, and he must also learn to distinguish between the more advanced scientific and technical journals and the trade literature. Experience and an appreciation of the nature and technical level of the information sought will usually provide the solution to this problem.

Searching for Highly Specialized Information

When highly specialized information is required, considerably more difficulty may be encountered in finding it in the literature. A good approach in such cases is to seek out the special bibliographies and literature surveys that are frequently sponsored and published by scientific and engineering societies in their own specialized fields. An example of this type of survey is one by Richardson (*55*) reviewing recent advances in plastics which are of interest to the mechanical engineer. Typical also are the surveys published annually in *Industrial and Engineering Chemistry* (*25*) covering the various chemical engineering materials of construction. Several scientific and engineering societies sponsor the publication of abstracts of current literature in their particular fields. These abstracts are generally well indexed. The *Chemical Abstracts* (*13*), *British Abstracts* (*10*), *Physics Abstracts* (*47*) (covering physics and electrical engineering), and *Abstracts and References* published monthly in the *Proceedings of the Institute of Radio Engineers* (*51*) are excellent examples. All of these are useful guides to sources of information relating to properties and applications of plastics in specialized fields.

Technical bulletins and house organs published by industrial concerns supplying plastics raw materials or finished plastics products are excellent sources of information on new materials and new applications. These frequently present new information that may not be available in the regular literature. This type of publication has been well covered in a recent paper by Lederman (*38*), who lists sixteen house organs in the fields of resins, rubbers, and paints; and also by Cheyney (*16*). Special technical releases by plastics manufacturers and fabricators giving properties, fabricating methods, and suggested applications of specific new products may also constitute fruitful sources of information. In general this type of literature is best obtained directly from the sales or advertising departments of the companies concerned, though in some instances its distribution may be restricted.

Much valuable information of a highly specialized character may be obtained from United States Government documents. The Office of Technical Services of the Department of Commerce has available bibliographies of reports in practically every field of technical interest, including plastics and protective coatings. Ball and Flagg (*7*) have recently dealt with the best ways of finding and using government publications; and Kline (*35*) has prepared a review and bibliography of plastics research and technology at the National Bureau of Standards, including numerous references dealing with properties and applications of plastics.

Conclusion

The volume of the literature on plastics has become so great that the problem of knowing where to seek required information, even that relating only to properties and applications, has become rather complex. In addition to naming some standard sources of information, this paper has attempted to rate the periodical literature in accordance with an empirical scheme based on an analysis of recent literature. No claim to an exhaustive treatment of the subject is made, but it is hoped that this discussion and the appended bibliography will give some assistance to the searcher for technical data relating to the properties and applications of plastics.

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Test Methods, Specifications, and Standards for Plastics

GORDON M. KLINE

National Bureau of Standards, Washington, D. C.

Sources of information for testing methods, specifications, and other standards pertaining to plastics are discussed and listed in a comprehensive bibliography. In the domestic field, there are two compilations of testing methods, one by the ASTM, the other, a federal specification. Indexes for domestic government, military, technical, and trade specifications are listed or discussed as are sources of information on other standards, such as nomenclature and recommended practices for constructing test equipment. Similar information is given for foreign specifications and testing methods. Developments in international and foreign standards are progressing.

The development and standardization of testing methods and specifications for plastics in the United States have been a cooperative undertaking involving several technical and trade organizations and technical personnel in industry, Government, and universities. The early work was done in the electrical insulation field which was the predominant market for plastics for many years. Thus, the American Society for Testing Materials' Committee D-9 on Electrical Insulating Materials, which was organized in 1910, was the center of such work until ASTM Committee D-20 on Plastics was organized in 1937. The organization of the Organic Plastics Section at the National Bureau of Standards in 1935 and the formation of Federal Specifications Technical Committee on Plastics in 1941 were further milestones in this transition period to broader markets for plastics.

Another significant event in the history of plastics standards was the first meeting of Technical Committee 61 on Plastics of the International Organization for Standardization in New York on September 8 and 9, 1951. Representatives from Australia, France, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States met to consider the establishment of testing methods and nomenclature for international use. The second meeting of ISO/TC 61 on Plastics was held in Turin, Italy, on October 2 to 4, 1952, and it is anticipated that this committee in the near future will be ready to recommend the first international testing methods on plastics to the member standards bodies of the various countries.

This paper surveys the domestic and foreign sources of information on developments in testing methods, specifications, and other standards pertaining to plastics.

Testing Methods

ASTM Committee D-20 on Plastics has subcommittees working on testing methods for strength, hardness, thermal, optical, and permanence properties, and analytical and molding procedures. Testing methods for electrical properties are under the jurisdiction of Committee D-9 on Electrical Properties. Some methods of immediate interest to those concerned with applications of synthetic resins are developed by Committee D-1 on Paint, Varnish, Lacquer, and Related Products, Committee D-14 on Adhesives, and Committee C-19 on Structural Sandwich Constructions. These methods are published by the society in the book of standards (*5*) or its supplements (*6, 7*) and in special compilations (*2–4*). The preprint of the annual report of Committee D-20 (*1*) is also a useful source of current information on the latest methods and revisions, pending the publication of the annual standards book.

Federal Specification L-P-406 (*31*) is another important compilation of officially recognized methods of test in the United States. Revisions of this specification are indicated by letters appended to the number, the current issue being L-P-406b. The methods are numbered in series according to the type of test as follows: Mechanical, 1000; Thermal, 2000; Optical, 3000; Electrical, 4000; Miscellaneous Physical, 5000; Permanence, 6000; and Chemical, 7000. It is the intention to coordinate and publish in this specification all of the common methods of test employed in federal and military specifications for plastic materials and products. Many of these test methods are, of course, identical in principle and procedure with the corresponding ASTM methods.

There are also compilations of testing methods in various other countries, such as those of Great Britain (*11*), France (*25*), Germany (*15*), and Switzerland (*37*).

The sources of development of new and improved testing methods reside in the industry, government, and university laboratories of this country. In addition to the American Society for Testing Materials, there are several other important forums for their presentation and discussion. Notable among these are the meetings and publications of the Rubber and Plastics Division of the American Society of Mechanical Engineers, the Division of Paint, Varnish, and Plastics Chemistry and the Division of Polymer Chemistry of the AMERICAN CHEMICAL SOCIETY, the High Polymer Division of the American Physical Society, the Society of Rheology, the Society of Plastics Engineers, the Society of the Plastics Industry, and the Packaging Institute. There are also many scientific and trade magazines in which contributions in this field are published, notably the following: *Transactions of the American Society of Mechanical Engineers, ASTM Bulletin, ASTM Proceedings, Analytical Chemistry, Industrial and Engineering Chemistry, Journal of Applied Physics, Kunststoffe, Modern Packaging, Modern Plastics, Journal of Research of the National Bureau of Standards*, and the *SPE Journal.*

Specifications

ASTM Committees D-9 and D-20 have prepared specifications for many types of commercial plastics, including allyl, cellulose nitrate, acetate and acetate butyrate, ethylcellulose, melamine, methacrylate, phenolic, polystyrene, urea, vinyl chloride and chloride-acetate, vinylidene chloride, vulcanized fiber, and thermosetting laminates. These have been published in the ASTM books of standards (*4–7*).

The Federal Specifications Technical Committee on Organic Plastics has prepared materials specifications (*32*) which are largely the counterparts of the ASTM specifications in so far as property requirements are concerned. This committee has also developed specifications for various plastic products (*32*). In addition to these, there is a large number of other federal specifications involving end items made in whole or in part of plastic materials. These are indexed annually (*33*).

Likewise, there is a host of government specifications promulgated by the military agencies for plastic materials and products. These can be located by consulting the semiannual indexes issued by the Departments of the Army (*27*), Navy (*30*), and Air Force (*26*), and the Munitions Board (*35*).

There are also a number of technical and trade organizations in this country which have prepared and issued specifications dealing with specialized aspects of the plastics field. The Laminated Products Section of the National Electrical Manufacturers Association has official specifications for laminated sheets, rods, and tubes (*20*) and for decorative laminated materials (*19*). The Aeronautical Material Specifications Group of the Society of Automotive Engineers has written specifications for plastic materials to be used in aircraft construction (*22*). The Society of the Plastics Industry through its Engineering and Technical Committee, Reinforced Plastics Division, and Plastics Film, Sheeting, and Coated Fabrics Division has programs under way to develop specifications for plastic products (*23*).

The British and German standards bodies have been particularly active in the preparation of specifications for plastics. The German specifications (*15*, *36*) have been concerned primarily with electrical insulation, whereas the British (*12*) have also covered applications in adhesives, tableware, toilet seats, and the building industry.

Other Standards

In addition to testing methods and product specifications, ASTM Committee D-20 on Plastics has also prepared definitions of terms and recommended practices for molding test specimens and constructing testing equipment, conditioning and weathering procedures, and related standards. These are published in the ASTM books of standards (*4–7*). There is also a federal standard for laboratory atmospheric conditions for testing (*34*).

The U. S. Department of Commerce has published a number of "Commercial Standards" (*28*) and "Simplified Practice Recommendations" (*29*) relating to plastics, prepared in cooperation with the Society of the Plastics Industry, American Hospital Association, Plastic Coatings and Film Association, and Manufacturing Chemists Association. "Simplified Practice Recommendations" and "Commercial Standards" are developed by manufacturers, distributors, and users in cooperation with the Commodity Standards Division of the Office of Industry and Commerce, Bureau of Foreign and Domestic Commerce, and the National Bureau of Standards. The purpose of "Simplified Practice Recommendations" is to eliminate avoidable waste through the establishment of standards of practice for stock sizes and varieties of specific commodities that currently are in general production and demand. The purpose of "Commercial Standards" is to establish standard methods of test, rating, certification, and labeling of commodities, and to provide uniform bases for fair competition. A "simplified practice recommendation" or a "commercial standard" originates with the proponent industry. The sponsors may be manufacturers, distributors, or users of the specific product. One of these three elements of industry submits to the Commodity Standards Division the necessary data to be used as the basis for developing a standard of practice. The division, by means of assembled conferences or letter referendums, or both, assists the sponsor group in arriving at a tentative standard of practice and thereafter refers it to the other elements of the same industry for approval or for constructive criticism that will be helpful in making any necessary adjustments. The adoption and use of a "simplified practice recommendation" or a "commercial standard" is voluntary. However, when reference to a "commercial standard" is made in contracts, labels, invoices, or advertising literature, the provisions of the standard are enforceable through usual legal channels as a part of the sales contract.

A standard of considerable significance because of its recognition by most states as the basis for approval of glazing material in licensed automotive vehicles is the American Standard Safety Code prepared by Sectional Committee Z26 on Safety Glazing Materials of the American Standards Association, under the sponsorship of the Association of Casualty and Surety Companies and the National Bureau of Standards (*8*). The original code issued in 1938 included requirements for some properties of laminated glass, which is commonly made with polyvinyl butyral plastic interlayer. The revision issued in 1950 also specifies certain locations in which rigid and flexible transparent plastics may be installed and sets forth the minimum property requirements for plastics for such use.

International and Foreign Standards

The International Organization for Standardization (ISO) was founded in 1946 and holds consultative status as a nongovernmental organization with the Economic and Social Council of the United Nations. It has as members the national standardizing bodies of 33 countries. Its work is carried on in technical committees, of which there are now 76. One of these, the Technical Committee on Plastics (TC-61), has as its objectives the standardization of nomenclature and test methods applicable to plastics to serve as a basis for a common international understanding among producers, distributors, and users of plastics. Fourteen countries—Australia, Belgium, Czechoslovakia, France, Germany, Hungary, India, Italy, Netherlands, Portugal, Sweden, Switzerland, United Kingdom, and United States—are participating members on TC 61, and fifteen others are kept informed regarding the work. The American Standards Association is the secretariat for TC 61. The committee has organized working groups on strength properties, thermal properties, physical-chemical methods, equivalent terms, and standard laboratory atmospheres and conditioning procedures. Any testing methods, nomenclature, or related items ultimately agreed upon by this committee will be published as ISO Recommendations if they are accepted by the majority of the ISO member bodies and the council, and as ISO standards if they are accepted by all the ISO member bodies (*17*).

The International Electrotechnical Commission (IEC) was founded in 1904 and is now affiliated with the International Organization for Standardization as a Technical Division. The IEC has a Technical Committee 15 on Electrical Insulating Materials, which is concerned with the standardization of testing methods and specifications in this special field. It met in Scheveningen, Netherlands, September 10 to 12, 1952. Approved test methods and specifications are issued as recommendations and standards (*16*).

The International Union of Pure and Applied Chemistry (IUPAC) was founded in 1894. It is now associated with the International Council of Scientific Unions (ICSU), which in turn is affiliated with the United Nations' Educational, Scientific, and Cultural Organization (UNESCO). The 16th Conference of IUPAC was held in New York in September 1951; the 17th Conference is to be held in Stockholm and Uppsala, Sweden, July 29 to August 7, 1953. IUPAC has two groups engaged in standardization activities in fields related to plastics. One is the Plastics and High Polymers Division of the Applied Chemistry Section, which has under consideration the standardization of technical terms, analytical methods, and identification tests for plastics. The other is the Commission of Macromolecular Chemistry of the Physical Chemistry Section, which has prepared a report on nomenclature for polymers (*18*) adopted by IUPAC at the September 1951 meeting, and is investigating methods for determining the size and shape of macromolecules.

The standardization organizations in many foreign countries have adopted plastics standards other than those previously mentioned. These may be located by consulting the indexes published by the sponsoring bodies (*9, 10, 13–15, 21, 24*). Our testing technicians will become better acquainted with these foreign standards in the next few years through the work of the Technical Committee on Plastics of the International Organization for Standardization on Plastics. It is certain that techniques and understanding of the properties of plastics will be improved through this pooling of ideas to achieve a common international language on the technical aspects of plastics.

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Plastics Literature in Government Reports

JAMES KANEGIS

Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

IRVIN WOLOCK

National Bureau of Standards, Washington 25, D. C.

Many reports by scientists working in the government or on government-sponsored contracts are not published in the recognized scientific journals. For searching the literature, a knowledge of government departments or agencies publishing or sponsoring the publishing of such reports, or agencies which collect and catalog such reports, is essential. The Office of Technical Services is responsible for aiding in the dissemination of government technical reports.

The discussion of technical literature on plastics in government reports is a timely one because such reports are rapidly multiplying into a larger and larger segment of the total technical literature each year. Formerly a literature search could be considered fairly complete when existing nongovernment sources were checked. With the advent of World War II the situation changed radically. The government initiated expenditures of large sums of money for scientific research. It developed and enlarged a contract type of research and development operation which has been continued since the war under the direct administration of various government agencies concerned with national defense. This rapid expansion of research and the corollary reports have greatly affected the dissemination of technical information and have brought into prominence the heretofore insignificant intragovernmental distribution channel (*2*).

Many reports by technologists and scientists working in the government or on government contracts are released through the recognized scientific and technical journals. These reports can be located through the usual media such as *Chemical Abstracts*. Many government reports, however, do not appear in the published literature. There are many reasons for this situation. Many reports are prepared to supply specific information and are not meant for publication. In the form prepared, they would be considered as not meeting the standards of the scientific journals. This type of report can be justified on the grounds that it produces a maximum amount of information with a minimum amount of time and money.

For example, a large number of research and development reports are written by personnel of the Atomic Energy Project to record procedures, data, and results of immediate interest to other scientists, engineers, and technologists throughout the project. These reports are reproduced by the contractor or the Technical Information Service of the Atomic Energy Commission for immediate distribution within the Atomic Energy Project. The journals often are not interested in such papers in their original form or may not be able to publish them promptly (*21*). These are typical of a large group of government reports that do not appear in the journals and that make the searching of government reports a slightly difficult and somewhat unique process.

Often, reports submitted to government agencies by industrial companies or government laboratories contain information of a proprietary nature. The circulation of these reports is closely controlled until such information is deleted. Typical of these are reports of evaluation tests conducted for government agencies. Unfortunately reports of this sort often are never revised for release to the public.

Possibly the main reason that many government reports do not appear in the standard periodicals is military-security restrictions. Much of the work done under government contract is of a classified nature and, as such, the circulation of the resulting reports must be closely controlled. These reports are not available to the general public until declassified.

Consideration must also be given to the fact that there is not enough space available in the regular journals for the publication of all government reports. If all government reports were prepared for and submitted for publication in the journals presently available, the results would be catastrophic. As it is, most of these journals have built up a backlog of the material presently channeled to them.

One finds that the search for pertinent literature among government reports is a process which is largely independent of a search conducted among nongovernment sources. It is the purpose of this report to indicate means of locating pertinent government reports, particularly those concerned with plastics, largely by indicating most of the more important agencies issuing such reports. It must be stressed that no attempt has been made to list every government agency which has issued reports concerning plastics, or to list every publication of the agencies which are mentioned. Rather this is an attempt to lend direction to the search for particular government reports, with explicit information furnished on many of the more important agencies.

Publication policies in government agencies vary from time to time, as the functions and appropriations of the agencies change. Many agencies have a very fluid publication policy which might make a literature search more difficult. Such a policy is followed to allow the agency to direct certain publications to the most interested audience and to allow the scientist more freedom of publication, even to the extent of indicating whether the report is ready for publication and, if so, in which journal. Such freedom of publication serves to attract more competent men into the government service.

There are several publications which will be of general assistance in searching for technical literature in government reports. Among them is an article by Jerome K. Wilcox (*64*), which lists guides and aids issued during the period 1945–1948 for the use of public documents. N. T. Ball and C. R. Flagg presented an article (*1*) which gives detailed information on the technical publications of government agencies of most interest to the chemist.

The technical information activities of the Department of Defense are described in another publication (*14*), with supplementary information on other government agencies.

One of the best ways of checking on reports by federal agencies is to know of the individual government agencies. The best and most recent listing of government agencies concerned with research will be found in an eight page appendix to a report (*11*), issued by the National Research Council in March, 1952, which lists the research and development facilities of the U. S. Government, giving the name and location of each laboratory under the headings of the various government departments.

Another publication which will familiarize the individual with the various government departments is the annual "United States Government Organization Manual" (*52*) which contains a description of all of the government agencies. An appendix therein lists representative publications available from the various government establishments.

Government Printing Office

The *Monthly Catalog* (*15*), issued by the Superintendent of Documents, is the most comprehensive periodical issued, listing publications of the various government agencies. The catalog contains both technical and nontechnical publications issued by the various departments and agencies of the U. S. Government. It is indexed annually.

A list, *Selected U. S. Government Publications* (*17*), arranged alphabetically by subjects, is issued semimonthly. Probably of most interest to plastics technologists is

"Publications Relating to Plastics" (*16*), issued in February 1951, containing titles and Government Printing Office catalog numbers only, of reports from many federal agencies. This listing is not comprehensive, and because of the date of issuance, must be supplemented by the *Monthly Catalog* for more recent reports.

Office of Technical Services

The Office of Technical Services (OTS), of the Department of Commerce, was established after World War II and is responsible for aiding in the collection and dissemination of technical reports of benefit to American science and industry. Reports are received from the civil and military agencies of the United States Government and from cooperating foreign governments. Many of the reports cover information captured in enemy countries. Thus the vast store of reports on German developments in plastics prepared after the last war was made available through OTS. Of present significance is the fact that all declassified Department of Defense reports, as well as those of the Office of Scientific Research and Development (OSRD), are distributed through OTS.

OTS maintains a voluminous card file of all of the above-mentioned classes of reports in Washington. Its listings of reports of federal origin in the plastics field is probably the most extensive to be found. There are over 2000 card listings under plastics, not counting those listed under specific plastics or other subject heads. No attempt has ever been made to furnish a full bibliographic listing of these reports, and it is extremely doubtful that such will be done. However, a selected "Bibliography of Reports on Plastics" (*44*) has been prepared, listing about 400 reports but mostly covering the German technology. That agency is planning a more extensive list to include declassified reports of federal origin.

OTS has two regular publications. The *Bibliography of Technical Reports* (*45*) is issued monthly, listing most of the pertinent reports received and abstracting most of those listed. The *Technical Reports Newsletter* (*46*), also a monthly publication, is a digest of outstanding technical reports available from federal and other sources. Special emphasis is placed on items of interest to smaller business firms.

National Bureau of Standards

The results of work conducted at the National Bureau of Standards (NBS), Department of Commerce, are made available through publication either in the bureau's own series of publications or in the technical journals. The bureau publishes a monthly *Journal of Research* (*6*) which presents complete papers reporting technical investigations. There is also a monthly *Technical News Bulletin* (*7*) which carries summary reports on some of the completed projects with emphasis on the results of research. Preliminary reports on work in progress are also presented along with a listing of all bureau publications during the preceding month. There are various circulars and miscellaneous publications issued from time to time. A list (*8*) of the titles of these publications and of reprints from the *Journal of Research* through December 31, 1951, is available.

Circulars of greatest interest to those concerned with plastics are "Plastics Research and Technology at the Bureau of Standards" (*9*) issued in June, 1950, which includes a bibliography of NBS plastics reports; and the "Bibliography of Recent Research in the Field of High Polymers" (*10*), issued September, 1950. A supplement to the former circular is now available to cover the period through August, 1952. Other agencies of the Department of Commerce will be noted later.

National Advisory Committee for Aeronautics

The National Advisory Committee for Aeronautics (NACA) is a valuable source of information concerning plastics materials used in aircraft, such as transparent plastics, adhesives, and laminates of various types. Many reports on these materials are included in two comprehensive indexes (*3*, *4*) of NACA technical publications. The reports are listed under subject headings, one of which is "Plastics." To supplement the above, *NACA Research Abstracts* (*5*) is issued biweekly, listing reports on projects sponsored by the NACA, along with abstracts of the contents. All NACA reports are available at the NACA library in Washington, along with numerous other reports regarding aircraft and aircraft materials from many sources.

Department of Agriculture

Work is sponsored by the Department of Agriculture on the use of agricultural products in making plastics, largely by the Bureau of Agricultural and Industrial Chemistry. In addition, the Forest Products Laboratory has conducted extensive work on the uses of resins in wood and paper adhesives, impregnates, and laminates.

The Department of Agriculture issues a *Monthly List of Publications* (*34*) giving the author, title, and issuing bureau of each printed publication. In addition, a list (*33*) was issued July 1951, giving the titles of all publications issued by the Department of Agriculture itself and still in print, but not those issued by all of its constituent bureaus. There are few reports concerning plastics in this catalog. The Bureau of Agricultural and Industrial Chemistry, however, has a listing of all of its processed publications (*30*), issued January 1952. This listing is of great interest to those concerned with plastics and is revised periodically.

The Forest Products Laboratory also has a semiannual "List of Publications" (*31*) and a "List of Publications on Chemistry of Wood and Derived Products" (*32*), which contains items pertaining to plastics.

Atomic Energy Commission

As a corollary to its main lines of endeavor, the Atomic Energy Commission (AEC) has produced a significant amount of information of interest to those concerned with plastics. Much of this has been declassified and is available to the general public through the usual information activities of the AEC.

A semimonthly journal, *Nuclear Science Abstracts* (*19*), is issued by the AEC. It contains abstracts and an index of all current nonclassified research and development reports disseminated by the AEC and its contractors, as well as pertinent nonclassified reports issued by other government agencies or appearing in foreign and domestic journals.

Several hundred declassified AEC reports appear in the National Nuclear Energy Series (NNES), which is a record of the research carried on by the Manhattan District and the AEC. These volumes are being published by McGraw-Hill, and their contents are listed in *Nuclear Science Abstracts.* Of special interest may be the volume, "Preparation, Properties, and Technology of Fluorine and Organic Fluoro Compounds" (*20*). Much of the development work on fluorocarbon polymers was done by the Manhattan District during the last war, and AEC-sponsored publications are a valuable source of information on these materials.

Over 1500 AEC reports published in the usual scientific and technical journals are also listed in *Nuclear Science Abstracts.* However, over 1600 reports not published in journals or listed in the NNES are for sale by OTS, from which price lists may be obtained. These reports are also listed in the monthly catalog of the Government Printing Office. Nearly all the nonclassified AEC research and development reports which are not published in journals or in the NNES are supplied to 40 depository libraries located throughout the country and are thus readily available to literature searchers. A list of these libraries is contained in a booklet, "Availability of USAEC Research and Development Reports" (*21*).

Department of Defense

It has been estimated that the research and development programs of the Department of Defense produce over 100,000 scientific and technical reports each year. The dissemination of this information has been handled by two separate agencies, the Central Air Documents Office (CADO) at Dayton, Ohio, and the Technical Information Division (TID) of the Library of Congress, formerly called the Navy Research Section. In May

1951, the Armed Services Technical Information Agency (ASTIA) was established to provide an integrated program of scientific and technical report services for the Department of Defense and its contractors by merging the two existing services. The process of integration is now taking place. It is the responsibility of ASTIA to collect, catalog, and abstract technical reports issued by various bureaus, offices, and contractors of the Department of Defense and any other reports in fields of interest to the National Defense. In addition to supplying abstracts of these reports to qualified agencies and contractors, a report lending service and reference and bibliographic service are conducted. At present, ASTIA has taken over the functions of CADO and is now in the process of integrating activities with TID.

ASTIA's main channel for distributing abstracts of reports is through its catalog cards. It also issues a monthly publication, the *Technical Data Digest*, which is now restricted, and which contains original articles, extracts of papers of interest in various fields of research, and abstracts of current magazine articles of a technical nature.

The TID issues a *Technical Information Pilot* (TIP) periodically, containing abstracts of all reports received; it is issued in four security classifications including unclassified. There is an annual index. TIP catalog cards are also available to qualified agencies and contractors for convenience in cataloging the reports; these cards contain abstracts identical with those appearing in TIP.

In addition to these functions, the Technical Information Division is preparing a series of book catalogs covering approximately 30,000 technical reports issued during World War II under the auspices of the Office of Scientific Research and Development (OSRD). The catalogs are issued by subject divisions, there being a total of 22, and distribution is handled by OTS. From the point of view of the plastics technologist, the matter of OSRD reports is complicated by the fact that none of the divisions were specifically concerned with plastics. Nevertheless, many reports were issued about plastics, and one should turn to the OTS to locate these reports. It should be kept in mind that the OSRD functioned from 1940 to 1946 only.

As noted previously, when Department of Defense reports are declassified and made available to the general public, distribution is handled by OTS through its normal channels. The majority of literature searchers will deal with OTS, and the statements previously made regarding OTS should guide the individual in finding and obtaining these reports.

The above is a very brief summary of the activities of ASTIA, CADO, and TID. Further details may be obtained in several recent publications (*1, 14, 18, 54*).

Bureau of Mines

The Bureau of Mines, Department of the Interior, because of its interest in mine safety and allied fields, has issued two recent reports on "Inflammability and Explosibility of Powders Used in the Plastics Industry" (*26*) and "Toxicity and Flame-Resistance of Thermosetting Plastics" (*29*). This bureau lists all of its publications in a main index covering the period 1910–1948 (*27*), with later reports covered in annual supplements (*28*).

Public Health Service

The Division of Occupational Health of the Public Health Service has published several articles on industrial hazards in the plastics industry (*56, 57, 59*). Most of these articles have appeared in their monthly publication, now known as *Occupational Health* (*58*).

Prevention of Deterioration Center

The Prevention of Deterioration Center, sponsored by the Department of Defense, functions within the National Research Council. It issues a monthly publication, *Prevention of Deterioration Abstracts* (*13*). It is the most comprehensive in the field and covers material from other sources in addition to government documents. One of the sections is designated as "Plastics, Resins, Rubber, and Waxes." A fairly liberal interpretation is placed on the term deterioration, so that coverage is somewhat more than one might anticipate. The center also has a monthly *Advance List* (*12*) which covers in bibliographic form only all reports received by the center. About one third to one half of these are later included in the abstracts.

The abstracts and *Advance List* are available free of charge to those agencies and institutions conducting deterioration studies for the Department of Defense. They are available to the general public on a cost subscription basis.

This center prepared a comprehensive book "Introduction to the Prevention of Deterioration of Materials," published by a commercial publisher early in 1953.

Bureau of the Census

Some of the data issued by the Bureau of the Census, Department of Commerce, will be of interest to those concerned with statistics of the plastics industry. In the "Census of Manufactures—1947" there is a section on industrial organic chemicals (*22*) and one on plastics products; miscellaneous manufactures (*23*). Each section is available as a separate publication. The former includes statistics on the plastics materials industry while the latter concerns the plastics products industry. Presented in each section are data on employment, pay rolls, value added by manufacture, value of shipments, cost of raw materials, expenditures for plants and equipment, and other categories. The next complete census of manufactures will be made in 1954 to cover 1953. An annual survey is published (*25*), but the information is not nearly as comprehensive as that in the "Census of Manufactures."

The Bureau of the Census also published a statistical history of the growth of plastics through 1939 (*24*) based on data from the "Census of Manufactures."

U. S. Patent Office

Patents relating to plastics can be found through the usual search routines, something which is outside the limited scope of this paper. Specific patents may be ordered from the U. S. Patent Office, Department of Commerce, or may be examined in the Patent Office in Washington or in a number of libraries throughout the country. At a nominal charge, the Patent Office will furnish a full list of patents for any class and subclass desired. This facilitates patent study in those cities which have bound volumes of U. S. patents.

One cannot always be sure which agency in the government will turn out a report of more than usual interest. Thus one might not expect the Patent Office to have any reports of unusual interest to the public. However, the only publication listed in the Government Printing Office's "Government Best Sellers" which has plastics as its main theme is one released in 1949 by the Patent Office (*55*). This report lists representative patents available for plastic products and processes from three types of patents: patents available for licensing or sale, government-owned patents, and dedicated patents. Instructions for locating other patents are given. Unfortunately, for really complete coverage, it would have to be brought up to date.

Department of Commerce and Other Agencies

The library of the Department of Commerce has just issued a comprehensive index of publications of the Department of Commerce and all of its agencies (*38*). The index covers reports issued through October 1950 and it is planned to issue regular supplements in the future. This publication contains a subject index with "Plastics" as one of the subheadings.

The library also issues a weekly *Business Service Check List* (*37*) which lists some of the recent and more useful department publications, including those of the National Bureau of Standards and the Office of Technical Services.

In 1949 a survey of basic information sources on plastics (*41*) was prepared by the office then known as the Office of Domestic Commerce. This survey lists publications of various agencies of the Department of Commerce as well as other government departments. Textbooks and periodicals concerned with plastics are also listed. Some of the information is dated and no longer correct, but the general information is still of value.

Another publication of unusual interest is the "Chemical Statistics Directory, No. 2" (*40*) which provides an index to the chemical statistics available from government sources for the years 1946–1947. This report has not been revised as originally planned; nevertheless, the sources listed are still mainly correct.

Among the Department of Commerce periodicals is a *Foreign Commerce Weekly* (*42*) issued by their Office of International Trade, containing news items and articles on various commodities, including plastics and resins, of interest to the foreign trader. In July 1952, the contents of this publication were completely changed. Its emphasis is now on special articles, and a definite attempt is made to obtain a more current discussion of pertinent information. A somewhat related publication by the same office is the "Foreign Commerce Yearbook" (*43*). These publications give appreciable statistical data on plastics and resins.

An excellent paper on sources of government statistics on chemicals (*39*) was presented recently at an American Chemical Society meeting by Miss Margaret Donnelly, formerly of the National Production Authority of the Department of Commerce. Reprints of this paper are available from NPA.

Department of Justice

The Office of Alien Property of the Department of Justice has many available patents formerly owned by our former enemies and seized by the government during the war. Thousands of ideas for new materials, new processes, and new products are disclosed in these patents which are put into use under a liberal licensing program administered by the Office of Alien Property. These patents have been abstracted, classified, and indexed. A list of all of the subjects under which the patents have been classified is available (*47*), from which the complete set of abstracts for any subject may be ordered. One group of patents is listed under the heading of "Plastics; synthetic resins." Individual patents may then be selected from the abstracts and ordered from the Commissioner of Patents.

U. S. Tariff Commission

Data issued by the U. S. Tariff Commission are of particular interest to plastics processors and consumers because that agency is primarily responsible for statistics on organic chemicals. The yearly issue of United States production and sales of synthetic organic chemicals (*63*) is an excellent guide to actual production and sales of plastics and resin materials, as well as plasticizers and the synthetic rubber polymers and copolymers with synthetic resins. The complete report is issued each fall for the previous year. A section on plastics is generally available in advance (*61*). In compiling the data for the annual report, the Tariff Commission depends somewhat on its monthly report on production and sales of synthetic plastics and resin materials (*60*). The production and sales figures in this publication are listed by types of plastics, using a grouping different from that employed in the annual report.

Many agency reports originate with requests from Congressional committees. An excellent example of this is the report on plastics products (*62*) issued by the Tariff Commission in 1948. This is part of the *War Changes in Industry* series prepared by the Tariff Commission when requested by Congress to investigate the principle domestic industries affected favorably or unfavorably by the war and to report regarding their prewar status, the changes and developments that occurred during the war, and, as far as possible, their probable postwar status in foreign trade and international competition.

Department of Labor

Typical publications issued by the Bureau of Labor Statistics of the Department of Labor are two monthly bulletins, *Employment and Payrolls* (*48*) and *Hours and Earnings*

(*50*), each containing a subheading of "Plastics Materials." These will be of interest to a limited group. The annual supplements are contained in the respective April issues.

In 1948, this bureau published a report on "Employment Outlook in the Plastics Products Industry" (*49*).

Specifications

A detailed discussion of specifications is also outside the scope of this paper. Briefly, there are approximately 15,000 to 20,000 specifications available in two main categories, federal and military. An "Index to Federal Specifications and Standards" (*53*) is issued annually. The index to military specifications, issued semiannually, was published in four volumes: II, Army (*36*); III, Navy (*51*); and IV, Air Force (*35*). Volume I, Munitions Board, was discontinued as of October 1952 in the interest of economy and to avoid unnecessary duplication.

Discussion

The publication activities of the various agencies of the United States Government are very diversified and are constantly changing. Whereas years ago, any attempt to give a reasonably comprehensive coverage of federal publications was apt to remain accurate for some time, it is not true at the present time. With the many functions now being fulfilled by government agencies, there has been an increasing tendency to turn to a limited type of report as a medium for attaining the objectives, at least in part. While no great attempt is being made to publicize these reports, they are sent to inquirers whenever the agency finds the reports suitable and, in such cases, it will often supplement this material by special letter. Even nontechnical agencies such as the Department of State occasionally prepare reports of technical interest. Thus one finds a Foreign Service Despatch from Sweden discussing a method of restoring optical clarity to old glass by the application of a plastic film.

It is difficult if not impossible to track down all government reports in a reasonable time. Some attempts are being made to concentrate the activities into one or more agencies, but any discussion of such possibilities at this time would be premature. The judicious selection of federal agencies based upon their primary and secondary interests is a necessary supplement to any search activities.

If one checks over the indexes of the Government Printing Office *Monthly Catalog*, and certain of the published government agency indexes such as those of the Department of Agriculture and the National Bureau of Standards, then checks the Office of Technical Services on its publications and coverages of its 150,000 publications and solicits their aid in locating government reports on a given subject, it is possible to obtain fairly satisfactory coverage of such reports. This assumes, of course, that an agency in which there is a known supply of information such as statistical figures from the Bureau of Census or the U. S. Tariff Commission, has already been contacted. For a more meticulous search it would be necessary to take the more time consuming approach of contacting other agencies in government in which there exists even a slight suspicion that there is material of interest. This activity naturally follows the law of diminishing returns but, for the present, it is necessary to obtain a complete coverage.

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Editing, Publishing, and Abstracting Of Textile Literature

WILLIAM A. NEWELL

School of Textiles, North Carolina State College, Raleigh, N. C.

A valuable source list for searchers for information on the textile industry, processes, and research is presented. An outline of writing, editing, and publishing policies—to encourage and inform the technical writer—emphasizes the importance of organization, presentation, and clear, factual style.

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This paper broadly covers two subjects—how to get something out of the literature, and how to get something into the literature.

Using Textile Literature Resources

Textile information sources may be classified in three broad categories—books, periodicals, and manufacturer's bulletins.

Books. Books are helpful in providing broad and basic information on a given subject. Unfortunately, this information may also be somewhat obsolete by the time it gets into print in book form, but is useful, nevertheless, in providing historical background for the researcher. It is always well to know where we've been in trying to decide where we're going.

Sound basic information can be found in books. Books do a good job of furnishing information on the principles of the spinning, weaving, or mercerizing processes, for example. While the information on methods or such factors as speeds or concentrations may not be completely up to date, the principles are usually unchanged.

A bibliography titled "Textile Bibliography" compiled by *Textile World*, New York, in 1949 is available. This bibliography, when made up, attempted to list every book on textile processing, both in print and out of print, ever published in the English language.

Periodicals. Textile and chemical periodicals have been appropriately called "the postgraduate course of the textile student." These periodicals normally assume in their editorial coverage that their readers understand the basic principles of textile manufacturing and its terminology, and, therefore, rarely publish textbook-type articles explaining elementary principles. They do, however, carry out the function that textbooks do not and cannot perform—that of keeping their readers up to date on the newest in processing methods.

Periodicals can be easily used as sources of information in research studies by use of either the annual indexes to their contents published by the better magazines themselves, or by use of such standard indexes as *Industrial Arts Index*, *Engineering Index*, etc. The bibliography presented in this paper includes a list of every known textile periodical published in the world. This list, compiled by *Textile World*, also indicates in which standard references the issues are indexed, if they are indexed at all.

Manufacturer's Bulletins. A third and most valuable source of information is

In LITERATURE RESOURCES;
Advances in Chemistry; American Chemical Society: Washington, DC, 1954.

manufacturer's bulletins. These bulletins in many cases accomplish the purpose of both textbooks and periodicals, and in addition provide specific information on a specific piece of processing equipment. Many of these bulletins are not mere catalogs of equipment, but actually excellent technical treatises giving particular know-how information. Such bulletins as *Whitin Review, Saco-Lowell Bulletin, Calco Technical Bulletins,* and others, are good examples.

A researcher can keep up to date on what is new in bulletins by following the pages carried by most textile periodicals on which such bulletins are listed as they are issued. The researcher can also make use of the services of the magazine in securing these bulletins without charge, if desired.

Unfortunately, such bulletins are not indexed except in cases where the companies publishing them issue a periodic index to their own bulletins. However, the bulletins and catalogs can usually be obtained, if available, by writing manufacturers of the specific product in which the researcher is interested. A complete list of such manufacturers is contained in the buyer's guide section of prefiled textile catalogs published by McGraw-Hill Publishing Co., New York.

Information or answers to questions that cannot be found in any of these sources can usually be obtained by writing to the textile periodicals, trade associations, or textile schools. A list of these trade associations and schools is also presented in this paper.

Abstract Services. Abstract services are, of course, still another source of information for the researcher. The purpose of abstracts is to furnish enough information to enable the researcher to keep abreast of developments so that he can select the articles for reading which seem important.

The abstract situation in textiles is said to be confused at present. Researchers making literature searches must go to several sources to ensure a complete search, and in doing so they find much duplication of references. In other words, nobody seems to be doing a complete abstracting job in textiles, but too many people are doing an incomplete job.

Chemical Abstracts abstracts literature dealing with chemistry and dyeing, and even goes somewhat further in its coverage. Abstracts published by the Textile Institute of England are also reasonably complete, and if a researcher uses this service and *Chemical Abstracts*, he will not miss much of importance.

Writing for Publication

In addition to the problem of getting information from the literature, there is the problem of getting information into the literature.

Assuming that a researcher has carried out a research project and has obtained results that might be of benefit and interest to the industry, he is interested in having his results published. This paper tries to explain the criteria by which magazines judge material submitted as to its fitness for publication; the requirements, if any, of such magazines for material published; how such a paper should be written; how a paper should not be written; and give a little insight into what happens in the editing and publishing process.

The objective of the better textile magazines is to help textile mills raise their production, cut their costs, or improve their quality. These things can be done in many ways—by use of new equipment, by better use of old equipment, or through better human relations. Textile periodicals generally accomplish their objectives by publishing two types of papers—case history-type papers that tell how something was done, or "how to" articles telling how something should be done. A paper can also cover both methods.

A report on any research projects should also carry out one or more of these same objectives. If it does not, it is probably not worth publishing. If it does, then it probably fits the editorial formula of the better magazines, and it is therefore suitable for publication.

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The physical requirements for a manuscript for most magazines are very few and simple. About the only physical requirement is that papers be typed double-spaced. The better a paper is written, edited, and organized, the more favorably it will be looked upon by the editor of a publication and the better chance it has to be published quickly. If a paper requires considerable work to get it ready for publication, publication may be delayed for several months. However, if a researcher has some useful information, he should not hesitate to submit even a simple list of facts or a copy of the report that has been written on the project. If the report or the information it contains is of sufficient value, most of the better magazines will take the time and trouble to do the organizing and editing, submit the manuscript to the author for approval, and then publish the manuscript under his name. There is always room in a publication for good material, and good material is fairly scarce. An alert editor will cooperate to the fullest extent with the author in preparing manuscripts for publication.

There is usually no restriction on length of manuscripts that are desired. The staff of *Textile World* used to say that they measured the length of the manuscript in facts per inch. As long as facts and useful information were given, the author was permitted to go on to almost any length. But as soon as the writer stops giving facts and useful information, that is a good place for him to end the manuscript. The briefer a manuscript can be, the better. On the other hand, the magazines are in effect a consulting service for their readers and for the mills that they serve, and therefore thoroughness and detail are important and should not be overlooked.

Developing a Style. Most potential authors are very self-conscious about attempting to write for publication. Actually, this is a ridiculous attitude. Good writing is very simple. Probably part of the reluctance of potential authors to write can be traced to the great amount of bad writing that they have read in the past. Actually, in good writing there is no need to delve into history, attempt to be eloquent in wording, attempt to develop a certain "style," or pile up the table with dictionaries, thesaurus, and other potential aids to writing. The best writing is done almost every day in the week as letters are written to friends and business acquaintances. In such cases, we usually know what we want to say and we go ahead and say it. The secret of good technical writing is also to know what you want to say, and simply to go ahead and say it. Every person has his own individual style whether he knows it or not, and to attempt to emulate the style of some novelist or other technical author will simply complicate these writing projects and harm the effectiveness of the presentation.

Perhaps the best advice to potential writers is to follow the advice of the old-time minister who, in advising a younger minister on how to preach, said, "First you tell 'em what you're going to tell 'em, then you tell 'em, then you tell 'em what you told 'em."

Preparing an Outline. One of the most effective ways to get thoughts onto paper is simply to sit down and boil down into one paragraph containing one, two, or three sentences, the substance of what the research project proves or disproves. In other words, boil it down to a simple exposition of the results and leave out the details. After this has been done, the writer should go back to his sixth-grade training and make an outline of what he plans to say. This outline could follow the chronological steps in the research project, classify the various avenues of research that were explored, or follow any other orderly means of expressing the information. The function of the outline is simply to organize thinking and to be sure that in writing all related facts are put together, and not scattered from one end of the paper to the other. Actually, writing is very simple. The hardest job is the thinking before the writing. But if this thinking is effectively and carefully carried out, the writing will be easy, well organized, and effective as well.

Once the one-paragraph summary of results has been prepared, it can probably be used as it stands or with slight modifications as the lead paragraph of the paper.

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Once started, the rest is generally easy. The steps of the outline are followed and a full explanation of each subject or topic listed in the outline is given. As a conclusion, a summary of what was done may be included. However, this is not really necessary. The writer should not make the mistake of describing the entire project and then summarizing at the end of the paper. This is a common writing fault, and editors are constantly reading through manuscripts to the last paragraph, cutting off the last paragraph, pasting it on the front of the manuscript, and publishing the story pretty much as it is.

Things to Avoid. Three things to avoid in good technical writing or in preparing a paper for publication are history, mystery, and romance.

The history type of writing is commonly found in British publications. In describing a new loom, for instance, the author will invariably start off with some such statement as, "The art of weaving is one of the oldest known to man." He then traces the weaving process as it was carried out by the Egyptians, the Greeks, the Romans, and many of the other civilizations. On page 3 or 4 of his manuscript, he finally gets to the point, a new weaving development has come forth that promises great things for the future. He then tells what the reader really wanted to know in the first place.

The mystery story is also interesting. In this type of story the author begins by telling that certain results have been achieved. Then he spends page after page describing the magnificent accomplishments of some new process or product, and then near the end of his story, as in a detective story, answers the question of how it was done.

The romance story is another interesting type of manuscript. In the romance story, the author sometimes gets to the point fairly quickly and tells what has been done, but then spends several pages explaining that the results obtained are the results of research work carried out over a period of many, many years and involving the services of literally hundreds or thousands of people. He delves in detail into the many engineering or chemical problems that had to be overcome by himself or by his associates in arriving at the final result. Some even go into explanation of how the particular results show what can be done under the great free enterprise system as opposed to other political systems.

Although such romance is unquestionably interesting, and it undoubtedly does show how free-thinking men can overcome stupendous obstacles in arriving at a result, the technical paper for publication is not the place for this sort of material. The readers of a textile publication are basically interested in what a new product or a new process is going to do for them. They feel that even though it took 10 years and the services of hundreds of men to develop a product, such work basically is the job of the supplier and they don't want to be bothered with it. The place for the romance is in the company house organ or institutional advertising.

Therefore, the technical writer should avoid romance, get directly to the point, and tell the reader exactly what the research project is going to do for him and how he can make the best use of it. The basic editorial formula should be remembered—all material should help cut costs, raise production, or improve quality. If these criteria are applied by the writer, a good technical paper is produced.

Authors are sometimes mystified by the great time between the time a paper is submitted and publication of the paper. Admittedly, in some cases, this time lag is great. However, in the publishing business one has to work far ahead. Printing, engraving, editing, proofreading, and other editorial matters all take time. Usually, it takes about 6 weeks from the time the specific issue of a magazine is closed to the time the magazine is actually received by the reader. Added to this are up to 30 days required for reading a manuscript, deciding if it is desirable, accepting, editing, organizing, and in some cases, resubmitting it to the author for approval. It sometimes takes 3 or 4 months to get a paper published.

Chemists and researchers whose work involves seeking information on the textile industry and on textile processing will find the textile industry large and

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complex, but intensely interesting. They will also find cooperative people and institutions willing to assist in finding information. Trade papers and business magazines are numerous and appear periodically—from daily to annually. The textile industry is also unique in that it is served by ten college-level textile schools, all with extensive libraries, devoted exclusively to training men for the industry. In addition to the usual sources of information, these magazines and these schools are ready to help the researcher in the textile field. If the searcher cannot find what he is looking for, he should not hesitate to call on those in the field for assistance.

Textile Periodicals

Compiled by *Textile World.*

Index Key. Publications in which periodicals are indexed are indicated by: (1) *Chemical Abstracts*, (2) *Industrial Arts Index*, (3) *Engineering Index*, (4) *Journal of the Textile Institute*, (5) *Bibliography of Agriculture.*

ARGENTINA

Argentina Textil, San Martin 66, Buenos Aires.
Industria Textil Sud Americana, Buenos Aires.
Revista Textil, Argentine Confederation of Textile Industries, Avenida de Mayo 1157, Buenos Aires.

AUSTRALIA

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AUSTRIA

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BELGIUM

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BRAZIL

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CHILE

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FRANCE

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INDIA
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ITALY
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SPAIN
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Textil, Via Layetana 140, 3.0, Barcelona.

SWEDEN
Textil och Konfektion, Box 7007, Stockholm 7 (4, 5).
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SWITZERLAND
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TURKEY
Feshane Mensucat Meslek Dergisi, Istanbul.

UNITED STATES
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Hosiery & Underwear Review, 1 West 34th St., New York 1, N. Y. (5).
Knitter, P. O. Box 1225, Charlotte 1, N. C.
Papers of the American Association of Textile Technologists, Room 6337, 30 Rockefeller Plaza, New York 20, N. Y., published by Fairchild Publications, Inc., 7 East 12th St., New York 3, N. Y. (4, 5).

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Rayon and Synthetic Textiles, Rayon Publishing Corp., 303 Fifth Ave., New York 16, N. Y. (1, 2, 3, 4, 5).
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Directory of Textile Associations

Alabama Cotton Manufacturers Association, Montgomery, Ala. D. H. Morris, III, president; Dwight M. Wilhelm, executive vice president.
Alabama Textile Operating Executives. Wilson Patterson, general chairman; Ben H. Crawford, secretary, West Point, Ga.
American Association of Textile Chemists & Colorists. H. C. Chapin, secretary, Lowell Textile Institute, Lowell, Mass.
American Association of Textile Technologists. George H. Hotte, president; Bernice S. Bronner, secretary, American Cyanamid Co., 30 Rockefeller Plaza, New York, N. Y.
American Cotton Manufacturers Institute, Inc., Charlotte, New York, and Washington, D. C. Chas. C. Hertwig, president; F. S. Love, secretary-treasurer.
American Cotton Waste Exchange, 222 Summer St., Boston, Mass. Maurice J. Simon, president; Frank E. Hanington, Jr., secretary.
American Lace Manufacturers Association, Inc., 212 Turks Head Bldg., Providence 3, R. I. Harold G. Truman, president; Richard Bloch, secretary; Edward F. Walker, executive director.
American Silk Council, Inc., 489 Fifth Ave., New York 17, N. Y. George Elbogen, president; Alvin Barber, secretary.
American Society of Mechanical Engineers, Textile Division. A. B. Studley, northern representative, 160 Washington St., N., Boston, Mass.
American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. C. L. Warwick, executive secretary.
Asbestos Textile Institute, Ceramics Department, Rutgers University, New Brunswick, N. J. M. C. Shaw, secretary.
Association of Commission Wool Scourers & Carbonizers. P. Morelle, Jr., secretary, Star Carbonizing Co., 706 Diamond Hill Rd., Woonsocket, R. I.
Association of Cotton Textile Merchants of New York, 40 Worth St., New York 13, N. Y. W. Ray Bell, president; John L. Severance, secretary.
Association of Cotton Yarn Distributors, 5th & Chestnut Sts., Philadelphia 6, Pa. Frank E. Slack, president.
Association of Knitted Fabrics Manufacturers, 1450 Broadway, New York 18, N. Y. Jacob M. Wallerstein, president; Jacob P. Rosenbaum, executive secretary.
Association of Narrow Fabrics Manufacturers, Inc., 5th & Chestnut Sts., Philadelphia 6, Pa. Frank E. Slack, managing director.
Atlanta Textile Club, Atlanta, Ga. H. I. Avery, Jr., president; J. W. Waddell, secretary, 530 Trust Co. of Ga. Bldg., Atlanta, Ga.
Bobbin Manufacturers Association, 715 Hospital Trust Bldg., Providence, R. I. Matthew E. Ward, secretary.
Boston Wool Trade Association, 263 Summer St., Boston, Mass. C. Willard Bigelow, secretary-treasurer.
Brattice Cloth Manufacturers Association, 54 Worth St., New York 13, N. Y. F. C. Larson, president; H. E. O'Neill, secretary.
Burlap & Jute Association, 425 W. 25th St., New York, N. Y. Joseph Epstein, president; R. S. Carraway, secretary.
Canadian Association of Textile Colorists & Chemists. R. W. Redston, secretary of the Quebec Section, 5493 Viau St., Montreal 36, Quebec; R. W. Graham, secretary of the Ontario Section, 32 Tuxedo Ave., S., Hamilton, Ont.
Canadian Woolen & Knit Goods Manufacturers Association, 50 King St., West, Toronto, Ont. W. M. Berry, secretary.
Canvas Waterproofers Association, P. O. Box 168, Poughkeepsie, N. Y. E. L. Johnson, president.
Carded Yarn Association, Inc., Johnston Bldg., Charlotte, N. C. D. R. La Far, Jr., president; Juanita Nixon, secretary.
Carpet Institute, Inc., 350 Fifth Ave., New York, N. Y. M. A. Watson, president; King Hoagland, secretary.
Chattanooga Yarn Association, Chattanooga, Tenn. David Gott, secretary, Chattanooga Bank Bldg., Chattanooga, Tenn.
Chicago Yarn Men's Club, 222 West Adams St., Chicago, Ill. E. W. Wood, president; Wm. E. Feery, secretary.

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Committee D-13 (American Society for Testing Materials). W. H. Whitcomb, secretary, 41 Norman Ave., Cranston, R. I.

Cordage Institute, 350 Madison Ave., New York 17, N. Y. DeWitt C. Schieck, secretary.

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Dominion Wool Dealers' Association, 217 Bay St., Toronto 1, Ont. C. M. Kent, president, W. J. Cannon, secretary.

Durene Association of America, 350 Fifth Ave., New York, N. Y. A. C. L. Newsom, executive secretary.

Eastern Maine Woolen Overseers Association. James Halliday, secretary, Oakland, Maine.

Fall River Textile Manufacturers Association, 57 North Main St., Fall River, Mass. L. R. Morley, secretary-treasurer.

Felt Association, 74 Trinity Pl., New York, N. Y. H. S. Blake, Jr., executive secretary.

Fiber Society. J. T. Wigington, secretary, Clemson, S. C.

Full-Fashioned Hosiery Manufacturers of America, 3701 North Broad St., Philadelphia 40, Pa. Richard F. Peden, secretary pro tem.

Green Mountain Textile Overseers Association, Proctorsville, Vt. Henry Cushman, president; Guy Morse, secretary.

Greenville Textile Club, Greenville, S. C. Ray W. Bayne, president; D. W. Stevenson, secretary.

Hard Fibres Association, 425 West 25th St., New York, N. Y. Chester P. Smith, president; R. S. Carraway, secretary.

Hosiery Mill Representatives Club of Chicago. A. D. Crawford, president, 176 West Adams St., Chicago, Ill.

Hosiery Wholesalers National Association. L. Guzik, counsel & executive director, 32 Broadway, New York 4, N. Y.

Independent Association of Stocking Manufacturers, 11 North Juniper St., Philadelphia, Pa. E. M. Rand, executive secretary.

Knitting Machine Manufacturers Association of the United States, 350 Fifth Ave., New York 1, N. Y. K. W. Howie, president; Beale J. Fausett, secretary.

Maine Woolen & Worsted Association. John Robinson, president, Oxford, Maine; Everett Greaton, secretary, Augusta, Maine.

Master Dyers Association, Main St. & Walnut Lane, Philadelphia, Pa. Horace T. Greenwood, president; Graham J. Littlewood, III, secretary.

National Association of Cotton Manufacturers, 80 Federal St., Boston, Mass. William F. Sullivan, president.

National Association of Finishers of Textile Fabrics, 40 Worth St., New York, N. Y. Alice C. Moore, secretary-treasurer.

National Association of Hosiery Manufacturers, 468 Fourth Ave., New York 16, N. Y. Samuel F. Rubin, chairman; Earl Constantine, president; Reuben C. Ball, secretary.

National Association of Lace Curtain Manufacturers, 366 Madison Ave., New York, N. Y. W. J. Parker, commissioner.

National Association of Textile Machinery Manufacturers. J. Hugh Bolton, president, Whitinsville, Mass.; Max F. Thompson, Secretary, Whitinsville, Mass.

National Association of Textile Printing Colorists, 465 Main St., Cambridge, Mass.

National Association of Waste Material Dealers, Inc., 271 Madison Ave., New York 16, N. Y. Clinton M. White, secretary.

National Association of Wool Manufacturers, 386 Fourth Ave., New York, N. Y. Arthur Besse, president; E. Wilkinson, assistant to president; Walter Humphreys, secretary & treasurer, 80 Federal St., Boston, Mass.

National Association of Woolen & Worsted Overseers. Raymond T. Bourey, president, Lebanon, N. H.; James J. Burns, secretary, 65 Wellesley Road, Holyoke, Mass.

National Canvas Goods Manufacturers Association, Inc., 224 Endicott Bldg., St. Paul, Minn. Lawrence H. Stevens, president; James E. McGregor, executive secretary-treasurer.

National Cotton Council, Memphis, Tenn. Harold A. Young, president; Wm. Rhea Blake, executive vice president and secretary.

National Cotton Ginners Association, 1004 Cravens Bldg., Oklahoma City, Okla. W. O. Fortenberry, president; Roberta Reubell, acting secretary.

National Council of Textile School Deans, E. T. Pickard, treasurer's office, Kent, Conn.

National Federation of Textiles, Inc., 389 Fifth Ave., New York 16, N. Y. Alexander F. Ix, president; Irene Blunt, secretary-treasurer.

National Knitted Outerwear Association, 386 Fourth Ave., New York, N. Y. Milton Davis, president; Sidney S. Korzenik, executive director.

National Safety Council, Textile Section. C. J. Hyslup, chairman, Elkin, N. C.

National Textile Processors Guild, 51 Chambers St., New York, N. Y. H. E. Kenworthy, president; H. T. Greenwood, Jr., vice president; Harold Korzenik, secretary-counsel.

National Wool Trade Association, 263 Summer St., Boston, Mass. C. W. Bigelow, secretary-treasurer.

New Bedford Cotton Manufacturers Association, Masonic Building, New Bedford, Mass. F. W. Steele, executive-secretary.

New England Rayon & Synthetic Yarns Peddlers Association, Providence, R. I. Earl V. Litchfield, president.

New Hampshire Manufacturers Association, Manchester, N.H. Leon H. Rice, president; Philip M. Darling, executive secretary.

New York Association of Hosiery Mill Salesmen, 350 Fifth Ave., New York, N. Y. Frank Doherty, president.

New York State Textile Overseers Association. Joel McCannon, president, Stottville, N. Y.; Emil Tegtmeier, secretary, Stottville, N. Y.

North Carolina Cotton Manufacturers Association. Julian Robertson, president, Salisbury, N. C.; Hunter Marshall, secretary-treasurer, Charlotte 2, N. C.

Philadelphia Textile Manufacturers Association, Public Ledger Bldg. E. K. Pierson, managing director.

Philadelphia Wool & Textile Association, Philadelphia, Pa. H. J. Ferren, secretary, Eavenson & Levering, Camden, N. J.

Plastic Coatings & Film Association. P. F. Johnson, executive secretary, 9 Rockefeller Plaza, New York 20, N. Y.

Plastic Materials Manufacturers Association, Inc., Washington, D. C. F. H. Carman, general manager.

Primary Textiles Institute, 50 King St., West, Toronto, Canada. H. G. Smith, chairman; W. M. Berry, executive secretary-treasurer.

Rayon Yarn Producers Group, 350 Fifth Ave., New York, N. Y. Matthew H. O'Brien, secretary.

Rhode Island Textile Association, 212 Turks Head Bldg., Providence 3, R. I. K. B. Cook, president; E. F. Walker, secretary-treasurer.

Salesmen's Association of the Textile Dyeing & Printing Industry, Inc., Eighth Ave. & 51st St., New York, N. Y. Leo J. Brill, president.

Shenandoah Valley Textile Executives Association, Oella, Md. John J. Burger, president; Richard Petrie, secretary.

Silk & Rayon Institute, 50 King St., West, Toronto, Canada. W. M. Berry, secretary.

Silk & Rayon Manufacturers Association, University Tower, Montreal, Canada. A. Wesley Mason, president.

Silk Commission Manufacturers Association, 132 Market St., Paterson 1, N. J. Herbert Susser, executive secretary and counsel.

Silk & Rayon Printers & Dyers Association of America, Inc., 1450 Broadway, New York, N. Y. Dean M. Lewis, president; Geo. F. Gaede, secretary; Charles A. Grant, manager.

Skein Dyers Association of America, 418 17th Ave., Paterson 4, N. J. Beptiste J. Lanza, president; Fred Kern, secretary.

Soft Fibre Manufacturers Institute. G. F. Quimby, secretary, 9 Rockefeller Plaza, New York 20, N. Y.

Southern Combed Yarn Spinners Association, Gastonia, N. C. H. E. Rietz, executive secretary-treasurer.

Southern Hosiery Manufacturers Association, Charlotte, N. C. T. F. Dooley, chairman; Taylor R. Durham, president and secretary.

Southern New England Textile Club, 1201 Lonsdale Ave., Saylesville, R. I. Arthur C. Adams, president.

Southern Textile Association, P. O. Box 1225, Charlotte, N. C. James T. McAden, Jr., secretary-treasurer.

Textile Associates Club, 749 Narragansett Pkwy., Providence, R. I. Charles A. Haynes, Jr., secretary-treasurer.

Textile Manufacturers Association of South Carolina. W. H. Beattie, president, Greenville, S. C.; John K. Cauthen, executive vice president, Columbia, S. C.

Textile Brokers Association, 247 Church St., New York, N. Y.

Textile Color Card Association of the United States, Inc., 200 Madison Ave., New York 16, N. Y. Margaret Hayden Rorke, managing director and secretary.

Textile Designers, Analysts & Technicians Association, Fall River, Mass. Frank Kustecki, West Warwick, R. I., president; M. J. Wayner, New Bedford, Mass., secretary.

Textile Distributors Institute, Inc., 469 Seventh Ave., New York, N. Y. Walter Ross, president; H. A. Wiedenfeld, executive secretary.

Textile Export Association of United States, 271 Church St., New York 13, N. Y. Harold N. Pratt, president; John W. Murray, secretary-treasurer.

Textile Fabrics Association, 40 Worth St., New York, N. Y. W. P. Fickett, president-treasurer; A. W. Davis, secretary.

Textile Operating Executives of Georgia. H. M. Jackson, general chairman, Atlanta, Ga.; Herman A. Dickert, secretary, Georgia Tech., Atlanta, Ga.

Textile Research Institute, Kingston Road, Princeton, N. J., Publications Department, 10 East 40th St., New York 16, N. Y.; Paul C. Alford, Jr., secretary.

Textile Waste Exchange, P. O. Box 4547, Atlanta 2, Ga. W. T. Coleman, president; John M. Bell, secretary.

Thread Institute, Inc., 11 West 42nd St., New York, N. Y. Josef Pollack, Chairman; David Snyder, executive director and secretary.

Tufted Textile Manufacturers Association, P. O. Box 256, Dalton, Ga. Henry C. Ball, president: E. J. Moench, executive vice president.

Underwear Institute, 2 Park Ave., New York, N. Y. Roy A. Cheney, president.

United Knitwear Manufacturers League, 51 Chambers St., New York 7, N. Y. Harry Katz, president, Harold Korzenik, executive counsel.

Warp Knit Fabric Manufacturers Group, National Federation of Textiles, Inc., 389 Fifth Ave., New York 16, N. Y. G. V. P. Marks, chairman.

Webbing Manufacturers Institute. E. B. Pomeroy, secretary, 13 Masonic St., New London, Conn.

Wholesale Dry Goods Institute, Inc., 40 Worth St., New York, N. Y. Henry Matter, executive vice president.

Wool Bureau, Inc., 16 West 46th St., New York, N. Y.

Woolen Wholesalers National Association. L. Guzik, counsel & executive director; 32 Broadway, New York 4, N. Y.

Woolknit Associates, Inc., 745 Fifth Ave., New York, N. Y. Neil MacLellan, president; Herman G. Lustfield, secretary.

Woonsocket Association of Manufacturers, Woonsocket, R. I. Henry Dursin, president; J. C. Winn, secretary-treasurer.

Yarn Merchants Association, Inc., 171 Madison Ave., New York, N. Y.

Textile Schools

Alabama Polytechnic Institute, School of Textile Technology, Auburn, Ala. W. Charles Knight, acting head.

Bradford Durfee Technical Institute, Fall River, Mass. Leslie B. Coombs, president.

Clemson School of Textiles of Clemson Agricultural College, Clemson, S. C. Hugh M. Brown, dean.

Fashion Institute of Technology, 225 West 24th St., New York 11, N. Y. G. E. Linton, dean.

Georgia Institute of Technology, A. French Textile School, Atlanta, Ga. H. A. Dickert, director.

Institute of TextileTechnology, Charlottesville, Va. Jack Compton, chairman executive committee and technical director; J. L. Vaughan, chairman academic committee; P. F. Coburn, mill liaison.

Lowell Textile Institute, Lowell, Mass. Martin J. Lydon, president.

Massachusetts Institute of Technology, Division of Textile Technology, Cambridge, Mass. Edward R. Schwarz, head.

New Bedford Textile Institute, New Bedford, Mass. George Walker, president.

North Carolina State College, School of Textiles, Raleigh, N. C. Malcolm E. Campbell, dean.

North Carolina Vocational Textile School, Belmont, N. C. Chris. E. Folk, principal; Martin L. Rhodes, superintendent.

Philadelphia Textile Institute, Philadelphia, Pa. B. W. Hayward, director; Richard S. Cox, dean.

Rhode Island School of Design, Division of Textiles & Clothing, 14 College St., Providence, R. I. W. D. Fales, division chairman.

State University of New York, Institute of Applied Arts and Sciences at Utica, Utica, N. Y. Paul B. Richardson, president.

Texas Technological College, Textile Engineering Department, Lubbock, Tex. L. E. Parsons, department head.

Textile Evening Trade School, 351 West 18th St., New York, N. Y. Jon B. Leder, principal.

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Literature of the Natural Fibers

RUBY K. WORNER

Southern Regional Research Laboratory, New Orleans, La.

DOROTHY B. SKAU

U. S. Department of Agriculture Library, New Orleans Branch, New Orleans, La.

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The literature on natural fibers is reviewed; an extensive bibliography is provided. The references are discussed according to subject—i.e., classification and varieties of fibers; nomenclature; treatises, monographs, and reviews containing general information; and sources of information on specific fibers. Also discussed are abstracting and indexing services; bibliographies, reading lists, and library catalogs; periodical lists; and sources of miscellaneous information.

From antiquity until around 1900, the natural fibers were the only important raw materials of the textile industry. In 1900, they represented at least 99.9% of the world production of textile fibers. In 1950, they accounted for approximately 85%, although their production had almost doubled.

The first use of the natural fibers antedates written records by many centuries. Patterns of weaves on clay vessels attributed to the Old Stone Age and spindle whorls found among the relics of the New Stone Age are evidence that both weaving and spinning were practiced during those times. Because of the perishable nature of fibers, actual specimens of fabrics were not found until archeological investigations uncovered them in early Egyptian tombs and in the remains of the Swiss Lake Dwellers. Such findings along with the very earliest written records show that our most prominent modern fibers—flax, wool, cotton, silk, and hemp—were among the first fibers used, illustrating perhaps, the survival of the fittest.

The technical literature of the natural fibers covers a very wide scope and is peculiarly complex. The natural fibers are exceedingly numerous. Our understanding and evaluation of their behavior are based on knowledge gained from diverse fields, including botany, biology, geography, and economics, as well as the many different branches of chemistry and physics. The literature reflects also many historical aspects, for a number of the crafts practiced through the centuries are the basis for modern textile technology and science. Therefore, if fibers are to be used wisely, it is necessary to consider and attempt to correlate the influences of the various fields of science on their constitution, properties, and performance.

It is obviously impossible to present a comprehensive, impartial, and balanced survey of all the useful sources in so short a time. It is hoped that the presentation will serve as a key to the literature of the scientific and technological aspects of the natural fibers. Most of the sources cited contain bibliographies which will refer to sources having other bibliographies, and so on—like an endless chain. The pay-off is best if the chain is not broken before the original sources are reached. Few journal references are included, since these are available from the abstracting and indexing services, and from the treatises, monographs, and reviews.

In LITERATURE RESOURCES;
Advances in Chemistry; American Chemical Society: Washington, DC, 1954.

In order to avoid repetition, the books listed in the "Textile Bibliography" (*233*) are not included in the bibliography of this paper unless they are mentioned in the text. Some well-known authoritative references, not listed in this paper, will be found there.

The references given are, for the most part, those readily available and used in the United States and other English-speaking countries; but an effort has been made—largely through the appended bibliography—to include outstanding sources regardless of language or country of origin. These are discussed in the same order as listed in the bibliography.

Classification and Varieties

Although natural fibers are usually classified according to their origin as animal or vegetable, chemists generally think of them from the viewpoint of their chemical nature as protein or cellulosic. The mineral kingdom also produces an important fiber—asbestos —which has had limited use in the textile field because of processing difficulties.

The cellulosic fibers can be subdivided further into seed, bast, leaf, and fruit; and the protein fibers into wool and hair, and secretion, as shown in Table I.

The "World Fiber Survey" (*5*), prepared by the Food and Agriculture Organization of the United Nations in 1947, considers nine of these fibers as of major economic importance—namely, cotton, jute, flax, hemp, abacá, sisal, henequen, wool, and silk. Ramie and kenaf might be added to these nine in the light of present investigations to find substitutes for strategic fibers that may be in short supply.

A more comprehensive list of commercially available natural fibers arranged in tabular form is included in the latest edition of "ASTM Standards on Textile Materials" (*25*). This list gives the commercial as well as the botanical or biological names.

The exact number of natural fibers that have served textile purposes cannot be determined, since a great many of them have been tried on a small scale but have never attained economic importance. Vegetable fibers, in particular, are extremely numerous and diversified in character. In 1897, Dodge listed 1018 species in his "Descriptive Catalogue of Useful Fiber Plants of the World" (*3*). He described these species fully, treating them from botanical, agricultural, and industrial standpoints. The economic data are, of course, antiquated, but the scientific, commercial, common, and native names which have been included in so far as possible are still invaluable. Also given are the kind of fiber produced, the part of the plant from which it is taken, and the position of the species in the vegetable kingdom. Unfortunately, this classic reference book has long been out of print, but it can still be consulted in many libraries.

A similar catalog of fiber-producing plants was published in Germany in 1924 by Schilling (*4*). This work lists 1926 plants—almost twice as many as given by Dodge in 1897. This book is strictly a catalog without the complete descriptions included by Dodge. Instead, there is a bibliography of 460 references to literature in all parts of the world.

Nomenclature

A discussion of where to find textile information inevitably presents the problem of nomenclature or terminology. This subject is particularly difficult for newcomers and

Table I. Partial List of Natural Fibers

[Adapted from (*5*)]

Cellulosic Fibers				Protein Fibers	
Seed	Bast	Leaf	Fruit	Wool and Hair	Secretion
Cotton	Jute	Abacá	Coir	Sheeps' wool	Silk
Kapok	Flax	Sisal		Hair of the:	
	Hemp	Henequen		Camel	
	Ramie	Cantala		Alpaca	
	Sunn	Caroa		Llama	
	Kenaf	Istle		Vicuña	
	Urena Lobata	Phormium Tenax		Goat	
		Palm		Rabbit	
				Horse	
				Cattle	

occasional workers in the textile industry. As in most specialty fields, common words are sometimes used with special meanings; also British and Americans may use the same word but with different interpretations or they may have entirely different words to express the same idea.

Textile definitions most generally accepted for reference in the United States are those standardized by the American Society for Testing Materials and published in "ASTM Standards on Textile Materials" (*10, 25*). The Federal Trade Commission has also established definitions for use in enforcing its Trade Practice Rulings (*20*). These may differ from the ASTM definitions—for example, the ASTM restricts its definition of wool to "the fiber from the fleece of the sheep," whereas the Federal Trade Commission defines it as "the fiber from the fleece of the sheep or lamb or hair of the Angora or Cashmere goat (and may include the so-called specialty fibers from the hair of the camel, alpaca, llama, and vicuña)."

Other organizations also set up standard definitions for special purposes—for example, the Trade Standards Division of the U. S. Department of Commerce in connection with commercial standards (*19*); the Federal Specifications Board for government purchase specifications; and the American Association of Textile Chemists and Colorists as part of textile test methods.

On the international basis, a serious effort to standardize textile nomenclature is being made by the Textiles Subcommittee of the International Standardization Organization (ISO/TC38). Committee D-13 of the American Society for Testing Materials and the British Textile Institute, both working through their national standards associations, are especially active in this effort (*17*). It is interesting to note that the other member nations have recommended that the Americans and British reach an agreement in their use of words before translating definitions into other languages.

Textile dictionaries generally give more descriptive definitions than those of the organizations just mentioned. Among recent dictionaries that are fairly comprehensive in scope are "Callaway Textile Dictionary" (*11*) and Higgins and LaVault's "Comprehensive Dictionary of Textile Terms" (*13*). For British usage, there is " 'Mercury' Dictionary of Textile Terms" (*18*).

Background References

General References. Treatises, monographs, and reviews are part of this class.

TREATISES AND MONOGRAPHS. "Matthews' Textile Fibers" (*52*) is the outstanding reference for an all-inclusive treatment of the various aspects of the different fibers and classes of fibers. It covers history, chemical and physical properties, microscopy, testing, utilization, and economics; and it provides an extensive biblicgraphy with each chapter. It is interesting to remember that the first edition in 1904 represents "the author's endeavor to bring together as far as possible, all of the material available for the study of textile fibers." Much of this same ambition is sensed in the fifth edition, published in 1947, which is a complete revision of the earlier pioneer editions. A board of 45 experts cooperated in its preparation with Herbert R. Mauersberger as editor.

The Marberg lecture of the late Harold DeWitt Smith can be highly recommended for its philosophical presentation on the physical and mechanical properties of the different fibers. This lecture, entitled "Textile Fibers; an Engineering Approach to their Properties and Utilization" (*65*), was delivered before the American Society for Testing Materials in 1944.

The more fundamental aspects of fiber constitution and behavior are dealt with in Astbury's "Fundamentals of Fibre Structure" (*27*) and "Textile Fibres under the X-Rays" (*28*); Hermans' "Contributions to the Physics of Cellulose Fibres" (*39*), and "Physics and Chemistry of Cellulose Fibres" (*40*); Marsh's "Textile Science" (*49*); Preston's Fibre Science (*59*); and the "High Polymers" series of monographs, three of which are concerned with natural fibers—Volume IV, "Natural and Synthetic High Polymers," by Kurt H. Meyer (*53*); Volume V, "Cellulose and Cellulose Derivatives," edited by Emil Ott (*56*); and Volume VI, "Mechanical Behavior of High Polymers," by Turner Alfrey, Jr. (*21*),

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The more strictly chemical aspects of the vegetable fibers are treated in Dorée's "Methods of Cellulose Chemistry" (*30*), Heuser's "Chemistry of Cellulose" (*44*), and Marsh and Wood's "Introduction to the Chemistry of Cellulose" (*50*). Chemistry of the animal fibers was reviewed in the papers presented at the Fibrous Proteins Symposium, published by the Society of Dyers and Colourists in 1946 (*66*). Fibers in general are dealt with in two textbooks, Hartsuch's "Introduction to Textile Chemistry" (*36*), and Fierz-David and Merian's "Abriss der chemischen Technologie der Textilfasern" (*33*); also in Heermann and Agster's "Färberei- und textilchemische Untersuchungen" (*37*); Frenzel's "Einführung in die Textilchemie" (*34*); and Valkó's "Kolloidchemische Grundlagen der Textilveredlung" (*72*).

"Microbial Decomposition of Cellulose" by R. G. H. Siu, published in 1951 (*63*), is a comprehensive review of the various aspects of this field. Emphasizing cotton, Siu includes a chapter on morphological, physical, and chemical features of cotton with 304 references, and sections on the mechanism of degradation and prevention of degradation. Each chapter is followed by an extensive bibliography, with a grand total of over 2000 references. Indexes of authors, micro-organisms, and subjects are given.

The most generally accepted methods for evaluating the chemical, physical, and microbiological properties of fibers and their products are given in the latest editions of "ASTM Standards on Textile Materials (with Related Information)" (*25*); Federal Specification "Textile Test Methods" (*70*); the "Technical Manual and Year Book" of the American Association of Textile Chemists and Colorists (*23*); and British Standards Institution Handbook "Methods of Test for Textiles" (*29*). Helpful references on testing methods include the AATCC 1949 monograph on "Analytical Methods for a Textile Laboratory" (*22*); "Textile Testing, Physical, Chemical, and Microscopical," by J. H. Skinkle (*64*); "Textile Analysis," by S. R. and E. R. Trotman (*69*); and "Textile Untersuchungen" by M. Nopitsch (*54*).

For microscopy, Hanausek's "The Microscopy of Technical Products" (*35*) is helpful when examining cordage and hair products; Shillaber's "Photomicrography in Theory and Practice" (*62*) is useful for these techniques. Von Bergen and Krauss' "Textile Fiber Atlas" (*74*) and Wildman's "Animal Fibres of Industrial Importance: Their Origin and Identification" (*77*) are general references. Also valuable to the microscopist are two recent books in German, Herzog's "Handbuch der mikroskopischen Technik für Fasertechnologen" (*41*) and Luniak's "Die Unterscheidung der Textilfasern" (*47*). For identification and analyses of fiber mixtures, the methods of the American Association of Textile Chemists and Colorists, the American Society for Testing Materials, and the British Textile Institute are all well-known and widely used working tools.

"Textile Microscopy in Germany," Report No. 13 in the Quartermaster Textile Series (*71*), provides a valuable set of reference photomicrographs from Germany plus some electron micrographs of fibers, illustrative of techniques employed in the United States and Holland.

REVIEWS. Since 1917, a review chapter on fibers, textiles, and cellulose has been included by the Society of Chemical Industry in its annual "Reports on the Progress of Applied Chemistry" (*81*).

In 1932, the United States Institute for Textile Research published "Textile Research, A Survey of Progress" which reviewed the literature for 1931 and was intended as the first of a series of such compilations. Unfortunately only one volume was published (*88*).

In 1949, "Review of Textile Progress," a new annual devoted exclusively to the textile industry, was started by a group from the Textile Institute and the Society of Dyers and Colourists who felt the need for more complete information on textiles. The prominently featured subjects include physics and chemistry of fibrous materials, fiber production, and conversion of fibers into finished yarns. Two volumes have so far been issued, covering 1949 and 1950 developments, respectively (*87*).

In 1950, the staffs of the Textile Research Institute and the Textile Foundation began publication in the *Textile Research Journal* of annual reviews of research and development in the field of textiles. The review of 1949 literature includes 826 references, that of 1950 literature, 1622 references (*84*).

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The 1951 Conference of the Textile Institute had as its theme: "Textiles—the Past, Present and Future." Progress during the past 100 years received particular attention in the papers which are presented in full in the proceedings (*86*).

In 1949, a series of authoritative papers on the structure of textile fibers was published by the Textile Institute in the Proceedings section of *Journal of the Textile Institute* (*85*). Three of the papers are general and five deal with specific natural fibers.

Specific Fibers. Literature on specific fibers is subdivided into the following classes: cotton, wool and hair, silk, and the long vegetable fibers, with jute, flax and linen, hemp, ramie, and kenaf as constituents of the last class.

COTTON. The scope of the "American Cotton Handbook" (*97*) by Merrill, Macormac, and Mauersberger is well described in its subtitle as "A Practical Reference Book for the Entire Industry." This handy and widely used book includes the historical, statistical, and economic background of the American cotton industry, and all phases of cotton manufacture from the growing of the plant through the testing and laundering of the finished products. An extensive bibliography is included.

In 1896, the U. S. Department of Agriculture published a 433-page Office of Experiment Stations Bulletin entitled "The Cotton Plant: Its History, Botany, Chemistry, Culture, Enemies, and Uses" (*103*), which is packed with interesting summaries of historical information, including a 62-page chapter on "Chemistry of Cotton." The material presented is well documented with references up to that time. The historical review by R. B. Handy is especially worthy of notice.

Of historical interest also is "The Structure of the Cotton Fibre" by F. H. Bowman, published in 1908 (*92*).

In 1923, in the early days of the British Cotton Industry Research Association, seven reviews of literature pertaining to cotton were published in the Transactions section of the *Journal of the Textile Institute* (*94*).

Botanical and agronomical aspects of cotton are treated in "The Wild and Cultivated Cotton Plants of the World" by Sir George Watt (*104*); "The Development and Properties of Raw Cotton" (*90*) and "Studies in the Quality of Cotton" (*91*) by W. Lawrence Balls, one of the deans of the cotton industry; in "Cotton: History, Species, Variety, Morphology, Breeding, Culture, Diseases, Marketing and Uses" by H. B. Brown (*95*); and in "The Evolution of Gossypium" by Hutchinson, Silow, and Stephens (*96*).

"Cotton Research Proposals, a compilation of needed technical research on cotton fiber utilization based on a report to the Secretary of Agriculture from the Cotton Advisory Committee" is the lengthy title of a pamphlet prepared and published by the National Cotton Council of America in 1947. This report will be of special interest to those who plan and direct research programs (*100*).

WOOL. "American Wool Handbook. A Practical Text and Reference Book for the Entire Wool Industry" well describes this useful volume by Werner Von Bergen and Herbert R. Mauersberger. The second edition, published in 1948, includes chapters on historical and economic background, sheep breeds and raising, specialty fibers, physical and chemical properties of wool, chemical and mechanical processing, testing, and bibliographies (*115*).

William McMurtrie's "Report upon an Examination of Wools and Other Animal Fibers" published in 1886 by the Government Printing Office is still quoted (*113*). This comprehensive report is based on a scientific examination of the fineness, strength, elasticity, and felting properties of the wool of various breeds of sheep exhibited in 1880 at the International Exhibition of Sheep, Wool, and Wool Products in Philadelphia.

Bowman's "Structure of the Wool Fibre" published in 1908 is also of historical interest (*107*).

"Wool Quality" by S. G. Barker (*105*) presents a resume of world-wide chemical, physical, and biological research on the wool fiber through 1931. The same author, in 1929, summarized the existing state of scientific knowledge of wool in an Empire Marketing Board publication, "Wool: A Study of the Fibre" (*106*).

Beginning in 1950, the Wool Bureau, Inc. (U. S. A.) has issued an annual bulletin in which current wool research activities are reviewed, and suggestions are given for research

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and development studies in the areas of mill processing, laboratory tests and standards, fundamental research, product development, and production and marketing. The 1952 edition adds a list of domestic and foreign research laboratories that are actively engaged in wool research (*116*).

"Wool and Wool Manufactures (Basic Information Sources)" was issued in 1949 by the Inquiry Reference Service of the U. S. Department of Commerce. Especially helpful in locating publications of the different federal agencies it also includes lists of nongovernment books, directories, trade and professional associations, trade papers, and research associations concerned with wool (*114*).

SILK. "Bibliography of the Technical Literature on Silk" by F. O. Howitt (*119*) is a comprehensive survey of the technological and scientific aspects of the literature to 1944. An explanatory introduction to silk technology and glossary of silk terms are included.

Handbook No. 2 in the Textile Institute's technology series, also by Howitt (*120*), covers the origin, properties, and economics of silk.

A recent book is "Silk, Biology, Chemistry, Technology," by Carboni of the Silk Experiment Station in Milan (*117*). This work is an up-to-date revision in English of a standard Italian reference which covers the field from the cocoon through dyeing, with chapters on analysis and properties of the fiber.

The U. S. Department of Commerce issued "Silk and Synthetic Fibers, Yarns, and Fabrics (Basic Information Sources)" in 1948 (*122*). Government and nongovernment publications, directories, trade associations and papers, and research organizations are among the sources listed.

LONG VEGETABLE FIBERS. The long vegetable fibers include the bast or soft fibers, such as jute, flax, and hemp; and the leaf or hard fibers, such as sisal and abacá. Flax and hemp are the oldest; jute gained commercial prominence since 1832, now ranking second only to cotton in production; sisal and abacá are relatively newcomers. The U. S. Department of Agriculture has been publishing bulletins and reports on cultivation and processing of vegetable fibers since 1880. Significant contributions were the Office of Fiber Investigations series (*127*) and Dewey's "Fiber Production in the Western Hemisphere" (*125*). "Long Vegetable Fibers" by Weindling, published in 1947 (*140*), describes cultivation and commercial practices with emphasis on the American cordage fibers. The "World Study of Hard Fibers and Hard Fiber Products" of the Department of Commerce appeared in two parts in 1949 and 1951 (*139*). Fabric Research Laboratories, under a Navy contract, investigated the mechanical properties of hard fibers with reference to their use in cordage structures and reported results in their Technical Reports 3 and 4 (*130*). With soft fibers classed among strategic materials, the production and processing of vegetable fiber plants have been accented since World War II. Progress of sansevieria, ramie, and kenaf are reviewed in the Yearbook of Agriculture, 1950–51 (*123*). Economic aspects are covered in the Bureau of Agricultural Economics' annual "The Jute and Hard Fibers Situation," begun July 1951 (*138*).

The 1950–51 annual report of the Indian Central Jute Committee (*145*) mentions the compilation of a 900-item bibliography covering jute science and technology since 1920. This committee published "A Review of the Position Reached in Technological Research in Jute" by C. R. Nodder in 1949 (*146*). Chaudhury's "Jute and Substitutes," published in 1933, is a useful treatise (*142*). The Textile Institute's handbook on jute, by H. L. Parsons, is already out of print (*147*).

An extensive bibliography on flax and linen may be found in Tobler's "Der Flachs als Faser- und Ölpflanze" (*152*). Two reports were issued in 1946 by the Georgia Institute of Technology on processing of domestic flax for textile use (*151*). U. S. Department of Agriculture Farmers' Bulletin No. 1935 dealing with the growth and harvesting of hemp was revised slightly and reissued early in 1952 (*153*).

The most recent general reference on ramie is Luniak's book in German published in 1949 (*159*). History, nomenclature, botany, production, processing, and manufacture are treated in the first part and the properties and uses in the second part. The latter includes chemical, physical, and mechanical properties of the fiber including optical and electrical—also information on identification. In 1948, the Office of Technical Services issued a report, "Ramie Production in Florida" (*161*); in 1949, the Fabric Research Laboratories issued one on degumming of ramie (*160*). The latter investigation was conducted under contract with the Office of Naval Research. A critical survey of ramie by G. L. Carter and Paul M. Horton appeared in 1936 (*154*).

In March 1952, a bibliographical survey, "Kenaf (Hibiscus cannabinus L.)," by Lewis P. McCann was published by the U. S. Department of Agriculture (*165*). A review of the literature is followed by a bibliography of 115 references. An earlier review by Julian C. Crane with 53 references appeared in 1947 (*164*). A joint contribution from the Ministry of Agriculture of Cuba and the Office of Foreign Agricultural Relations of the U. S. Department of Agriculture, published in 1951, concerns producing kenaf for fiber and for seed (*163*). The work reported was carried out as part of the Point IV program of technical cooperation administered by the Technical Cooperation Administration, U. S. Department of State. The Office of Foreign Agricultural Relations has issued several other fact sheets on kenaf.

Abstract and Index Services

The textile field is served by several outstanding abstracting journals and indexing services.

Chemical Abstracts (*200*) is usually the first choice. World-wide coverage of chemical aspects of natural fibers, and annual and decennial subject and author indexes are among its valuable features. It is interesting to note the first issue in 1907 contained a section entitled "Dyes, Bleaching and Textile Fabrics." The late L. A. Olney was in charge of this section, a post he held until his untimely death in 1949.

The abstract section of the *Journal of the Textile Institute* (*207*), begun in 1918, has undoubtedly the most complete coverage in the general field of textiles. The abstracts are classified, and author and subject indexes are published annually. The subject index, largely title entries arranged alphabetically under broad subjects, does not compare favorably with the excellent, specific indexing in *Chemical Abstracts*.

Abstract sections are included in several other textile journals, among them *Bulletin de l'institut textile de France* (*198*), *Canadian Textile Journal* (*199*), *Journal of the Society of Dyers and Colourists* (*206*), *Melliand Textilberichte* (*208*), *Textil Praxis* (*211*), *Textil Rundschau* (*212*), and *Tiba* (*215*). *Textile Research Journal* (*213*) had its own abstracts through 1949. The *American Dyestuff Reporter* (*193*) occasionally carries foreign notes which are reviews of articles appearing in foreign publications.

In 1944, both *Natural and Synthetic Fibers* (*209*) and *Textile Technology Digest* (*214*) were started. The former, edited by Harris and Mark, is a loose-leaf literature and patent service with full abstracts of selected articles. The latter, compiled by the Institute of Textile Technology, has relatively short abstracts and covers leading textile journals.

Other useful abstract sources include *Biological Abstracts* (*195*), *British Abstracts* (*196*), *Chemisches Zentralblatt* (*201*), *Coton et fibres tropicales, Bulletin analytique* (*202*), *Empire Cotton Growing Review* (*203*), and *Engineering Index* (*204*).

Bibliography of Technical Reports (*194*) is an important guide with brief abstracts to the many technical reports of investigations made by or for the United States military forces and which have been released since the end of World War II.

The outstanding indexing journal is U. S. Department of Agriculture Library's *Bibliography of Agriculture* (*224*). With its monthly author, and annual subject and author indexes and its coverage of world literature in agriculture and related sciences, it is especially helpful in locating some of the less publicized reports. Superseding *Cotton Literature* (*225*), which served the cotton interests so well from July 1930 through June 1942, it extends the service to other fiber interests.

Monthly Catalog of United States Government Publications (*222*) with both monthly and annual indexes, is the most complete list of current U. S. government publications.

The "Technical Manual and Year Book of the American Association of Textile Chemists and Colorists" (*217*) includes a very comprehensive annual index on chemical, physical, technological, and biological aspects of textiles. This index has developed from a modest beginning into one of the most convenient listings, since it now contains the year's crop of articles arranged by authors, followed by an extensive subject index based on the pattern set by *Chemical Abstracts*. The 1951 list included 937 references, for which much credit is due W. H. Cady.

Agricultural Index (*216*) and *Industrial Arts Index* (*221*) include references on the natural fibers and list the periodicals covered.

Bibliographies, Reading Lists, and Library Catalogs

Bibliographies, reading lists, and library catalogs often yield obscure references that might otherwise be missed. Textile World's *Textile Bibliography* (*233*) compiled by Richard C. Scott, is the latest comprehensive list of English-language books. A similar compilation, restricted to books published between 1930 and 1951 on scientific and technological aspects, is found in the 1951 "Technical Manual and Year Book of the American Association of Textile Chemists and Colorists" (*228*). In 1938, the Bureau of Foreign and Domestic Commerce published its third edition of "Textile Reading List, a Partial Bibliography on Textile Information" (*235*).

The 1951–52 year book of the Textile Institute (*231*) includes both a listing of its library catalog and a classified list of books suggested for general reading on textile subjects. Fifty-five pages of fine print were required for the library catalog.

The North Carolina School of Textiles Library maintains an up-to-date mimeographed accession list of its excellent collection of books and periodicals relating to textiles (*230*).

Periodicals

Journals to be scanned regularly will be determined by individual interests and requirements. In making selections, the wide scope of the natural fibers should be remembered, plus the fact that journal titles are often misleading. Lists of periodicals are available (*236–40*).

Many of the more important domestic and foreign technical journals are the official organs of associations that either conduct or sponsor research. A few, with their sponsors, are listed.

Country	Journal Title	Sponsor
Australia	*Textile Journal of Australia*	Associated Cotton Textiles Manufacturers of Australia Textile Society of Australia Woolen and Worsted Manufacturers of Australia
Belgium	*Textielwezen*	Unie van Textielingenieurs en -bedrijfsleiders, L'Union des Ingenieurs et Directeurs Textiles
Canada	*Canadian Textile Journal*	Canadian Association of Textile Chemists & Colourists Textile Society of Canada
France	*Bulletin de l'institut textile de France*	L'Institut Textile de France
	Fleur bleu	Confédération Générale des Fabricants de Toile de France
Germany	*Melliand Textilberichte*	Vereins der Textil-Chemiker und -Coloristen (VTCC)
Great Britain	*Empire Cotton Growing Review*	Empire Cotton Growing Corp.
	Transactions of the Faraday Society	Faraday Society
	Discussions of the Faraday Society	
	Journal of the Textile Institute	Textile Institute and British Cotton, Linen, Silk, and Wool Research Associations.
	Journal of the Society of Dyers and Colourists	Society of Dyers and Colourists
India	*Jute Bulletin*	Indian Central Jute Committee
Norway	*Norsk-Tekstil Tidende*	Norsk Tekstil Tiknish Forbund
Sweden	*Meddelanden Från Svenska Textilforsknings-institutet*	Svenska Textilforsknings-institutet
Switzerland	*Textil Rundschau*	Schweizerischen Vereins der Chemiker-Coloristen und der Kommission (Textilindustrie) des Schweizerischen Verbandes für die Materialprüfungen der Technik
U. S. A.	*American Dyestuff Reporter*	American Association of Textile Chemists and Colorists
	ASTM Bulletin	American Society for Testing Materials
	Papers of the American Association of Textile Technologists	American Association of Textile Technologists
	Textile Research Journal	Textile Research Institute
	Textile Technology Digest	Institute of Textile Technology

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Miscellany

In addition to the general references, abstracting and indexing services, bibliographies, and periodicals, there are many miscellaneous sources of original data and information. These include government agencies, national and international trade and research organizations, research and consulting laboratories, and textile schools. Some sources have been listed in the bibliography. The "ASLIB Guides to Sources of Information in Great Britain" (*241*) is a guide to relevant libraries, loan services, museums, the Department of Scientific and Industrial Research, organizations, and publications (including periodicals in general and those printing abstracts or lists of references, directories, annuals, and yearbooks). The "World of Learning, 1952" (*246*) is a guide to educational, scientific, and cultural institutions. The "Year Book of the Textile Institute and Library Catalogue No. 4" (*244*) includes general information on the Textile Institute and its services; list of publications; a library catalog, including periodicals received; technical information; information on standardization in textiles, terms, and definitions; and addresses of research associations, textile societies, and other organizations. The "Yearbook of International Organizations" (*251*) is a guide to the United Nations, the Specialized Agencies, and other intergovernmental bodies and some international nongovernmental organizations.

No doubt many other possibilities will be suggested by particular circumstances. Knowledge of where research is being conducted and by whom can usually be acquired through reading scientific and trade periodicals and by attending scientific meetings.

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Literature of Man-Made Fibers

C. C. CONRAD and P. M. LEVIN

Textile Fibers Department, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

Searchers in the literature of man-made fibers should be familiar with sources of literature on fundamental scientific research work, applied research, testing methods, economic aspects of the industry, and other general news. This paper introduces the newcomer in the industry to the most important literature sources of the field and presents a bibliography of sources, grouped according to their relation to these various aspects of the man-made fiber industry. This bibliography is adaptable to the individual requirements of the searcher.

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The searcher who dips into the literature of man-made fibers finds himself faced with a young but sprawling field. The sharply increased production of man-made fibers in the past few decades has been accompanied by a widening range of interests on the part of the fiber manufacturer. His activities have spread from the raw material sources, through fiber manufacture, then to textile processing, and finally to the end use of the textile material itself.

For this reason the searcher may find that on one hand he must be familiar with sources of fundamental scientific research work, whereas on the other hand he may be required to look in as empirical a field as fiber sizing agents.

The appearance within the past 5 or 6 years of new annual reviews of textile fibers literature exemplifies the growing awareness of the need for some form of periodical that will regularly tie together the widespread edges of the industry.

In this paper the newcomer in the industry is introduced to the most important literature sources for man-made fibers; and the experienced worker is given some new ideas on literature sources. Many references cited will also be found in other papers of this series on the literature of textile fibers. This duplication is illustrative of the impossibility of completely separating the literature of man-made fibers from that of natural fibers. The authors feel that this duplication is necessary because it points up the common practice of combining in one source information on both types of fibers. The searcher should be aware of this practice, so that valuable sources will not be overlooked.

A definition of man-made fibers will help set the stage for the bibliography. Man-made fibers are those fibers that do not occur in nature as useful textile fibers but can be made from naturally occurring or synthetic chemicals; thus these fibers include regenerated cellulose, regenerated protein, cellulose-derivative, polyamide, polyester, polyvinyl, and polyacrylic fibers. To distinguish fibers made of naturally occurring chemicals, such as cellulose, casein, corn zein, and peanut protein, from fibers made of synthetic chemicals, the latter group is called synthetic fibers.

When the searcher consults the literature, he more or less consciously directs his attention to a specific type of literature source, depending on his objective. With this in mind, various sources have been classified from the standpoint of content and are arranged in groups in the bibliography presented at the end of this paper; where testing

In LITERATURE RESOURCES;
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methods can be found, where economic figures on textile fiber production can be found, where fundamental research work is recorded, and where some of the other many facets of the industry are described.

History

The most thorough historical treatment of man-made fibers appeared recently in the book "Development of Some Man-Made Fibres" (*15*). The chapter on synthetic fibers has an especially good bibliography. Detailed descriptions of the history of man-made fibers in the United States can be found in the "American Handbook of Synthetic Textiles" (*9*), recently off the press, and "Matthews' Textile Fibers" (*10*). A new and sixth edition of the latter volume is believed to be under way.

A price-trend history of the United States rayon industry can be found in Markham's recent book, "Competition in the Rayon Industry" (*8*).

The first book on manufacture appears to have been Foltzer's "Artificial Silk and Its Manufacture," published in France in 1903 (*3*). The struggles during the formative years, the first production methods, and subsequent developments through the late twenties have been covered by a number of authors writing in the period 1903 to 1930: Avram (*1*), Faust (*2*), Foltzer (*3*), Hottenroth (*5*), Reinthaler (*13*), and Margosches (*7*).

Abstracts and Indexes

With the coming of age of the industry, specialized abstract services have made their appearance. Probably the most thorough of these is offered in "Natural and Synthetic Fibers" (*21*), edited by Harris and Mark. This compilation contains a good subject index and publishes detailed abstracts. The abstract pages are issued in loose-leaf form and may be filed in various ways depending on the needs of the library. The usefulness of these abstracts is, however, limited by the youth of the service—it was established in 1944.

A monthly abstract service is offered by the Institute of Textile Technology, Charlottesville, Va., under the title *Textile Technology Digest* (*24*). This digest may be of particular interest to organizations that do not maintain a library or information group. Each issue is subdivided by headings covering various fibers and various aspects of the industry.

While these new services are of distinct value, a searcher must rely principally on the older abstract journals and indexes. The Department of Scientific and Industrial Research of Great Britain concluded recently, contrary to many popular opinions (*120*), that 90% of the useful technical and scientific papers is eventually abstracted. The chief problem is how to find these abstracts. The man-made fiber field has fairly adequate resources in this respect.

The extensive value of *Chemical Abstracts* (*19*) is well known. The *Engineering Index* (*20*) covers the engineering field selectively, not comprehensively; important engineering advances such as dielectric drying are well covered. This index, issued annually, contains major and minor subject headings, with abstracts, and extensive cross-indexing. An alphabetical list of all names mentioned in the abstracts is also included.

The abstracts of the *Journal of the Textile Institute* (*23*) are very convenient, once the user has become accustomed to the slight differences in terminology—for example, an important index heading is "Manufactured Fibers." These abstracts have annual subject, name, and patent number indexes.

Fairly general and less technical articles on man-made fibers can be found in the *Industrial Arts Index* (*22*), which lists only titles and sources.

A cumulative bibliography of unclassified government reports was issued in 1947 by the Office of Technical Services of the Department of Commerce (*28*). A current bibliography, *Bibliography of Technical Reports* (*17*), with abstracts, is published monthly for publication board (PB) reports and contains a section on textiles. These reports are most generally useful because they record the results of government textile testing programs, which would indicate new fields of uses for man-made fibers, and surveys of foreign production.

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During the period 1946 to 1948, coverage included a great volume of German documents seized at the conclusion of World War II. While occasionally even today a number of such items still appear as entries, their volume has materially diminished.

Periodic Reviews

Two outstanding periodic reviews have recently appeared. One is published jointly by the Textile Institute and the Society of Dyers & Colourists, both in England (*29*). The first volume of this review appeared in 1949 with the stated purpose of being addressed to "all scientists and technologists concerned with textiles." Each volume has major headings such as research, production, etc.; and these are subdivided according to fiber type. Each volume also contains an author and subject index.

In 1950, the Textile Research Institute published in the May issue of the *Textile Research Journal* (*30*) a review for 1949 covering the field under several major headings such as high polymer studies, fiber-fabric relationships, etc. The reviews for 1951 and 1952 occupied full monthly issues.

The "Technical Manual and Year Book" (*16*) of the American Association of Textile Chemists and Colorists offers an annual review that covers dyeing, testing methods, identification of fibers, and other material often related primarily to fabrics.

Sources on Basic Research

Chemical Abstracts (*19*) will probably satisfy most requirements for literature on research in fiber-forming materials. The first United States articles on synthetic fibers and fiber-forming polymers appeared largely in the *Journal of the American Chemical Society* (*32*). The rapid growth of polymer science fostered the establishment of the *Journal of Polymer Science* (*35*) in 1945. The usefulness of this monthly journal as a medium for the publication of fundamental research papers has also been enhanced by the fact that details appear in this journal that would ordinarily be edited out of other journals.

The German counterpart of the *Journal of Polymer Science* is *Makromolekulare Chemie* (*38*) which appears irregularly.

The *Textile Research Journal* (*40*) is one of the most familiar publications for fundamental research in both man-made fibers and fabrics. The transactions of the *Journal of the Textile Institute* (*36*) usually carry articles on the physical chemistry of fibers, as well as more general material designed for the entire industry.

The *Bulletin de l'institut textile de France* (*31*) first made its appearance in 1947. Coverage includes reports of laboratory work with summaries in both French and English, and abstracts of world textile literature.

The *Shirley Institute Memoirs* (*39*) began to include research papers on rayon in 1930 and now reports some of the more important British research.

General Journals

The textile industry is characterized by a host of journals that are marginal in the sense that they contain a little bit of everything. For example, *Modern Textiles Magazine* (*46*), formerly known as *Rayon and Synthetic Textiles*, usually contains some articles on fairly fundamental research in man-made fibers or textiles. Besides this, the journal contains at various times articles for mill operating personnel, articles on dyeing, production and consumption statistics, articles on new equipment, yarn prices, and similar material that could be of interest to almost anyone in the industry.

Despite its title, the *American Dyestuff Reporter* (*41*) frequently publishes material relating to man-made fibers because it publishes the proceedings of the American Association of Textile Chemists and Colorists. It also runs abstracts of other literature and patents, a feature found in most of the general journals of this type.

In England, *Skinner's Silk and Rayon Record* (*50*) covers the industry in a similar way, perhaps on a more expansive scale. This monthly journal has an interesting technical column entitled "What's New" and a useful list of trade-marks in each issue, in

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addition to the usual general articles and abstracts. Of particular value is the section "Modern Textile Auxiliaries" which has been featured since February 1950. The first 1500 entries in this series have recently been published in book form (*68*).

The *Journal of the Society of Dyers and Colourists* (*44*) is somewhat like *American Dyestuff Reporter* as far as man-made fibers are concerned.

The best French journal in this category is *Rusta-Rayonne* (*49*), which recommenced publication following a suspension during World War II. The Swiss representative in this class is *Textil-Rundschau* (*51*).

Melliand Textilberichte (*45*) covers the entire textile industry; it carries fundamental and applied research, economic figures, and literature abstracts. This journal also offers its abstracts in a separate service printed on one side of a sheet to permit individual indexing of each abstract. *Reyon Zellwolle* (*48*) is similar but devoted to man-made fibers. Covering the same field is a new journal, *Faserforschung und Textiltechnik* (*43*).

Many other textile journals are published both here and abroad and generally aimed at mill operating personnel and textile executives. Some of these, such as *Textile World* (*59*), *Canadian Textile Journal* (*53*), *America's Textile Reporter* (*52*), *Textile Industries and Fibres* (*57*), *Papers of American Association of Textile Technologists* (*47*), and the *British Rayon & Silk Journal* (*42*), frequently print good survey articles on man-made fibers. These articles are useful in keeping up to date in a field of increasingly rapid developments. In most instances, these general articles are picked up by *Industrial Arts Index* or the *Engineering Index.*

Testing Methods

The two best sources for testing methods are the "Standards on Textile Materials" of the American Society for Testing Materials (*92*) and the "Technical Manual and Year Book" of the American Association of Textile Chemists and Colorists (*16*). The latter group has also published a separate manual on analytical methods.

Garner (*93*) has recently published in England the most thorough volume yet available on various testing procedures.

New experimental testing methods and test instruments are frequently described in the *Review of Scientific Instruments* (*96*) and the *Journal of Applied Physics* (*94*).

Production Methods

The most extensive information on methods for producing man-made fibers lies in the patent literature. A thorough search of chemical patents since 1907 can be made by use of *Chemical Abstracts*; fortunately, the searcher interested in man-made fibers will have little occasion to go back earlier. Süvern's "Die Künstliche Seide" (*85*) and Faust's "Celluloseverbindungen" (*65*) offer useful literature and patent digests. Unfortunately, both these appear to be out of print and thus not generally available. Süvern's fifth edition and first supplement covers the period through 1928 and Faust, in two volumes, through 1935.

Weber and Martina (*89*) have recently published a volume that includes the patent literature on man-made fibers for 1939 to 1950. This survey is recommended especially for its coverage of European patents.

Forthcoming volumes of the "Encyclopedia of Chemical Technology" (*99*) will have sections on rayon, acetate, and synthetic fibers, accompanied by extensive bibliographies. With the exception of the patent literature, the material in the encyclopedia will represent most of the latest production methods.

Many of the general books listed in the bibliography, such as Preston's "Fibre Science" (*77*), Leeming's "Rayon—The First Man-Made Fiber" (*6*), Moncrieff's "Artificial Fibers" (*76*), Houwink's "Elastomers and Plastomers, Their Chemistry, Physics, and Technology" (*73*), Götze (*67*), and Herzog (*98*) have descriptions of production methods which, although sometimes out of date, are generally informative to newcomers in the industry.

Economics

The most valuable source of price, production, and consumption statistics is *Textile Organon* (*101*). 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 trade-marks for synthetic fiber types.

Dictionaries and Directories

Words are frequently met which are old in the textile industry but new to the increasing numbers of technically trained people entering the man-made fiber industry. The "Callaway Textile Dictionary" (*103*) and the "Mercury Dictionary of Textile Terms" (*105*) are useful reference sources. The latter is more detailed and extensive in its coverage.

Another fairly useful reference volume is the "Textile Brand Names Dictionary" (*106*) which covers the years 1934 through 1947. Even more valuable is Haynes' book, "Chemical Trade Names and Commercial Synonyms" (*104*), which is a good source for the identification of the numerous chemicals used in the production of man-made fibers.

Spinning and Weaving Man-Made Fibers

Although the word "spinning" frequently means the production of man-made fibers, it is used here in the sense of spinning man-made staple into yarn.

The latest compilation of developments in this field of spinning and weaving man-made fibers can be found in an annual section published each September by *Textile World* (*118*).

Development of blends containing man-made fibers is too new a subject to have an extensive literature. The most complete information available to date is a series of papers published in the August 1952 issue of the *Journal of the Textile Institute* (*112*).

Books

In the bibliography, books that the authors of this paper have found especially useful are listed. These are, of course, in addition to those books listed under other headings in the bibliography.

All these books are most useful as introductory material for newcomers or for those seeking general information from the widespread corners of the man-made fiber industry.

The bibliography contains more references than are actually cited in this paper. It does not, however, cover all the available literature on man-made fibers. Only those sources are described that are believed to be immediately useful. Individual requirements can modify and slant this bibliography toward individual uses.

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Literature of Dyes, Mordants, and Bleaches

DOROTHY M. CROSLAND, *Georgia Institute of Technology, Atlanta, Ga.*

W. H. CADY, *U. S. Finishing Co., Providence, R. I.*

The development of the dyeing industry is discussed. An extensive bibliography, although not a complete survey of sources, lists books on bleaching, dyes and dyeing, and textile printing; textile journals, journals containing occasional papers of value; publications containing trade names; yearbooks; house organ reports; application manuals; and sources of bibliographies, abstracts, and patent literature.

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The ingenuity of man no doubt led to the first use of color as a dye. Primitive peoples from all parts of the world are known to have used vegetable and animal dyes. Historians and archeologists have found evidence that dyes were used for clothing many thousands of years before the Christian era. As communications opened up the world and as civilization advanced, products and methods of dyeing were taken by merchants from one country to another. There were no great dye industries; in fact, the dyeing process was almost a domestic chore. Methods of dyeing were passed on verbally. Little was put into writing about how to extract colors or dye textiles. Histories contain some information on colors—mention is made of Tyrian purple, scarlet red, and indigo blue.

Development of Industry

Much of the advancement of dyeing must be attributed to chemists. As knowledge spread through Europe into England, chemistry began to play an important part in revolutionizing the world. Today, it is vital in most walks of life. The date 1856 divides "before and after aniline dyes," for up to that time only natural dyes, vegetable and animal, had been used successfully. During the year 1856, a young student, William Henry Perkin, working with the famous German chemist, A. W. Hoffman, discovered the azine dye, mauve. In 1859, magenta appeared, and during the next 10 years, additional aniline dyes were discovered.

Dyeing became an industry full of intrigue, politics, and economics—one that advanced with new discoveries of colors. Up until 1876, Germany had no patent of protection; many of its country's finest chemists were found working in England. With the discovery of aniline and azo dyes, Germany realized the possibilities of a great new industry. The English patent laws became more restrictive, and many of the German chemists returned home. Thus began Germany's leadership in the dye field, which it held up to World War I, and in production of dyes, it retained leadership up to World War II. During the first world war, the dye situation was critical because Germany supplied dyes to most countries of the world. The great I. G. Farbenindustrie combine was organized in 1916, of seven, later eight, large dye industries in Germany. The United States, dependent upon Germany for 80% of its dyes was forced to establish its own dye factories. Dye production in the United States increased tremendously, and in the late thirties, became independent of outside sources of supply. C. Z. Draves, in his paper, "Textile Chemical Specialties" (*3*) made the following statement:

In LITERATURE RESOURCES;
Advances in Chemistry; American Chemical Society: Washington, DC, 1954.

Since World War I, the dye industries, backed by adequate resources and research facilities have flourished. As a result of this development we were able to dye with fast colors during World War II the largest output of highgrade textiles of all the warring countries. Furthermore, with the cessation of hostilities we remain entirely independent of foreign sources in all classes of dyestuffs and even lead the world in total production in this highly technical and specialized field.

The art of coloring or dyeing grew from a domestic process to a leading industry in European countries, Great Britain, and the United States.

Publications

There is a little material published on the early dyes. As stated, methods and processes of dyeing were handed down from dyer to dyer, verbally. According to the Encyclopedia Britannica (*4*), the first European book on dyeing was published in Venice in 1429; the first English book, "An Apparatus for the History of the Common Practices of Dyeing," was published in 1662. Publication was initiated by the Royal Society.

A small volume, "A Bibliography of Dyeing and Textile Printing, Comprising a List of Books from the Sixteenth Century to the Present Time (1946)," by L. G. Lawrie (*13*), was published in 1949. Mr. Lawrie states that "this book makes no pretense to be a detailed bibliography, in the bibliophile's sense of the term, nor does it attempt to attain completeness; it does provide a useful list of references both for historical and practical use." Mr. Lawrie found that in the first 200 years, from 1500 to 1700, there are listed only 23 books on dyeing. During the next 50 years, 27 books on dyeing appeared. From 1750 to 1850 as many as 187 books were published. With the discovery of coal-tar colors and the developments in chemistry, Mr. Lawrie found nearly 300 books listed in the latter part of the century. This rate, he states, has remained approximately the same up to the present time. In his book are listed 816 titles; Germany led with 273 titles, followed by Great Britain (199), France (172) and the United States (64).

Journals. One can not depend upon books for up-to-date literature on dyeing. Just as in other scientific and engineering fields, a book is often said to be out of date when it comes from the press. For current developments, the chemist and the dyer must turn to journal literature and to material published in bulletin or report form by the large dye industries. The librarian or literature searcher must be on his toes to get all current literature for the research chemists and dyers. Good illustrations of journal articles where the material has not yet been published in book form are an article on the use of dyes in the location of aircraft forced down at sea, by spreading dye over the surface of the water (*2*) and continuous piece goods dyeing with vat dyes, including the use of molten metal (*1*). The article on continuous dyeing includes mention of several continuous processes; the Stanfast process will not be found in any of the books yet published.

Patent Literature. Patent literature is highly valuable. Some dye factories have highly skilled specialists who do nothing but search through available patent literature.

Indexes and Abstracts. The literature searcher must learn to use the periodical indexes, *Chemical Abstracts* (*33*), *British Abstracts* (*31*), and the journals that regularly publish abstracts of articles appearing in other journals. Often material needed can be found only in the most recent journal. The *Engineering Index* (*11*) and the *Industrial Arts Index* (*12*) are excellent sources for current literature. The *American Dyestuff Reporter* (*29*) the *Journal of the Society of Dyers and Colourists* (*35*), *The Journal of the Textile Institute* (*36*), the *Textile Research Journal* (*39*), and the *Textile Technology Digest* (*40*), publish abstracts and contain patent literature.

Yearbooks. The "Technical Manual and Year Book" of the American Association of Textile Chemists and Colorists (*20*) is one of the more valuable reference books. It is divided into five sections. The first describes the organization. The second contains committee reports. The chairmen of various committees report on new methods and processes explored during the year. The Bibliography Committee's Report contains a list of current literature, arranged by author and subject, and a list of books. The 1951

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volume contains current literature published between July 1, 1949 and December 31, 1950, and books published from 1930 to 1951. For books published prior to 1930, the 1947–48 volume and earlier volumes should be consulted. There is also a list of the journals from which the current literature articles are cited. Section III covers test methods, standard, tentative, and temporary. Testing procedures which have been thoroughly tried are designated standard tests by an open vote of the research committee. Procedures which are not yet wholly satisfactory and reliable are designated as Tentative Test Methods. Temporary Test Methods are mainly British in origin and have been assigned to new research committees for further study and revision. The fourth section lists dyestuffs and textile chemical specialties, classified alphabetically and according to color index and foreign prototype numbers. The prototype list is invaluable in a library. There is a list of dye makers with addresses and a list of registered trade-marks of different classes of dyestuffs. Membership, arranged alphabetically and geographically, is given in Section V. This particular reference book, is one that should be known for its valuable reference sources.

The American Dyestuff Reporter Annual Volume (*21*), contains a list of the latest dyes and chemicals. There are other yearbooks and buyers' guides that are important and useful; their titles are given in the bibliography.

Manufacturers' Literature. The manuals, technical bulletins, and reports issued by the Calco Chemical Division, American Cyanamid Co.; Ciba Co.; Sandoz Chemical Works; E. I. du Pont de Nemours & Co.; General Dyestuff Corp.; Division of General Aniline; Geigy Co. Inc.; National Aniline Division, Allied Chemical and Dye Corp.; and Imperial Chemical Industries are valuable sources of information on new dyes and applications. There are other companies that publish literature equally as valuable and useful.

Government Publications. Government, society, and academy publications must be included in any source list. The "FIAT Review of German Science" (*5*) and our U. S. government publications must be considered.

Reviews. In 1949, the Society of Dyers and Colourists with the Textile Institute began publishing a "Review of Textile Progress" (*26*). The Jubilee issue of the *Journal of the Society of Dyers and Colourists* (1884–1934) (*299*), and for American dyes, the Silver Jubilee issue of the *American Dyestuff Reporter,* December 2, 1946 (*116*) are good sources for the progress of the dyeing industry.

Books. There are books that were published some years ago that are still useful. Some of these are still classic, including: "A Manual of Dyeing," by Knecht, Rawson, and Loewenthal, first published in 1893 (*239*); "The Bleaching, Dyeing, and Chemical Technology of Textile Fibres," by S. R. and E. R. Trotman (*311*); "Dyeing with Coal-Tar Dyestuffs, the Principles Involved, and the Methods Employed," by Whittaker and Wilcock, first published in 1918 (*323*); "The Development of Commercial Synthetic Dyes," by F. M. Rowe (*287*); and "Bleaching and Related Processes," by J. M. Matthews (*258*). Another excellent source is the "Colour Index" of the Society of Dyers and Colourists (*298*). A new edition of this work is now in preparation; it is expected to contain the chemical constitution of at least 3800 different dyes, together with much detail on their application, fastness, and other properties.

Today, the work considered classic by many textile chemists is Diserens, "Neueste Fortschritte und Verfahren in der Chemischen Technologie der Textilfasern" (*163*) to be published in two parts, totaling five volumes. Part I was originally published in 1938/39 in a French edition of two volumes. The German edition will have three volumes in Part I, and two volumes in Part II. There is an American translation of the second German edition of Part I, entitled, "Chemical Technology of Dyeing and Printing." There is a third German edition of Volume III, Part I. The books contain useful bibliographies, and the detailed formulas from literature references are a good feature. This is a set of books that every library on dyeing and printing should own. Mr. Diserens has made a distinct contribution to literature.

Discussion. Opinions will vary as to which are the best sources for dye literature just as they vary as to which is the best book on dyeing. Familiarity with cer-

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tain books brings out useful features of particular interest to one person or to a research staff. Who then will say one book is the best in its field? The individual must be aware of many bibliographies, indexes, manuals, government and society publications, to determine which will give most promise of turning up the desired information with the least effort and in the quickest time. The source materials listed with this paper will generally suffice; however, since special needs may call for others, searchers must be alert to all opportunities.

Bibliography. The bibliography does not comprise a complete survey of sources in the field. It has been compiled to help the technical man and others, who must start from nothing to find literature they need on dyes, mordants and bleaches.

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Literature of Processing and Textile Chemicals

S. JACK DAVIS

Research Laboratory, Chemstrand Corp., Decatur, Ala.

Sizing and finishing represent an ancient art, with literature correspondingly old. Proofing processes for protection against water, fire, mildew, creasing, insects, and other adverse influences are less ancient and represent the liveliest aspect of the modern textile processing art. The records of textile processing and the chemicals used cover a wide range of organic, inorganic, physical, and applied chemistry with colloids and high polymers scattered throughout. A selected bibliography of the field is presented to aid the searcher of the literature of this wide subject area.

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This paper is not addressed to the specialist in the textile field. Rather, it is a review, elementary in nature, designed to acquaint workers in the field of chemical literature with source lists pertaining to the textile industry, an important consumer of manufactured chemicals.

No apology is made, nor need be, for incompleteness in a survey of such a comprehensive field. The purpose of this paper is to establish adequate guideposts. A selected bibliography of textile literature on processing and textile chemicals is presented at the end of the paper.

Raw Materials

The raw material of the textile industry is the fiber—cotton, wool, silk, linen, nylon, or glass. Fiber characteristics vary in many important respects. Among these characteristics are fiber length (often referred to as "staple length" or merely as "staple"); fiber diameter, usually defined in terms relating to the weight per unit length ("denier" or "grex"); and stress-strain characteristics. Such typical physical characteristics result from the chemical nature of the fiber and the source of the material, and are further supplemented by processing and finishing qualities arising from the chemical composition of the fiber. Thus, the natural fibers such as cotton and wool and the regenerated fibers such as viscose rayon and the azlons are all more or less water-absorbing; acetate rayon and the pure synthetics such as nylon, the acrylic fibers, and the polyester fibers generally are hydrophobic. This results in the formation of static electrical charges during textile processing and in end use if some chemical additive (called "finish") is not applied to the fiber during fiber manufacture.

Fiber Finishes. The natural fibers, of which cotton and wool are most important, are endowed by nature with a finish which affords textile processibility. The cotton fiber is coated by a layer of pectin and wax which supplements the natural hygroscopicity of the fiber with a lubricant which aids in the manifold drafting operations of the textile manufacturing process. Raw wool also occurs naturally with a coating of wool grease, but this is often removed by scouring the raw stock before textile processing,

In LITERATURE RESOURCES;
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and it then becomes necessary to add a lubricant in the form of an oil emulsion for processibility.

The regenerated and pure synthetic fibers emerge from the basic manufacturing process as more or less pure polymeric materials. Viscose rayon and the azlons require only a lubricant-type finishing additive, whereas the pure synthetics require an additional hygroscopic agent to minimize static electricity during textile processing. Finishes for manufactured fibers are carefully guarded secrets and little published information is available on this point.

Yarn Manufacture

It is perhaps the length of the fiber that has influenced the systems of textile processing more than any other quality. Cotton rarely exceeds 1.5 inches in staple length, whereas good flax should average 20 inches in length and be free from fibers less than 12 inches in length. It is obvious to even a casual observer that the machinery required for handling these extremes should be significantly different.

The manufacture of fibers, both regenerated and pure synthetic, where it is possible to produce fibers of indefinite continuous length, or to cut them to any desired length, has not profoundly changed the systems of textile processing, many of which date back, with only slight modification, to the industrial revolution era. For staple fibers —i.e.,fibers of relatively short length—the following systems have been used, some extensively, others only slightly: cotton, woolen, worsted, silk, and linen flax systems.

Complications within these systems, such as ring spinning and mule spinning, etc., are beyond the scope of this paper, as is any discussion of the eccentricities of the various systems. The systems are designed for a specific purpose and they must accommodate the fiber in question. Manufactured fibers may be cut in proper lengths to be processed on the various systems, and consequently the handling of staple fibers has not been radically changed.

The main problems of any staple fiber manufacturing process are to:

1. Separate fibers from neighboring fibers—individualize fibers.
2. Arrange the fibers essentially parallel to each other—organize fibers.
3. Insert twist to the parallelized organization—secure the organized fibers in yarn structure.

The product resulting from this operation is the "spun" yarn which is the primary product of the staple fiber industry. Several of these yarns may be twisted together to form a plied yarn, or the "singles" yarn may be used alone for weaving.

Chemicals Used in Processing. Water is perhaps the most important chemical used in the textile manufacturing process. It is supplied primarily as high atmospheric humidity, often sprayed into the air to supplement the natural humidity. Water serves to plasticize the hydrophilic fibers and to minimize static electrical effects with the hydrophobic. Humidifying the air has made the expansion of the textile industry in the South possible, and now air conditioning has entirely removed geographical limitations on textile processing.

The textile processing oils are generally oil-soluble or water-dispersible fatty materials which are used to provide either lubrication of fiber surfaces or higher moisture content, or both.

Twist-setting agents are usually surface active materials used to facilitate the entry of moisture into the fiber in order to plasticize the fiber polymer to adjust it to its new environment with minimum strain.

Colloidal silica dispersions in water (Syton, Ludox) have been found to improve the processibility of wool and are reputed to improve the processing of cotton.

Tints are fugitive dyestuffs, either oil- or water-soluble, which are used for identification of blends in processing. They are readily removed from the yarn or fabric at a later stage of manufacture.

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Weaving

Although thousands of pounds of spun and continuous filament yarn are used for sewing thread, tire cord, as strength-giving members in power-transmission belting, conveyor belts, and in other engineering uses requiring flexible strength, the largest portion of yarn production is utilized by the textile industry in weaving fabrics. For this purpose, singles spun yarns, continuous filament, and plied yarns may be employed, alone or in combination.

Weaving is a mechanical process wherein a sheet of hundreds and even thousands of parallel yarns (the warp) is furnished the machine, and a filling yarn is placed alternately above and below adjacent warp yarns. Weaving proceeds without the use of many chemicals, but it is necessary to "size" the singles warp yarns before weaving, and occasionally it is desirable to size plied yarns. The reasons for sizing are not clearly understood, but are believed to include (*a*) strengthening the warp, (*b*) "laying" the projecting fiber ends to form a more perfectly cylindrical structure, (*c*) alteration of the stress-strain properties of the warp yarn, (*d*) improving its abrasion resistance, and (*e*) altering its hygroscopic properties.

Sizing a warp yarn usually consists of the application of some film-forming material in aqueous dispersion along with a dispersible lubricant, usually a dispersible humectant, and many other odd components which may be used by an individual operator. The literature in this field is extensive and inconclusive.

Sizing materials may include, variously or in combination, starch (native or chemically modified), tallow, sulfonated tallow, fatty combinations with ethylene oxide condensates, gelatin, polyacrylic acid, and a host of other natural and synthetic materials.

Fabric Finishing

The textile manufacturing operation is primarily a specialized mechanical engineering operation requiring a limited amount of auxiliary chemicals. The product of this process is a relatively crude, typically boardy, and perhaps tinted greige fabric.

The finishing of fabrics is a specialized chemical engineering operation.

Finishing Cotton Fabrics. DESIZING. Desizing is generally accomplished by treating the fabric with 0.5% sulfuric acid solution which hydrolyzes the starch, or with amylolytic enzymes. Steeping with acid is not generally favored because of danger of tendering the goods and because the method does not adapt itself to high-speed continuous production. Enzymes which operate very rapidly at high temperatures have been developed so that desizing may be accomplished in the J-box of a continuous finishing assembly.

SCOURING. Scouring is accomplished by boiling the goods with a hot caustic solution, usually containing a soap or synthetic detergent. This operation removes the residual desizing agent, saponifies or emulsifies the fats used in the size, saponifies or emulsifies the natural waxes on the cotton, and removes the pectic material of the cotton, which consists largely of polyuronic acids. Following scouring and washing, the fiber is essentially pure cellulose.

Large quantities of alkalies are required for the scouring operation. Technical sodium hydroxide, sodium silicate, sodium carbonate, and trisodium phosphate are among the alkalies used. Occasionally ordinary soaps are employed to assist in penetration and emulsification, but more generally the cheaper soaps, such as pine oil soap, or synthetic detergents, though not cheap, can be used sparingly and economically.

BLEACHING. Bleaching is generally accomplished by treating the goods with sodium hypochlorite or sodium peroxide. The use of these reagents is generally well known. They both may be used in continuous processes.

MERCERIZATION. Mercerization consists of treating cotton under tension with strong (18% or stronger) sodium hydroxide solutions, usually at room temperature. A yarn or fabric of increased luster and strength results from the profound swelling of the fiber, accompanied by stretching. The mercerization usually is accomplished by application to the fabric of the solution, followed by stretching the fabric on a "tenter frame" which applies the tension, and then followed by washing with warm water, a subsequent washing with very dilute (about 1%) sulfuric acid, and two or three more washings.

DYEING. Dyeing fabrics or yarns is discussed in other papers in this group and is beyond the scope of this paper. Aside from the dyes themselves, enormous quantities of chemicals are consumed in dyeing, including sodium hydrosulfite, sodium nitrite, soaps, surface active penetrants and detergents, acetic acid, sodium hydroxide, mineral acids, sodium chloride, and Glauber's salt.

With the exception of dyeing, the operations mentioned thus far in this section could more appropriately be called "fabric preparation" and the following operations could be named "fabric finishing." Clear distinction between these terms is not generally made in the trade, however.

SHRINKAGE. Shrinkage with laundering is one of the difficulties encountered in utilizing cotton fabrics. This problem has been rather successfully solved by the Sanforizing process, which employs compressive shrinkage of the wet fabric. This is primarily a mechanical process, but surface active agents are used in wetting the fabric.

Urea-formaldehyde and melamine-formaldehyde resins may be applied to cotton fabrics in different ways to accomplish shrink resistance and wrinkle resistance. A stiffer, crisper "hand" also results.

Various thermoplastic resins such as polyvinyl chloride, polyacrylic acid, and polystyrene are widely used to impart draping characteristics and hand to the fabrics.

MILDEW. Mildew is the cause of rapid deterioration of cotton fabrics, particularly in the tropics. A variety of mildew-proofing chemicals are available, including salicyl anilide, pentachlorophenol, copper naphthenate, and copper 8-hydroxyquinolate.

WATER REPELLENCY. Water repellents may be applied to cotton fabrics to be used for special purposes, such as tentage. The simplest water-repellent treatment is the application of wax either in emulsion form or as solution. The addition of certain salts, such as aluminum acetate, improves the durability of the treatment. A more durable process of treating for water repellency consists of treating the fabric with a quaternary pyridinium compound containing a long-chain fatty acid radical and curing, whereupon presumably a chemical reaction with the cellulose occurs, affixing the radical to the cellulose.

FLAMMABILITY. Flammability of cotton fabrics is not a dangerous characteristic, but certain uses require flame resistance. Impregnation of fabrics with certain inorganic salts such as borax–boric acid and ammonium sulfamate and with chlorinated organic compounds has been used. Other methods have been proposed but have not become generally useful. One of these is the urea-phosphate process and another is the Erifon process.

Finishing Rayon Fabrics. Finishing processes for rayon are very similar to those outlined for cotton. Scouring generally requires less alkali and milder conditions of pH and temperature. Bleaching is not necessary, and rayon cannot well endure a mercerization. Shrinkage in laundering remains a serious problem, although a considerable improvement has resulted from the use of urea-formaldehyde and melamine-formaldehyde treatments. An interesting process for arresting shrinkage of rayon is the cross linking of the cellulose by means of glyoxal. Since acid catalysis and heat curing are involved, however, the method has not become generally useful. Water repellency and flame repellency, where required, are accomplished much the same as for cotton.

Finishing Wool Fabrics. The fundamental chemical structure of the wool fiber, together with its fiber morphology, impose an entirely different procedure in finishing wool fabrics than that outlined for the cellulosic fiber fabrics. Wool is sensitive to strong alkali, the fiber shrinks markedly with wetting, and the fiber felts under a suitable combination of mechanical work, chemical action, moisture, and heat.

Bleaching may be done by use of sulfur dioxide, peroxide, and stabilized hydrosulfite compounds. Occasionally, combinations of these reagents are used.

DRY CLEANING. Dry cleaning by continuous process with a variety of solvents—e.g., trichloroethylene—may be used to clean the fabric of spinning oils and other impurities. The dimensions of the fabric are essentially unchanged in such an operation.

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CRABBING. Crabbing is a wet-processing procedure which employs hot and finally cold water, together with mechanical tensioning, and finally drying for the purpose of equalizing tensions in the fabric.

SCOURING. Scouring for fabrics which are not dry cleaned involves the removal of spinning oils or other lubricants, and consists of washing with soaps or synthetic detergents or weak alkalies such as ammonia.

FULLING. Fulling is a chemicophysical process in which the fabric is treated with acid or soap solutions on the fulling mill which works the fibers mechanically to felt them.

CARBONIZING. Carbonizing consists of treating the fabric with mineral acid, drying and baking, dusting by mechanical means, and neutralizing. This procedure reduces the vegetable fibers to carbon, which is removed as a dust. The acid does not seriously affect the wool.

WET DECATING. Wet decating results in a fairly permanent setting of fiber and imparts a degree of luster. Combination of heat, moisture, and tension is used.

FELTING. Felting may be performed on non-woven fibers or on fabrics. This process combines mechanical intertwining of fibers and shrinkage by mechanical and chemical means.

SHRINKAGE. Shrinkage of woolens may be caused by relaxation shrinkage which occurs with steaming, etc., or by felting in washing. Rendering the wool non-felting may be accomplished by chemical treatments involving wet chlorination or resin impregnation.

Aftertreatments with copper sulfate, chromium fluoride, or formaldehyde are used to prevent or minimize bacteria and fungi. Mothproofing may be accomplished in a temporary basis by use of inorganic fluorides, pentachlorophenol, dinitronaphthol, *p*-dichlorobenzene, or even naphthalene. More permanent treatments include the Eulans—e.g., Eulan CN: pentachlorodihydroxytriphenylmethane sulfonic acid—or Mitin FF (a halogen-substituted acylaminosulfonic acid). These latter treatments are applied by conventional dyeing techniques.

Finishing Synthetic Fiber Fabrics. This field of finishing is in the formative stage, and very few generalizations can be made at the present stage of development.

The techniques of weighting and coating of fabrics already in use with fabrics made from other fibers have been adapted to synthetic fiber fabrics.

Synthetic fibers are generally thermoplastic, and the careful use of heat—either wet or dry—has been used to "set" the twist or weave in fabrics. Heat setting for nylon, although it is not a chemical process, is necessary to prevent unwanted wrinkles or other distortions from appearing in subsequent processing and use. Glass fiber fabrics are subjected to the coronizing process where the fabric is heated to about 1100° F.

The fabrics from synthetic fibers also may be embossed with hot rolls, or may be coated with resins by an assortment of techniques.

Selected Bibliography of Textile Literature on Processing and Textile Chemicals

Compiled by Katharine McDiarmid, North Carolina State School of Textiles, Raleigh, N. C.,
Katherine Glass, Research Division, Callaway Mills Co., LaGrange, Ga., and
Mary E. Emerson, Institute of Textile Technology, Charlottesville, Va.

This bibliography is not intended to be an exhaustive list of references, but rather a selective list designed to help the chemist new to the textile field. Therefore, it is only a guide to the main sources of the textile literature on processing and textile chemicals, with suggested examples for each of the various types of literature available.

Books, bibliographies, patents, trade literature, directories, technical reports, indexes, abstract journals, and periodical articles were examined. Periodical references are

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included only where other literature is relatively unavailable or if the reference is unusually comprehensive or includes a particularly good bibliography. Individual patents are not included.

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Introduction and General Discussion— Food Industries Literature

MORRIS B. JACOBS

Bureau of Laboratories, Department of Health, City of New York, N. Y.

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Literature concerning the food industries has its origins in biblical times and its growth has been concomitant with that of chemical and technological literature in general. The literature of the food industries is grouped under such major subdivisions as chemistry, composition, analysis, technology and processing, including preservation, unit operations in the food plant, nutrition, and food inspection and control. Specialized fields—fish and fish products, beverages—and allied fields—packaging, flavors, and food chemicals—are also noted. The more important books, periodicals, and trade journals in each category are considered. A comprehensive bibliography is presented.

Food has always been an important factor in the lives of nations and individuals, and the steadily increasing population of the world and the fact that food production is apparently not keeping apace of this population increase bring the problem of an adequate food supply urgently forward. The literature resources of the food industries are aids in meeting this problem. The bibliography presented at the end of this paper has been grouped under main subdivisions such as history, chemistry, composition, analysis, etc., in the same order these categories are discussed.

Literature concerning the food industries has its origins in biblical times and much of it, in a historical sense, is really part of the general literature of the particular period or era (with the exception of relatively more recent times) considered. Thus Roman history as such and the private lives of the Romans, in particular, have to be studied to gain some idea of the food industry of that period. Much of food literature of early times is inextricably woven into the pharmaceutical and medical history of those periods.

Modern food literature may be said to have been initiated with the appearance of "Opera medicochymica" in 1606 by Libavius (1546–1616), the eminent German iatrochemist, who considered in this work the compositions of grain and wine. Possibly the next really important work was that of Redi who wrote a book on food adulterations. In 1702 Leméry published his "Traité des Aliments" which became the standard text on foods in the 18th century. Many of the greatest chemists did work related to foods—Robert Boyle published analyses on milk, olive oil, and flour; Lavoisier was among the first to recognize that food was the fuel of the body; and Liebig placed the science of food chemistry and analysis on a firm basis.

Along with the development of food chemistry from the point of view of analytical chemistry came the development of interest in food chemistry from the nutritional point of view with Rubner, Voit, Atwater, and Lusk stressing the need for proteins, fats, and carbohydrates as essential food components. It was in relatively recent times that the requirements of vitamins, minerals, and other essential food factors were recognized.

In LITERATURE RESOURCES;
Advances in Chemistry; American Chemical Society: Washington, DC, 1954.

There are a number of ways of classifying the literature of the food industries. It will be convenient for the purposes of this discussion to group food industries literature under the headings of history, chemistry, composition, analysis, technology, nutrition, food poisoning, food control, chemicals or additives and flavors in foods, and the special fields of fish and fish products, poultry and eggs, vegetables and fruits and their products, and alcoholic and nonalcoholic beverages. Other papers in this group consider the literature of flour milling and baking, the dairy industry, the meat packing industry, the edible oil industry, canning and preserving, cacao and chocolate, and sugar production.

History

The literature of the modern food industry or food technology has a history which extends as far back as the history of chemistry itself. Before the beginning of the 20th century, it was, however, not termed food industry or food technology because the significant phases of this development were considered part of chemical technology. For example, Wagner's "Handbook of Chemical Technology" which first appeared in Germany about 1850 (8th edition translated into English by W. Crookes in 1872) covered the topics of starch, sugar manufacture, cane sugar, beet sugar, fermentation, wine making, beer brewing, bread baking, vinegar, and essential oils.

The literature concerning the history of food industries is very widely scattered. Actually there is no good book on the history of the food industries. One must seek this information in each particular field of interest. A chronological listing of the more important texts, journals, and articles in food literature is given by Neto in his "Subsídio à História da Bromotologia" published in Bahia, Brazil, in 1946 in Portuguese. The stress in this pamphlet, however, is on the analytical chemistry aspects of food. There is a small section on history in Blyth and Blyth, "Foods: Their Composition and Analysis" and in generalized histories of chemistry such as Von Meyer, "History of Chemistry," and Partington, "Origins and Development of Applied Chemistry." Some interesting sidelights, particularly related to baking, are given by Filby in a "History of Food Adulteration and Analysis."

Chemistry

There are and have been available for some time a number of well-known texts which consider the chemistry of foods—their chemical character as carbohydrates, proteins, lipides, vitamins, vitagens, mineral matters, coloring matters, and related categories. In some of these the stress is on the nutritional aspects, as in Sherman's "Chemistry of Food and Nutrition" and "Food Products"; Bailey's "Food Products from Afar"; and Olsen's "Pure Foods: Their Adulteration, Nutritive Value, and Costs." One of the earliest of such texts was that of Richards and Woodman, "Air, Water, and Food" (1900), which stressed sanitary aspects. Possibly the first book to tie chemistry directly to food industries was "Chemistry and Technology of Food and Food Products" edited by Jacobs in 1944.

An interesting booklet by Monier-Williams was "Chemistry in Relation to Food." The first text clearly devoted to the physical chemistry of foods from a technological point of view was that of Clayton on "Colloid Aspects of Food Chemistry and Technology."

Consideration of the many journals in which articles concerning the chemistry of foods appear is given in the sections devoted to the analytical chemistry of foods, the technology of foods, and in some instances, the special topics that are discussed.

Composition

The literature on the composition of foods is tremendous and has origins as early as any scientific literature. For instance, in 1743, Marggraf discovered crystals of sugar in the red beet and suggested it might be possible to extract the sugar on a commercial basis. It was not until 28 to 30 years later that oxygen was discovered. The most famous names in chemistry are found among those who worked on the composition of foods: Boyle, Boerhaave, Fourcroy, Berthollet, Magendie, Prout, Berzelius, Liebig, and others.

One of the first major texts on the composition of foods was that of König, "Chemie der menschlichen Nahrungs- und Genussmittel," which first appeared in 1879 and was republished in several editions. Other early texts considering this topic were Blyth's "Manual of Practical Chemistry—The Analysis of Foods and the Detection of Poisons" (1879), later revised as Blyth and Blyth, "Foods: Their Composition and Analysis"; and that of Tibbles, "Foods, Their Origin, Composition and Manufacture."

The classical work in this field, work that was initiated and performed in the United States, was that of Atwater and Bryant, published as a U. S. Department of Agriculture bulletin which first appeared in 1899. Almost every book considering the composition of foods published since that time has leaned heavily on this work or its revisions.

This Department of Agriculture bulletin was revised several times; an important revision was made by Atwater and Bryant in 1906. It was brought relatively up to date by Chatfield and McLaughlin (1928) and then by Chatfield and Adams (1940).

A monumental work is that of the Wintons on the "Structure and Composition of Food." This is the most comprehensive book on the microscopic structure of food and is a development of their "Microscopy of Vegetable Foods" (1916). This four-volume treatise culminated a lifetime of work by Andrew Lincoln Winton and Kate Barber Winton in the food field—work for which all should be grateful.

The second volume of "Chemistry and Technology of Food and Food Products" (second edition) is devoted to the descriptive aspects of food and deals with the composition of food. The chapters written by Lee relating to vegetables and mushrooms and fruits and nuts are illustrative of a competent survey of the literature concerning these foods. In all, some 1216 literature references are given.

A glance at the Wintons' books or the treatise edited by Jacobs discloses the widespread journal and bulletin sources of articles on food composition. In the Lee chapter on vegetables (in the latter treatise), there are approximately 100 journals cited in 433 references. Those cited most frequently were: *Journal of Biological Chemistry, Plant Physiology, Journal of Agricultural Research, Food Research, Biochemical Journal, Contributions from Boyce Thompson Institute, Proceedings of the American Society for Horticultural Science, Biochemische Zeitschrift, Journal of Nutrition,* and *Journal of the American Chemical Society.* The first had 36 citations and the tenth had 13 citations.

A similar comparison of the sources for the Lee chapter on fruits discloses that out of approximately 800 references, 164 different journals or bulletin sources are mentioned. These are in order of frequency: *Journal of the American Chemical Society, Proceedings of the American Society for Horticultural Science, Journal of Agricultural Research, Journal of Biological Chemistry, Plant Physiology,* Department of Scientific and Industrial Research (British government), U. S. Department of Agricultural sources, *Industrial and Engineering Chemistry, Biochemical Journal,* and *Biochemische Zeitschrift.* The first had 72 citations and the tenth had 22 citations. In both instances the period covered was about 50 years and the bulk of the articles in *Journal of the American Chemical Society* and *Journal of Biological Chemistry* appeared before 1935.

It is likely that in the future journals such as *Food Technology* and the *Journal of Food Agriculture of the Science of Food and Agriculture* and the *Journal of Agricultural and Food Chemistry,* published by the AMERICAN CHEMICAL SOCIETY, will assume greater importance as sources of information for the food industries. It would be helpful if food articles were not so widely dispersed.

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A great deal of the literature concerning food composition is issued from governmental sources such as the U. S. Department of Agriculture and the various state agricultural experiment stations. Of the 800 references for fruits (discussed above) governmental agencies contributed 72, and of the 433 references on vegetables 47 were issued by such agencies. This is true not only in this country but in many foreign countries which issue such information through analogous governmental agencies.

Analysis

In the field of food analysis great strides and contributions have been made, particularly in the United States of America. The foremost text is the collaborative effort, "Methods of Analysis," of the Association of Official Agricultural Chemists. This text was an outgrowth of a bulletin of the U. S. Department of Agriculture in which members of the association, first organized in 1884, took an important part.

The first edition of this text appeared in 1920, and a new edition is issued every 5 years. This text has a number of significant advantages—it is a collaborative effort based on a reference system and it has received official and legal recognition. It could be improved, however, by the incorporation of explanatory material, by a more complete index, and by reference to the original literature rather than almost exclusive reference to the *Journal of the Association of Official Agricultural Chemists.* It is also regrettable that the food portion is slowly being swallowed by the other sections of the text dealing with fertilizers, insecticides and fungicides, drugs, and cosmetics.

In addition to this book, four well-known texts on food analysis are published in the United States: Leach, "Food Inspection and Analysis," first published in 1904; and later revised by Winton; Woodman's "Food Analysis," first edition published in 1915; Winton and Winton, "Analysis of Foods," and Jacobs, "Chemical Analysis of Foods and Food Products." Each of these texts has its advantages. It should, however, be noted that the last revision of Leach was made 32 years ago. The text by Jacobs is the most recent and is more directly related to the food industries by its stress on technical control methods than are the other texts in which the stress is mainly on detecting adulteration.

Some older texts are Leffmann and Beam, "Select Methods of Food Analysis" (1901), the text of Blyth and Blyth, and Thurston's "Pharmaceutical and Food Analysis." The book by Cox, "Chemical Analysis of Foods," has a great deal of merit but is written with British food standards in mind. "Allen's Commercial Organic Analysis" contains large sections devoted to the analysis of foods. There is a new book on food analysis by Joslyn.

A study of the citations to the literature in Jacobs' "Chemical Analysis of Foods and Food Products" indicates that out of 632 journal references covering a period of about 50 years, *Industrial and Engineering Chemistry, Analytical Edition,* and *Analytical Chemistry,* its successor, are cited 119 times; *Journal of the Association of Official Agricultural Chemists,* 70; *Analyst,* 53; *Journal of Biological Chemistry,* 39; U. S. Department of Agriculture bulletins and circulars, 39; and U. S. Federal Security Agency, Food and Drug Administration releases, 37. Others among the first 10 are *Journal of the American Chemical Society, Industrial and Engineering Chemistry, Zeitschrift für Untersuchung der Lebensmittel,* and the *American Journal of Public Health.* The wide spread of the sources is reflected in the fact that 84 different journals were cited.

The earliest journals in this field were the *Analyst* (1876), *Zeitschrift für Untersuchung der Nahrungs- und Genussmittel sowie der Gebrauchsgegenstände* (1898), *Annales de falsifications et des fraudes* (1908), and the *Journal of the Association of Official Agricultural Chemists* (1915).

Technology and Processing

Modern literature in food processing and technology is often considered to have begun with the publication by Appert in 1810 of "L'Art de conserver pendant

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plusieurs années les substances végétales et animales." One of the first texts to consider the food industries generally and in the more modern sense was that of Vulté and Vanderbilt, "Food Industries" (1914). Wiley's "Foods and Their Adulteration, Origin, and Manufacture" stressed food adulteration. Tibbles' "Foods, Their Origin, Composition, and Manufacture" and Lebbin's "Allgemeine Nahrungsmittelkunde" (1911) were early texts.

With the appearance of "Food Technology" by Prescott and Proctor in 1937, the literature of food industries really came of age. Since then other valuable texts in this field have been published. Among these are "Outlines of Food Technology" by Von Loesecke, "Handbook of Food Manufacture" by Fiene and Blumenthal, and "Food Manufacturing" by Blumenthal. Each of these books has much to commend it. The foremost book on food industries, processing, and technology is the three-volume, collaborative treatise, "Chemistry and Technology of Food and Food Products," edited by Jacobs. Too much praise cannot be given to the group of 40 collaborators who made this treatise possible by contributing to it, and to the publishers for underwriting this valuable text.

Other texts and sources of value are Cruess, "Commercial Fruit and Vegetable Products"; "Food Industries Manual" issued by *Food Manufacture;* and "Flow-Sheets of the Food Processing Industry" published by *Food Engineering,* formerly *Food Industries.* Some other texts are "Food Processing" by Duncan (1949), "Nahrungs- und Genussmittelkunde" (1949) by Delarich, and "Foods: Production, Marketing, Consumption" by Stewart. Some older texts in which the stress is on preservation are Chenoweth's "Food Preservation" and Rector's "Scientific Preservation of Foods."

As in the case of other aspects of the literature of the food industries, the journal sources are very widespread. They will be considered with certain of the subtopics. Some have already been mentioned in connection with the discussion of the literature on the composition of foods.

Dehydration. Few texts are devoted solely to this method of food preservation. The U. S. Department of Agriculture has issued an excellent booklet, "Vegetable and Fruit Dehydration—A Manual for Plant Operators." There is the text by Von Loesecke on dehydration. Additional information is available in some of the texts mentioned previously, particularly, "Chemistry and Technology of Food and Food Products," and in sections of texts covering special fields, such as Tressler's "Marine Products of Commerce" and Hunziker's "Condensed Milk and Milk Powder" which consider dried fish and dried milk products, respectively.

In a study of 109 references given in a chapter (Mrak and Mackinney) devoted to this topic, the five leading journals are: *Food Industries,* now *Food Engineering,* California Agricultural Experiment Station, circulars, *Journal of the Society of Chemical Industry* (London), *Food Technology,* and *Advances in Food Research.* The latter is issued annually. In all, 30 different journals comprise the sources used in this chapter.

Freezing. The literature on the freezing preservation of foods is also widely scattered. Much of it is in journals devoted to special food fields or to refrigeration. Among the important texts are Tressler and Evers, "Freezing Preservation of Foods" and "Refrigerating Data Book—Applications Volume." *Food Industries* has published a large number of articles on this topic and has made several surveys of the field.

Preservation with the Aid of Microorganisms. Since only a limited number of foods such as pickles, kraut, olives, a very few vegetables, and meat are preserved by this method, most of the texts considering it are in specialized fields. There is the Cruess book, "Commercial Fruit and Vegetable Products," Hammer's "Dairy Bacteriology," and Jensen's "Microbiology of Meat." Another excellent book is "Industrial Microbiology" by Prescott and Dunn.

In a study of 67 references (as cited by Fabian) related to this topic, those cited most frequently were New York State Agricultural Experiment Station, bulletins, *Food*

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Research, Michigan Agricultural Experiment Station, bulletins, and *Fruit Products Journal*. In this subtopic, 27 references were made to agricultural experiment stations. In all, 28 different journals were used as sources.

Unit Operations. Only one book considers food processing from the point of view of unit operations. Gaver is the author of these chapters in "Chemistry and Technology of Food and Food Products." The unit operations common to a number of industries are also indicated in "Flow-Sheets of the Food Processing Industry."

Food Machines and Instruments in the Food Plant. These topics are also covered in the Jacobs text, the former by Abrahamson. They are seldom considered except in trade journals designed for a special field, for instance, the confectionery industry, and in the descriptive material of the manufacturer of the machine. An important article on instrumentation in the food plant is that of Urbain in *Food Technology*.

Chemicals in Foods—Preservatives, Flavors, Colors, Vitamins

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The question of the use of chemicals in and on foods is now moot. Many articles have recently been written concerning such additions. There is one book devoted to the broadest aspect of this field covering the actual use of colors, flavors, preservatives, stabilizers, vitamins, and other food additives by the food industries—Jacobs' "Synthetic Food Adjuncts." Some information is also given by Blumenthal in "Food Manufacturing." There are other texts with more limited scope in this connection—Hirsch, "Chemische Konservierung von Lebensmittlen" (1952) in which the stress is on East German practice; Jacobs, "Chemical Analysis of Foods and Food Products" (1951); and the much older text by Folin, "Preservatives and Other Chemicals in Foods" (1914).

Among the more important articles dealing with this topic in recent years are those of Kaplan and Korff (1946), White (1946), and Lehman (1950–52) in Association of Food & Drug Officials of the United States, *Quarterly Bulletin*, Bing in *American Journal of Public Health* (1950), and Jacobs in "Encyclopedia of Chemical Technology." Symposia on this topic have been published in *Food Technology* (1951) and in *Chemistry & Industry* (1951–52). A very important source are the Reports of the Select Committee to Investigate the Use of Chemicals in Foods and Cosmetics (1950, 1951, and 1952).

In a chapter concerning the use of chemicals in foods, the journals listed most frequently in a total of 104 references are *Food Industries, Journal of the American Chemical Society, Industrial and Engineering Chemistry, Journal of Pharmacology and Experimental Therapeutics, Food Technology*, and *Oil & Soap*, with some 40 different journals mentioned.

Flavors. A most important text dealing with flavors as applied in food industries and to their preparation is Jacobs' "Synthetic Food Adjuncts." Older texts in English are Walter's "Manual for the Essence Industry" (1916) which has recently been reprinted; Clarke's "Flavouring Materials: Natural and Synthetic"; Martin's "Perfumes, Essential Oils, and Fruit Essences"; Gazan's "Flavours and Essences," which is out of print; and Kessler and Higby's "Practical Flavoring Extract Maker." Books in German are Wagner's "Aromastoffe" (1933), Burger's "Das Buch der Aromen," and an older text, Cohn's "Die Organischen Geschmacksstoffe."

Other aspects of flavor in foods are covered by Crocker in his text on "Flavor." An important leaflet "Flavoring Extracts" is issued by the Food and Drug Administration.

Among the journals which have specific departments on the topic of flavor and flavoring materials are the *American Perfumer and Essential Oil Review* and *Essential Oil Perfumery Record*. Both the *Spice Mill* and *Flavours*, a British journal, have been absorbed by other journals in recent years.

Packaging. Few texts consider the topic of food packaging adequately. A principal text is "Modern Packaging Encyclopedia" edited by Browne. Among the journals considering food packaging are *Modern Packaging* and the *Food Field Reporter.* The various trade journals consider the problems of their field from time to time.

Nutrition

It is beyond the scope of this discussion to consider the texts dealing with nutrition adequately, but a worker in the field of food industries should know of McCollum and coworkers, "Food, Nutrition, and Health" and "Newer Knowledge of Nutrition"; Silver, "Foods and Nutrition"; Rose, "The Foundations of Nutrition" and "Feeding the Family"; and Sherman and Lanford, "Essentials of Food and Nutrition." "Canned Food Reference Manual," issued by the American Can Co., is also of interest.

Among the important journals in this field are the *Journal of Nutrition, Journal of the American Medical Association,* particularly the section of the Council on Foods, *Journal of Home Economics, Journal of the American Dietetic Association,* and the *American Journal of Public Health.* An interesting quarterly is the *Nutritional Observatory,* published by the Heinz Co. There are also a host of pamphlets, articles, bulletins, circulars, and reports published by governmental agencies—federal, state, and municipal. Many trade journals publish such articles.

Food Control—Governmental, Sanitary, and Quality

Governmental Regulation. The impact of governmental regulation on the food industries cannot be minimized. These controls include (1) protection of citizens from deleterious foods and from being defrauded by adulterated and sophisticated foods; (2) exaction of taxes and duties on foods and beverages for revenue and restrictive control; (3) purchase of foods to specifications of governmental agencies; and (4) resolution of the conflicting interests of various food industries and sections of the country.

The notion that many of the ills of mankind are the result of the ingestion of adulterated foods is not new, and publications stressing this aspect have had marked influence in the development of regulations for the protection of the people. In 1660 Francesco Redi was writing about adulterated foods. It was in 1820 that Accum stirred all of London and England with his "Death in the Pot—A Treatise on the Adulteration of Food and Culinary Poisons." Throughout the 19th century a stream of such books was published in many countries: Garnier and Harel, "Des falsifications des substances alimentaires et les moyens, chimiques de les reconnaitre" (1844); Hassall, "Food and its Adulteration" (1855, first started in "Lancet" in 1851); Soubeiran, "Nouveau dictionnaire des falsifications et des altérations des aliments." Other texts have already been mentioned in the section on analysis. Neto's chronological summary shows the stress of articles and books on the topic of adulteration.

In the performance of its functions, the U. S. Food and Drug Administration has issued *Service and Regulatory Announcements* 2, as revised from time to time, on "Definitions and Standards of Foods," No. 3 on certification of colors, and also *Notices of Judgement under the Federal Food, Drug, and Cosmetic Act,* which contains information necessary for nearly all food processors. Many states and cities have sanitary codes to regulate the production and sale of foods. There are available legal texts which cover this phase of the subject.

An interesting book, though now somewhat outdated, is Brooks' "Critical Studies in the Legal Chemistry of Foods."

Sanitation. An important aspect of food production is manufacture under sanitary conditions. Great stress has been placed in recent years on this topic, and there has been a significant advance in the detection and estimation of filth in foods. The principal texts covering this subject are "Methods of Analysis" of the Association of Official Agricultural Chemists and *Circular* 1, "Microanalysis of Food and Drug

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Products," issued by the Food and Drug Administration. Jacobs considers this topic in "Chemical Analysis of Foods and Food Products."

Articles concerning the detection of filth in foods have been published in the *Journal of the Association of Official Agricultural Chemists, Food Industries,* and Food & Drug Officials of the United States, *Quarterly Bulletin.* There is an excellent article by Marquez in *Revista de Sanidad y Asistencia Social* of Venezuela.

In order to achieve good sanitation, the food industries have a number of additional texts: Adams, "Milk and Food Sanitation Practice"; Kleiner and Coleman, "Sanitation Manual—A Guide for Management"; Parker, "Food-Plant Sanitation," Shrader, "Food Control"; Clay and Jameson, "Sanitary Inspector's Handbook"; and Geiger, "Health Officers' Manual."

Food Poisoning and Toxicology

The food industries are concerned mainly with one type of poisoning—food poisoning—and its prevention. Ideas on food poisoning covering, in the broadest sense, food infections, food intoxications, and the transmission of disease by food, have undergone considerable change within the past decade so that more modern texts are generally preferred. The principal books discussing this topic are: Dack, "Food Poisoning"; Damon, "Food Infections and Food Intoxications"; Hull, "Diseases Transmitted from Animals to Man"; Jordan, "Food Poisoning and Food-Borne Infections"; Savage, "Food Poisoning and Food Infections"; and Tanner, "Food-Borne Infections and Intoxications."

The only text discussing chemical food poisoning systematically is Jacobs' "Chemical Analysis of Foods and Food Products."

Vegetables, Mushrooms, Fruits, Nuts, and Their Products

Food literature concerning vegetables, mushrooms, fruits, nuts, and their products has already been evaluated in connection with the discussion concerning the composition of such foods. Books in which other phases of this field, such as the manufacture of juices, jams, jellies, and preserves, are described are "Fruit and Vegetable Juices" by Tressler, Joslyn, and Marsh; the text by Cruess; "Apples and Apple Products" by Smock and Neubert; "Fruit Juices and Related Products" by Charley and Harrison; "Bananas" by Von Loesecke; and "Citrus Products" by Braverman. A number of texts dealing with canning and food preservation also discuss the manufacture of jams and jellies.

Fish and Fish Products

Much of the literature on fish and fish products is issued from governmental sources because considerable research in this field is carried on by such agencies. In the United States of America a principal literature source is the Division of Commercial Fisheries of the Fish and Wildlife Service of the Department of the Interior which puts out such publications as *Commercial Fisheries Reviews, Research Reports,* and *Fishery Bulletins.* In Canada many of such reports are published in the *Journal of the Fisheries Research Board of Canada* which is the successor to the *Journal of the Biological Board of Canada* and *Contributions to Canadian Biology and Fisheries.*

Tressler's "Marine Products of Commerce" is the most comprehensive text in this field. Among the more important journals are *Fishing Gazette* and *Pacific Fisherman* which issue important yearbooks. Much information concerning fish and fish products is also found in articles and books on the freezing preservation of foods and on the spoilage of foods.

Tea, Coffee, and Beverages

These divisions of the food industries are fairly well supported with texts and journals. The best known, relating to tea and coffee, are thoses of Ukers, "All About

Coffee," "Romance of Coffee," "All About Tea," and "Romance of Tea." There is also the chapter on coffee and tea by Ukers and Prescott in the Jacobs treatise. Neumann, in 1735, wrote "Vom Tee, Caffee, Bier, und Wein." Wiley's "Beverages and Their Adulteration" was a well-known text. The topic *Genussmittel* looms large in German literature.

The subject of alcoholic beverages is fairly well covered in texts. A comprehensive work is that of Herstein and Jacobs, "Chemistry and Technology of Wines and Liquors." A recent book is that of Valaer, "Wines of the World." There is the well-known book by Cruess, "Principles and Practice of Wine Making." Considerable information is issued by the Wine Advisory Board and the Wine Institute with headquarters in California. Several firms issue journals and information relating to yeast, enzymes, hops, and the like, of interest to the fermentation industries—e.g., *Wallerstein Laboratories Communications* and *Yeast* (Anheuser-Busch). This industry is well supplied with trade journals.

The topic of carbonated beverages is not so well documented. There are the old books of Sulz, "Treatise on Beverages" (1888) and Walter, "Manual for the Essence Industry" (1916) and the relatively recent text of Morgan, "Beverage Manufacture" (British). American Bottlers of Carbonated Beverages has issued the pamphlets "Plant Operation Manual" and the one by Medberg, "Manufacture of Carbonated Beverages." There is also the chapter by Jacobs in "Chemistry and Technology of Food and Food Products." There are a number of trade journals serving this industry.

Trade Journals

The food industries are well supplied with trade journals. While no attempt was made to make a really comprehensive survey, there are some 60 such publications which have their offices in the New York area. Of these, 16 serve the bottling and alcoholic and nonalcoholic beverage industries; nine, baking and milling; six, candy and confectionery; six, fruits and vegetables; four, coffee and tea; four, sugar; three, foods in general; three, poultry and eggs; three, fish and fisheries; three, canning; two, meats; two, frozen foods; and four publications serve other aspects of the food industries.

Abstract Services

A principal abstract service related to the food industries is the section on foods of *Chemical Abstracts*. Other sections of this journal occasionally bear germane material, particularly the sections on flavors and on analysis. *Food Technology* contains an abstract section, as does *Food Engineering*. *British Abstracts* has a section on food and agriculture and on occasion it is well to consult *Biological Abstracts*, *Index Medicus*, and the U. S. Army Medical Library listings. The Fish and Wildlife Service offers an abstract service, *Commercial Fishery Abstracts*. There are also *Nutrition Abstracts and Reviews* and abstracts in the *Nutritional Observatory*. Many of the trade journals carry abstracts, often reprinted from other journals, pertaining to their specialty. Subscription abstract services are available in the fields of fats, oils, and detergents, and legal aspects of the food industries. Specialized food survey services are offered by some consulting firms.

Cookery and Allied Fields

It has not been possible to go into the vast literature concerning food cookery or the fields allied to food—agriculture, biochemistry, enzymes, bacteriology, sanitary chemicals, and insecticides and rodenticides. Anyone working in the food industries should, however, be aware of the large number of such texts and journals treating such topics.

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Conclusion

The literature resources of the food industries are vast and widespread.

This is a field that is growing very rapidly. For instance it was in checking through *Chemical Abstracts* for 1951 and 1952, that approximately 50 journals were noted, mainly in Spanish, Italian, French, Russian, and German, which are not mentioned in this paper nor in the chapters which were surveyed reference by reference. It has become an urgent problem to survey and digest this literature properly.

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A Review of Milling and Baking Literature

MARGARET P. HILLIGAN, *General Mills Research Department, Minneapolis, Minn.*

MYRTLE J. KRAUSE, *The Miller Publishing Co., Minneapolis, Minn.*

Today there is increased activity, not only to improve the actual milling and baking processes, but to learn the effects of these processes on the constituents of the products. There are now over 300 technical and trade associations whose activities center around these industries; over 200 of them are in the United States. A selected group of these associations is included to show the many facets of the industry. Some of them provide excellent sources of information. A representative list of the books and journals specifically related to the literature of milling and baking is given; and, since so large a part of the literature is found in other sources, a secondary list of periodicals frequently repeated in bibliographies is also considered. Secondary sources, such as abstracting devices, indexes, reviews, and bibliographies are evaluated as a means of searching the literature.

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Milling and baking are the oldest of all industries. What we know of the earliest civilizations indicates that grain has always been prepared for food by pounding, crushing, or grinding. The Egyptians gave us pictorial records of flour milling and baking. The Old Testament is full of references to the grinding of wheat, to bread, and to bread baking (*3*). Through the centuries, bread has been a motivating factor which has shaped the political, social, economic, and even religious customs of the world (*6*).

The technology of milling and baking has run parallel to the advance of the scientific method. The Egyptians made bread by fermentation, yet an understanding of the process had to await the discovery of the microscope. In 1728 Beccari reported that he had separated flour into two fractions. Fortunately an English translation of this work was prepared from the medieval Latin in which it was originally written (*1*). As early as 1767 Malouin published an article on baking, which was probably the first time the science of chemistry was applied to improve the art of baking (*9*). In 1760 Malisset in Paris made a significant contribution to milling. He discovered that by holding the millstones apart at first, the coarser parts of grain could be removed. A final close grind produced flour free of bran (*7*). This was a forerunner of the present day milling process. As steam-driven engines became more common, milling engineers looked for a more efficient device for grinding than the millstone. The first roller mill was built in 1832. By 1900 roller mills had almost completely replaced the millstone.

The functions of the milling process and the baking process have not changed over the centuries, for the aim of the miller is still to effect a separation of the endosperm from the bran layers and the germ. The baker is still engaged in making a palatable loaf. Primary concern is with improvements in products and methods and this so broadens the picture that soil conditions and plant breeding; entomology; infestation and grain storage; preparation of the grain for the mill; the chemical composition of grain and milled products; the relation between grinding effects and baking properties; the interaction of ingredients; fermentation processes; and above all, the nutritional aspects must be considered. The feed industry as well as the flour industry is considered, for normally only about 70% of the wheat is obtained as white flour. The residue or offal, consisting largely of bran and some adhering endosperm, is used for the feeding of livestock.

In common with all industries the food industry has felt the full attack of science and the technological method. Chaucer's miller who could open a door "at a renning with his hede" has given way to no less manly men, but to those who use their heads more wisely. The miller who used to travel alone rather than chance to have his secrets wrested from him by an enterprising fellow miller now participates in associations and societies for the advancement of his trade. The formation of trade and professional associations since the turn of the century marks a new era in milling and baking. The 1952's Almanack Number of *The Northwestern Miller* (*10*) lists in the "Roster of Trade Associations" over 300 such organizations of which more than 200 are in the United States. While many are local feed, bakery, and grain organizations, such societies 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, National Association of British and Irish Millers, Associazione Italiana Fra Gli Industrali Molitori, and Arbeitsgemeinschaft Getreideforschung, are also listed.

Associations

These societies provide us with the first insight into the topic under discussion—the literature of milling and baking. They provide a confraternal nurturing of the very knowledge of the field itself. The services of these associations are invaluable to milling and baking, and men's accomplishments in the various fields of endeavor through the association are outstanding and worthy to be noted by future generations.

Millers National Federation. The Millers National Federation has been in operation for the past 50 years and illustrates many of the problems and successes of the millers through the years. It was founded on March 25, 1902 at a meeting in Chicago attended by millers representing 23 state and sectional associations. The purposes of the federation are to promote the welfare of the wheat flour milling industry in the United States; to provide a means of contact with appropriate federal and state agencies; to promote good relations with the general public and an understanding by the public of the economic functions performed by the milling industry; to perform a general trade service of education among the millers of the United States by the dissemination of statistical and economic information; to conduct educational and promotional activities among consumers for the purpose of obtaining increased acceptance of mill products; to improve the methods and practices of the industry in the manufacture and distribution of its products; to establish appropriate relationships with other agencies and associations; and to inculcate and promote a spirit of public service and responsibility among the members of the industry (*11*).

In 1928 the Wheat Flour Institute was formed. It is the educational division of the Millers National Federation. Its basic function is to halt the trend of declining per capita consumption of flour through education and basic product promotion. The Wheat Flour Institute joins bakers and millers, doctors, dentists, nutritionists, educators, research workers, and editors and writers to gain a merited place for bread on America's family table. In 1 year more than 5,000,000 separate pieces of educational literature were distributed by request from the Wheat Flour Institute. These numerous pieces of literature deal with subjects pertaining to the story of wheat and flour, good food, and human nutrition (*37–41*).

Some publications of a statistical nature issued by the Millers National Federation and made available only to members contributing their own data are listed (*28, 30, 34, 36*). There were, in addition, these special publications: "Flour and Feed Laws and Regulations" (*31*), "Carrying Charge Chart" (*29*), and "List of Flour Brokers" (*32*). Supplementing the above general information media are the innumerable letters, telephone calls, and personal conversations by which the federation staff brings its information services to bear on specific problems of individual members (*33*). The federation published "Studies for Flour Salesmen" (*35*) in 25 chapters in 1947 and 1948. It sponsored flour granulation studies at the Kansas State College, Agricultural Experiment Station. A technical report (*52*) was published in April 1950 on this subject.

Association of Operative Millers. The Association of Operative Millers is probably the oldest still active association in the cereal milling field. It was organized in 1895, and its first convention was held in 1896 in Chicago. Professor B. W. Dedrick was the first president, and the association was first called Fraternity of Operative Millers of America. Later the name was changed to the Association of Operative Millers. With the exception of 1945, a convention has been held every year since the first one. At the present time there are 14 district organizations in the United States and Canada, and the association has members all over the world. The present enrollment of the association is approximately 2400 members.

For the past 7 years the association has attempted, quite successfully, to become the technical service organization of the milling industry. The annual meeting is called the "Annual Technical Conference." An official organ of the association is published under the title *Association of Operative Millers Bulletin* (*110*) and is discussed elsewhere.

American Society of Bakery Engineers. The American Society of Bakery Engineers was founded in March, 1924 at the American Institute of Baking, Chicago. The society is composed of bakery scientists, bakery supervisors, and others associated with bakery production. The chief object of the society is to keep bakery production people informed of technical advances in the field. This is done, chiefly, by means of talks given by leaders in the various departments of bakery production and research at the annual meeting held in Chicago in March. Afterwards, these addresses are issued as *Proceedings* (*27*) to all members. The activity is supplemented by bulletins issued from time to time, keeping the membership posted on matters of current interest. Special committees study and report on general problems of the industry, such as sanitation, standardization of equipment, and the definition of technical terms. The safety committee of the society developed a safety code for bakery equipment, approved and published by the American Standards Association in 1947. This code, called Z-50, has had widespread use in the baking and allied industries.

In addition there is the important information service which receives requests for information from members, refers them to experts on the particular subject, and endeavors to supply the requested data to the members. The Department of Visual Education has about 25 films in its library pertaining to bakery production, safety, and related subjects, which are loaned to schools, clubs, and other groups requesting them. Approximately 900 bookings are completed each year.

American Bakers Association. Before the turn of the century, the baking industry felt the need for an educational and scientific organization and thus the American Bakers Association was founded in 1897. It seems incredible today that mechanical equipment for bakery operation was almost unknown only 50 years ago. But the American Bakers Association's first meeting, with those to follow during the next few years, gave impetus to rapid development and improvement of ovens and new equipment which were to have a great effect on the progress of the whole industry.

American Institute of Baking. Through the efforts of the American Bakers Association, The American Institute of Baking was founded in 1919 at Minneapolis; it was later moved to Chicago. It became the scientific and education center of the baking industry. The Louis Livingston Library of the American Institute of Baking has in its possession over 4000 books which provide information on baking, chemistry, fermentation, nutrition, and other subjects of interest to the baking industry.

American Association of Cereal Chemists. The American Association of Cereal Chemists is one of the most renowned professional societies in its field. It was founded in 1915 by a handful of chemists who were connected with the flour milling industry. Today the membership of this organization approaches 1000. The first publication of the AACC was a journal which was published from 1915 through 1923. In 1922 the American Society of Milling and Baking Technology joined ranks with the

American Association of Cereal Chemists, and in 1924 the first volume of the newly organized associations was published. *Cereal Chemistry* (*114*) is now in its 29th volume and year. It issues six numbers a year and publishes scientific papers dealing with analytical procedures, technological tests, and fundamental research related to the raw materials, processes, or products of the cereal industries. Papers must be based on original investigations not previously described elsewhere which make a definite contribution to existing knowledge. Space permitting, papers of scientists other than members of the association are accepted. *Cereal Chemistry* has established itself as a scientific journal of the highest rank.

The AACC has two other series publications. The *Transactions* (*127*) publishes scientific and technical papers consisting of the reviews of literature, discussion of problems in the cereal industries, and other problems of general interest to cereal chemists, and papers presenting results of studies which, though not classed as original research, make a definite contribution to existing knowledge. The papers published in the *Transactions* must be scholarly and treat the subject matter comprehensively. *Transactions* is issued twice a year. *Cereal News* (*16*) prints association announcements, news items, financial reports, and in general, the business of the association.

The association also publishes "Cereal Laboratory Methods" (*15*). Through the continued collaborative works of association committees, standard methods of analysis and testing in cereal laboratories have been worked out.

There is one other publication of the association which deserves consideration. This is the *Supplement to Cereal Chemistry* (*17*) which is issued each time the Thomas Burr Osborne medal award is made. In 1926 the AACC founded the Thomas Burr Osborne medal as an award for distinguished contributions in cereal chemistry. Since then eight awards have been made, and the addresses have been published (*18–25*). A selected bibliography of the medalist's works is usually included; these bibliographies cannot be overlooked as source material.

World Conferences

In 1927 the First International Conference on Flour and Bread Manufacturing was held in Prague; in 1932 the international scientific breadmaking conference was held in Rome. Proceedings of both of these conferences were published. It is fortunate that the abstracts of many of the papers are included in *Chemical Abstracts*. The contents of both of these proceedings are of interest, if only from an historical point of view. Some of the papers presented at these conferences have been listed (*42, 43*) to provide a means of measuring the progress of the last 25 years.

Government Agencies and Educational Institutions

Government agencies and educational institutions are also contributing to the knowledge in the field. A few years ago the Institute of Technology of the University of Minnesota introduced a curriculum on milling technology. Literature on flour particle size is emanating from this institution. Kansas State College has a Department of Milling connected with the Agricultural Experiment Station at Manhattan. A new x-ray technique for detecting insect infestation has recently been developed there by Milner, Lee and Katz (*48, 49*). The Division of Industrial Research of the Washington Agricultural Station at Pullman developed an experimental high-speed rotary flour mill which grinds the entire wheat berry into an exceedingly fine flour known as "Unifine" flour (*51*). Bread staling studies are being carried out in various universities under government contract for the United States Quartermaster Food and Container Institute for the Armed Forces. While these last reports are not generally available, some of them have become accessible through the Office of Technical Services. For example, PB 99032 is a report on "Prevention of Bread Staling," by Roy L. Whistler (*57*).

State and federal agencies contribute a very important portion of the literature in the form of department and bureau bulletins, technical reports, and bibliographies. A few examples are cited (*44–56*). This list is not indicative of the quantity of this type of

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material, nor of the subjects covered, nor limiting as to issuing agencies; it is included to point out a fecund source of information. An immediate association should be formed between this reportlike material and the publications which list them (*144, 145, 150*).

Bibliographies and Book Reviews

A unique catalog of books and pamphlets on cereals was published in 1938 (*61*). The title page bears the imprint, "A Bibliography of Cerealiana, a list of books and pamphlets on cereal production and marketing, milling and baking, and insect and fungus infestations of cereals and cereal products, including publications, of state, provincial and national agricultural experiment stations and boards of agriculture." The compiler states that this bibliography does not include the numerous and often important articles in chemical, milling, and baking journals, since such a list would comprise a large part of the contents of such journals as *Cereal Chemistry*, *Zeitschrift für das Gesämte Getreide-Mühlen- und Backereiwesen*, and *Das mühlenlaboratorium*. An effort has been made to include the number of pages, the date of publication, the publisher, and the place of publication, but in some cases these are not available. The publications are arranged in two groups: first, the books and pamphlets are listed alphabetically under authors' names; and second, publications are listed under official, national, state, and provincial agricultural institutions. The whole bibliography is remarkable. Not only may it be considered a catalog of books in the field, including many rare and out-of-print items, but it includes a large number of more obscure publications of associations, societies, and companies. In the second section publications are listed by title only, in numerical series sequence under the issuing body. Included here are the circulars and bulletins of the Department of Agriculture and its various bureaus, and the publications of state agricultural experiment stations. Although predominantly American, there are also included a lesser number of governmental publications of Canada, Australia, New Zealand, Union of South Africa, India, and Great Britain. While it is difficult to make a statement as to its completeness, this bibliography is truly an accomplishment. Now out of print, it can only be hoped that it may yet inspire a revised and enlarged edition.

In addition to "Cerealiana," the Almanack number of the *Northwestern Miller* (*10*) includes a bibliography of the standard books on flour and feed milling, commercial baking, foods, and nutrition. Book reviews appear in Cereal Chemistry (*114*), and the combination of these three sources will include the majority of books published on cereals and cereal products.

Books

Milling. A few of the more recent books and some of the classic reference books will be discussed in detail. On the milling process itself, there are six books (*63, 67, 70, 71, 73, 76*) worthy of mention. Although out of print and, it would seem out of date, Kozmin (*70*) is still highly regarded for its theoretical consideration of the milling process and for its discussion of fundamental principles of the action and design of machines. Lockwood (*71*) and Scott (*76*) cover additional phases such as conditioning, storage, infestation, and bleaching. With these books on milling the technical bulletins of the Association of Operative Millers should be discussed. The technical papers which have appeared in the monthly bulletins over a period of years have been reprinted in two volumes (*77*) with future volumes anticipated. The papers are presented in chronological order rather than with reference to subject matter, but the indexing is adequate for locating information. All phases of the milling technique are covered.

Cereal Chemistry and Baking Technology. Some classics on cereal chemistry and baking technology will be discussed. Now in its fourth edition "Modern Cereal Chemistry" (*69*) continues to present the most complete coverage of cereal technology in the English language. The book is more than a compilation and review of the literature for the authors discuss and evaluate controversial topics. Several chapters are concerned with the composition of wheat and products of milling. Other small grains discussed include barley, rye, oats, maize, rice, and soya. There are chapters on the physicochemical aspects of flour, flour strength, conditioning, the technique and the chemistry of the baking process, bleaching and flour-improvers, and dough-testing apparatus. The nutritive value of cereals and the use of cereals in livestock rations are included, but there are other more inclusive sources of such information. The chapter on microbiology of cereals is especially valuable because it brings together facts not readily available elsewhere. Analytical methods are taken up, with methods of vitamin assay being treated separately.

Two books by C. H. Bailey have become standard references. The first (*59*) covers wheat as a raw product and is concerned with varieties and environment in respect to composition, the milling process and its effects on the milled products, and the characteristics of flour. The second (*60*) is primarily a biochemical study concerned with the proteins, starches, sugars, gums, lipids, minerals, and vitamins of the wheat kernel. Both are extensively documented.

Amylases, proteases, lipases, oxidases, and fermentation enzymes are discussed in a book edited by Anderson (*58*). The various chapters have been contributed by authorities.

"Baking Science and Technology" (*75*) presents the scientific and technological aspects of baking with emphasis on the production of bread. The first volume is concerned with the basic science and covers the chemistry of carbohydrates, fats and oils, proteins, enzymes, vitamins, and yeasts and molds. The colloidal nature of ingredients and doughs is discussed. The second part of Volume I on materials of baking, takes up wheat flour and other flours, and ingredients common to baking. A complete chapter is devoted to water and its effects on the baking process. Volume II on baking technology is concerned with the physical treatment of dough, the baking process, bread staling, and physical and chemical testing methods. Cake baking and other sweet-line goods are taken up as a unit. The text is well documented; the combined bibliographies list in excess of 500 individual references.

Economics. No consideration of the literature would be complete without the economic study made by the Food Research Institute of Stanford University (*66*). The studies are mainly concerned with crops, markets, and economics, and comprise a monumental contribution to the literature of wheat. Some technical papers on wheat in the diet, wheat protein, starch and flour quality, bread staling, utilization of wheat germ, and physical tests of flour quality are included. An index to this series (*62*) consists of abstracts of the annual reviews and special studies, and a chronological list of the individual issues, and lists, by author and subject, of the special studies.

Animal Feeding. A few selected books on animal feeding will be discussed. "Provender Milling" (*72*) describes the machinery and processes by which animal foods are manufactured. "Feeds and Feeding" (*74*) covers fundamentals of animal nutrition, feeding stuffs, and feeding farm animals.

Compendiums, Reviews, Encyclopedias. There are also sections of compendiums, reviews, and encyclopedias which are important. For example, the new edition of "The Chemistry and Technology of Food and Food Products" (*68*) has four sections dealing with cereals and bakery products. Other noteworthy references are cited (*4*, *5*, *13*, *64*. *65*. *78*, *79*).

Journals

The journals in the field range from what might be considered a labor paper to *Cereal Chemistry* which includes only those papers reporting original scientific research. A partial list of journals is given in the bibliography (*80–128*). The accompanying number is that of an early 1952 volume. The majority are primarily trade magazines concerned with crops and markets, sales promotion, news items, and advertising. The percent of technical information contributed is small, and the majority are not included in standard chemical abstracting and indexing services.

Some journals selected for their significant contributions to the technical knowledge of the industry are listed in Table I.

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Table I. Journals Containing Significant Contributions to Milling and Baking Technology

American Miller (*109*)	*Cereal Chemistry* (*114*)
Association of Operative Millers, Bulletin (*110*)	*Feedstuffs* (*88*)
Baker's Digest (*99*)	*Meunerie française* (*117*)
Baking Industry (*100*)	*Milling* (*119*)
Brot und Gebäck (*103*)	*Milling Production* (*120*)
Bulletin des anciens élèves de l'école française de meunerie (*112*)	*Die Mühle* (*122*)
Bulletin de l'ecole officielle de la meunerie belge (*113*)	*Northwestern Miller* (*125*)
	Transactions of the American Association of Cereal Chemists (*127*)

In addition there are several journals no longer being published which form a permanent part of the literature (*118, 128*).

Each year, usually in April, the Miller Publishing Company issues an Almanack number as Section II of the Northwestern Miller (*10*). This is a valuable statistical publication covering facts and figures of the flour, grain, feed, and baking industries. It is also a guide to legislation concerning grains, mill products, baked goods, and packaging. For example the "Definitions and Standards of Identity for Flour and for Baked Goods" as promulgated by the Food and Drug Administration are found there. It is interesting to note that after years of investigation the "Definitions and Standards for Bakery Goods" was announced May 15, 1952 (*14*). In this connection the Bread Hearings before the Administrator of the Federal Security Agency may be considered vital literature.

Other information of interest in the Almanack number are lists of large bakeries and baking schools; a roster of trade associations; a bibliography of books and movies on bread, baking, and nutrition; and the "United States Farm Animal Population by States."

Cereal Chemistry may be considered the most prominent journal in its field. It publishes at least two thirds of all of the scientific and technical literature appearing in cereal, milling, and baking magazines. This figure is based on a survey of bibliographies, abstracting and indexing services, and the cereal and baking section of General Mills Research Library card index to current literature for the years 1948 to date.

Other periodicals not primarily concerned with milling and baking literature have pertinent contributions. On the basis of a study of bibliographies and practical experience a list of journals most frequently containing pertinent articles is cited (*129–142*).

A list of more than 200 additional journals has been made from the bibliographies of books and reviews, indexes, and abstracts. This is evidence of the fact that the cereal chemists enjoys the universal predicament of all scientists. It points out clearly his dependence on abstracts and indexes, not only for maintaining inroads to past experience and inventions, but for keeping abreast with current literature. The cereal chemist, for example, may or may not have seen the article in the *Journal of Colloid Science* entitled "The Action of Polyoxyethylene Monostearate upon Starch with Reference to Its Softening Action in Bread" (*8*).

Abstracts and Indexes

The American Association of Cereal Chemists appointed an Abstract Committee to study the problem of abstracts and indexes. Upon the recommendation of the committee, arrangements were made with Biological Abstracts (*146*) to publish a separate section, Section J, Abstracts of Cereals and Cereal Products. This has been published since 1948. Financial support is given by the AACC and the Millers National Federation (*12*). It is too early to evaluate Section J as a tool. Since it is part of so huge a service it cannot hope to attain the position of a current review-type service. There are no plans for separate indexing; the index to the complete edition is included with each section subscription. The December 1951 issue has a "Numerical Key to Contents of Section J." The latest subject index to *Biological Abstracts* is Volume 23, 1949. However, future editorial policy may improve this situation.

Ranking with Section J is the section on cereals of *Food Science Abstracts* (*149*), previously appearing under the title *Index to the Literature of Food Investigations*. This service has been published since 1929. Part VII entitled "Cereal Grains; Pulses; Edible

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Nuts; Seeds; Forage Crops" is subdivided under such headings as Milling, Baking, and Chemical Composition. *Food Science Abstracts* is not widely known by workers in this country, and it is regrettable, for the coverage and the abstracts are excellent. *Food Science Abstracts* does not cover as many related aspects of milling and baking as does Section J, and this is especially true in the field of agronomy and plant breeding.

Section J and *Food Science Abstracts* should cover a large part of the literature of interest. Other services found useful are cited (*143–151*). *British Abstracts* (*III*) (*147*) includes patents covering machinery used in milling and baking. The *Agricultural Index* (*143*) and the *Bibliography of Agriculture* (*144*) include state agricultural experiment station bulletins and publications of the United States Department of Agriculture. *Nutrition Abstracts and Reviews* (*151*) and *Food Science Abstracts* are the most likely sources for publications of the British Empire. *Chemical Abstracts* (*148*) includes patents, foreign as well as domestic. Where chemical aspects of milling and baking are concerned, *Chemical Abstracts* continues to be an effective tool. It must be kept in mind that a number of milling and baking journals are not included in the list of journals abstracted.

From the point of view of searching the literature, the value of *British Abstracts, Nutrition Abstracts and Reviews*, and *Biological Abstracts* is limited by the tardiness of their annual indexes.

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(91) *The Grain and Feed Review*, Minneapolis, **41.**
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BAKING

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(98) *Baker's and Confectioners' Journal*, Chicago, **66.**
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(100) *Bakers' Helper*, Chicago, **97.** (Title changed to Baking Industry in 1952).
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(102) *Biscuit and Cracker Baker*, New York, **41.**
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(104) *Canadian Baker*, Toronto, **65.**
(105) *Dough Boy*, New Orleans, **13.**
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MILLING AND CEREAL TECHNOLOGY

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(133) *Food Engineering.*
(134) *Food Manufacture.*
(135) *Food Research.*
(136) *Food Technology.*
(137) *Industrial and Engineering Chemistry.*
(138) *Journal of the American Chemical Society.*
(139) *Journal of Biological Chemistry.*
(140) *Journal of Nutrition.*
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Abstracts and Indexes

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(144) *Bibliography of Agriculture.*
(145) *Bibliography of Technical Reports.*
(146) *Biological Abstracts.*
(147) *British Abstracts.*
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Dairy Industry Literature

F. L. SEYMOUR-JONES

The Borden Co., 350 Madison Ave., New York 17, N. Y.

Textbooks and manuals of value in the dairy industry are not numerous; the best are listed. Two thirds of the periodical dairy science literature appears in journals not devoted to dairy science. Abstract journals must be consulted; the most valuable of these is *Dairy Science Abstracts*. Bulletins are issued by miscellaneous sources such as experiment stations and research institutes.

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The scientific literature of the dairy industry in its nature follows the pattern of scientific literature in general. It may be divided, on the one hand, into summaries of what is already known and, on the other, into reports on research and development work. The known is published in text books and manuals, in reviews and summaries in journals, in bulletins from government bureaus, experiment stations, research institutes, and the like. The new will normally appear in journals, bulletins, and patents; occasionally in trade journals and in reports of meetings and congresses.

The term "scientific literature" rather than purely "chemical literature" is used advisedly. The chemist in the dairy industry finds himself engaged with far more than pure chemistry. It is impossible to put exact limits on the dairy chemistry field. As an example, while a dairy chemist is not necessarily also a microbiologist, he is obviously interested in the chemical changes brought about in dairy products by inherent or added microbiological flora. Hence, according to his particular field of interest, he must be prepared to follow pertinent work in microbiology, biochemistry, nutrition, and kindred sciences.

Dairy science itself covers far too wide a field for discussion here. There are some topics classified under dairy science which lie, as a rule, outside the interests of the average chemist in the industry. In order to keep within reasonable bounds, no consideration is given here to such topics as dairy husbandry, dairy engineering, legal controls, economics, and physiology. This leaves chemistry, physics, microbiology, and the technology of the various branches of the industry.

Textbooks and Manuals

Considering first textbooks and manuals, Marsden has recently remarked that, "For one reason or another there seems to be fewer books written on dairying than on many other subjects of similar size and importance. This is probably fortunate for the dairy scientist since the quality of many modern textbooks in other subjects is not very high" (*21*). Which statement is to some degree confirmed by a resolution passed in June, 1951, by the manufacturing section of The American Dairy Science Association, the first part of which reads: "Whereas there is an apparent and urgent need for a new and up-to-date book on the chemistry of milk" (*18*). With this last statement there can be but little disagreement.

The classic, and still a very useful book, is the AMERICAN CHEMICAL SOCIETY monograph, "Fundamentals of Dairy Science" (*27*) by Associates of Lore A. Rogers, now out

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Advances in Chemistry; American Chemical Society: Washington, DC, 1954.

of print, the second edition having been issued in 1935. Probably the best British book is "The Chemistry of Milk" (*7*) by W. L. Davies, the second edition of which appeared in 1939.

The industry is closely regulated by government at all levels and therefore is well provided with books of analytical methods. The Milk Industry Foundation, an association of those dealing in fluid milk and allied products, produced in 1949 the second edition of their laboratory manual (*23*), which also covers other foods and materials in which the industry has an active interest, and includes useful reference data. The "Standard Methods for the Examination of Dairy Products" (*1*) of the American Public Health Association and chapter 15 of "Official Methods of Analysis of the Association of Official Agricultural Chemists" (*2*) are kept up-to-date by frequent revision and have legal standing. There are sections on the analysis of dairy products, possibly of more interest to chemists outside the industry than to those in it, in such standard works as Winton & Winton's "The Analysis of Foods" (*40*) and Woodman's "Food Analysis" (*41*). The British point of view is presented in "Richmond's Dairy Chemistry" (*10*) as revised by Elsdon & Walker, which contains considerable analytical matter from the angle of the regulatory analyst. The second volume of Ling's "A Text Book of Dairy Chemistry" (*20*) covers a laboratory course in dairy chemistry for a British college. In this country college dairy students are adequately taken care of by such textbooks as "Milk and Milk Processing" (*12*) by Herrington, and "Milk and Milk Products" (*9*) by Eckles, Combs and Macy.

The main branches into which the industry is commonly divided are covered by textbooks. The fluid milk division has "Market Milk and Related Products" (*28*) by Sommer, "Market Milk" (*19*) by Kelly and Clement, and "The Market Milk Industry" (*26*) by Roadhouse and Henderson. The ice cream division can refer to "The Theory and Practice of Ice Cream Making" (*29*) by Sommer or "The Ice Cream Industry" (*34*) by Turnbow, Tracy, and Raffetto. Wilster's "Practical Butter Manufacture" (*38*) is an up-to-date practical manual, including recent developments in continuous butter making. Hunziker's "The Butter Industry" (*15*) has long been a standard work, as has his "Condensed Milk and Milk Powder" (*14*), which deals with sweetened condensed milk, evaporated milk, dried milk, and malted milk. Whittier and Webb, in "Byproducts from Milk" (*37*), cover a whole galaxy of products derived from skim milk, whey, and buttermilk.

Modern textbooks on cheese of broad scope are lacking, although Van Slyke and Price's "Cheese" (*35*) covers cheddar, cottage, and cream cheese. It also devotes one chapter to process cheese, which subject is normally treated very inadequately, considering the size of that branch of the industry. Wilster's "Practical Cheese Manufacture and Cheese Technology" (*39*) is, as its name implies, a very detailed practical manual, mainly on cheddar but with about 50 pages devoted to 16 other varieties of cheese. For information on many types of cheese one must have recourse to bulletins of the Bureau of Dairy Industry of the U. S. Department of Agriculture or from Agricultural Experiment Stations, notably those of New York and Wisconsin. Sometimes the material is old. With Camembert cheese the standard references would be Matheson's bulletin of 1924 (*22*) and two bulletins (*32*, *33*) by Thom issued in 1909. A U. S. Department of Agriculture Bulletin No. 608 (*8*), revised in 1932, describes nearly 300 varieties of cheese and gives numerous analyses, mainly from the 19th century; the latest in 1914. One goes back to 1858.

The subject of casein is covered by Sutermeister and Browne in "Casein and Its Industrial Applications" (*31*). For the general microbiology of the industry Hammer's "Dairy Bacteriology" (*11*) is a standard work.

Sometimes the dairy chemist will have to step outside the literature of his industry. One seeking reasonably up-to-date information on butterfat, for example, would probably turn to Hilditch's "The Chemical Constitution of Natural Fats" (*13*) or to Bailey's "Industrial Oil and Fat Products" (*3*). The same reasoning applies to specialized information on milk proteins.

No reference has been made to textbooks in foreign languages. A check on the book reviews for the last year or two does not reveal any significant new publications in languages other than English, except for the third edition of "Chemistry and Physics of Milk and Dairy Products" (*42*) by Zaykovskiy, published in Moscow in 1950.

Besides books devoted exclusively to dairying or to some special phases of the industry, there are numerous more general manuals which contain one or more chapters on the subject. Thus the second volume of Frear's "Agricultural Chemistry" (*17*) has a chapter on "The Chemistry of Milk and Dairy Products" by A. H. Johnson. Among other manuals, more or less directly chemical in interest, which have something to say on milk and dairying, there may be mentioned Jacob's "The Chemistry and Technology of Foods and Food Products" (*16*). Von Loesecke's "Outlines of Food Technology" (*36*), Blumenthal's "Food Products" (*4*) and the Prescott-Proctor book on "Food Technology" (*25*). Some of the various annual volumes of "Advances" in various branches of science will contain matter of interest to the dairy scientist. Thus the third volume of *Advances in Food Research* (*5*) has a comprehensive review by Coulter, Jenness, and Geddes on "Physical and Chemical Aspects of the Production, Storage and Utility of Dry Milk Products."

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Periodicals and Bulletins

The periodical literature was very well reviewed in 1951 by A. W. Marsden in an article on "The Literature of Dairy Science" (*21*). Many of the facts and statistics embodied here are from his review.

Possibly the most striking characteristic of periodical dairy science literature is that some two thirds of it appears in journals not devoted to dairying. As one example, consider the National Research Council bulletin "The Composition of Milks" (*24*). This lists 280 references as authorities for its data. These are taken from 76 publications, made up of five books, nine bulletins, and 62 journals. These 62 journals can be classified as 26 medical, 15 chemical, 15 biological, agricultural, food, nutrition, or general science, and only six of the 62 specifically dairy, one of them being a trade magazine. Geographically there are references from three American countries, seven European, three Asiatic and two Australasian. The five dairy science journals were published in the United States, Great Britain, France, Germany, and Sweden.

As a further example, the British Commonwealth Bureau of Dairy Science has listed (*6*) the periodical literature regularly searched in preparing *Dairy Science Abstracts.* This list is exclusive of bulletins, circulars, and reports issued irregularly by government departments, universities, research institutes, and experiment stations. Their latest list of periodicals contains some 453 titles of which only around 73 (or about 16%) are dairy journals. The geographical scope is world wide, including periodicals from such unlikely spots as the Isle of Man, Cyprus, and the Fiji Islands. Actually *Dairy Science Abstracts* obtains only about 35% of its abstracts from dairying journals.

Today about 60% of world dairy science literature is published in English, whereas prior to World War II the figure was 75%. The foreign languages of principal interest are German, French, Swedish, Russian, and Danish. The U. S. A. produces about 45% of total dairy science papers with Great Britain ranking next with 15%.

There are various reasons for the wide scattering of dairy articles. Principally, while the subject matter may be dealing with dairy products, the topic may have its greatest interest to workers in other fields, such as nutrition, pediatrics, geriatrics, biochemistry, or veterinary medicine. Also in smaller countries the population may be insufficient to support a scientific journal devoted to dairying, and hence articles of dairy interest will appear in journals of general agriculture or science.

From all of this it follows that anyone wishing to keep reasonably up-to-date with the progress of dairy science must trust to abstract journals. *Chemical Abstracts* has a rather limited range for the dairy field. Moreover papers of interest to the dairy chemist may be found not only in section 12 on foods but may also, according to subject matter, appear in such a section as analytical chemistry or in the subsection on nutrition under biochemistry.

The alternative in this country is the abstract section of the *Journal of Dairy Science,* the organ of The American Dairy Science Association. These abstracts are prepared in cooperation with the International Association of Ice Cream Manufacturers and the Milk Industry Foundation. They are arranged in 17 sections, some covering branches of science such as chemistry, others, products such as butter, still others, topics such as sanitation and cleaning.

Undoubtedly the most adequate abstract journal is the British *Dairy Science Abstracts,* formerly a quarterly but, beginning in 1952, a monthly. The abstracts are logically arranged in eight sections, suitably subdivided. Thus the section on chemistry and physics is broken down into general, milk and milk products, processing and manufacture, analysis, and defects. This makes for economy of time and effort in scanning them.

A bibliography of papers on dairying of the war years and thereafter, including some abstracts, was issued by Dr. M. E. Schulz in 1948 and 1949 under the title "Manuale Lactis" (*30*). A few abstracts also appear in the German journal *Milchwissenschaft.*

For the publication of original matter and occasional reviews, some papers in dairy chemistry, but not very many, appear in AMERICAN CHEMICAL SOCIETY journals, as also in the *Journal of Biological Chemistry.* The main publication in the field in this country is the *Journal of Dairy Science,* of the American Dairy Science Association. This, however, covers a very much broader field than chemistry. The *Journal of Milk and Food Technology,* which is the official organ of the International Association of Milk and Food Sanitarians, is primarily concerned with papers of public health interest. The *Journal of the Association of Official Agricultural Chemists* contains some reports on analytical methods appertaining to the dairy field. There are also numerous trade magazines in which scientific and technical articles appear from time to time.

In Great Britain the *Journal of Dairy Research* and the *Journal of the Society of Dairy Technology* are standard sources. Germany has several journals devoted to dairy science. An examination of the "List of Periodical Literature regularly searched by the staff of the Commonwealth Bureau of Dairy Science" (*6*) reveals that scientific dairy journals appear in about a dozen foreign countries. Naturally papers of dairy interest will also appear in numerous journals of a more general nature.

There are other miscellaneous sources of information which should be mentioned. There are bulletins from the Bureau of Dairy Industry of the United States Department of Agriculture, from the National Research Council, from experiment stations, agricultural colleges and universities, from research institutes. Periodically an International Dairy Congress meets (the last in Sweden in 1949, the next in Holland in 1953), and the papers read are usually published collectively. One paper to be submitted at The Hague conference will be an extensive review of dairy science literature from the British Commonwealth Bureau of Dairy Science. There are annual meetings in this country of the Milk Industry Foundation and of the International Association of Ice Cream Manufacturers. Scientific papers there presented are published in the laboratory section of the *Association Bulletin* (*Milk Industry Foundation*), formerly *Proceedings of the International Association of Milk Dealers,* and in the *Report of Proceedings of the Annual Convention, International Association of Ice Cream Manufacturers, Vol. II. Production and Laboratory Council.* Patents are a relatively minor source of information in dairy science.

According to Marsden (*21*) in 1951 at least 6000 publications were examined yearly in preparing *Dairy Science Abstracts.* He states that prior to and immediately after World War II the annual average number of abstracts was from 1000 to 1500. Since 1949 the number has risen steeply to a figure close on 3000 per annum at the present time. One may therefore conclude that dairy research is emphatically growing and that it will be just so much more difficult to keep abreast of the literature.

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Literature of Meat and Meat Packing

BARBARA J. PAYNE and H. R. KRAYBILL

American Meat Institute Foundation, The University of Chicago, Chicago 37, Ill.

A selected bibliography of the literature of meat and meat packing and the by-products of the industry was compiled. The literature is scattered in books, technical and trade journals, and publications of research organizations. With the aid of the abstracts, indexes, and reviews available to him, the investigator will not find the task of locating the literature an insurmountable one.

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Research on the science and technology of livestock, livestock processing, and livestock products is a development of little more than the past hundred years. In 1847, Liebig (*3*) described the situation in regard to research on the food animal in this way, "in Animal Chemistry, which is a frontier district, belonging neither to Chemistry nor to Physiology, as commonly happens on the frontiers of thinly-peopled countries, adventurers of all kinds roam about; and it is on the observations made, and tales related by these adventurers, during their occasional expeditions or excursions, that the greater part of our knowledge of this district rests." In the century since Liebig wrote these words, gave his analyses of animal flesh, and described the famous meat extract, the number of adventurers has swelled considerably, and their expeditions are no longer merely occasional.

The last half of the nineteenth century saw much classic research on the food animal and on the constituents of animal food products carried on in the universities and, in this country, in the United States Department of Agriculture and the agricultural experiment stations. The chemist even entered the packing industry which previously had concentrated, and concentrated very effectively, on mechanical and technological advances. Appearing first in the by-product industries, the chemist arrived in the packing industry proper about 1890, according to Richardson (*5*). In the nineteenth century there also was increasing emphasis, particularly in Germany, on the scientific aspects of the ancient practice of meat inspection, as evidenced by Ostertag's nine thousand item "Bibliographie der Fleischbeschau" (*4*), published at the time the Meat Inspection Act of 1906 was under consideration in this country.

In the present century there has been ever-increasing research on meat and meat products. In the constant search for new methods of processing and new uses for animal products, the packing house laboratory has grown from the one-man department of the turn of the century into a laboratory with a large staff of scientists engaged in research covering a wide range of subjects related to meat, meat processing, and meat by-products. The experiment stations have continued to make major contributions, particularly in the areas of research on the meat animal, on the nutritional aspects of meat food products, and on the preparation of meat. A great deal of research in the field is carried on in the laboratories of various governmental agencies, both in this country and abroad, and on government-sponsored research projects in the universities and other research agencies. In the last thirty years has come group-industry-sponsored research on the part of the meat packing and allied industries. A by-product of all this research has been, of course, publication.

The chemist entering the field of meat research finds a complex situation in regard to the literature. One factor contributing to this complexity is that, actually, there are two literatures, often intermingled. The one deals with the technology of the industry, the actual methods of operation involved in processing the meat animal; the other constitutes the publication resulting from scientific investigation in the field. Both are important to the research man.

By-Product Literature

Further complexity comes with the fact that the meat packing industry is no longer concerned with meat packing alone. The continued search for new uses for the so-called by-products, many of which were considered waste products a century ago, has widened the boundaries of the industry enormously. The industry is engaged in supplying the raw materials for such fields as edible and inedible fats and oils, hides and leather, glue and gelatin, pharmaceuticals, and animal feeds in which animal products are used. In many cases, the industry has entered into the manufacture of the products of these fields. Having the facilities for the efficient processing and marketing of poultry and poultry products, several packers have entered into these phases of the poultry industry. Now, most of these fields have extensive literatures, much of which is of immediate or relative interest to the modern packing industry. Space does not permit a thorough coverage of each of these literatures here. A selected list of the journals and books that are of interest to the researcher investigating these allied aspects of the industry are included in the bibliography. A book in the American Meat Institute series, "By-Products of the Meat Packing Industry" (*157*), presents a unified discussion of the uses of the by-products and the operational methods involved in their processing. This serves, at least, as an introduction to the by-product field.

Literature of Meat and Meat Packing

A selected list of books, technical and trade journals, abstract and index services, and reviews is given in the bibliography. Types of publications issued by group-industry-sponsored research organizations and those issued by domestic and foreign government-sponsored research organizations are also listed. Various bureaus of the U. S. Department of Agriculture issue numerous types of publications which have not been included.

Books. The literature of the technological aspects of the industry extends back to antiquity. As is frequently pointed out, the packing industry is one of the oldest, having its beginnings in prehistoric times as a household industry. Throughout his book, "Meat and Meat Foods" (*90*), Jensen gives an interesting historical account of the beginnings of various processes and also a historical review of the use of meat as food. Jensen's book is particularly useful as a nontechnical introduction to the processing and preservation of meat, especially in regard to the microbiological aspects. For more detailed discussions of industrial operations, the investigator will find very useful the American Meat Institute series which includes "Beef, Veal and Lamb Operations," "Pork Operations," and "Sausage and Ready-To-Serve Meats" (*84–86*). The first two of these describe the methods involved in processing the meat animal from the time it comes to the packing plant to the time its various products are dispersed into the marketing channels. The last discusses methods of making sausage and other specialty meats, as well as ingredients and formulas. Supplementing these are Urbain's chapter on meat and meat products in Jacob's "Chemistry and Technology of Food and Food Products" (*39*), Gerrard's "Meat Technology" (*101*), describing British operations, and the German and other European texts on industrial operations noted in the bibliography. Several texts, also indicated in the bibliography, discuss operational methods in light of special subjects, such as meat inspection and microbiology. Additional sources for the technological literature are the trade journals and the patent literature.

Abstracts and Indexes. The scientific literature of meat and meat packing may be described in a word: scattered. The chemists, bacteriologists, biochemists, nutritionists, and others who have contributed to the field have quite naturally tended to publish in their own journals. Much of the material is found in the technical reports and bulletins of the agricultural experiment stations and other research agencies, both government and privately sponsored. This being the case, the abstract and index services, as sources of the literature, assume a position of very great importance.

For looking into the early investigations, *Chemisches Zentralblatt* (*12*) the *Experiment Station Record* (*13*) begun in 1889, and the *List of Publications of the Agriculture Department*, with its successor, *Index to Publications of the United States Department of Agriculture* (*20*), will prove useful. Parenthetically, references to much of the classic work of the nineteenth century and the first decade of the twentieth are to be found in Richardson's excellent review on meat and meat products in "Allen's Commercial Organic Analysis" (*35*).

For the more recent work, the chemist will naturally turn first to *Chemical Abstracts* (*11*). Here in the current issues he will find most of the papers on meat abstracted in the foods section, Section 12. However, the biological chemistry section, 11, and the analytical section, 7, warrant attention with regard to methods, and, in the case of the former, the nutritional and physiological aspects of the field. Then there are Section 27, "Fats, Fatty Oils, Waxes and Detergents," and Section 29, "Leather and Glue," for those by-product areas. The subject indexes have quite consistently grouped references related to the field under the one heading, "Meat," with a few technological references under "Packing Industry" and "Slaughterhouse." For the animal products other than meat, there are the specific headings, "Lard," "Hides," "Gelatin," and so on.

Biological Abstracts (*9*) yields a few more references. It has a brief subsection on meat and meat by-products in the food technology section. In addition to this section, references related to the field are scattered through the sections on animal physiology, animal production, and food and industrial microbiology. When the lagging indexes do come out, most of the pertinent references are found under the heading, "Meat."

Section B III, "Agriculture, Foods, Sanitation," of *British Abstracts* (*10*), though not so complete in coverage nor so current, gives some supplementary references from journals not covered by the other two.

A good, specialized abstract service, begun in 1929 by the Food Investigation Board of Great Britain and until 1949 called *Index to the Literature of Food Investigation*, is *Food Science Abstracts* (*14*). The bimonthly issues contain abstracts of interest to the meat field in the sections, "Fats and Oils, Processes, Packing Methods, Engineering" and the section entitled, with a nice British touch, "Meat (Including Pig-Flesh)."

For special aspects of the field there are *Refrigeration Abstracts* (*18*), *Abstracts of Vitamin Literature* (*7*), *Fats-Oils-Detergents* (*132*), and *Nutrition Abstracts and Reviews* (*17*), which are of interest in regard to the material in the fields indicated by their titles. The last, *Nutrition Abstracts and Reviews*, covers a wide variety of subjects related to the nutritional aspects of meat, but lacks a unified arrangement with regard to this field, and is further made difficult to use by the dropping of the indexes during the war. These indexes are now gradually being published, beginning with the first volume lacking them.

The Wilson indexes, *Agriculture Index* (*8*) and *Industrial Arts Index* (*15*), prove quite useful in the location of some of the technological material which is not covered by the services mentioned above. The unified arrangement of the material under general subject headings and the extensive cross references make them convenient to use. The Department of Agriculture Library's *Bibliography of Agriculture* (*19*), though considerably less conveniently indexed, is a valuable source because of its complete listing of experiment station and Department of Agriculture publications and its prompt coverage of the current literature. Since the separate listing of Department of Agriculture publications was terminated, the U. S. Government publications monthly catalog (*16*) serves as the most complete index of technical reports and bulletins coming from the research carried on by the various bureaus of the department.

Journals. No American scientific journals deal exclusively with the field of meat research. The "Journal of Meat Science" is yet to be published. Russia appears to be the only country that has brought out a journal approximating this. The Library of Congress list of periodicals of the Soviet Union (*6*) cites three journals in the field of meat, two of which deal with both the meat and dairy industries, but the third, *Miasniia Industriia S.S.S.R.* (*79*), carries research papers entirely within the field, and they appear to be quite interesting ones. The Library of Congress list locates files of the Russian periodicals in American libraries.

Other than this, periodicals devoted to meat and meat packing run to trade journals. The most recent edition of *Ulrich's Periodical Directory* (*2*) lists just seven periodicals in the field. Of these, four, by design or practice, are concerned primarily with marketing. The weekly, *The National Provisioner* (*50*), and the monthly, *Meat* (*49*), both published in Chicago, report, in addition to news of the market and of the industry in general, important new technological and scientific developments. Since these publish only brief indexes for each volume and are not covered by any of the abstracting or indexing services, they require an issue-by-issue scanning.

The journals listed here that are general to the food industries contain much that is directly pertinent or applicable to the meat industry. Several, particularly the Canadian and British publications, carry, from time to time, extensive reports of experimental work or review articles on the field. Nearly all contain sections that provide a quick survey of the new trade literature. With the exception of *Food Processing* (*48*) and *Food Machinery* (*45*), all of those listed are indexed or abstracted by at least one of the services discussed above.

At the present time, the two American journals carrying the greatest proportion of research papers in the meat field are *Food Research* (*55*) and the comparatively new *Food Technology* (*56*). In 1950, the Society of Chemical Industry, London, introduced the *Journal of the Science of Food and Agriculture* (*77*) which promises to add much to the field. From Germany comes *Zeitschrift für Lebensmittel-Untersuchung und -Forschung* (*83*) which has presented numerous papers in the field during the half-century it has been published, under various names.

Beyond these are the literally thousands of journals that carry an occasional article on meat and meat products or on basic information pertinent to the field. In the listing here, only those journals have been listed which have appeared to be most useful to the investigator in the field, either in regard to the number of papers reporting experimental work directly in the field or from the standpoint of papers that are important with regard to methods and the like. Selection of such journals makes one most conscious of the fact that it is difficult to draw a line and say, "Here ends the literature of meat research." By way of example, the histochemist may report in *Stain Technology* a piece of work on beef muscle tissue and call it muscle tissue, but in the last analysis that tissue is meat, and his findings are of interest to the meat investigator.

Reviews and Advances. Among the serial review sources listed here, *Advances in Food Research* (*22*) gives the best coverage of research that will interest the meat investigator, both with regard to that which lies directly in the meat field and those topics in other areas of the food field which may be applicable to meat research. The other reviews fall into the basic-information category.

The proceedings of the research conferences, held annually since 1949 by the Council on Research of the American Meat Institute (*29*), constitute a specialized source which contains material primarily of a review nature.

The reviews on the applications of analytical methods to food research, published annually in *Analytical Chemistry* since 1949 (*30*), are rich sources for material on this particular area.

The most comprehensive review of meat research is the "Report of the Review Committee" of the Conference on Cooperative Meat Investigations, published by the National Livestock and Meat Board (*31*). The committee undertook the enormous task of reviewing and abstracting all of the noteworthy meat research literature in English, as well as some unpublished work, for the twenty-year period, 1925 through 1945. Distribution of the report was limited, and it is not now available for purchase; however, copies are to be found in the agricultural colleges of the country.

Patents. There is an extensive patent literature on the processing of meat and meat products. Frequently the prior art sections of these patents are of interest in determining certain typical operational methods, where those methods have not been described elsewhere. There are the usual difficulties in locating the patents; however, in addition to the listing of patents in *Chemical Abstracts,* most of the meat and food trade journals report on major new patents.

Publications of Research Agencies. It has been emphasized that the publications of several research agencies have made major contributions to the literature of meat research. Agricultural experiment stations of the various states and the bureaus of the Department of Agriculture issue bulletins, circulars, and technical papers.

Three organizations of the British Commonwealth have been particularly active in the field. Most notable is the Food Investigation Board which was organized in 1917 by Great Britain's Council of Scientific and Industrial Research. In its four laboratories and stations this organization has studied a wide variety of problems in the meat field and has published extensively. In addition to the *Food Science Abstracts,* its own publications range from comprehensive special reports, many of which stand as excellent reviews of the particular subject under investigation, to leaflets, which note work currently in progress (*120–124*).

Australia's Commonwealth Scientific and Industrial Research Organization established the Division of Food Preservation and Transport in 1938. This group has contributed particularly in the areas of the freezing and chilling of meat and the preservation of meat.

The Division of Applied Biology of the National Research Council of Canada has concentrated its research activities in recent years on the preservation of food, particularly pork products, and on the industrial utilization of agricultural wastes and surpluses. Publications are issued (*125–127*), or papers appear in the National Research Council journal series.

In this country, the American Meat Institute Foundation, organized in 1944, publishes the results of its research in technical papers, bulletins, and circulars.

In the case of each of these organizations, and this includes the agricultural experiment stations, it is possible to obtain complete lists of available publications upon request. These lists prove to be very useful in locating much of the recent literature in the field. Also useful from the standpoint of their surveys of research projects currently in progress are the annual reports, or their counterparts, which are published by each of these organizations. The annual report (*128*) of the National Livestock and Meat Board should be added, for it surveys the research projects which the Board sponsors in various universities.

Related Subjects. Much of the literature on the effects of livestock breeding and raising on the quality of meat will be found in sources indicated here, particularly the publications of the agricultural experiment stations and the Department of Agriculture.

The literature on the marketing of meat and meat products has been very effectively covered by the "Bibliography on the Marketing of Livestock, Meat and Meat Products" (*1*), issued by the Department of Agriculture in June, 1951. This annotated bibliography, which is well-arranged and well-indexed, lists 1600 references from the period 1932 to July, 1950.

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The Technical Literature of The Edible Oil Industry

RICHARD NICHOLSEN

Archer-Daniels-Midland Co., 600 Roanoke Bldg., Minneapolis 2, Minn.

Chemical, food, and biochemical and nutritional journals contain technical literature on edible oils. The American Oil Chemists' Society publishes a monthly journal which contains an annual literature review. Publications on methods of sampling and testing are discussed as are abstracting services. The author recommends numerous books for specific information and a few for establishing a small technical library.

The technical literature of the edible oil industry can be divided conveniently into three broad classifications: the technology of the production and processing of animal and vegetable oils, the chemical composition and reactions of the oils, and biochemical and nutritional aspects. Of course there is much overlapping of the groups, and most journals in which technical articles are presented also publish papers dealing with other aspects of the food industry and with other totally unrelated subjects. Moreover, some of the most important publications in the field of edible fats are as much concerned with inedible fats. This is not unfortunate, however, for in many ways the technologies of the two types of products are similar, and various fats and oils are, to a certain extent, interchangeable. For example, soybean oil is one of the most important edible oils being consumed today, yet it is also one of the most important raw materials of the paint and varnish industry.

Scientific Journals

U. S. There are occasional references to edible oil technology in most of the chemical periodicals, for this is a field in which there has been much investigation by academic, industrial, and government scientists alike, and many of the reports are suitable for such publications as the *Journal of the American Chemical Society*, *Industrial and Engineering Chemistry*, *Analytical Chemistry*, and the like. And magazines devoted to food processing, such as *Food Engineering*, *Food Technology*, and *Food Research*, frequently include articles of interest to edible fat processors. Most of the biochemical and nutritional aspects of the subject are dealt with in the journals appropriate to those fields, such as the *Journal of Biological Chemistry* or the *Journal of Nutrition*.

American Oil Chemists' Society. Although there is no publication devoted exclusively to the field of edible fats, there is one very excellent American periodical devoted to the broader field of all fats and oils and related materials. This is the *Journal of the American Oil Chemists' Society*, which is now in its thirty-fifth year of publication, initially as the Chemists' Section of the *Cotton Oil Press*. In 1924 it was a quarterly called the *Journal of Oil and Fat Industries*, and it became a monthly in 1926. In 1932 the name was changed to *Oil and Soap;* in 1947 the present title was adopted. This magazine not only publishes technical papers presented at the society meetings or written specifically for publication, but also it includes each month a thorough abstracting service which attempts to cover all technical publications dealing with fats and oils or related products. And each year the Literature Review Committee of the society summarizes the entire field of technical literature related to fats and oils with sufficient information about each item to enable readers to keep abreast of recent developments.

The American Oil Chemists' Society contributes to the technical literature of the edible oil industry in other ways besides the publication of its journal. In 1949 it sponsored a "Short Course on the Production and Processing of Edible Fats" at the University of Illinois. The lectures were not only published in the society's journal, but were also bound in book form (*2*).

Foreign. There are a number of foreign journals devoted to the field of fats and oils. Among the most important are *Fette und Seifen* in Germany, *Oleagineaux* in France, *Olearia* in Italy, and *Masloboino Zhirovae Delo* in Russia. As in America, many other technical journals carry articles of importance to the edible oil industry.

Methods for Sampling and Analysis

Another most important contribution to the technical literature is the book, "Official and Tentative Methods of the American Oil Chemists Society" (*1*), which describes in great detail methods of sampling and methods of analysis which are approved by the society. This book is published in loose-leaf form, since additions and revisions are frequent. The society's committees on methods of analysis continue the never-ending job of trying to improve and simplify the procedures. The official methods are accepted as standard by most of the trade and are also recognized by other technical organizations, such as the AMERICAN CHEMICAL SOCIETY, the National Cottonseed Products Association, the National Soybean Processors Association, and the American Association of Cereal Chemists.

There are other organizations which publish specifications and standard methods of interest to the edible oils industry. For example, although the American Society for Testing Materials does not concern itself with edible oils as such, it does have well known and highly respected specifications and methods of sampling and analysis for some of the semidrying oils which, as was pointed out earlier, are used in the edible oil field as well as in the industrial field (*3*). Likewise, the Association of Official Agricultural Chemists has authoritative methods which are published regularly (*4*). The United States Government, as well as many of the states and foreign countries, publishes specifications which must be met by suppliers; but usually these refer to official methods, such as those of the American Oil Chemists' Society or the American Society for Testing Materials. The official German methods are those of the Deutsche Gesellschaft fur Fettwissenschaft, formerly known as "Wizoff." The British Standards Institute publishes the official methods of the British Society of Public Analysts, and also the methods of the International Fat Commission, which is a committee of the Union of Applied Chemistry.

Publications of Technical and Trade Associations

It is almost impossible to maintain a complete and up-to-date listing of the publications dealing with limited special fields within the edible oil industry. Many of these are sponsored by technical or trading associations. For example, there is the *Cotton Gin and Oil Mill Press* of the National Cottonseed Products Association, the *Peanut Journal and Nut World* of the National Peanut Council, the *Soybean Digest* of the American Soybean Association, the *Bulletin of the Institute of Margarine Manufacturers*, the *Journal of Milk and Food Technology*, the *American Butter and Cheese Review*, and the *National Provisioner*. In Canada there is *Butterfat;* in Italy there is *Olive Culture;* and in France there is the *Bulletin of the International Office of the Cocoa and Chocolate Industry*.

Government and Institutional Publications and Patents

Maintaining a complete list of the publications of agriculture experiment stations and similar bulletins which frequently deal with edible oil products is just as difficult. Many agricultural colleges and governmental agencies, both in this country and abroad, are included in this category. Also of importance are patents issued in this country and many foreign countries as well. These are particularly important sources of information about methods of extracting, refining, or otherwise processing edible oils, and they also cover many fat additives, particularly antioxidants.

Abstracts and Reviews

A reference which must be mentioned by anyone discussing almost any phase of the technical chemical literature is *Chemical Abstracts*. The most important sections concerning the edible oil industry are those on "Fats, Fatty Oils, Waxes, and Detergents," "Biological Chemistry," and "Foods." Fortunately, practically all of the varied sources of information on edible oils are covered by *Chemical Abstracts*, *Biological Abstracts*, and the Report of the Literature Review Committee in the *Journal of the American Oil Chemists' Society*. Nutritional aspects are reviewed periodically in *Nutrition Abstracts and Reviews*, and in the *Journal of the American Dietetic Association*. The Department of Agriculture classifies much information, including that of foreign patents, into specialized groups, such as edible oils. The Quartermaster Food and Container Institute for the Armed Forces published a detailed bibliography on filing cards with particular emphasis on fat rancidity and its prevention by antioxidants; an index to this card system was published in 1949 (*27*). A similar survey was published by the Hormel Institute in 1947 (*21*). The Field Information Agency, Technical reports (FIAT reports) and the United States Technical Industrial Intelligence Committee reports, which came out of Germany after the war, have been gathered together and summarized by W. H. Goss in "The German Oilseed Industry" (*12*). A useful commercial abstracting service which includes edible fat products is *Fats, Oils and Detergents* published in loose-leaf form by Interscience Publishers.

Scientific Meetings

Papers of interest to those in the edible oil industry are presented frequently at AMERICAL CHEMICAL SOCIETY meetings, usually before the Division of Agricultural and and Food Chemistry or the Division of Biological Chemistry, but occasionally at almost any of the other divisional meetings.

Books

Technical information about edible fats and oils has developed so fast that usually only books published very recently are of value for more than historical purposes. One, which was almost the Bible of the oil chemist in its day, and which is still of considerable value, particularly since it describes in some detail many of the less common fatty oils which are not mentioned by most authors, is "Chemical Technology and Analysis of Oils, Fats, and Waxes" by Lewkowitsch (*20*). This was first published in 1895, but it was revised several times, the latest revision being in 1923, when it was published in three volumes by Macmillan Co.

A more recent book of somewhat the same type, but limited to vegetable oils, is "Vegetable Fats and Oils" by George S. Jamieson of the United States Department of Agriculture; the second edition was published in 1943 as Number 58 of the AMERICAN CHEMICAL SOCIETY Monograph Series (*17*). There are several other volumes in this series of interest to the edible oil technologist including the following: No. 6, "The Vitamins" by H. C. Sherman and S. L. Smith (*32*); No. 9, "Carotinoids and Related Pigments" by Leroy S. Palmer (*26*); No. 41, "Fundamentals of Dairy Science" by Associates of L. A. Rogers (*29*); No. 44, "Glycerol and the Glycols" by James W. Lawrie (*19*); No. 93, "Biochemistry of Fatty Acids and their Compounds, the Lipids" by W. R. Bloor (*8*); No. 110, "The Biochemistry of B Vitamins" by R. J. Williams, R. E. Eakin, R. E. Beerstecker, and W. E. Shive, Jr. (*38*); and No. 112, "The Phosphatides" by Harold Wittcoff (*40*).

Probably one of the most useful recent books of a general nature is Industrial Oil and Fat Products" by Alton E. Bailey (*6*). Despite its title, the book includes a wealth of information about edible oils and their processing. Two others of general usefulness, published in Germany just before the war, are "Chemie und Technologie der Fette und Fettprodukte" by Hefter Schoenfeld, (*30*) and "Ubbelohde's Handbuch der Chemie und Technologie der Oele und Fette" by L. Ubbelohde and H. Heller (*34*). A Dutch book by H. A. Boekenoogen "De Scheikunde de Olien en Vetten" (*9*) is also general in nature. A very recent book is "Properties of the Principal Fats, Fatty Oils, Waxes, Fatty Acids, and Their Salts" by M. P. Doss (*11*), and another very complete work is soon to be published in England under the title, "Fats and Oils, Their Chemistry, Technology, and Utilization."

Many of the recent important books deal with a particular field of the broad subject of fats and oils. "The Lipids" by H. J. Deuel, Jr. (*10*) is in two volumes, the second of which is now in preparation and will put particular emphasis on the biochemical and nutritional aspects. "Continuous Processing of Fats" by M. K. Schwitzer (*31*) is concerned with engineering problems and equipment. It includes information about suitable materials of construction and lists the names of suppliers. "Oils, Fats, and Fatty Food, Their Practical Examination" by K. A. Williams (*37*) obviously describes methods of testing and analysis. "Hydrogenation of Fatty Oils" by H. I. Waterman (*36*) obviously describes the important specialized technique of hydrogenation, but it also contains much information about other industrial processes as well. "The Chemical Constitution of Natural Fats" by T. P. Hilditch (*14*) contains much general information as well as a listing of the component acids of many of the natural fats and a description of the methods of determining the compositions.

A new theory concerning fatty acid distribution in fats is presented by A R. S. Kartha in two volumes, "Studies on the Natural Fats," published privately by the author in 1951 in India (*18*). "Fatty Acids and Their Derivatives" by A. W. Ralston (*28*) and "Fatty Acids" by K. S. Markley (*22*) give much background information of value to the edible oil technologist, although most of the derivatives to which Ralston refers are inedible materials.

There are a number of recent books which are concerned with a particular fatty material. Two of the most important are part of a series of monographs on the chemistry and technology of fats which is being published by Interscience Publishers. The most recent (1951) is "Soybeans and Soybean Products" edited by K. S. Markley (*23*). This is in two volumes and includes much information about soybean oil, both as an edible product and as an industrial material. Another is "Cottonseed and Cottonseed Products" edited by A. E. Bailey (*5*). The first book of the series was "Fatty Acids" by Markley (*22*) which was mentioned before. One book of particular interest to the olive oil industry is "Olive Culture and the Technology of the Olive Oil Industry" by R. F. Simari and G. B. Martinenghi (*33*).

Of interest to the peanut industry is an "Abstract Bibliography of the Chemistry and Technology of Peanuts, 1830–1939" by Nelle J. Morris and F. G. Dollear of the Southern Regional Research Laboratory (*25*). Concerning sesame oil, there is the "Proceedings of the First International Sesame Conference" by J. A. Martin of Clemson College (*24*). And the vitamin contents of fish oils are described in "Marine Oils" edited by B. E. Bailey and published as Bulletin 89 by the Fisheries Research Board of Canada in 1952 (*7*).

The afore-mentioned books have all been concerned primarily with fatty oils or with the sources of fatty oils, but there are also several recent valuable books which are concerned primarily with foods and which include excellent chapters on edible oils. One of the more recent is "Outlines of Food Technology" by Harry W. von Loeseke (*35*). A much more ambitious work which appears in three volumes is "The Chemistry and Technology of Food and Food Products" edited by Morris B. Jacobs (*16*). Analytical methods are described in "Chemical Analysis of Food and Food Products" also by Jacobs (*15*), and in "The Analysis of Foods" by Andrew L. Winton and Kate Barber Winton (*39*). And one book designed for home economics students and containing laboratory experiment instructions is "Foods, Chemistry and Cooking" by Evelyn G. Halliday and Isabel T. Noble (*13*).

Establishing a Technical Library

For one who is just establishing a technical library for a small edible oil processing plant, perhaps some suggestions and recommendations will be of value. Of course, the specialized volumes will depend on the nature of the oil being processed, but in general, it can be said safely that most such libraries should contain "Industrial Oil and Fat Products" by Bailey (*6*), "Fatty Acids" by Markley (*22*), "The Chemical Constitution of Natural Fats" by Hilditch (*14*), "The Chemistry and Technology of Food and Food Products" by Jacobs (*16*), and "The Analysis of Foods" by Winton (*39*). Certainly there should be a current subscription to *Chemical Abstracts* and to the *Journal of the American Oil Chemists' Society* with back issues of each magazine for at least the last fifteen years. There should also be an up-to-date copy of "Official and Tentative Methods of the American Oil Chemists' Society" (*1*) and perhaps also of the standards of the American Society for Testing Materials (*3*) and the "Official Methods of Analysis of the Association of Official Agricultural Chemists (*4*). With these volumes as a nucleus the library can be expanded in the particular fields of interest to serve the greatest need.

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Literature of Canning and Preserving

LORRAINE CIBOCH

Research and Technical Department, American Can Co., Maywood, Ill.

The literature of the canning and preserving field is closely woven into that of agriculture, food chemistry, biochemistry, nutrition, organic chemistry, and other basic sciences. While some literature and reference tools indispensable to the searcher are well known, there are other valuable tools which are not so widely known, such as the publications of the state agricultural experiment stations and agencies of the Federal Government. A bibliography of reference sources presenting data of particular interest to the canning and preserving industry is given, and examples of methods used in answering typical questions brought to the library are discussed.

It is unfortunate that the literature of canning and preserving cannot be contained in a specific section of the literature ready for inspection by those interested. Some divergence into other fields is true of almost any branch of science; and when the nature of a canned food is considered, the extensive interrelation with other phases of the literature is not surprising. The preliminary choice of the proper variety of fruit or vegetable for canning, its cultivation, harvest, and preparation of the raw material, and the technology involved in manufacturing the proper container for the product are all factors of importance. The nature of the finished product indicates the obvious relationship to the literature of nutrition and biochemistry. A discussion of all these factors would be a dissertation beyond the scope of one paper and would involve great lists of books and reference sources. This discussion, therefore, is limited as far as possible to the literature on food preservation, sources of information on legal regulations important to the canner and preserver, directories, the important and inevitable statistics, and the use of the current literature. The bibliography presented at the end of the paper is grouped according to similar classifications.

Those who work extensively with the literature view it analytically. They constantly ask questions such as: Just what does this book tell me that none other does? Can this particular index help me find information that would be hidden otherwise? Which class of questions will this help me answer? This paper is presented from this approach.

Naturally, the actual mechanics of getting a product ready for the market are of primary importance. The canner wants to know which varieties best lend themselves to the processing involved; he wants to see a flow diagram of the process; he considers the size of the container to be used and the processing temperature and time necessary. More concisely, the technologist wants the "how-to" book. The canning industry is fortunate in that there are several books which serve this purpose; some of these present discussions of the equipment available, important patents in the field, patented processes in use, a history of the product, and frequently a bibliography supplementing the discussion. While it is not possible to mention all of the books available, there are several which are in constant use. Among these are: Bitting, "Appertizing or the Art of Canning. Its History and Development"; Campbell, "Campbell's Book. A Manual on Canning, Pickling and Preserving"; and Cruess, "Commercial Fruit and Vegetable Products."

In the field of frozen food, the book by Tressler and Evers, "The Freezing Preservation of Foods," and for dehydrated foods, Von Loesecke's "Drying and Dehydration of Foods" are valuable references.

Conformance with Standards and Specifications

It is not sufficient for the canner to set up his factory, choose his process, and start packing a food. In order to obtain uniformity in the interest of consumers, standards have been set up by the Government to which the product must conform. While the *Standards for Grades* which relate to the commercial quality levels of the product are voluntary standards set up as a guide by the Production and Marketing Administration of the Department of Agriculture, the *Standards of Identity, Quality, and Fill of Container* for foods promulgated by the Federal Food and Drug Administration are mandatory. The *Standard of Identity* tells the packer exactly what his product must contain, what optional ingredients may be included, and what information the label of the product must present. For example, it prescribes required percentage composition limits of fruit cocktail; and indicates that mint leaves may be used to flavor canned peas if their addition is declared on the label. The standard also gives the methods of analysis to be used in testing the product for conformance. The *Standard of Quality* sets the minimum acceptable level of factors such as maturity, workmanship, color, etc. These standards are used as the basis on which the standards of grades mentioned above are formulated. At the present time, only a limited number of precise *Standards of Fill of Container* have been promulgated. However, a general method for capacity and fill of container has been published in regulations issued by the administration, and presumably additional standards and regulations in this field will be forthcoming.

Any changes in the standards or any new administrative regulations of the Government are published in the *Federal Register*. This is the official government newspaper which publishes daily the full text of presidential proclamations and executive orders and any order or regulation, notice or similar document which has general applicability and legal effect promulgated by federal administrative agencies. Another government publication, the *Notices of Judgment under the Federal Food, Drug and Cosmetic Act*, of the Food and Drug Administration, is a monthly publication which gives complete information on the shipment, processor, product, nature of charge, and disposition of the case in those instances when a product has been subject to seizure by the administration. The *Annual Report* of the Food and Drug Administration is a resume of the work of the agency and reports of the scientific investigations carried on by the agency.

If the canner plans to sell his product to a government agency, he must consult the specifications from the "Federal Standard Stock Catalog" which may be applicable. As a type of literature, this specification is similar to the *Standard of Identity*. When the canner wants to sell his product to the armed forces, still other specifications may apply. These are the military specifications, which are most commonly issued by the Quartermaster Corps. While the specifications from the "Federal Standard Stock Catalog" and the military specifications are listed in the *U. S. Government Monthly Catalog*, the military specifications are also indexed in the four-volume *Index to Military Specifications* which is published semiannually with monthly supplements for each volume. In this index, the specification number, the date it became effective, and the agency from which it may be obtained are listed.

Use of Directories

Eventually, a canner will have a question which requires the use of one of the directories. Perhaps he will want to know who manufactures a special piece of equipment or who sells a particular type of sugar sirup. He may need to know the address of a processor, the owner of a particular label, or how many packers of tomato products there are in the state of Utah. When these questions arise, the sources most frequently consulted are: "Food Products Directory," published by the *Western Canner and Packer;* "Canners Directory," compiled by the National Canners' Association; "Directory of Frozen Food Processors," published annually by *Quick Frozen Foods;* and the "McGraw-Hill Catalog Service for Food Industries Catalogs."

Locating Statistical Information

As soon as one can of food has been packed, a statistic has been created. At least one third of the questions received at one library associated with the canning industry deal with statistics in one form or another: The quantity of No. 2 cans of cream style corn packed in 1951, the size of the cherry crop in Michigan, the per capita consumption of frozen broccoli are typical queries. The variations of these questions can be endless, bringing in factors of price or numbers of employees, etc. The most comprehensive sources of statistical information are: the statistical review and yearbook number of the *Western Canner and Packer;* "Canned Food Pack Statistics," published by the National Canners' Association; the convention number of *Quick Frozen Foods;* the yearbook number of *Pacific Fisherman;* and "Canning Trade Almanac," published by *Canning Trade.*

The "Canning Trade Almanac" also has a section on food laws and regulations in which some of the United States grades and the *Standards of Identity, Quality, and Fill* are listed. Finally, there are three publications of the Bureau of Agricultural Economics of the United States Department of Agriculture. These short, mimeographed papers are issued quarterly and they contain the most current information on estimates of acreage, price comparisons, and trends in the industry. The titles of these papers are the *National Food Situation,* the *Fruit Situation,* and the *Vegetable Situation.*

Periodicals Related to Canning and Preserving

No matter how highly organized the literature is, or how comprehensive the reference tools, those in literature work are acutely aware that the current literature must be searched and used constantly—the piece of information that is sought is usually hidden in an article. It is also necessary to keep up with current developments in technology and research. There are less than 10 journals devoted entirely to the field of canning and preserving. Probably the oldest of these is *Canning Trade,* which has been published weekly since 1878. In addition, the *Canner* which began publication in 1895, the *Food Packer, Western Canner and Packer,* and *Quick Frozen Foods* are the most important of these periodicals. However, these are trade journals and there is no technical magazine or journal devoted specifically to research in canning and preserving. Results of this type of research are reported in the journals devoted to food technology and research, and in journals of related fields. There are approximately 20 journals of this type when the journals of the basic sciences are not included.

Indexes and Abstracts

There is no commercial index or abstract journal devoted to canning and preserving. Even the "Library Abstracts" of this laboratory prepared for staff use include references from the fields of metals, nutrition, organic chemistry, and engineering, since they naturally reflect the diverse interests of the staff food technologists. The United States Department of Agriculture Library publication, the *Bibliography of Agriculture,* is a very useful abstract journal. This is a monthly publication which gives short abstracts and includes some state publications. Although the publication did not begin until 1942, it is possible to go back into the literature by using the *Experiment Station Record* which was published from 1889 to 1946. With the additional use of the *Agriculture Index, Chemical Abstracts, Biological Abstracts,* and, occasionally, *Industrial Arts Index* and *Engineering Index,* the literature of canning is covered adequately. For foreign coverage, the British publication, *Food Science Abstracts,* is useful and is hindered only by conditions which have greatly delayed publication.

Perhaps the area which is least comprehensively indexed and abstracted is that of state publications. Information must literally be dug from these sources. Locating these publications and indexing them more fully than is normally done commercially is one approach to the problem. A publication of the Library of Congress called the *U. S. Monthly Checklist of State Publications* serves the same purpose for state publications as the *U. S. Government Monthly Catalog* does for publications of the Federal Government.

Manufacturers' Literature

Naturally, manufacturers' literature is valuable, particularly in descriptions of equipment. These bulletins and data sheets can be located only through constant scanning of the free literature columns and advertisements, and adequate indexing or classification of the literature once it is in the library.

In limiting this paper to the discussion of the literature of canning and preserving, the most obvious sources, the commonly used handbooks, encyclopedias, etc., which are found in most technical libraries have been omitted. It has been necessary to limit even those references which, while not strictly a part of canning, are indispensable to the literature of the field. There are many references on foods, composition of foods, agricultural chemistry, and analytical methods which are used constantly. A list of some of the more commonly used tools is presented in the bibliography of this paper.

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The Literature of Cacao

W. TRESPER CLARKE

Rockwood & Co., Brooklyn 5, N. Y.

Cacao has been known to the scientific world for only about 450 years, but in that time it has become firmly established in our economic, historic, cultural, romantic, and scientific lives. Agronomists from various parts of the world have occupied themselves principally in the tropical areas of production. Economists have dealt with cacao and its effects upon social, political, and national cultures. Historians have recorded its transition from the pre-Columbian world of the Middle American cultures to the Spanish conquerors, and those who followed.

The thread of the history of cacao, completely unknown to and unsuspected by Europeans, has been spun by discoverers, voyagers, military conquerors, religious missionaries, merchant princes, and pirates with conflicting national ambitions. In the past hundred years its industrial development has enlisted the assistance of food manufacturers, chemists, nutritionists, biochemists, home economists, traveling salesmen and advertisers. In the various branches of the growing food industry the confectionery industry has been joined by the baking, beverage, ice cream, and dairy groups. The pharmaceutical, tobacco, and fertilizer subgroups have further swelled these forces. The poet, musician, artist, etymologist, physician, student of folklore and jurisprudence, and the common man, both rich and poor, have expanded the literature to its present relatively enormous size. The very diversity of these sources has made it appear to the casual investigator that the literature of cacao has been neglected. Yet the fine spinning of related and unrelated threads of cacao endeavor and their weaving and interweaving have produced a wonderfully sturdy fabric.

Prehistory

The prehistory is probably the least well-known phase of cacao. Archeologist and botanist indicate that many of the plants found on the middle American scene give highly acceptable evidence of the antiquity of cacao. Carter (*19*) is convincing in his statement that the cultural development found in Central and South America required a long developmental period. The evidence of plant domestication gives an entirely new perspective to the antiquity of that area and, by extension, to other surrounding areas. Yucatan, Guatemala, and the Amazon-Orinoco basins seem to be the most likely original sources of cacao.

How many millenniums the natives may have cultivated cacao before the arrival of Columbus may never be known. "Literary references" in the form of stelae or hieroglyphs may yet be awaiting the archeologist's pick and shovel. Morley hints this in his monumental studies of the Mayas (*53*). The origin of cultivated plants is a particular phase of botany which requires specialists who can work equally well in archeology, ethnology, history, native languages, cultures, and religions. This highly specialized field of study has to rely on the testimony of such workers as Lundell (*49*) and Bartlett (*6*), who are convinced that the high correlation of cacao and other botanical species of food plants with the presence of Maya ruins in the Petén forests indicates that human agencies determined these associations many centuries ago. Cacao seems traditionally associated with religious worship and ritual among those people. It therefore seems natural that the plazas and streets near their temples should be lined with venerable plants such as cacao, ramon, and mamey. Even in clearing new fields for agriculture, these trees received selective protection and it is perhaps not too far off literary base to include this as unwritten vital literary evidence.

Dahlgren (*25*) briefly indicates the gradual extension of cacao northward. The Mayas, the Toltecs, and the Aztecs for many centuries had set the stage for the arrival of Columbus in 1502 and Cortez in 1519.

Perhaps the earliest account is an entry in the log of Columbus during his fourth voyage to the New World. In July 1502, off Yucatan, he intercepted a coastwise canoe loaded with products of agricultural commerce. Among them was cacao, one of the many unique vegetable legacies from the Americas (*23*).

Cacao was on the scene when Cortez advanced into the Valley of Mexico in 1519. His letters to the Spanish King, Charles V, mention it as one of the unusual gifts offered by the somewhat frightened emissaries from Montezuma II (*24*). Later he found it popular at the Aztec Court and its use already widespread. It did not grow in the capital province, but had to be imported from the outlying reaches of the empire. This commerce of cacao was large and extensive. Montezuma ordered the establishment of a special cacao plantation for Charles, but other immediate gifts and loot proved more attractive to the conquerors. However, cacao grew into popularity with the Spaniards and their adoption of the word "cacauatl" as used by the natives for this food and the plant reached us through contacts with the Aztec and Maya people.

The history of its technology and description are suggested in the etymology of the two principal words by which cacao products were designated. According to Davila Garibi (*26*), the word cacao is older than the word chocolate. Cacao is derived from the hybrid Maya-Aztec form consisting of two root words which signify a bitter beverage. Judging from the trustworthy recipes used by these early Mexicans, such a beverage made today would probably be just as unappealing to us as it was to the conquistadores. It was not until sugar, spices, and milk were added and the beverage was cooked and served warm that its popularity among Europeans became established. Today's food technology, and in fact all lexicography, whatever the language, is indebted to the phonetic Maya adjective "Choqui" signifying warmth as the source of the first two syllables in the word chocolate. Spanish orthography of the next 100 years brought about the simplification of these terms to their present-day Spanish and English. Rarely have words from such obscure aboriginal languages been so gratefully and universally adopted into all tongues of the world. Clarke has given more widespread publicity to these derivations (*21*).

However fascinating is the history of cacao, its acceptance in our current practical lives scarcely gives due credit to the exalted status it enjoyed in the ancient Central American cultures. Social custom and traditions passed over into and shaped its acceptance in our European culture, and in many countries it still constitutes an expensive luxury. Poetry and music, as esthetic forms of literature, have not neglected cacao and chocolate as themes. However, commercial exploitation and technological advances in agriculture and the manufacturing and processing arts and sciences constitute the major portion of our literature on this subject today.

Histories of Cacao

Few books on cacao have been written which do not provide the reader with one or more copies of woodcuts taken from the early classics. Perhaps the most outstanding popular historical work is "Quatre Siècles d'Histoire du Cacao et du Chocolat" by Bourgaux (*10*). The technological developments from aboriginal to World War II days are marked, and Bourgaux gives the reader copies of many of the original etchings taken from de

Blegny (1687) (*8*), Bontekoe (1679) (*9*), Thomas Gage (1648) (*32*), Benzoni (1565) (*7*), William Hughes (1672) (*37*), and many others.

Another equally well illustrated history is by Historicus 1892 (*36*), with reprints from early works of the seventeenth century. The work of Historicus was sponsored by the great English firm of Cadbury and, aside from being filled with valuable excerpts from many early works, seems to be the first to introduce to cacao literature colored reprints of the Mexican picture writings relating to the subject. Unfortunately, this work as well as most of the early references are out of print and available only in a few large libraries and private collections.

Three publications by Walter Baker & Co. in 1886 (*4*), 1890 (*3*), and 1904 (*5*) provide substantial excerpts from Gage (1648) (*32*), Brookes (1724) (*14*), Mangin (1860) (*50*), and Colmenero de Ledesma (1631) (*48*). These three books constitute one of the most important single groups of cacao history in English.

Whymper, whose writings are accepted as classics on the subject, includes a chapter on the history and growth of the cacao industry (1921) (*75*). Quotations from Prescott (1843) (*62*), Peter Martyr (1526) (*61*), and DeCandolle (1883) (*18*), and popular accounts that are current in sixteenth, seventeenth, and eighteenth century news journals, and references to Humboldt's travels (1799) (*38*) and to the famous scholar and physician Henry Stubbe (1662) (*67*) make interesting reading which invites a study of the original sources.

Cultural aspects of cacao are supplied by Valerian Tornius (1931) (*68*), who describes briefly the method of preparing cacao as a food, its use as currency in old Mexico, and the gradual evolution of recipes for use in the modern world. One of the special attractions is a group of photographs of the ancient equipment used in preparing cacao for food uses and a series of picture writings given in early Mexican codices. The references to chocolate and cocoa in poetry, painting, and music are unusually complete. The bibliography includes references to still more fascinating history, such as the diatribe by Cardinal Brancaccio against the widespread use of chocolate in 1665 (*11*), de Cailus' natural history of cacao (1719) (*17*), and Brillat-Savarin's chocolate recipes to tease the palate (1826) (*12*).

The German chocolate expert, Heinrich Fincke (1936) condenses his references to cacao history into four short pages (*30*), quoting most of the previously mentioned authorities.

Many interesting small works shed light on the early history of cacao. For example, the legend of cacao given by Denis (*27*, *50*) recounts a few of the rather apocryphal stories of cacao in the early history of Mexico. These oft-told tales reach us from Torquemada (1614) (*69*), Sahagun (1560) (*64*), and the remarable grand folio on the antiquities of Mexico by Lord Kingsborough (1830) (*44*). From the latter work come many of the earliest representations of hieroglyphics showing cacao trees, pods, its processes of preparation as a food, the god of cacao, various scenes of cacao agriculture, and consumption as a beverage. In still another small important work Garcia-Icazbalceta (1896) (*33*) gives the story of cacao in the history of Mexico.

Negative Evidence

There are no Biblical references to cacao. Romans and Greeks celebrated their festivals without the foaming bowl of chocolate. The Egyptians and Hindus lay no claim to its use. Although so many other literary references go back to the ancient Chinese pharmacopoeia, that source fails to bridge the gap with either myth or fact in the case of cacao. Medieval literature is deadly silent.

Omar Khayyam, Roger Bacon, Dante, Marco Polo, Petrarch, Chaucer, and all other pre-1500 A.D. poets, scientists, and travelers who sang and wrote of the pleasures of their day would never have missed the opportunity to write of cacao and chocolate. Even Shakespeare seems to have been born too soon. The inference of these negative data shows that cacao was unknown to the world in that day. No one knew what new worlds lay in wait for Columbus, da Gama, Torres, and Magellan. The story of the circumstances of cacao as it has now developed would have seemed another Munchausen tale.

Classifications and Bibliographies

The state of cacao literature is rather chaotic, in that it is dispersed in piecemeal fashion throughout European and American scientific and trade journals. The subject has become so formidable that no one has accepted the challenge of preparing a definitive, all-inclusive text since Fincke did so magnificant a job in the German language in 1936 (*30*).

Only since the end of World War II does there seem to have been a general realization of this disorder. Several classifications of subject matter have been prepared, the most thoroughly detailed system of documentation being that proposed by Mikulaschek to the Office International du Cacao et du Chocolat in 1949 (*51*). Based on the Dewey decimal system, it covers confectionery and other allied products as well. It has not yet been accepted by the industry, which seeks something simpler. Its classification index numerals frequently run to twelve and fourteen integers. Further study, possibly with the Fédération Internationale de Documentation at the Hague, may improve it. It is at present available in French and German.

Two notable bibliographies have become available since the end of World War II. The Watrous bibliography (1950) (*72*) on the cacao plant, its culture, and the primary processing of cacao holds special interest to the worker in agricultural research and extension. Listing approximately 1400 separate items published chiefly between 1920 and 1949, it embraces the cultural aspects of distribution throughout the world, the propagation, types of soil, fertilizers, yields, taxonomy, and physiology of the cacao plant, fungus and virus diseases, and insect and other pests. It also covers the harvesting, curing, grading, storage, and biochemistry of the cacao bean and various research programs undertaken in different parts of the tropical world. A convenient feature of this bibliography is its use of the classification call numbers used in the Department of Agriculture Library.

The second bibliography is that of Mueller (*54*). Somewhat more general than the Watrous, it covers the history, cultivation, use, manufacture, and economic importance of cacao. It roughly divides the literature chronologically into 1500 to 1900 A.D. and 1900 to 1950, and presents an index by subject. Although the latter part numbers 2700 references alone, certain notable omissions of recent literature will be corrected in later editions. The student of early cacao history will find Mueller most helpful, even though many of the references are unavailable except in the rare book rooms of the world's foremost libraries.

Earlier bibliographies have been absorbed and covered in the two just mentioned. Among these are those of Alfred Rüger (1925) (*63*), the serial bibliographies of tropical agriculture prepared by the International Institute of Agriculture (1932–1935) (Rome), (*41*), and van Hall (1931) (*34*). Still smaller bibliographies covering specific subjects have proved most valuable to researchers in more limited fields. Some excellent examples are to be seen in the annotated bibliography on the phytophthora pod rot by Newhall (1949) (*56*), to which Desrosiers has added some twenty other titles 1951 (*28*). The broad bibliography of manuscripts, printed materials, and maps make Erneholm's (1948) work on cacao production in South America noteworthy (*29*). The appended bibliographies in outstanding texts by Fincke (*30*), Knapp (*45*, *46*), Jensen (*42*), Jordan (*43*), Whymper (*75*), Bourgaux (*10*), and Bywaters (*15*) are most helpful to those fortunate enough to have access to them.

The excellent reports of Schwarz (*66*), on cacao production in practically all the principal cacao-growing countries make excellent documentary material for the investigator. There are over two dozen available.

Scientific and Trade Journals

Contributions to the scientific and technical literature are to be found in most of the internationally recognized journals, such as the publications of the chemical societies of the United States, Great Britain, Germany, Austria, France, Switzerland, and the Low Countries. Notable contributions are also recorded from Sweden, Hungary, Czechoslovakia, Italy, Australia, Brazil, Argentina, and Japan. In the United States as in Great

Britain, trade journals provide many up-to-date practical papers, but not all of these journals are in form to encourage permanency of literary recording. Articles on cacao, cocoa, and chocolate have appeared in all publications of the AMERICAN CHEMICAL SOCIETY.

Trade journals such as *Food Engineering, Manufacturing Confectioner, Confectioners Journal, International Confectioner, Candy Industry, Confectionery and Ice Cream World,* and *Food Processing* supply current literature of original papers by contributors from the industry. Federal and state experiment station bulletins are relatively easy to obtain and are usually listed in *Chemical Abstracts* and the "Bibliography of Agriculture" (*70*).

European publications are *Food Manufacture* (London), *Gordian* (Hamburg), *International Chocolate Review* (Zürich), *Zucker- und Süswaren-Wirtschaft* (Hamburg), *Cacao, Chocolade en Suikerwerken* (Bussum, Holland), *Consudel* (Amsterdam), *Chocolaterie Confiserie de France* (Paris), *Confectionery Production* (Surbiton, Surrey), *Industries Agricoles et Alimentaires* (Paris), and others. Many important articles appear in one or more of the above publications, frequently in English translations. *Gordian* and *International Chocolate Review* are multilingual, using German, English, French, Spanish, Italian, and Dutch. No serious student of cacao science can afford to overlook these sources and he will find a knowledge of two or more of these languages a distinct asset.

The standard encyclopedias contain authoritative works on the subject—e.g., Encyclopedia Britannica has a concise section by Knapp (*47*), Encyclopedia of Chemical Technology one by Clarke (*20*), and "Chemistry and Technology of Foods and Food Products" one by Schoen (*65*).

Publications of the scientific societies are the repositories of many valuable contributions. The more important ones are those of the AMERICAN CHEMICAL SOCIETY (*Journal of the American Chemical Society, Analytical Chemistry, Journal of Agricultural and Food Chemistry, Industrial and Engineering Chemistry*), *Journal of the Society of Chemical Industry* (London), *Proceedings of the Institute of Food Technologists, Chimie et Industrie* (Paris), *Zeitschrift für Lebensmittel-Untersuchung und-Forschung* (Germany), *Journal of the Association of Official Agricultural Chemists* (*2*), *The Analyst* (London), *American Association of Candy Technologists* (United States), *Journal of the American Oil Chemists' Society, Cereal Chemistry* (United States), and others.

Two major index sources are *Chemical Abstracts* and "Bibliography of Agriculture," both of which list contributions on a world-wide scale. The "Bibliography of Agriculture" (*70*) lists cacao under miscellaneous economic plants and chocolate and cocoa products under beverages and condiments. Specific articles on plant diseases of cacao must be sought under diseases, viruses, or other headings. The chocolate paper may be indexed under a specific heading, such as history, market statistics, economics, or fats and oils. The reader is advised to exhaust the sections headed miscellaneous before presuming he has checked everything likely to lead him to a work on cacao.

Organizations and Institutes in Industry

Certain national, international, and state trade associations and institutes have encouraged and supported conferences and congresses in various parts of this country and the world. At these conferences important reports on scientific programs and research are given, which usually become available in records and transactions. Although most of these papers are circulated freely, some have been limited to members and associate organizations in other countries. In recent years many of these restrictions have been removed and the findings are now freely shared with mutual advantage.

Among those in this category are:

1. American Association of Candy Technologists (AACT), New York
2. American Cocoa Research Institute (ACRI), Washington
3. Association of Cocoa and Chocolate Manufacturers of the USA (ACCM), Washington
4. British Food Manufacturing Industries Research Association (BFMIRA), London
5. Cocoa, Chocolate and Confectionery Alliance (CCCA), London
6. Forschungs-Institut für Kakaowirtschaft (FIK), Hamburg
7. Imperial College of Tropical Agriculture (ICTA), Trinidad

8. Inter-American Institute of Agricultural Sciences (IAIAS), Turrialba, Costa Rica
9. National Confectioners' Association (NCA), Chicago
10. Office International du Cacao et du Chocolat (OICC), Brussels
11. Pennsylvania Manufacturing Confectioners' Association (PMCA), Philadelphia
12. West African Cacao Research Institute (WACRI), Tafo, Gold Coast

The American Association of Candy Technologists, does not publish a journal but circulates reprints of scientific articles by its members as they appear in print in the trade journals. The National Confectioners' Association has no scientific journal, but circulates to its members copies of reports on research work (*55*) done under its auspices at the Southern Regional Research Laboratory, U. S. Department of Agriculture, and at the Georgia Experimental Station.

The most outstanding contributions to American chocolate and confectionery literature have grown out of the annual conferences (*60*) sponsored by the Pennsylvania Manufacturing Confectioners' Association held at Lehigh University since 1947. These papers (*61*) have been published in single yearly volumes and later published in the trade journals. Many of them have been translated into German and French and published in European trade journals. Much of this literature is of the practical type, disclosing technical improvements and application of immediate value to industry as distinguished from the basic research. Although both are necessary, the chocolate and confectionery industries have generally been slow to apply more than rule of thumb science and engineering.

Another source of important and valuable papers has been the annual conferences held in London since 1945 by the Cocoa, Chocolate, and Confectionery Alliance, which has concentrated its endeavors on investigations of the agricultural problems of cacao, its extension to new areas of the world, the pests, diseases, and hazards to which cacao seems an easy victim, the specific problems of cacao viruses and their hosts, rehabilitation of devastated areas, improvement in cacao quality by dissemination of new methods of fermentation, drying and grading of the commercial supply of raw cacao, research on the soil, and investigation of insecticides, trace minerals, sunlight, rainfall, and fertilizers (*22*).

One of the oldest cocoa and chocolate associations is the Office International du Cacao et du Chocolat, which is the successor to the Office International des Fabricants de Chocolat et de Cacao, originally founded in Belgium, 1930. Prior to 1940 it published bulletins (*57*), but then it ceased all activities until about 1947, when it was reactivated. In place of its bulletins there now appears its monthly *Circulaire Périodique* (*58*), which is restricted to members or to chocolate and cocoa manufacturers affiliated with a member association. Its principal contents consist of association news, business statistics, and abstracts. The office has sponsored important scientific congresses which have been productive of much good, with its major efforts directed to investigating manufacturing processes, analytical methods, industrial statistics, utilization of cacao by-products, quality controls, literary indexes, and international cooperation between the countries of cacao production and those in which it is consumed (*59*).

In the Americas the Association of Cocoa and Chocolate Manufacturers sponsors the American Cocoa Research Institute and contributes sizable support to the Inter-American Cacao Research Center founded in 1947 at the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica. The special attention at Turrialba has been directed to intensive training of competent personnel to further the study of specific cacao problems, which differ in the various Pan-American countries. The information from Turrialba is covered in *Cacao* (*16*) (formerly *Cacao Information Bulletin*) which appears in two editions, English and Spanish. It reports the transactions of the inter-American conferences such as those held in Turrialba (1947–49), St. Augustine, Trinidad (1940), and Guayaquil, Equador (1952). The center maintains a highly specialized library and copying service for the benefit of the cacao world at large, and serves as a repository for available technical information.

Among the subjects covered in *Cacao* are current articles on specific fungus, virus and deficiency diseases of cacao in the Americas; insects and fungicides; attempts at immunization of cacao against these hazards; use of machines for cultivation in plantations; extension of cacao into such plantations where scientific controls may be adopted and developed still further; pruning, grafting, budding, rooting, pollenization, and breeding; study of many old and new varieties to determine disease resistance, flavor, and yields; encouragement of student projects and arrangement of seminars; cacao curing; production economics; standardizing the units of measure for cacao; special studies of the cacao problems in individual countries of the Pan-American Union, in the South Pacific, and other parts of the cacao-growing world; and exploration for new types of cacao.

Needless to say, the work of these organizations is of the utmost importance to the cacao-consuming world, for during World War II considerable advantage was gained by the enemies of cacao. National economies of many cacao-growing countries were adversely affected. Disruption of the normal life of the consuming countries by war, the sinking of millions of tons of cacao en route to the Allies, the control of prices, and the allocation of the world's diminished supplies all created artificial surpluses in distant countries of growth and serious shortages in the warring nations of consumption. These factors also affected the index of literary activity, and it is but natural that with the end of the active fighting and return to more normal national order, cacao literature should follow in the wake of a revival of scientific study.

Since 1921 the Imperial College of Tropical Agriculture has been known for its outstanding basic researches in cacao agriculture (*39*). It continues in this important role, and coordinated with the West African Cacao Research Institute (*73*) it serves the entire British cacao-growing areas and indeed the world. It has developed and put into actual practice many of the procedures for propagating large quantities of cacao plants. Investigations into the toxicity of soils, effect of shade and light, diagnoses of mineral deficiency by leaf injection, and a basic study of the nutrients required for normal and improved growth are among the researches conducted by its soil chemists and physiologists.

The publications of the British Food Manufacturing Industries Research Association (*13*) have until recently been restricted to members of the association. In keeping with the general trend to share the information for the common good of the industry, an excellent technical paper on the cacao tannins by Hallas (*35*) has been released.

Papers for the Forschungs-Institut für Kakaowirtschaft appear in *Gordian* and other German food journals.

Patent and Food Law Literature

Some of the most interesting sources of cacao literature are the patent offices of the world. It relates largely to manufacturing technology and primary and secondary products. Patents are often a rich source of information, which lead others to still more ingenious adaptation. However, it is important not to confuse pseudoscientific claims, such as are to be found in some processing patents, with genuine cacao science. The patent literature cannot always be depended on. Sometimes the specifications leading up to the claims of a patent may be indistinguishable from science fiction, which can be entertaining or instructive or provoke a "flash of genius" in the reader. However, the trained technologist can be greatly stimulated by keeping abreast of the patent science, by consulting the *Official Gazette of the U. S. Patent Office* (*71*), *Chemical Abstracts*, or *Food Engineering*.

Nor should the legal literature be ignored. The Food, Drug and Cosmetic Act of 1938 (*31*) provides findings of fact, largely based on the technology as of 1940, upon which were established the definitions and standards of identity of chocolate, sweet chocolate, and milk chocolate, three types of cocoa based on range of fat content and products with or without the addition of specified alkali ingredients. The chemist, manufacturer, consumer, and various enforcement agencies in municipal, state, and federal government divisions find it a remarkable part of the scientific, jurisprudential literature which spells out in almost unmistakable prose the precise status of cacao processing and the products of this food technology. In its fundamental concepts this Food and Drug Act and the regulations and standards promulgated thereunder are outstanding in their thoroughness and understanding of the basic principles of chocolate and cocoa manufacture. It is protective in effect, in that it establishes the conditions and technical boundaries within which those who work at these products may range.

This is not a dead literature. It is subject to revision when the boundaries are changed and as technology shows the need. Interestingly enough, the act itself outlines the legal procedures for the modifications which will keep it very much alive and up to date. Although there have been no changes in the cacao products standards since they were first announced, it is a tribute that they were drawn up so meticulously as to have stood nearly 12 years without alteration. However, today cacao technology has begun to feel the need for revisions which are in the interest of the consumer and in pace with an active postwar industry; hence the reader must anticipate changes and know where to look for them when they come.

Chemists have built up a substantial branch of analytical science which is part of the official literature of the Federal Security Agency. Research conducted by government chemists, often with assistance of collaborators in industry, provides the currently accepted official methods which enjoy legal recognition in enforcement of the Food and Drug Act. Every five years the volume of "Methods of Analysis" of the Association of Official Agricultural Chemists is revised and reissued (*1*). The progress of these changes may be followed in the quarterly issues of the *Journal of the Association of Official Agricultural Chemists* (*2*).

Statistical Information on Cacao

Cacao of commerce is shipped in hemp, jute, or sisal fiber bags. In this form it is often referred to as cocoa or cocoa beans. Statistics on production and consumption are compiled by several recognized authorities. Prior to World War II the statistical records prepared by *Gordian* were issued from Hamburg. The New York Cocoa Exchange and the Cocoa Association of London release compilations of world cocoa movements. The *International Chocolate Review* (Zürich) circulates reliable figures. At annual conferences in London the Cocoa, Chocolate, and Confectionery Alliance (*22*) prepared excellent resumés of supplies, demands, trends, prices, and distribution. These timely data serve a world which in 3 years (1948 to 1951) produced an average of about 760,000 long tons, approximately 38% of which was absorbed by the United States. The Instituto de Cacau in Bahia, Brazil, issues monthly statistics from the world's second largest producing country (*40*).

Whitmore (*74*) and Montgomery and Taylor (*52*) present a complete report of cacao production and world trade, reviewing the causes for fluctuations, discussing the cacao diseases common to various parts of the world and their effects on the statistical figures, and giving prices and sketches of developments in most of the countries of the world. A more specific study of the historical and economic growth of Central and South American production is that of Erneholm (*29*). This major work is valuable for the student of economics seeking a source book of details of climate, rainfall, geological facts, extent of diseases, and early colonial history of cacao in Latin America. The extensive bibliography of source materials, manuscripts, maps, and references is noteworthy. The U. S. Department of Foreign and Domestic Commerce and the Pan-American Union compile and release figures of occasional surveys. Both have offices in Washington.

Official data are available from some embassy and consular offices in Washington or from the local departments of agriculture in the capitals of the various countries.

General Remarks and Conclusion

From the point of view of cacao-growing and agriculture, the literature is more voluminous than for the food-manufacturing phases, which are more correctly classified as cocoa and chocolate processes. This may seem odd, as one might expect a greater technical literature from an industry which is so greatly dependent upon machines and the technicalities of food processing. The reason is not too clear, but it may be that barriers involving competitive secrecy have played a part. Relatively few people have been at work in manufacturing, as compared to a multitude of people in agricultural pursuits. Whatever the causes, it is relatively more difficult to avail oneself of the literature on chocolate and cocoa processing. However, in the past 20 years there has been a general improvement and the cocoa food technologist now finds a growing literature which will have to be classified and made more easily available.

References mentioned as showing a way to bring some order to the literature (*20, 30, 51*) are based on considering the sequence of manufacturing processes—i.e., storage and cleaning, roasting, winnowing, grinding, pressing, and pulverizing to a powder, or making into sweet goods followed by conching, tempering, solidification, storage, and shelf life. Other phases of these operations, such as alkalization, solvent extraction, detheobrominization, making of cocoa butter, refining, and utilization of by-products, constitute special side operations or elaborations of the main theme. Other phases would have to include the chemical and physical characteristics of cacao ingredients (fat as well as nonfat) or their components (tannins, glycerides, plant acids, etc.), the nutritional values of chocolate, and many other subjects of more immediate interest to the chemist than to the manufacturing operator.

Wartime needs of the military forces pointed to the desirability of having this information available and in orderly arrangement. There is always a daily need by the younger technicians, who some day must operate the industry profitably. There is no central office where all cocoa and chocolate literature could be filed and disseminated, no agency which has taken upon itself the responsibility of sponsoring its collection and reproducing it in periodic form. The Office International du Cacao et du Chocolat comes closest to performing that task for the industry and would seem a likely place to start or expand on what has been begun. The American Cocoa Research Institute is another possible starting place, and the job is big enough to have several parallel international projects under way.

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Sugar Production

PIETER HONIG

West Indies Sugar Corp., 60 East 42nd St., New York 17, N. Y.

Journals, annual reports, and yearbooks devoted to sugar production, or containing some papers of value, are listed. Publications originate from three main sources—the research centers sponsored by governments or sugar producers, the engineering firms which develop new types of equipment, and the individual chemists or technologists. Approximately 1000 to 1500 original publications appear each year. They are scattered in numerous journals published in a variety of languages. Existing abstracting services are inadequate in their coverage and no satisfactory review is available.

To be acquainted with all the new literature appearing today in the relatively small field of sugar production is a tremendous task.

Reference Libraries

No matter how amazing it may seem, it is a fact that this industry, producing more than 30,000,000 tons of sugar over the whole world, with an estimated sales value of over 4,000,000,000 dollars, organized in a relatively small number of producing units, namely 1400 modern cane sugar mills and approximately 350 beet sugar factories, has such a small number of reference libraries in the different cane sugar–producing areas that they can be counted on the fingers of one hand.

Excellent reference libraries are found in the Library of Congress, the library of the U. S. Department of Agriculture, the Sugar Research Foundation, the Louisiana State University, and the Hawaiian Sugar Experiment Station. In Europe two excellent libraries exist in the Netherlands; in Germany there is a good library in Berlin; in England there is the Tate & Lyle library. An excellent library existed in Java before the war, in the Sugar Experimental Station at Pasuruan. In Australia, the Bureau of Experimental Stations of the Department of Agriculture has a good library. In South Africa, the Mount Edgecombe Experiment Station has the same. But even among this group it cannot be stated, as a rule, that complete sets of the most well-known periodicals are available for study.

Abstracts

Publications related to sugar are scattered in a large number of periodicals; in many cases important studies are published in scientific journals devoted to organic chemistry, food engineering, agricultural engineering, or botany. Although it is the endeavor of the *Chemical Abstracts* (*1*) to give abstracts of all publications connected with sugar, it has to be stated that as far as sugar is concerned, *Chemical Abstracts* are far from complete. The number of abstracts in *Chemical Abstracts* in Section 28, Sugars, Starch and Gums, is about 400 to 500 per year. In the *Chemisches Zentralblatt* (*2*) it is about 500 to 700, but

Chemisches Zentralblatt gives 100 to 200 articles not abstracted in *Chemical Abstracts*. The most complete review of the literature can be found in the *Sugar Industry Abstracts* (*6*), published monthly in England. But even this abstracting periodical cannot be considered as giving a complete review. The reason for this imperfection is that the sugar industry, in many cases, has a tendency to present the findings of agriculturists, botanists, chemists, and technologists in local sugar magazines having a limited distribution, and their existence is only discovered by accident. Another reason is that a number of studies are published in periodicals with a distribution only for members. It is a kind of Iron Curtain policy on a limited scale, with the philosophy that the results of research studies financed by a certain interested group have to be made available exclusively to the participating members. This is especially the case with some experimental stations. It is a pity that such a policy has been adopted, because the number of research centers devoted to sugar production is extremely small.

Sources and Quality of Contributed Papers

The publications appearing today originate from three main sources—research centers, organized and sponsored by governments or by sugar producers; engineering firms, developing new types of processing or controlling equipment; and active chemists and technologists, who have the opportunity to devote a part of their time to the study of special problems.

The first-mentioned studies are usually found in governmental publications or in publications edited by a group of sugar producers. The second group is found in trade journals, or in special pamphlets published by manufacturing firms. The third group is found in journals, but most frequently in the proceedings of technologists associations.

It has to be recognized that there exists a great difference in the quality of these different types of papers. The highest standard is usually found in the studies of research centers and experimental stations. In these publications a critical survey is made of the existing literature, and due recognition is given to what has been achieved in the past. This kind of publication can, as a rule, be qualified as objective and scientific. The second group of publications is, in many cases, one-sided, because the main aim of the publications is to introduce a new type of equipment, method of processing, or system of control. It is evident that under these circumstances such publications have a certain one-sidedness, and that true objectivity is not the main feature. The third group has definite merit, namely, the attempt to enrich our knowledge when the observed facts are presented in a proper way, but they often lack critical judgement and, what is far more serious, due recognition is very seldom given to what has been done by others in the same field, because the authors are not familiar with the existing literature.

It has been estimated that approximately 1000 to 1500 original publications appear each year. Less than 50% of these papers present new and original data, or methods of analyses. Most publications are a mere repetition of methods and observations published elsewhere, or a summary of a number of other articles.

Approximately 50% of these publications are published in English, 15% in German, 10% in French, 15% in Spanish, and the rest in Russian, Polish, Czechish, Dutch, Chinese, Japanese, and Portuguese.

A selected list of journals, annual reports, and yearbooks is presented in Table I. Addresses are given for some publications; addresses of others are obtainable by consulting the "List of Periodicals Abstracted by Chemical Abstracts" (*3*).

Dividing the different groups, it can be stated that approximately 50% of all publications deal with sugar technology (with extraction, purification, evaporation, crystallization, and centrifuging), 20% deal with analytical methods, control systems, and control equipment, 15% are related to the physical and organical chemistry of sugars, 10% deal with the chemistry, the use, and transformations of by-products, and 5% deal with equipment. The interest shown in these different fields is partly the result of the training of the chemists and technologists in service of the sugar industry.

The developments in cultivation of sugar beet, and sugar cane are usually found in the same periodicals as chemical and technological studies, when they are results of special research studies at experiment stations. Journals on agricultural engineering or agricultural chemistry, on soils, and physiology also publish some papers. The number of studies published today, relating to the growth of sugar beet and sugar cane, which are of an agricultural, engineering, botanical, or physiological character, is estimated to be between 200 and 400 annually. This does not include special studies on phytopathology or entomology, or studies on the control of weeds and general agricultural practices. These are specialized fields, and they have found their proper place for presentation, discussion, and criticism of new facts in their own journals.

Table I. Publications Containing Literature on Sugar Production[a]

North America

UNITED STATES

Advances in Carbohydrate Chemistry, annual, 1946.
American Sugar Refinery Co.'s Library Bulletin, Philadelphia, monthly, 1948.
Analytical Chemistry, monthly, 1929. Contains a few publications on sugar analysis.
Bulletin of the Sugar Research Foundation, 52 Wall Street, New York 5, N. Y., monthly, 1943.
Gilmore, A. B., ed., 805 Queen & Crescent Bldg., New Orleans, La., "Louisiana Sugar Manual," annual.
La Hacienda, Hacienda, Inc., 20 Vesey Street, New York 7, N. Y., monthly, 1905. Contains a great variety of subjects related to agriculture and agricultural industries.
Industrial and Engineering Chemistry, monthly, 1909. Contains a few publications on sugar analysis.
Journal of the Association of Official Agricultural Chemists, quarterly, 1915. Contains a few publications on sugar analysis.
Journal of Research of the National Bureau of Standards. monthly, 1928. Contains studies of the carbohydrate division of the bureau.
Louisiana State University and Agricultural and Mechanical College, Engineering Experiment Station Bulletin, irregular, 1886.
Mayo, E. W., Jr., ed., "Sugar Reference Book and Directory," New York, Mona Palmer Publications, annual. Gives a general survey of the world sugar industry with a review of technical progress.
Mayo, E. W., Jr., and Peña, J. M., ed., "Sugar Directory," New York, Mona Palmer Publications, annual. Gives a complete list of sugar companies, mills, and staff personnel of all sugar producing areas.
Mundo Azucarero (Spanish edition of *Sugar*), monthly, 1912.
National Bureau of Standards Technical News Bulletin, monthly, 1928. Contains references to the *Journal of Research of the National Bureau of Standards*.
Proceedings of the American Society of Sugar Beet Technologists, biannual, 1944.
Sugar, monthly, 1913.
Sugar Abstracts, monthly, 1931. Gives references and abstracts compiled by O. W. Willcox, published in *Sugar*.
Sugar Beet, Amalgamated Sugar Co., Ogden, Utah, quarterly.
Sugar Bulletin, semimonthly, 1923.
Sugar Industry Technicians Reports, 150 Nassau Street, New York 38, N. Y., annual,
Sugar Journal, monthly, 1938.
Sugar Molecule, quarterly, 1947.
Sugar Research Foundation, New York, Scientific Reports Series, irregular, 1945. Gives excellent monographs related to sugar production and by-products.
Sugar Research Foundation, New York, Member Reports, irregular, 1948.
Sugar Research Foundation, New York, Technological Reports, irregular, 1947.
Through the Leaves, Great Western Sugar Co., Denver, Col., semiannual.
Tropical Plant Research Foundation, Scientific Contributions, Tropical Plant Research Foundation, 1086 North Broadway Street, Yonkers, N. Y., irregular, 1925.
U. S. Department of Agriculture, Technical Bulletins, irregular, 1926.
Weekly Statistical Trade Journal, Willett and Gray, 72 Wall Street, New York, N. Y., weekly, 1877
West Indies Sugar Corporations Reports, 60 East 42nd Street, New York 17, N. Y., irregular, 1952.

HAWAII

Gilmore, A. B., ed., 805 Queen & Crescent Bldg., New Orleans, La., "Hawaiian Sugar Manual," annual.
Hawaii Agricultural Experiment Station of the University of Hawaii, Reports, irregular, 1881.

The Hawaiian Planters' Record, quarterly, 1909.
Hawaiian Sugar Planters' Association Experiment Station, Agricultural and Chemical Series, Bulletins, irregular, 1905–1945. Now included in the *Hawaiian Planters' Record.*
Proceedings of the Hawaiian Sugar Planters' Association, annual, 1881.
Reports of the Association of Hawaiian Sugar Technologists, annual, 1942.

VIRGIN ISLANDS

Report of the Virgin Islands, Agricultural Experiment Station, U. S. Government Printing Office St. Croix, Virgin Islands, annual, 1919.

PUERTO RICO

Annual Report of the Agricultural Experiment Station, University of Puerto Rico, Bureau of Supplies, Printing & Transportation, Rio Piedras, P. R., annual, 1912.
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One of the most important things that could be done in regard to the presentation of original studies on sugar chemistry and technology is to have a universal periodical, such as *Rubber Chemistry and Technology*, that would, as far as possible, publish all the original studies. This could be combined with an annual review for the different fields.

Annual Reviews

There was a time when annual reviews were published on the progress of sugar production. One of the best known publications was "Stammers Jahresbericht für die Zuckerindustrie" (*5*). This has been discontinued. The *Reports on the Progress of Applied Chemistry* (*4*), published by the British Society of Chemical Industry, is one of the best publications for a historical and systematic survey. An annual technical review is also published in the "Sugar Reference Book" (*7*), giving a summary of some of the important developments, but this review is far from complete, and it must often be judged as lacking in a critical attitude of the reviewer.

The sugar industry is such an important one, that it is worth while to consider the publication of an annual progress report with different chapters for the fields to be distinguished, such as analytical chemistry, technology of cane sugar manufacture with the different subdivisions, technology of the beet sugar manufacture, technology of sugar refining, properties and use of by-products, biochemistry and nutrition, equipment of the sugar industry, and physiology of sugar and sugar products. Such a publication could present, in a critical way, all the recently published data, facts, observations, ideas, patents, applications, and new developments. In this way it would be possible for all those who have found a career in the sugar industry to be informed as fully as humanly possible on all the developments going on in the field of sugar production. This is practically impossible with our present system of too many journals, too many languages, and not enough coordination between the large number of authors and research men working in this industry.

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The Literature of the Essential Oils

W. PHILIP LEIDY

Fritzsche Brothers, Inc., New York, N. Y.

The literature of the essential oils has a long history, during which it has developed along two distinct lines: preparation and application of the oils, and identification, structure, and synthesis of their components. Even in a geographical sense the literature is extensive, although most of the analytical work has been done in Europe. Nomenclature presents a major problem to the research worker, partly because botanical exactitude with regard to essential oil plants is a very recent development. The multitude of trivial chemical names also confuses the searcher. Comprehensive texts are included in an annotated bibliography, which also lists books and periodicals that give important information on essential oils.

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The chemistry of the essential oils is not only one of the most difficult provinces of organic chemistry, it is also one of the least popular.

This neglect is disappointing to those who work in the field, and who know the genuine importance of the essential oils. By comparison with petroleum or steel or textiles, the oils are a modest commodity; by comparison with cortisone, or with certain molds, they are a bit lacking in drama. But they are available in such limited quantities, yet so widely employed, that they plainly have a utility quite out of proportion to the volume of their production. Our annual trade in them (exclusive of turpentine) does not exceed $100,000,000; but the oils themselves, or chemicals made from them, are valuable ingredients in products worth conservatively 200 times that sum. This is a sober trade estimate.

The oils have an astonishing number of uses. They serve as flavoring in foods, as perfumes, as odor masks. They improve or disguise the taste of unpleasant drugs. They act as medicines, as starting materials for the synthesis of valuable chemicals. They perfume our soaps, make our dentifrices palatable, render our plastics inoffensive. One of them supplies the basic compound from which vitamin A is commercially synthesized.

Most of these applications are modern. In an earlier day the essential oils had other, perhaps more romantic, uses. They were credited with miraculous medicinal properties, but their supposed curative powers have been usurped by the antibiotics. Certain of them were thought to possess marvelous rejuvenative abilities; and here the steroids have taken over. Others were said to keep the devil away; nothing has replaced these.

History of Literature of Essential Oils

The oils have been produced for a long time, by a number of methods, and in practically every country in the world. As a consequence, a very extensive—and a very diffuse—literature has grown up around them.

In general, the techniques of searching this literature will not differ from those familiar to most scientific workers. The researcher in the field of the essential oils will use many of the same reference tools the researcher in every other field uses—*Chemical Abstracts*, for example, or Beilstein. Obviously, however, some of his problems, and some of his sources, will be different.

The literature of the essential oils has a long history, in the course of which it has tended to develop along two fairly distinct lines, one dealing with the preparation and applications of the oils, the other with the identification, structure, and synthesis of their components. Both areas of research have their own lengthy histories, although the oils were produced long before they were investigated chemically. The study of the earliest methods of preparation, and of the first uses of the essential oils, is properly the field of the historian of the subject; an excellent account is given in the historical introduction to the work of Gildemeister and Hoffmann (*16*).

Reports of the chemical investigation of the oils date from the seventeenth century, a period coinciding with a considerable advance in methods of distillation. At that time, the oils were thought to consist of two elements—one a resinous, water-insoluble substance, unitary and common to all oils, the other a "spirit" peculiar to individual oils and responsible for their distinctive odors and tastes. So long as this theory held, which is to say to the end of the eighteenth century, research was limited to the observation of physical properties and of the most elementary chemical reactions—that of strong acids on the oils, for example. Here again, the literature describing all this activity may safely be left to the historian.

A more modern period begins with the early 1800's; but it is usual to place the significant beginnings even later, in the pioneer work of Otto Wallach on the terpenes (*34*), in the 1880's. With the work of Wallach, as one historian has pointed out, research on the essential oils matured from an empirical to a scientific study. By contrast with many of the workers who had preceded him, Wallach was methodical and systematic; he devoted himself to the complete investigation of a single class of compounds, not "here and there an oil or a terpene." If this interpretation is accepted, we may assume that practically all of the important published material on the essential oils has appeared within the last 70 years, in an age, in other words, of fairly adequate indexing and abstracting, and of excellent editorship. This means that all of it is moderately easy to get at, and that there is not much danger of missing anything of value. Since searching the scientific literature is frequently a tedious business even at best, we may be grateful that this is the case.

A further word ought to be said about the history of the subject. Since the time of Wallach the whole field of synthetics has expanded, increasing the bulk of the literature on the essential oils. In its earliest phase investigation of the oils was confined to a study of their properties, or to the isolation of components—for example, of the multitudinous "camphors" that so incensed Berzelius in the 1820's. At a later stage the systematic study of classes of compounds was undertaken. To this we owe the literature of the terpenes, the aldehydes, the ketones, and so on. At about the same time, the first attempts at synthesis were made. The work of Perkin, Tilden, and others belongs to the 1870's; but the main development is, of course, much later. In this connection Finnemore (*15*) has pointed out that the history of such products as the essential oils follows three stages: The first is that in which the natural product holds the market, the second that in which the natural product and the synthetic strive for supremacy, and the final stage is that in which the synthetic prevails.

World-Wide Essential Oil Studies

In the course of the last century and a half probably at least 6000, and possibly more than 10,000 essential oils have been analyzed or reported in one way or another. Of the single plant family *Pinaceae*, for example, more than 200 oils have been examined; of the single genus *Eucalyptus*, an equal number; of the single species *Citrus*, at least 21—14 of these from the single subspecies *amara*.

Even in a geographical sense the production and study (and therefore the literature) of the essential oils are most extensive. The major part of the analytical work on the subject has been done in the laboratories of Europe; but the rest of the world has not been idle. From Australia reports have been coming out regularly for well over 50 years, chiefly about oils of the *Eucalyptus* species so preponderant there. In this area the work of Baker and Smith (*27*), and of Penfold and Morrison, has been outstanding. In the Dutch East Indies—the home, probably, of a wider variety of essential oils than any similarly limited region on earth—the research done at the famous laboratory in Buitenzorg was important for many years. In Japan, India, and Zanzibar (among others) private and government agencies have done excellent work, analyzing oils, maintaining standards, and guarding against adulteration. The expansion of the industry into the western hemisphere within recent years has introduced new types of oils to the world market, and has broadened research. All of these movements are reflected in the literature of the subject.

Because the study of the subject has been world-wide, its literature has become remarkably polyglot. It is therefore not true in this field, as it is in others, that the important works are in a limited number of western languages. The essential oils have been described in a dismaying variety of tongues. Until very recently, the most reliable reports on camphor were in Japanese. The most detailed treatment of rose geranium oil is in Russian. Much of the best work on the East Indian oils is in Dutch. Fortunately the greater part of this work has been abstracted into German, English, or French; but language remains a serious barrier, particularly because abstracts are so frequently late in appearance. There are indications that the Russians are at present engaged in an intensive cultivation of essential oil plants, trying to develop varieties with higher yields of oil. They also appear to be doing extensive analytical work. But only a fraction of their literature is available, and even where it is, translation is a problem. The situation is even worse with regard to the Japanese material. In September 1951 Fujita, one of the outstanding Japanese workers in this field, published a book of over 600 pages (*26*), "Fundamental Studies of Essential Oils." To anyone familiar with Fujita's work the book is of great interest; it apparently represents considerable original research, and deals with a number of oils not previously reported. It is crammed with suggestive tables and provocative diagrams; but only the title has been translated.

In a strict sense, of course, the only real "literature of the essential oils" is that which deals directly with the oils themselves, or with the properties of their components—certainly a considerable body of material, and one that answers most questions that ordinarily arise. But for the solution of some problems at least, it will be necessary to step beyond these limits into other literatures dealing with other sciences. The chemist who is attempting to identify a particular oil or to set up standards for its purity may find himself faced with a thorny issue of botany, on which he must take some stand whether he wants to or not. If he decides to work on the biogenesis of the oils he will find himself in plant physiology or in biochemistry. Above all, if he is concerned with the structure of the component of an oil, or with its synthesis, he will find it necessary to search in the broadest reaches of organic and analytical chemistry.

All this is merely to say, as a final bit of characterization, that like practically every other branch of science, the study of the essential oils cannot successfully be isolated from a wider body of knowledge, and that its literature has the customary shifting boundaries.

Problems of Nomenclature

It would be well, now, to discuss one or two of the major problems that face the research worker when he first confronts the literature of the essential oils. Apart from the language difficulty, the chief problem is undoubtedly that of nomenclature, a problem faced, of course, by every researcher in every field. But in the case of the essential oils, the difficulty seems somehow aggravated. A long history, a world-wide traffic, and the customary conservatism have all contributed to the invention and retention of an inappropriate and ambiguous terminology, both botanical and chemical. This condition is of direct concern to every one who works in the field. It influences the acceptability of a good deal of the literature on the subject.

The worker in the essential oils soon learns that commercial geranium oils are extracted from several species, varieties, and strains of *Pelargonium* and not from *Geranium* at all; that bay oil has nothing to do with sweet bay or with bay laurel, being distilled from the leaves of the bay rum tree, or *Pimenta racemosa*, which is not to be confused with *Pimenta officinalis*, from the leaves of which pimenta leaf oil is obtained; that cedar *leaf* oil comes from a species of *Thuja*, while cedarwood oil comes from two species of *Juniperus;* that oil of Niobe is in fact only methyl benzoate. He remembers that East Indian oil of sandalwood is distilled from the wood of *Santalum album*, while West Australian oil of sandalwood comes from *Eucarya spicata*, and African oil of sandalwood is derived (perhaps) from a species of *Osyris*. He never forgets that anise oil is distilled from *Pimpinella anisum*, family *Umbelliferae*, while star anise oil comes from *Illicium verum*, family *Magnoliaceae;* nor that the name opopanax oil, which formerly designated the oleo-gum-resin of *Opopanax chironium*, family *Umbelliferae*, today designates the gum of *Commiphera erythraea* var. *glabrescens*, family *Burseraceae*.

The ambiguity is by no means limited to popular names such as geranium or sandalwood. A constant shuffling of botanical genera and species goes on, with consequent headaches for the chemist. Bois de rose is a case in point. The Cayenne type of oil has successively been labeled *Ocotea caudata*, *Protium altissimum*, and *Aniba rosaeodora*, where it now rests. The Brazilian type has gone through the stages of *Aniba parviflora*, *Aydendron parviflorum*, *Ocotea parviflora*, and *Aniba rosaeodora* var. *amazonica*, where it now stands. The Eucalypts are in even worse shape; they have suffered particularly rough handling from overzealous botanists.

These names are not cited merely to be impressive. The exact botanical identification of an essential oil plant is of obvious and primary importance to the chemist who investigates that oil; and botanical exactitude with regard to essential oil plants is an appallingly recent development.

In many cases the confusion is explainable. Local merchants, planters, and distillers must be forgiven if they classed together everything that smelled of geranium, or of sandalwood, or of cedar; or if when opopanax became unavailable, they resorted to its nearest equivalent. There is less excuse for the scientific investigators who worked at the components of oils described as bois de rose, careless of their origin, so that much of their work must be discarded; or analyzed with commendable thoroughness an oil which they neglected to identify as Petitgrain Paraguay or Petitgrain Bigarade.

Unfortunately, these are not isolated or theoretical cases. They recur, and they raise issues which must be considered carefully. Obviously, research done upon an unidentified or wrongly identified oil is valueless. Unhappily this has not always been recognized, and some of the finest compilers in the past have burdened their books with questionable material.

Nor is the confusion limited to botanical terms. The multitude of "trivial" chemical names in this field is again testimony to the conservatism of scientists. The classic example of how meaningless a term can become is perhaps that of the "camphors," of which there must once have been at least 15—"bergamot camphor," "thyme camphor," "cardamom camphor," and so on. Berzelius protested against this indiscriminate use in the 1820's; Otto Wallach, 70 years later, persuaded his coworkers to drop the term. (It persists, however, in the trade.) The continued use of such words as "limonene" and "citral," when more descriptive and comprehensible terms are at hand, is justified only because tradition is behind it.

Here again the considerations are not theoretical; they are entirely practical. One of the results of the capricious use of terms in the past has been that single substances are designated by several unrelated names, and that the same name is used for several unrelated substances. Where this has been the case, it may be necessary to unravel some tangled threads. Moreover, it is necessary to watch current literature very closely. Only very recently, for example, was it shown that α-caryophyllene and humulene are identical, although this had been suspected for some time.

Variations in Production and Reporting

The problem of nomenclature is not limited to the field of the essential oils; it is a general malady. However, there are certain problems peculiar to the subject. In working with the essential oils, it is well to bear in mind that their quality and composition will depend on a number of variables. The mere fact of cultivation, for example, will make a difference: The cultivated clove contains 82 to 95 % of eugenol; the wild type contains none. The wild ylang ylang is practically odorless, while the cultivated type yields two heavily fragrant oils. The manner of production of an oil also affects the quality. Subtle components destroyed by steam distillation will be preserved by volatile extraction, or by *enfleurage;* and oils distilled for 2 hours will differ materially from those distilled for 4 hours. Certain types of oils cannot be distilled at all. Moreover, an identical species of plant, growing in different localities or under different conditions of cultivation, may yield different oils. Florida oil of orange differs from California oil of orange. Also, there are four types of *Ocimum* oils, varying at least to some degree according to geographical origin. Or trees belonging to the same species may yield oils of different composition, even though they grow in the same locality. The members of certain species of *Eucalyptus*, morphologically indistinguishable, have been observed to yield widely different types of oil.

Many plants yield more than one type of oil. The bitter orange, for example, yields a flower oil (Neroli), a leaf oil (Petitgrain Bigarade), and a peel oil (bitter orange oil). Each of these has its own properties, components, and uses.

All of these factors are of importance in studying and evaluating the literature of the essential oils. And unfortunately research workers have been careless. They have neglected to say how an oil was produced, or where it came from, or what part of the plant was used in making it—all of which determine the reliability of the literature on the subject.

What has been said emphasizes the desirability of going back to the original literature. Intermediate sources, such as abstract journals, do make errors, occasionally serious ones. It is not to the discredit of *Chemical Abstracts* that it is not perfect (what work of such scope could be?), but so long as it is not infallible, it ought to be used largely as an index. Compilers have more than once carried on the mistakes of their predecessors, and an initial typographical error may distort the literature for 50 years.

In connection with any judgment upon the work of previous workers in this field, it is well to remember that the personal factor is particularly important where essential oils are concerned. Slight variations in conditions of production, or of laboratory analysis, may result in divergences in physical properties—for example, in odor—which may lead to unfair conclusions.

One final thing remains to be said in this connection. In making any search of essential oil literature, it is important to bear in mind that one of the striking features about the history of research in this field is the intermittent nature of the study made of individual oils. Most of the work on American peppermint oil was carried out more than 50 years ago; and though this was by no means definitive, the only recent work of significance has been that on the menthofurans in the oil, a work of the late 1940's. Similarly, the major research on cinnamon bark and linaloe oils was done many years ago. It is not always easy, in this connection, to discover what has determined the intensity of research upon any single oil; there appears to be no one-to-one relationship between the importance of an oil and the total amount of work done upon it. Oil of orris root and camphor oil have been most extensively examined, while several equally important oils have never been thoroughly investigated at all, and others only very recently. English and Italian peppermint oil have not as yet been systematically studied; and lime oil was first carefully investigated as late as 1943, pepper oil in 1951.

For all these reasons, where any search is made, it ought to be an extensive one. Incidentally, a good many oils have probably not been mentioned in the literature since they were initially reported, perhaps as much as 70 or 80 years ago. It is probable that some of these may ultimately prove of value, in which case the literature dealing with them will have to be unearthed.

Searching the Literature

The literature of the essential oils is extensive and diffuse, but it is not difficult to search. The greater part of it has been adequately indexed in such abstract journals as

Chemische Zentralblatt and *Chemical Abstracts*. In addition to these general sources there is the excellent *Bericht* of Schimmel & Co., of Miltitz-bei-Leipzig, which has covered the field since 1877. Since 1939 the *Bericht* has been published irregularly, but it continues to be the best single abstract source in the field. An American publication, similar but with lesser coverage, is the "*Annual Report on Essential Oils, Aromatic Chemicals, and Related Materials,*" issued by Schimmel & Co. of New York (*44*).

There are also a number of periodicals devoted to the field of the essential oils; the bibliography at the end of this article lists these. This list is limited to those dealing exclusively with the subject; there are a great number of other journals carrying literature of interest to the worker in the subject—among them the *Journal of the American Chemical Society, Journal of the American Pharmaceutical Association, Journal of the Chemical Society* (of London), *Helvetica Chimica Acta*, the *Bulletin* of the Société Chimique de France, and *Recueil des travaux chimiques des Pays-bas*. No current index of these sources exists, and the researcher must rely on general abstract journals, which are, of course, usually several months behind in coverage.

For anyone unacquainted with the field of the essential oils the obvious start is with the general texts, notably that of Guenther, published between 1948 and 1952 (*17*). This is not only the most recent work on the subject, but the most comprehensive, with the further advantage of having been written by a scientist with extraordinary knowledge of market conditions, field procedures, and laboratory findings. The first volume of Guenther's series covers the origins of the oils in the plant, methods of production, and analytical procedures. The second volume is devoted to the constituents of essential oils, and constitutes the most complete text on the chemistry of this subject. The remaining four volumes of the series deal with individual oils, arranged by botanical family. Among other things, these monographs contain the most recent treatment of the cultivation of a great many commercially important oil-bearing plants. Perhaps the chief value of this work lies in its careful editing; every attempt has been made to check original sources, and to expunge data of doubtful usefulness. The result is a work of unusual accuracy and of immense bibliographic value.

Of the other general texts on the subject, that of Gildemeister and Hoffmann (*16*), the third edition of which appeared in 1928–31, is to be recommended. Though much of it has been superseded by Guenther's work, Gildemeister and Hoffmann's series is still of interest for analytical procedures, production techniques, and particularly for data on lesser-known oils. The historical introduction to the first volume is the only complete history of the essential oils, and of their chemistry.

For oils produced by means other than distillation, an excellent book is that of Naves and Mazuyer (*21*), published in 1939 in France, and available in an English translation in 1947. This deals with oils and concretes obtained by volatile extraction or by *enfleurage*.

In addition to these texts, a number of older sources are still of value—particularly the "Essential oils" of Finnemore (*15*) and Parry's "Chemistry of the Essential Oils and Artificial Perfumes" (*22*). And among much older works, the treatises of Charabot (*11*, *12*), Semmler (*25*), Wagner (*33*), and Wallach (*34*) are to be recommended, not alone for historical interest, but for their excellent bibliographies, which frequently note sources difficult to find elsewhere.

For the cultivation of essential oil plants, and for the distillation and extraction of the oils, such general texts as those of Guenther and Gildemeister and Hoffmann are to be recommended, as being more complete and more recent than the other titles noted in the bibliography. Much of von Rechenberg's "Theorie der Gewinnung and Trennung der ätherischen Ole (*10*) has been brought up to date in Guenther's second volume.

For the chemistry of the oils, once again the most recent general texts are to be preferred; but here there must be constant reference to current sources. For any single class of compounds found in the essential oils, the outstanding work is that of Simonsen (*32*), on the terpenes, sesquiterpenes, and diterpenes. Unfortunately, no other group of compounds has recently been treated in a single text; the older works of Wallach, on the terpenes, and of Wagner, on the aldehydes, must be supplemented by more recent material. A number of works on isolates and synthetics are noted in the bibliography.

In this country and abroad, private and government agencies are doing excellent work in this field. Primarily, however, these are regulative, and not publishing, agencies. They are intended to work toward standardization, or the maintenance of quality, or to guard against adulteration; they seldom publish data. In the United States the chief such agency is the Essential Oil Association, which issues specifications covering essential oils, isolates, and synthetics.

The bibliography contains no treatment of the literature covering the uses of essential oils, for the obvious reason that any such treatment would be impractical.

Bibliography

An exhaustive bibliography of the essential oils would be impractical. The titles noted below are intended as a general guide only. They are listed by broad subject, at times somewhat arbitrarily. The publisher is included where the title is known to be in print. For most immediate practical problems the general texts on the subject should be consulted first, notably the recent work of Guenther (*17*).

Books

Botany. Any serious question of botanical nomenclature or identification should be referred to a botanist. The staff of the New York Botanical Gardens, Bronx Park, New York, N. Y., are constantly helpful and welcome inquiries. For most routine questions of classification and synonymy, the following three books are to be recommended:

(1) Engler, A., "Syllabus der Pflanzenfamilien," 11th ed., revised by A. Diels, 519 pages, Berlin, 1936.
(2) "Index Kewensis," 12 vols., Oxford, 1895–1947. An enumeration of the genera and species of flowering plants from the time of Linnaeus to the year 1940, inclusive, together with their authors' names, the works in which they were first published, their native countries, and their synonyms. The original two volumes were published in 1895; 10 supplements carry the data through 1940.
(3) Rehder, A., "Manual of Cultivated Trees and Shrubs Hardy in North America, Exclusive of the Subtropical and Warmer Temperate Regions,'" 996 pages, New York, Macmillan Co., 1949.

Cultivation. The books noted here cover the subject generally. In addition to these titles, the works of Gildemeister and Hoffmann (*16*) and of Guenther (*17*) are to be recommended; the latter contains the fullest and most recent treatment of the cultivation of most of the commercially important oils.

(4) Craveri, C., "Coltivazione industriale delle piante aromatiche da essenze e medicinali," 307 pages, Milan, 1914.
(5) Parry, J. W., "Spice Handbook. Spices, Aromatic Seeds and Herbs," 254 pages, New York, Chemical Publishing Co., 1945.
(6) Ridley, H. N., "Spices," 448 pages, London, 1912.
(7) Rolet, A., "Plantes à parfums et les plantes aromatiques," 2nd ed., 406 pages, Paris, 1930.

In addition to these general works, there are a great number of monographs on the cultivation of individual oil-bearing plants. These are easily traced through the usual abstract journals. However, one title dealing with the broad group of the *Citrus* should be mentioned:

(8) Webber, H. J., and Batchelor, L. D., "The Citrus Industry," 2 vols., Berkeley and Los Angeles, University of California Press, 1943–48.

Methods of Production. In addition to the three titles noted below, the reader is again referred to the definitive works of Gildemeister and Hoffmann (*16*), Naves and Mazuyer (*21*), and Guenther (*17*).

(9) Gattefossé, G. M., "Distillation des plantes aromatiques et de parfums," 153 pages, Paris, 1926.
(10) Rechenberg, C. von, "Theorie der Gewinnung und Trennung der ätherischen Öle durch Destillation," 751 pages, Miltitz-bei-Leipzig, 1910, "Einfache und fraktionierte Destillation," 814 pages, Miltitz-bei-Leipzig, 1923.

General Texts. A number of titles of historical interest are included here (although "historical" with reference to the essential oils is a relative term); many of these titles are still valuable for the lesser oils, and for data not obtainable elsewhere.

(11) Charabot, E., "Les principes odorants des végétaux (méthodes de dosage, d'extraction, d'identification)," 388 pages, Paris, 1912.

(12) Charabot, E., Dupont, J., and Pillet, L., "Les huiles essentielles et leur principaux constituants," 1002 pages, Paris, 1899.
(13) Craveri, C., "Le essenze naturali (olii essenziali); estrazione; carratteri; anilisi," 2nd ed., 759 pages, Milan, 1927.
(14) Durvelle, J.-P., "Fabrication des essences et des parfums. Chimie des parfums," 3rd ed., 808 pages, Paris, 1930.
(15) Finnemore, Horace, "The Essential Oils," 880 pages, London, 1926.
(16) Gildemeister, E., and Hoffmann, F., "Die ätherischen Öle," 3rd ed., 3 vols., Miltitz-bei-Leipzig, 1928–31.
(17) Guenther, E., "The Essential Oils," 6 vols., New York, D. Van Nostrand Co., 1948–52.
(18) Jaminet, L. von, "Ätherische Öle, Riechstoffe und Riechdrogen," 180 pages, Hamburg, Cram, de Gruyter, 1949.
(19) Maier, J., "Die ätherischen Öle, ihre Gewinnung, chemischen und physikalischen Eigenschaften, Zusammensetzung und Anwendung," 201 pages, Stuttgart, 1862.
(20) Müller, A., "Internationaler Riechstoff-Index," 377 pages, Heidelberg, Hüthig, 1950.
(21) Naves, Y.-R., and Mazuyer, G., "Les parfums naturels; essences; concrètes, resinoïdes, huiles et pommades," 398 pages, Paris, Gauthier-Villars, 1939. An English translation by E. Sagarin is available from Reinhold Publishing Corp., New York, 1947.
(22) Parry, E. J., "The Chemistry of Essential Oils and Artificial Perfumes," 2 vols., New York, 1921–22.
(23) Parry, E. J., "Parry's Cyclopedia of Perfumery, A Handbook," 2 vols., London, 1925.
(24) Poucher, W. A., "Perfumes, Cosmetics and Soaps," 3 vols., New York, D. Van Nostrand Co., 1942. Vol. 1 is 5th ed., Vols. 2 and 3 are 6th ed.
(25) Semmler, F. W., "Die ätherischen Öle nach ihren chemischen Bestandteilen unter Berücksichtigung der geschichtlichen Entwicklung," 4 vols., Leipzig, 1906–7.

In addition to the titles just noted, a recent Japanese book should be mentioned:

(26) Fujita, Yasuji, "Fundamental Studies of Essential Oils," 627 pages, Osaka and Tokyo, Ogawa & Co., 1951. In Japanese.

And one work entirely devoted to a single genus:

(27) Baker, R. T., and Smith, H. G., "A Research on the Eucalypts, Especially in Regard to Their Essential Oils," 471 pages, Sydney, 1920.

Isolates and Synthetics. The major work on the chemistry of the essential oils is that of Guenther (*17*). In addition, the books of Gildemeister and Hoffman (*16*), Naves and Mazuyer, (*21*), and Parry (*22*) are still useful.

(28) Bedoukian, P. Z., "Perfumery Synthetics and Isolates," 488 pages, New York, D. Van Nostrand Co., 1951.
(29) "Givaudan Index, Specifications of Synthetics and Isolates for Perfumery," 378 pages, New York, Givaudan-Delawanna, Inc., 1949.
(30) Moncrieff, R. W., "Chemistry of Perfumery Materials," 344 pages, London, United Trade Press, 1949.
(31) Sabetay, H., and Sabetay, S., "Travaux récents d'analyse et de synthèse organiques et la chimie des parfums de 1935 à 1938," 821 pages, Paris, Gauthier-Villars, 1941.
(32) Simonsen, J. L., and Owen, L. N., "The Terpenes," 3 vols., Cambridge, University Press, 1947–52.
(33) Wagner, A., "Die Aldehyde," 1431 pages, Vienna, Hartleben, 1929–31.
(34) Wallach, O., "Terpene and Campher," 580 pages, Leipzig, 1914.
(35) West, T. F., Strausz, H. J., and Barton, D. H. R., "Synthetic Perfumes, Their Chemistry and Preparation," 380 pages, London, Edward Arnold & Co., 1949.

Methods of Analysis. Here again the best source for analytical procedures is the work of Guenther (*17*), particularly the first and second volumes. The books of Gildemeister and Hoffmann (*16*) and Finnemore (*15*) are still valuable. The various pharmacopeias noted below include methods of qualitative analysis, tests for identification and purity, and standards.

(36) Association of Official Agricultural Chemists, "Methods of Analysis," 7th ed., 910 pages, Washington, Association of Official Agricultural Chemists, 1950.
(37) British Pharmacopoeia, 1948, 914 pages, London, Constable & Co., 1948.
(38) British Pharmaceutical Codex, 1949, 1562 pages, London, Pharmaceutical Press, 1949.
(39) Codex Medicamentarius Gallicus, Codex Français, 1949, 1227 pages, Paris, Commission Permanente du Codex, 1949.
(40) Deutsches Arzneibuch, 6th ed., 854 pages, Berlin, 1926.
(41) National Formulary, 9th ed., 877 pages, Washington, American Pharmaceutical Association. 1950.
(42) Pharmacopeia of the United States of America (United States Pharmacopeia), 14th revision, 1067 pages, Easton, Pa., Mack Printing Co., 1950.

Specifications

The only specifications issued in the field are published by the Essential Oil Association of U. S. A., in New York. These now number 61, covering oils, isolates, and aromatic chemicals.

Abstract Journals

In addition to the regular general abstract publications, such as *Chemical Abstracts*, *Chemisches Zentralblatt*, and *Biological Abstracts*, two publications are devoted exclusively to the field of the essential oils.

(43) *Bericht von Variochem VVB Schimmel, Miltitz-bei-Leipzig, über ätherische Öle, Riechstoffe, usw.* Leipzig, 1877–. This is the recent title of the famous *Schimmel Bericht*, which was issued variously as an annual or biannual report from 1877 to 1944/47; the new title dates from 1948.

(44) "Annual Report on Essential Oils, Aromatic Chemicals, and Related Materials," New York, Schimmel & Co., 1945—.

Periodicals

Dead titles are not included here, nor are general titles which cover the essential oils as part of a broader treatment.

(45) *Ätherische Öle, Riechstoffe, Parfümerien, Essenzen und Aromen*, Hannover. Monthly.
(46) *American Perfumer*, New York. Monthly.
(47) *Bollettino ufficiale della stazione sperimentale per l'industria delle essenze e dei derivati dagli agrumi in Reggio Calabria*, Italy. Quarterly.
(48) *Drug and Cosmetic Industry*, New York. Monthly.
(49) *Givaudanian*, New York, monthly. House organ of Givaudan-Delawanna, Inc., New York.
(50) *Industrie de la Parfumerie*, Paris. Monthly.
(51) *International Perfumer*, London. Quarterly.
(52) *Parfümerie und Kosmetik*, Heidelberg. Monthly.
(53) *Parfumerie moderne*, Paris. Monthly.
(54) *Parfums de France*, Paris. Monthly.
(55) *Perfumery and Essential Oil Record*, London. Monthly.
(56) *Rivista italiana delle essenze, profumi, piante officinali, olii vegetali, saponi*, Milan. Monthly.
(57) *Seife, Öle, Fette, Wächse*, Augsburg. Monthly.
(58) *Soap, Perfumery and Cosmetics*, London. Monthly.

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Chemicals Derived from Petroleum—Introduction and Scope

CHARLOTTE SCHALER

Sinclair Refining Co., 600 Fifth Ave., New York 20, N. Y.

Those active in the field of chemicals derived from petroleum are not in complete agreement on just what these chemicals comprise. While the raw materials are petroleum and natural gas, when it comes to products the scope of the field is hard to bound, as such variable factors as end use, method of preparation, and economics enter the problem. The industry, moreover, is in a state of development, and new markets, the discovery of new processes, and the improvement of old ones alter the picture constantly, and no doubt will continue to do so in the future. A bibliography illustrates various views expressed in the literature with regard to scope. The term "petrochemical" has both adherents and opponents; the origin of the term in its present usage is traced, and a portion of the bibliographical material deals with opinions for and against its use.

It is not an easy matter to set the boundaries within which petroleum chemicals fall, as attested by the efforts of several nomenclature committees (*2–5*).

The obvious statement that petroleum chemicals are those chemicals obtained from petroleum and natural gas is vague, and different interpretations are placed upon it by different individuals, as is shown by an examination of the literature.

Definitions

W. F. Bland (*12*) conducted a survey, and finding different opinions among nearly a hundred individuals questioned, suggested that a petroleum chemical is "a chemical compound or element recovered from petroleum or natural gas or derived in whole or in part from petroleum or natural gas hydrocarbons and intended for chemical markets." However he added pessimistically, "We fully expect that ninety-nine percent of our readers won't agree with us—at least in some minor respect." The following issues of *Petroleum Processing* carried letters, some agreeing, others suggesting alterations (*1, 7, 33, 36, 37, 43, 49, 51, 60, 69, 73, 88, 89, 94, 96, 97*).

The concept of what a petroleum chemical is suffers from efforts at oversimplification.

R. G. Newhall considers that the above definition excludes by-products, marketed not strictly as chemicals but as chemical mixtures, e.g., naphthenic and cresylic acid mixtures (*60*).

There are those who look upon carbon black as a petroleum chemical, while others do not (*6, 13, 38, 45, 47–50, 52, 87, 95*).

George Weber (*95*) believes the basic differentiation is one of end use; that is if the products are used for chemical purposes, they are petroleum chemicals, otherwise not. To this author motor fuel components are not petroleum chemicals, even if synthetically made. C. W. Kelly (*47*), while he agrees that petroleum chemicals are those products obtained directly or indirectly from crude oil or natural gas and used in a chemical capacity, apparently looks upon alkylate, for use in aviation gasoline, as a petroleum chemical.

If one includes end use to establish the scope of the petroleum chemicals field, shifting boundaries are inevitable, due to changing uses, as well as different interpretations on whether a use is chemical or not.

Whether ammonia, sulfur, sulfuric acid, hydrogen, and helium, are to be included seems to vary from individual to individual (*13, 14, 38, 44, 48, 76, 95*).

There is also a group of opinions that make method of production the criterion. L. M. Roberts (*83*) defines petroleum chemicals as "direct derivatives, by chemical reactions, of products of oil refining or natural gas." In 1944 G. E. P. Smith and H. F. Palmer said petroleum chemicals were organic chemicals from petroleum and at times even referred to them as organic chemicals from both coal and petroleum (*86*). In 1940 L. Rosenstein thought that the chemicals must be synthetic to be included (*85*). Such ideas exclude chemicals obtained by extraction, distillation, or regular refining methods. In earlier years petroleum chemicals were often referred to as aliphatic chemicals. As late as 1951, F. Roffey (*84*) stated that the petroleum chemicals industry has its main influence in large scale production of aliphatic rather than aromatic products.

The idea that a petroleum chemical must be both synthetic and organic was expressed in the two definitions given in 1951 by the Office of Price Stabilization.

> Petroleum chemicals are synthetic organic chemicals containing one or more carbon atoms using fractions of crude petroleum, including hydrocarbon components or natural gas for raw materials.
>
> Petroleum chemicals are synthetic organic chemicals including hydrocarbons and derivatives containing oxygen, nitrogen, sulfur, the halogens, synthesized from fractions of crude petroleum or natural gas hydrocarbon components (*70*).

Most chemists object to these definitions as too restrictive, as they exclude extracts, distillates, by-products, elements, and inorganic chemicals without reason.

Besides chemical concepts, economic considerations enter the picture. B. T. Brooks considered that a petroleum chemical must now be manufactured from petroleum on a commercial scale or must give promise of being made from it within the severe limitations imposed by the fundamental necessity of profit (*16, 17*). This concept is shared by others (*27, 39, 48, 97*).

If variable factors such as end use, method of preparation and economics enter the definition, time and development must of necessity constantly alter the scope of the field.

Eugene Ayres (*8*) humorously points out the difficulty of definition, saying that most industries are chemical if a basic viewpoint is taken, and actually the miscellaneous "cats and dogs" left over, that are not specifically classified, are called the "chemical industry." As all compositions of matter are chemical, where can one draw the line? For example, the steel industry is actually a chemical industry, so is for that matter the petroleum industry itself. So where have we arrived?

A recent court decision in Britain that petroleum and natural gas are two separate materials shows the need for mentioning both in a definition of petroleum chemical, if for no other reason than to avoid misunderstanding outside the petroleum industry (*68*).

As R. F. Goldstein (*38*) points out, theoretically every synthetic organic chemical listed in Beilstein can be made in some way from methane. This, he says, confronts the technologist with the highly unproductive definition that every organic chemical can be considered a petroleum chemical. From that point of view medicinals might be classified as petroleum chemicals. To escape from this unworkable position, he assumes the following interesting and practical one. Petroleum chemicals, he says, may be those already present in crude petroleum or natural gas, those resulting from refining processes, and those synthesized from petroleum or natural gas sources. However, these must be considered on the basis of three points—what is possible, what is economical, and what has actually been done.

How far is one to go with regard to inclusion? Some include plastics, synthetic rubber, and textiles, if made from petroleum sources. A recent letter from R. F. Goldstein

(*39*) says, "I have always been afraid that the isolation of aromatics from petroleum might lead to the subject of dyestuffs manufacture being included as a special subsection of the petroleum chemicals industry." He cautions against going too far in the direction of secondary and tertiary derivatives of petroleum chemicals for inclusion in the conception of the petroleum chemicals field.

For clarity a definition of petroleum chemicals must indicate source, nature of material made, preparation, economic factors, and whether secondary and tertiary derivatives are included. Omission of any one of these points leads to vagueness or an excessively restrictive or an excessively broad meaning.

The following definition is suggested: Petroleum chemicals comprise chemicals, marketable chemical mixtures, and elements intended for chemical use, which occur naturally in petroleum or natural gas, or result from refining these, or are obtained from them by synthesis or reaction, and which are separable by known methods, and are now obtained or give promise of being obtained commercially within limits imposed by the necessity of profit; petroleum chemicals are the resulting chemicals themselves, and not their further secondary or tertiary derivatives. (While this definition is long, no briefer one seems adequate.)

Designations

Just as agreement is lacking on what petroleum chemicals are, so varying views exist on what they should be called. Some favor petroleum chemicals, others petrochemicals, petroleochemicals, petrolochemicals, and chemicals derived from petroleum.

Certain chemists and especially geologists object to "petrochemical" (*26, 36, 37, 43, 73, 74, 82*) on the ground that petro comes from the Greek, meaning rock, so that petrochemical would mean rock chemical. Petrochemical is a contraction of petroleum and chemical. Replacement suggestions have overlooked the sole reason for its use, namely that it is shorter and simpler than petroleum chemical. To replace the phrase "petroleum chemical" by a word not shorter would offer no advantage; it would be simpler just to continue to use petroleum chemical than to replace it by a single word of equal length. The now widespread use of petrochemical would also offer an obstacle to replacing it by another word or words.

Both chemical and petroleum journals use petrochemical, and American (*44*) and British firms have sometimes adopted it in company names. There are, for instance, the British firms, Petrochemicals, Ltd. and Petrocarbon Ltd., besides a number of American firms. "Boost for Petro-benzene" appears in the June 1952 issue of *Chemical Engineering* (*25*), despite the editorial department's telephonic statement that it did not approve of the term petrochemical but was resigned to its use. Both in America and other countries there is an increased use in the literature of the prefix, petro, to mean petroleum. (*20, 21, 61, 72, 75, 93*).

A preliminary search of the literature disclosed the possibility that *Oil and Gas Journal* might have coined petrochemical. Consequently I wrote to W. L. Nelson of that journal. His reply (*58*) concurred with this opinion; he believed the *Oil and Gas Journal* editorial offices had probably started the use of the prefix, petro, for petroleum by starting a section in that journal, called "Refining and Petro-Chemistry" in the June 25, 1942 issue (*64*).

However, a study of that issue showed three advertisements, using the term, petrochemical, itself (*10, 30, 81*), and a further search disclosed that two months earlier E. B. Badger and Sons, licensing agents for the Houdry Catalytic Cracking Process, used "petrochemical industry" in an advertisement in the *Oil and Gas Journal* itself (*9*). Also at the end of June, 1942, when *Oil and Gas Journal* created its section using the term, petrochemistry, *Chemical and Metallurgical Engineering* must already have had set up in type its July 1942 issue, also with an advertisement of E. B. Badger and Sons, using "Petrochemical" (*11*). *Petroleum Refiner* began using "petro-chemical" as part of its cover and masthead in August, 1942. Evidently chemical engineers originated the word, probably those connected with E. B. Badger and Sons, or engineers connected with the development of the Houdry Catalytic Cracking Process.

The attached bibliography indicates opinions and pitfalls in defining petroleum chemicals. Incorporated into the bibliography also are references dealing with the origin of the term, petrochemical, and opinions for and against its use. Such references are preceded by an asterisk.

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History of the Petroleum Chemicals Industry

RICHARD F. GOLDSTEIN

The British Oxygen Co., Ltd., Research & Development Department, Morden Rd., London, S.W.19, England

The petroleum chemicals industry was started and developed in America at the end of the first world war. In the first stage, an industrial aliphatic chemicals industry was developed utilizing olefins obtained from hydrocarbon cracking. The products were either new industrial chemicals, such as ethylene glycol, or were established products where petroleum had become the most economical starting material. The outbreak of the second world war led to the second stage of major expansions. Other types of hydrocarbons became as important as the olefins. Methane from natural gas has largely displaced coal processes for ammonia and methanol. The simple aromatics formerly isolated as coal processing by-products are now manufactured from petroleum. In addition, completely new industries have been created for the production of synthetic rubbers, fibers, detergents, etc., largely based on petroleum raw materials. Many by-products of petroleum refining can also be regarded as petroleum chemicals. Since the second world war other countries have developed petroleum chemicals from the available raw materials but have advanced only to the first stage of the American pattern.

Petroleum chemicals are defined as products intended for chemical markets, manufactured from petroleum or natural gas, or isolated as by-products in the working up of petroleum.

Petroleum chemicals fulfill two functions. They provide alternative and more economic routes to existing chemicals already made from other raw materials, and they lead to new industrial chemicals. The reactions of and outlets for chemicals more economically synthesized from petroleum have already been worked out, although perhaps not completely, in connection with the older routes. Those countries not favored with petroleum as an economic raw material have had to make use of alternative sources for these chemicals. In surveying the literature, it is, therefore, necessary to take account of the history of those petroleum chemicals which have been made from alternative sources. The reactions of methane are the same whether it is obtained from natural gas or as a by-product of the hydrogenation of coal or as a fraction in the liquefaction of coke oven gas; depending on the source, the economics may be quite different.

In view of the vast field now comprised within the term petroleum chemicals, it is necessary to restrict this historical survey to the highlights and to leave aside many interesting and potentially important lines of work.

Petroleum Chemicals in America, 1920 to 1940

The petroleum chemicals industry in the U.S.A. was created from research work carried out during the first world war. In the 1920's and 1930's it was mainly concerned with the methods of making and of using the simple olefins—ethylene, propylene, and the butylenes. The first olefin, ethylene, was made by direct cracking of liquid petroleum fractions or of propane. Propylene and the butylenes were obtained either simultaneously with ethylene in these direct cracking processes or as by-products of refinery operations, particularly as these became more and more chemical processes with the adoption of thermal reforming and later of catalytic cracking.

For separation of the olefins, reliance was placed largely on efficient fractional distillation under pressure, using techniques now familiar to the petroleum industry; the unusual feature was the low temperature required for concentration of ethylene. The main olefin reactions developed were hydration with sulfuric acid to give the alcohol, which was then dehydrogenated to the corresponding aldehyde or ketone, and conversion to the olefin oxide by reaction with hypochlorous acid. The ready commercial availability of the olefin oxides led to a continuous stream of new products, such as glycols, glycol ethers, and alkanolamines.

This indicates the two-fold function of petroleum chemicals; the hydration of olefins led to alcohols and to the family of derivatives of alcohols already made from other sources and, on the other hand, the olefin oxides and their derivatives were new industrial chemicals not previously made.

Ethylene was and, in fact, still is the most important olefin. Although it is believed that 2-propanol was actually the first petroleum chemical, as it was made on a limited scale in the early days of production, the outstanding feature of this period was the launching of the derivatives of ethylene oxide into the industry and their establishment on a firm and proved basis. These chemicals found new uses mainly in the automobile industry. Ethylene glycol was the basis of the first permanent antifreeze, while the glycol ethers were used in the new surface coatings being developed for automobiles. Simultaneously, ethanol was being made from ethylene by hydration with sulfuric acid, using a process the chemistry of which had been worked out many years before but which had never been economically successful.

The bulk utilization of ethylene was soon followed by that of propylene and then by the butylenes, which were converted to ketones via the alcohols made by the same hydration step as for ethyl alcohol. The ketones and their derivatives also found outlets in the automobile and solvents industries.

These developments progressed steadily up to the outbreak of the second world war. This can be shown in Table I, from U.S. Tariff Commission reports on synthetic organic chemicals, which shows how the number of ethylene and propylene chemicals marketed by only one firm, Carbide and Carbon Chemicals Co., increased between 1926 and 1939. The figures are approximate.

Table I. Number of Individual Aliphatic Compounds from Olefins Made by Carbide & Carbon Chemicals Co.

Year	Number of Compounds Derived from Ethylene	Number of Compounds Derived from Propylene	Total
1926	5	2	7
1929	15	4	19
1934	35	15	50
1939	41	27	68

Derivatives of the butylenes had been introduced from about 1930, though not by the company named.

At the same time, other work was in hand which was the basis of many of the later developments dealt with in the following section.

Petroleum Chemicals in America, 1940 to 1952

Whilst the first world war was responsible for the creation of the petroleum chemicals industry, the second world war led to its widespread expansion. Firstly, more types of hydrocarbons were used as the raw materials of the industry. Secondly, the end uses were enlarged from the limited outlets of the first period.

The techniques of preparation and of separation of hydrocarbons were improved. New construction materials led to cracking being conducted under more severe conditions, to increase the amount of olefins produced. This also permitted a change from propane to ethane as the raw material for ethylene synthesis. Aromatics became available from petroleum naphthenes. Diolefins and acetylene were also manufactured from petroleum sources.

Methods of separation of hydrocarbons became more diversified. Fractional distillation was improved by the use of azeotropic and extractive distillation. Continuous adsorption on solids such as active charcoal or silica gel was established. Liquid-liquid solvent extraction, already used in petroleum refining, was adapted to the concentration and purification of some of the raw materials for petroleum chemicals; finally, the formation of physical complexes, the so-called clathrate compounds, which permit separation of hydrocarbons of different shapes, is being developed as a new separation method, now known as extractive crystallization.

Olefins were the main building blocks of the industry during the first period. The second period brought into the picture the paraffins, the diolefins, acetylene, and the aromatic hydrocarbons. The magnitude of utilization of the olefins increased pari passu with that of the other hydrocarbons, but they were no longer the only type.

Although the initial work had in some cases been carried out earlier, important new olefin reactions established since 1940 were:

Direct oxidation of olefins to olefin oxides, partly replacing the hypochlorous acid route (discovered in Europe in 1929).

Direct hydration of olefins to alcohols without the use of sulfuric acid (known for many years but never successful until the discovery of new catalysts in Europe at the end of the second world war).

Reaction of olefins with carbon monoxide and hydrogen, leading directly to primary alcohols with one more carbon than the initial olefin (discovered in Germany in 1938).

High temperature substitutive chlorination of olefins, leading to synthetic glycerol and to new intermediates for the plastics industry (discovered in America, 1935 to 1939).

Methane from natural gas was used as a source of petroleum chemicals for making synthesis gas (carbon monoxide and hydrogen) and hydrogen, by reaction with water (methane-steam process) or with oxygen (methane-oxygen process). Methane from natural gas thus became the raw material for synthetic methanol and for synthetic ammonia. The synthetic ammonia synthesis had been worked out in Germany just before the first world war and synthetic methanol followed in the 1920's, both from coal. Similarly the methane-steam and methane-oxygen processes were European developments using by-product methane from coke oven gas separation or from coal hydrogenation.

In America methane has now largely displaced coal as the raw material for synthetic methanol and ammonia. It is being used as the starting material for the synthesis of liquid fuels, using an improved method of conducting the Fischer-Tropsch process, which will give a considerable tonnage of petroleum chemicals as coproducts. Toward the end of this second period, methane is being established for the manufacture of petroleum acetylene, again using a European process of the 1930's, which used methane from coal.

Propane and butane are directly oxidized with air to a range of oxygenated compounds, principally formaldehyde, methanol, and acetaldehyde. This is a development of work initiated in the 1930's, although an oxidation process of this type was first tried out in America in 1926.

At the same time as the lower paraffins were being pressed into service, the second world war led to the manufacture of aromatics from petroleum. New methods of isolating, isomerizing, and dehydrogenating petroleum naphthenes were devised on the basis of petroleum techniques. During the war, manufacture of toluene and xylene was established; since then, benzene has been added, because the growing demands of the chemical industry could not be met from the conventional source, coke-oven tar.

Simultaneously with this diversification of types of hydrocarbons, new industries were being created which turned to petroleum for many of their raw materials. These included synthetic rubbers, synthetic fibers, plastics, and detergents.

Synthetic rubber led to the development of specific petroleum routes to butadiene, from *n*-butane and 1- and 2-butenes, and to styrene, from benzene and ethylene. The techniques used were refinements of those already established by the petroleum industry for the manufacture of high octane gasoline.

The growth of synthetic fibers has led to the devising of syntheses from petroleum of the chemical intermediates required for this new industry. Leaving aside acetic anhydride from ethylene via synthetic ethanol and from propylene via acetone, already established and used for cellulose acetate in the 1930's, nylon has called for the isolation of petroleum cyclohexane and for the discovery of a route from butadiene to nylon salt; Dacron for the isolation of *p*-xylene from petroleum xylene, and the nitrile fibers for the synthesis of acrylonitrile from ethylene or acetylene.

Plastics require such a wide variety of raw materials that it is difficult to select the major petroleum chemical developments. Styrene, vinyl chloride, and polyethylene from ethylene, formaldehyde from petroleum methanol, and urea from petroleum ammonia are the chief contributions of petroleum chemicals.

Detergents, which now rival soap in demand, are based largely on petroleum; the variety of structures which confer detergent properties have led to some interesting syntheses. Alkyl aryl sulfonates are made by alkylation of benzene either with chlorinated kerosene or with a highly-branched olefin made from propylene. Long chain olefins for secondary sulfates were made from paraffin wax. Secondary alkyl sulfonates were made by direct sulfonation of paraffins with sulfur dioxide and chlorine, a reaction discovered in America in the 1930's.

Other Countries

Aside from one or two relatively minor operations, there was no petroleum chemicals industry outside America until after the second world war. The potential importance of the new chemical industries based on petroleum then led to the creation of petroleum chemical industries in several European countries and in Canada. In the few years available, it is not surprising that most of these countries are still in the first stage of American development; that is to say, their industries are directed primarily to making and using the lower olefins.

There are two factors which distinguish operations in some of these countries from American practice. In the absence of natural gas, petroleum chemicals have to be made from imported liquid hydrocarbon fractions. Compared with America, many of the Europeans countries are relatively well placed on aromatic compounds as by-products from coal processes and the relative price structure may not make manufacture of aromatics from imported oil attractive.

The United Kingdom has, at present, the largest petroleum chemicals industry outside America. It is based wholly on imported liquid fractions and directed very largely to manufacture and use of olefins. The position in France is similar, but in Italy, with new natural gas discoveries and no coal, manufacture of chemicals from methane is of equal importance. Canada can hardly be termed the most recent entrant to this field, as she participated in the manufacture of synthetic rubber from petroleum during and since the second world war. The postwar developments so far have, however, been on the European pattern.

By-Products

The main by-products from petroleum refining are oxygen compounds, nitrogen compounds, and sulphur compounds.

The principal oxygen compounds are phenols and naphthenic acids. These are present only in particular crude oils in significant amounts. By-product petroleum phenols have been industrial products in America since the 1930's, but the literature on their composition is limited. Naphthenic acids were found in considerable quantities in the early days of the oil industry in crude oils from Roumania and from Russia. These have, therefore, been worked upon in Europe before the first world war; this work is associated with the name of von Braun.

Nitrogen compounds are present only in certain crude petroleums and have not attracted much attention. Most work on their composition has been done in America by Bailey.

The main interest in sulfur compounds is their removal in order to upgrade the quality of petroleum fractions. Much literature is therefore to be found in petroleum refining on the removal of hydrogen sulfide, mercaptans, and sulfides since the 1920's. Comparatively little information is available on the composition of mercaptans present in petroleum products; if wanted for industrial purposes, they are usually synthesized. In recent years the recovery of sulfur from the hydrogen sulfide present in natural and refinery gases has reached the status of a major industry. The processes used, however, employ methods worked out in the nineteenth century in the coal gas industry for the removal and use of hydrogen sulfide. In the petroleum industry, this process was first used in Iran before the second world war; it is now being widely adopted in America, partly because of the sulfur shortage and partly to avoid effluent nuisance. Industrial sulfur compounds also occur at the other end of the refining industry, in working up of white oils and related products. Manufacture involves drastic treatment with sulfuric acid, giving rise to sulfonic acids, which are useful on account of their surface active properties. They have been known for many years, but their constitution is still uncertain.

Alternative Routes to Petroleum Chemicals

The importance of alternative routes to petroleum chemicals was discussed at the beginning of this paper. The position on the more important chemicals is summarized in Table II. This is intended as a guide on where to look in the literature on petroleum chemicals made from raw materials other than petroleum.

Table II. Alternative Routes to Principal Petroleum Chemicals

Chemical	Petroleum source	Alternative Sources, Europe (Except Where Stated)
Methane	Natural gas	Coal, as by-product of separation of coke oven gases (1920–30) or of coal hydrogenation (1930–40)
Ammonia	Methane	From coal via producer gas (1910–20)
Methanol	Methane	From coal via producer gas (1920–40); from methane (from coal) by methane-steam and methane-oxygen processes (1930–40).
Ethylene	Ad hoc cracking of gaseous or liquid hydrocarbons	Dehydration of ethanol (original route). By-product in fractional distillation of coke oven gas (1925–35). Hydrogenation of acetylene (1940–45).
Acetylene	Methane	Calcium carbide (original route). Methane from coal by partial combustion and by arc process (1935–45)
Ethylene glycol	Ethylene	From ethylene made as above (1925). In America from coal via carbon monoxide and formaldehyde (1935–40).
Ethanol	Ethylene	Fermentation of molasses (original route).
Acetaldehyde	Synthetic ethanol. Coproduct of paraffin gas oxidation	Fermentation ethanol or acetylene from carbide (1900–10).
Acetone	Propylene	Wood distillation (original process). Pyrolysis of acetic acid (1920–30) or ethanol (1930) or by acetylene-steam reaction (1930–40).
Glycerol	Propylene	By-product of soap manufacture (original process).
Butadiene	1- and 2-Butenes, Synthetic ethanol	Ethanol (1915); acetaldehyde via 1,3-butanediol (1920–30); acetylene and formaldehyde from coal via 1,4-butanediol (1940–45); from 2,3-butanediol by fermentation (1940–45).
Aromatic hydrocarbons	Aromatic rich fractions, naphthene rich fractions	By-products of coal tar distillation.

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Raw Materials for Chemicals from Petroleum

MARSHALL SITTIG, *Ethyl Corp., New York, N. Y.*

B. H. WEIL, *Research and Engineering Department, Ethyl Corp., Detroit, Mich.*

Petroleum and natural gas are today being used in increasing quantities for the production of billions of pounds of chemicals—over 40% of the organic chemicals produced in the United States, and large quantities of such inorganic chemicals as sulfur and ammonia—although less than 1% of the petroleum and natural gas produced is so consumed. This paper deals with the literature on these substances, on the composition of commercially available fractions, the composition of refinery by-products, physical processes for separating specific materials, and the economics of specific raw materials, not from the standpoint of literature sources alone, as such, but rather by way of an extensive bibliography attached to a topical discussion.

Petroleum, vital to world economy as a source of fuels and lubricants, is a complex mixture of hydrocarbons and minor impurities. In the early days of the petroleum industry, petroleum products were separated by simple distillation and were simply mixtures of the original constituents, differing in composition from one fraction to another in accordance with the boiling points of the individual compounds. Later, with the advent of cracking, reforming, solvent extraction, and other methods of conversion and separation, the number of differently constituted fractions produced from petroleum by refiners began to swell logarithmically.

Today, normal refining processes for fuels and lubricants yield hundreds of different streams—fractions of narrow or wide boiling ranges and widely varying chemical compositions. Even such impurities as hydrogen sulfide are available in quantity in a concentrated manner. When to these normal methods are added processes designed to produce or separate even more specific compounds or cuts for chemical use, it can be seen that the refiner of petroleum is in every sense the producer of a wide variety of chemical raw materials. In other words, the raw materials for chemicals from petroleum are, quite evidently, petroleum and the products that are produced in its refining to yield fuels and lubricants.

Much the same is true for natural gas. As it comes from the ground, this material also is a mixture of compounds (albeit less complex than petroleum). It, too, is chiefly used as a fuel, and its normal processing—removal of LPG (liquefied petroleum gas) and natural gasoline—is part of that picture. In turn, LPG and natural gasoline are primarily used as fuels, although they are finding rapidly increasing use as chemical raw materials. In other words, "dry" natural gas, LPG, and natural gasoline are themselves basic raw materials for the production of chemicals.

Any paper on the literature of raw materials for production of chemicals from petroleum and natural gas must therefore be concerned with the composition of these substances and their basic refined derivatives, with processes for the separation of pure chemical raw materials from these products, and with the basic economics involved.

In this paper, the literature of the raw materials for chemicals from petroleum has been covered, not from the standpoint of literature sources as such, but by way of an extensive bibliography attached to a topical discussion of the raw materials aspect of the petroleum chemicals field.

The initial manufacture of chemicals from petroleum raw materials was the manufacture of alcohols from olefinic refinery gases by the Standard Oil Co. (N.J.) in 1919 (*60*). Other pioneering efforts in the field involved synthesis of chemicals from hydrocarbon gases by Carbide and Carbon and the manufacture of oxygenated chemicals from natural gas by Cities Service Oil Co., dating from 1926 (*61*).

According to Egloff (*25*), only 150,000 pounds of chemicals, principally isopropyl alcohol, were made from petroleum hydrocarbons in the year 1925. Today, over 3,000,000,000 pounds of natural gas and petroleum compounds are being used yearly for the manufacture of chemicals. Egloff goes on to state that 40% of the organic chemicals manufactured in the United States are made from petroleum raw materials. Amazingly enough, this volume of chemical production accounts for less than one-half of 1% of total crude oil and natural gas production, so large are our fuel and lubricant requirements. Egloff (*25*) foresees no great increase in this percentage—forecasting that 1% of our petroleum and natural gas can supply the petrochemical industry of the year 2000.

Origin and Composition of Raw Materials

Natural Gas. Natural gas is the simplest source of hydrocarbon raw materials for chemicals since it consists of a small number of compounds which are easily separated. Nonhydrocarbon constituents include water vapor (up to 2.5% by volume, the saturation value), carbon dioxide (up to 95% from some wells in Mexico, New Mexico, and Colorado), inert gases (nitrogen and helium), and sulfur compounds (largely hydrogen sulfide). The hydrocarbon constituents of natural gas contain up to 8 carbon atoms. "Wet" natural gas contains larger proportions of the heavier hydrocarbons in this range.

According to Egloff (*24*), the United States produced and consumed about 7,800,000,000,000 cubic feet of natural gas in 1950, of which less than 10% was used for the manufacture of carbon black and chemicals.

The compositions of some typical natural gas samples (*71*) are presented in Table I.

Table I. Composition of Natural and Oil-Field Gases

Field	Sp. Gr. (Air = 1.00)	Percentage Composition of Constituents							
		N_2	CO_2	H_2S	CH_4	C_2H_6	C_3H_8	C_4H_{10}	$C_5H_{12}^+$
Av. Pa. dry	0.65	2	..	..	85	8	4	1	..
Av. Pa. wet	0.90	1	..	..	60	16	12	8	3
Av. Okla. dry	0.65	..	..	..	85	9	4	2	..
Av. Okla. wet	1.00	1	3	..	45	25	17	5	4
Av. Kansas dry	0.60	5	..	..	94	1	..	..	..
Kansas, N_2-rich	0.95	88[a]	..	..	10	2	..	..	..
Av. Texas dry	0.60	2	..	3	89	3	2	1	
Texas, N_2-rich	0.83	38[b]	..	..	51	..	..	11	..
Av. W. Va. dry	0.70	..	..	..	52	10	5	2	1
Av. W. Va. wet	0.95	..	..	..	59	18	13	6	4
Av. La. dry	0.60	..	..	..	92.5	4	2	1	0.5
Av. Calif. dry	0.65	2	10	..	87	1	..	..	..
Av. Calif. wet	0.85	2	5	..	68	9	8	5	3
Portero, Mexico	1.16	..	14.0	4.5	36	20	12	7	6.5
Poza Rica, Mexico	0.93	0.1	16.3	..	64.5	5.4	7.8	3.6	2.3
Baku, Russia	0.57–0.70	..	2.3–13.0	0.01–0.1	82–97	0–3	0–1	0–1.4	0.1–2.2
Grozny, Russia	1.24	..	..	..	47.6	10.4	17.3	17.3	7.5
Maikop, Russia	1.05	6.9	..	..	53.6	14.2	11.7	8.2	5.4
Masjid-i-Suleiman, Iran	1.06	..	..	10.4	45.3	13.5	15.3	10.8	4.7

[a] Including 1% helium.
[b] Including 2% helium.

Natural Gasoline. Natural gasoline is produced from wet natural gas or from casing-head gas by compression or by absorption under pressure. Adsorption on carbon is another method of producing natural gasoline, but is little used in this country. Natural gasolines commonly are composed of C_4 to C_8 hydrocarbons.

The compositions of raw and stabilized natural gasolines are given in Table II (*17*).

A complete distillation analysis of unstabilized California natural gasoline has been published by Boultbee (*6*).

Table II. Compositions of Natural Gasolines

	Raw	Stabilized	Debutanized
API gravity, 60° F.	92.5	77.8	74.5
Specific gravity, 60°/60° F.	0.6309	0.6761	0.6869
Vapor pressure (Reid), lb./sq. in., 100° F.	60.0	17.5	11.0
Percentage composition, vol. %			
Ethane	1.5	..	..
Propane	14.7	..	..
Isobutane	10.2	1.5	..
n-Butane	30.3	15.3	3.2
Isopentane	4.8	7.2	8.5
n-Pentane	15.0	21.0	24.5
Heavier	23.5	55.0	63.8

The results of a precise fractionation of two West Texas natural gasolines have been presented by Ratzlow and Ruoho (*69*).

Liquefied Petroleum Gas (LPG). Liquefied petroleum gas is produced from the overhead of natural gasoline stabilizing units and consists primarily of propane and butane (*50*). Carney and Meyer have summarized the potentialities of LPG as a chemical raw material (*13*).

Crude Oil. Crude petroleum consists essentially of mixtures of paraffinic, naphthenic, and aromatic hydrocarbons containing from 1 to over 70 carbon atoms per molecule and may contain dissolved gases or solids. The naphthenic hydrocarbons are based on cyclopentane or cyclohexane or on fused C_5 and C_6 rings. There is no evidence of the existence of C_3, C_4, C_7, or C_{7+} cycloparaffins in crude oil. Olefins, diolefins, and acetylenes are absent. The aromatics are mainly benzene derivatives; naphthalene, tetralin, and their substituted derivatives have been isolated in a few cases.

Extensive treatments of the composition of crude petroleum appear in "Chemical Constituents of Petroleum" (*71*) and in "Science of Petroleum" (*73*).

A summary of the components of crude oil and their approximate compositions, based on the data of Goldstein (*36*) and Boyd (*7*), is presented in Table III.

Table III. Composition of Fractions of Crude Petroleum

Fraction	Boiling Range, ° F.	Number of Carbon Atoms (*36*)	Number of Carbon Atoms (*7*)
Naphtha	80–450	...	3–13
Gasoline	100–400	4–12	...
Kerosene	330–530	9–16	12–16
Gas oil	450–625	15–25	15–20
Lube oil	...	20–70	19–37
Residue	(Does not distill)	...	70 or more

Naphtha. The compositions of the naturally occurring naphthas from seven different crudes have been determined by Forziati, Wellingham, Mair, and Rossini (*30*). All were found to contain normal paraffins, isoparaffins, alkylcyclopentanes, alkylcyclohexanes, and aromatics in varying proportions.

The composition of naphtha from fluid catalytic cracking has been reported by Melpolder, Brown, Young, and Headington (*55*).

Gasoline. A complete analysis of a Houdry-cracked gasoline in terms of individual hydrocarbon components has been published by Glasgow, Willingham, and Rossini (*35*).

The composition of gasoline from coal hydrogenation has been presented by Feldman and Orchin (*28*).

Kerosene. As shown in Table III, kerosene hydrocarbons range from C_9 to C_{16} as opposed to gasolines which range from C_4 to C_{12}, gas oils which range from C_{15} to C_{25}, and lubricating oils which range from C_{20} to C_{70}. Goldstein (*36*) points out that the increasing number of isomers present in fractions boiling above 200° F. makes full chemical analysis impossible.

Kerosene is used as a raw material for the manufacture of keryl benzene sulfonates (*38*). A close-cut, highly acid treated, or solvent refined material boiling in the range of 425 to 475° F. is used for this purpose.

Petroleum Wax. Petroleum wax consists of solid hydrocarbons, mostly paraffinic, which occur in crude oils, distillates, and residues and have a waxy structure and melting points above 30 to 35° C. (86 to 95° F.), according to Sachanen (*71*):

Goldstein (*36*) divides petroleum wax into three primary constituents:

Paraffin wax—a mixture of solid normal paraffins with 18 to 35 carbon atoms and with a setting point up to 70° C.; the usual paraffin wax melts at 50 to 60° C. and is a mixture of C_{22} to C_{30} normal paraffins.

Petroleum ceresins (microcrystalline waxes)—hard, brittle waxes melting above 70° C., sometimes as high as 95° C. They contain from 25 to 55 carbon atoms. They are much more soluble and give higher viscosity solutions than paraffin waxes of the same molecular weights. They are believed to be branched-chain paraffins with short side chains near the center of the fundamental long chain. They form very small crystals.

Petrolatum wax—this wax may melt within the range of 35 to 80° C., is soft and plastic, and is probably more highly branched than the ceresins.

Petroleum ceresins and petrolatum wax are isolated from residues. Paraffin wax, on the other hand, is almost invariably isolated from distillates by solvent extraction or precipitation followed by sweating or emulsion de-oiling. According to Sachanen (*71*), the wax content of lubricating oil fractions is commonly 10% ± 5%.

Paraffin wax consists mainly of normal paraffin from $C_{23}H_{48}$ to $C_{29}H_{60}$. Commercial products contain small amounts of naphthenes and branched paraffins.

Microcrystalline waxes are predominantly of naphthene-containing paraffin structure according to McKittrick, Henriques, and Wolff (*52*), and Minchin (*58*).

A review on petroleum waxes has been published by Hughes and Hardman (*45*).

Refinery Vent Gases. Refinery vent gases arise from a variety of sources. The approximate yields from these various sources are shown in Table IV (*71*).

Table IV. Production of Refinery Vent Gases

Process	Gas Produced (Cu. Ft. per Bbl. Charge)
Cracking (mixed-phase) (receiver)	350
Coking	200
Stabilization (cracked gasoline)	600
Straight-run distillation (60–70% overhead)	10

Cracked gases are the major item in volume as well as in importance as chemical raw materials; therefore, they will be discussed separately in the next section.

The composition of coking gases is similar to that of cracked gases, but coking gases are richer in butane and heavier constituents.

The gases from straight-run distillation and storage are very rich in heavier hydrocarbons, as shown in Table V.

Table V. Composition of Gases from Straight-Run Distillation

Methane	5%
C_2	10%
C_3	30%
C_4	35%
C_5	20%

Cracked Gases. Cracked gases are produced as by-products from all cracking operations. The quantity of such gases produced depends on many variables, such as the nature of the charging stock and process conditions (temperature, time, and pressure), as shown in Table VI (*71*).

Table VI. Production of Cracked Gases

Cracking Conditions	Cracked Gas Produced (Cu. Ft. per Bbl. Charge)
Mixed-phase, noncatalytic residual process with maximum gasoline yield (60–65%)	500
One-pass catalytic (clay) cracking at 45% gasoline yield	200
Vapor-phase cracking	1500
Nonresiduum thermal cracking to maximum gasoline, coke, and gas	1000

The composition of receiver gases, produced directly from cracking units, differs substantially from that of stabilizer gases. This contrast is shown for cracked gases from mixed-phase (*27*) and vapor-phase (*43*) cracking in Tables VII and VIII. The per cent of stabilizer gas in the total volume of cracked gases depends on the condensation pressure and is close to 30 or 40% of the total gas produced in cracking.

Table VII. Chemical Composition of Cracked Gases from Mid-Continent Kerosene Distillate

(Produced in mixed-phase process at 950° F. and 400 lb./sq. in.)

	Receiver, 30 Lb./Sq. In.	Stabilizer
Hydrogen and methane	63.0	11.3
Ethane	20.6	18.6
Ethylene	4.4	2.2
Propane	8.7	19.5
Propylene	7.0	14.5
Butanes	3.1	10.3
Butenes	1.9	7.6
Butadiene	..	6.9
Heavier	9.1	..

Table VIII. Chemical Composition of Cracked Gases from Gulf Coast Crude

(Produced in vapor-phase cracking)

	Receiver (30 Lb./Sq. In.)	Stabilizer
Hydrogen and methane	38.81	11.37
Ethane	13.15	12.35
Ethylene	20.31	15.56
Propane	3.68	...
Propylene	13.15	44.87
Butanes-butenes	6.43	13.86
Higher	2.47	1.99

It is seen that the olefin content is appreciably higher as a product of this high-temperature operation than was the case from mixed-phase cracking. Actually, olefin content increases with increasing temperature up to a maximum, then decreases due to decomposition of olefins to hydrogen and methane, as shown by Groll's results (*39*).

A comparison of cracked gas compositions for a number of cracking processes has been presented by Sachanen (*72*), as shown in Table IX.

Table IX. Composition of Cracked Gases from Various Processes

	Composition, Vol. %				
	Mixed-phase cracking	Reforming	Vapor-phase cracking	Polyforming	Cat cracking
Hydrogen	3	7	7	7	7
Methane	35	40	30	50	18
Ethylene	3	4	23	8	5
Ethane	20	18	12	25	9
Propylene	7	6	14	3	16
Propane	15	10	4	6	14
Isobutane	2	3	1	..	16
n-Butane	8	7	2	1	5
Butenes	7	5	6	..	10
Butadienes	..	..	1	..	..

Gases from catalytic cracking operations show a greater percentage of C_3 and C_4 hydrocarbons and hydrogen than do gases from thermal cracking. A high percentage of branched-chain hydrocarbons is also typical, as shown by the isobutane content.

Modern trends in the design of gas plants for catalytic cracking units have been discussed by Gilmore and Bauer (*34*). Detailed analysis of gas streams in a Thermofor gas plant are presented.

The composition of the butane-butene (B-B) fraction resulting from mixed phase cracking has been reported by Snow (*75*) and may be compared with a similar analysis of the B-B fraction from Houdry cracking presented by Sachanen (*71*). The Houdry product is richer in isobutane (53% *vs.* 11%), poorer in isobutene (6% *vs.* 10%), and poorer in butadiene (none *vs.* 0.9%).

Aromatics from Reforming Operations. The catalytic reforming of naphtha charge stocks to give high yields of aromatic hydrocarbons, in addition to high octane gasolines, has assumed great importance in recent years.

Read has discussed the production of high purity aromatics for chemicals manufacture (*70*).

Polymers. Olefins having 9 to 15 carbon atoms with the unsaturation near the end of the molecule may be used to alkylate benzene to make alkyl benzene sulfonates, as outlined by Griesinger and Nevison (*38*). Such olefins may be economically prepared by propylene polymerization.

Synthetic Crudes. Analyses of synthetic crudes made from natural gas have been published by Bruner (*9*) and are shown in Table X.

Table X. Compositions of Hydrocarbon Synthesis Products

	Normal Pressure Fischer-Tropsch		Medium-Pressure Fischer-Tropsch		Hydrocol Process	
	Wt. % of total	Olefins, vol. %	Wt. % of total	Olefins, vol. %	Wt. % of total	Olefins, vol. %
$C_3 + C_4$	14	45	10	40	32	82
Light oil	47	37	26	24	56	85–90
Diesel oil	28	14	37	9	8	75–85
Wax	11	..	27	..	4	...

Additional data on the compositions of both hydrocarbon and oxygenated products of hydrocarbon synthesis have been presented by Morrell *et al.* (*59*).

The compositions of shale oils have been published by Dinneen, Ball, and Thorne (*19*) and by Cady and Seelig (*12*).

Naphthenic Acids. Naphthenic acids are cycloparaffinic organic acids and usually are monocarboxylic. These acids occur in crude oils and normally are recovered with the straight run gasoline and distillate oil fractions in a topping unit. If these fractions are caustic scrubbed, the naphthenic acids are recovered as the sodium naphthenates (*5*).

Sachanen (*71*) presents data on the occurrence of petroleum acids, which include fatty and naphthenic acids and phenols, but which are primarily naphthenic acids. The naphthenic acid contents of crude oils vary from 0.03% (Pennsylvania and East Texas) to 1.5% (California) and 1.6% (Russia and Roumania).

The molecular weights of naphthenic acids range from 114 (for cyclopentane carboylic acid) to over 1000, according to Goldstein (*36*). Commercial naphthenic acids have a molecular weight range of 180 to 350. They are liquids of unpleasant odor and are usually dark in color. The lower molecular weight acids are sparingly soluble in water and are distillable at ordinary pressure. A commercial acid of average molecular weight 188 is reported as having a distillation range (10 to 90%) of 240° to 300° C. Acids with between 8 and 12 carbon atoms are monocyclic; those with 13 to 23 carbon atoms are bicyclic, probably with both dicyclopentane and fused ring systems present.

The annual production of naphthenic acids has been stated to be of the order of 25,000,000 pounds per year (*24*).

Pyhälä (*68*) reports that distillates from two Russian petroleums contained 11 to 12 times as much naphthenic acids as the undistilled crude oils, indicating that, like the nitrogen bases, the naphthenic acids are mainly thermal decomposition products of more complex materials.

Commercial naphthenic acids marketed in the United States contain 5 to 25% of oil; when corrected for oil content, the acid material shows acid numbers of 238 to 302, according to Klotz and Littman (*46*).

A review of the occurrence and composition of naphthenic acids in petroleum has been presented by Lochte (*51*).

Cresylic Acids. Cresylic acids, or petroleum phenols, are obtained from cracked distillates, such as heavy catalytic naphtha and cracked heating oil. They usually exist in these distillates in amounts up to about 0.2% and are removed by extraction with a 10 to 40% sodium hydroxide solution (*77*). The extract is subsequently steamed, then carbonated with carbon dioxide to spring the alkyl phenols from the naphthenic acid soaps (which remain in solution). The product is subsequently distilled.

Field, Dempster, and Tilson have published data (*29*) on the phenols extracted from a California cracked distillate and have compared these analyses with those of coal-tar phenols boiling in a similar range.

It has been found that catalytic naphthas contain about ten times as much cresylic acid as do thermal naphthas (*32*). The cresylic acid may easily be recovered by treatment with dilute caustic soda to give a product containing 20% phenol, 25% xylenols, 45% cresols, and 10% impurities. Removal of sulfur from this extract to give marketable cresylic acid is a problem, being solved by air blowing, partial neutralization, distillation, or a combination thereof.

Sulfur Compounds. The sulfur present in natural gas or in refinery cracked gases is predominantly hydrogen sulfide and may range from 0 to 15 volume per cent.

Sulfur compounds isolated from the lighter petroleum fractions include mercaptans (*R*SH), dialkyl sulfides and disulfides (*R*S*R*, *R*SS*R*), and cyclic sulfides such as thiophanes and thiophenes.

Most crude oils contain sulfur, the usual amount being 1 to 2%. Some of this sulfur is lost as hydrogen sulfide in distillation of the crude, and most of the remainder is concentrated in the higher-boiling fractions as shown in Table XI, taken from Tait (*78*).

Table XI. Sulfur Content of Distillation Products

(% wt.)

Crude oil		Gasoline and Naphtha		Kerosene		Gas Oil		Residue
Source	%S	Mercaptans	Total S	Mercaptans	Total S	Mercaptans	Total S	Total S
Far East	0.15	0.003	0.003	0.003	0.01	0.003	0.15	0.3
East Texas	0.36	0.003	0.012	0.003	0.03	0.003	0.28	0.78
East Venezuela	0.55	0.003	0.011	0.003	0.05	0.003	0.35	1.2
Iranian	1.4	0.063	0.087	0.008	0.15	0.004	0.90	2.3
West Texas	2.0	0.14	0.17	0.09	0.62	0.05	1.6	3.2
West Venezuela	2.2	0.003	0.023	0.003	0.20	0.003	1.0	2.7
Kuwait	2.45	0.010	0.015	0.004	0.16	0.003	1.3	3.8

Above Data Converted to Lb. S in Each Product/100 Lb. S in Crude

	Gasoline and Naphtha	Kerosene	Gas Oil	Residue
Far East	0.3	3.6	38.6	57.5
East Texas	0.9	1.3	15.4	82.4
East Venezuela	0.5	1.7	15.5	82.3
Iranian	1.1	1.5	12.6	84.8
West Texas	1.8	4.2	14.8	79.2
West Venezuela	0.05	0.55	6.6	92.8
Kuwait	0.1	0.8	9.5	89.6

Sulfuric Acid Sludges. The water-soluble sulfonic acids resulting from the acid treatment of oils boiling under 550° F. are known as "green acids" in the trade (*38*). These green acids are monobasic acids which cover a molecular weight range of 150 to 1000 and have the general formula $C_nH_{2n-9}.SO_3$ (*36*).

The oil-soluble sulfonates resulting from the acid treatment of oil boiling above 550° F. are typified by the mahogany or white oil sulfonates. Mahogany sulfonates are most readily formed by the action of fuming sulfuric acid on a naphthenic-type petroleum distillate. Following treatment of such a distillate with 40 vol.% of acid, the oil is neutralized and extracted with alcoholic caustic. The mahogany sulfonates are then freed of excess sodium sulfate and caustic by drying and redissolving in a low-boiling hydrocarbon (*38*).

Mahogany acids are monobasic acids of the general formula $C_nH_{2n-12}.SO_3$ and have a molecular weight range of 350 to 500 (*36*).

Nitrogen Compounds. The preparation of secondary amines from the nitrogen bases present in California cracked petroleum has been discussed by Millèr (*56*). The bases were extracted by contacting with 45% aqueous sulfuric acid. The extract was diluted with water and allowed to stand for 12 to 24 hours. The aqueous layer was made alkaline, and a heart cut of nitrogen bases was distilled.

Bratton and Bailey (*8*) have reported on the compositions of nitrogen bases extracted from thermally cracked gasoline. Seven homologs of pyridine as well as quinoline and quinaldine were found. In addition to these compounds, Hackmann, Webant, and Gitsels have reported (*41*) nine other homologs of pyridine, five methyl and dimethylquinoline homologs, isoquinoline, two isoquinoline homologs, plus other unidentified compounds.

The nitrogen contents of 153 crude petroleums from all parts of the United States have been reported by Ball, Whisman, and Wenger (*3*). Most were below 0.10%, but a few contained as much as 0.7% nitrogen.

Petroleum Coke. Petroleum coke is an important raw material from petroleum for the chemical industry. Unlike most petroleum raw materials which go into organic synthesis, petroleum coke is important in inorganic technology. Anodes for aluminum manufacture consume 600,000 tons of petroleum coke annually—18% of U.S. petroleum coke production. About 0.7 pound of petroleum coke is consumed for every pound of aluminum produced. The next most important chemical use is in the manufacture of graphite electrodes for the steel industry, a use which consumes about 5% of current coke production.

Thomas has reviewed the petroleum coke picture over the last 25 years (*80*). Earlier reviews include those by Stroud (*76*) and Gould (*37*).

Petroleum coke has the approximate formula $(C_3H_4)_n$, according to Thomas (*79*).

Processes for Separation of Pure Chemical Raw Materials from Petroleum Fractions

Most processes which utilize petroleum raw materials require a preliminary separation of a more-or-less pure component from a petroleum fraction. An exception to this is the direct oxidation of natural gas, as currently practiced by such companies as Celanese Corp., Tennessee Eastman Corp., and Cities Service Oil Co.

In general, the important factors governing the supply of a petroleum raw material are the (1) composition and cost of the raw material, (2) quantity and quality of the hydrocarbon desired, and (3) processing steps required and their relation to existing refinery operations.

Yields of individual hydrocarbons will vary from crude to crude. The picture is further complicated, as Boyd points out (*7*), by difference in refinery operations, available equipment, market conditions, and company policies.

Absorption and Extraction. Separation may be accomplished by gas absorption and solvent extraction.

Gas Absorption. Oil absorption may be used for the separation of ethylene from cracked gases, as outlined by Kniel and Slages (*47*). Absorption in cuprous salt solutions may also be used for the extraction of ethylene from gas streams, as outlined by Sergeys (*74*).

Solvent Extraction. Diethylene glycol extraction of benzene, toluene, and xylene from Platformates is one commercial method for the recovery of these materials. The process has been named the Udex process and has been described by Read (*70*).

Phenols may be removed from refinery wastes and recovered by a multistage countercurrent extraction process such as practiced by Ohio Oil (*15*). A mixed benzene-gasoline solvent is used in the extraction process and is regenerated with caustic.

A modified Edeleanu process for the recovery of aromatic hydrocarbons from petroleum fractions has been described (*65*).

Distillation. Distillation processes are also used to effect separation of chemicals.

Extractive Distillation. Two important extractive distillation processes were placed in commercial operation during World War II: the recovery of butadiene from a C_4 fraction using furfural as the entrainer (*10, 11, 40, 42, 44*), and the segregation of toluene from petroleum fractions by means of phenol (*20, 21, 23*).

The Shell benzene recovery process uses phenol or, in special cases, other solvents such as cresylic acids or sulfolanes, to separate benzene from nonaromatics by extractive distillation. This process has been described by Dunn and Lieholm (*22*), and others (*63*).

AZEOTROPIC DISTILLATION. Methanol may be used to separate toluene from cracked motor fuel fractions (*31*), and the use of sulfur dioxide in butane-butene separation has been reported by Matuszak and Frey (*54*).

Mair, Glasgow, and Rossini have discussed the laboratory aspects of hydrocarbon separation by azeotropic distillation (*53*).

LOW-TEMPERATURE FRACTIONATION. Low-temperature fractionation is used to separate 75% of the ethylene produced in the United States (*62*).

Pratt and Foskett have described the separation of ethylene by this method (*66*).

Adsorption. Adsorption processes are now being used commercially.

HYPERSORPTION. The applications of Hypersorption in modern gas processing plants have been outlined by Berg (*4*). The recovery of ethylene from refinery gas streams is discussed, and analyses of process streams are presented.

SILICA-GEL ADSORPTION. The Arosorb process is an aromatic adsorption process developed by the Sun Oil Co. and uses silica gel to separate aromatics from naphtha reformates (*64*). Operating and investment costs for Arosorption were presented as follows:

Capacity BPD aromatics	1000	2000
Investment cost	$1,200,000	$1,900,000
Operating cost, cents/gallon of aromatics	$6^1/_2$	5

Davis, Harper, and Weatherly have also described the Arosorb process (*18*).

ION EXCHANGE. The removal of nitrogen bases from petroleum may be accomplished by an ion exchange process (*57*).

Crystallization. Crystallization processes are also used in separating chemicals.

EXTRACTIVE CRYSTALLIZATION. Extractive crystallization is a new process whereby the desired component in a mixture is made to form an adduct, the adduct is crystallized out, and the desired component is then recovered. Urea forms such adducts with straight-chain organic compounds, and thiourea forms adducts with branched-chain and ring compounds. A review of the process has been published by Kobe and Domask (*48*).

FRACTIONAL CRYSTALLIZATION. The separation of *p*-xylene from a Hydroformate by fractional crystallization has been described in the literature (*14*). This process is operated commercially to produce para xylene as a raw material for Dacron fiber manufacture.

Economics of Specific Raw Materials for Chemicals

The over-all size of the petroleum chemicals industry and its projected future production has been estimated by various authorities. Table XII summarizes these data.

Table XII. Total Output of the Petroleum Chemicals Industry

Year	Total Capital Investment, Millions of Dollars (*60*)	Output, Million Lb./Year: Neuhaus & Sommer (*60*)	Egloff (*24*)	Presidents Material Policy Commission (*67*)
1940	350	4,000	...	...
1945	1,000	10,000	...	...
1950	1,600	17,000	12,000	...
1955	...	...	...	20,240
1960	8,000	64,000	...	29,240
1965	...	...	...	37,470
1970	...	...	...	45,610
1975	...	...	...	54,180
...	...	...	...	...
2000	...	...	48,000	...

With this general predicted growth potential for the entire industry in mind, it is now pertinent to examine the trends in production and sales value of specific raw materials from petroleum, as taken from U.S. Tariff Commission publications (*16*). These data are summarized in Table XIII.

Economic data on specific raw materials are not widely available since, like most cost data, they are frequently confidential in nature. General data on market trends and market prices are all that are available in most cases.

Table XIII. Production and Sales Values of Specific Raw Materials[a]

(Production in million pounds, sales value in cents/pound)

Material	1943		1944		1945		1946		1947		1948		1949		1950		1951	
	Production	Sales Value	Production	Sales Value	Production	Sales Value	Production	Sales Value	Production	Sales Value	Production	Sales Value	Production	Sales Value	Production	Sales Value	Production	Sales Value
Cresylic acids	14	..	..	..	..	..	..	..	..	..	..	..	..	..	16	3.4	20	5.0
Naphthenic acids	17	..	28	8.7	30	7.5	28	6.0	32	6.0	25	9.0	23	10.0	24	9.7	39	10.6
Ethylene and ethane	166	..	272	4.5	..	..	295	2.0	342	5.0	383	6.0	1151	5.7	1822	4.2	1799	4.3
Propylene and propane	395	..	215	0.8	179	1.0	209	2.0	464	2.0	713	2.0	1087	1.1	1693	1.0	2122	1.2
Butanes	673	..	..	..	255	1.0	..	..	..	..	..	..	..	..	..	..	..	..
1- and 2-Butene	..	..	202	2.0	306	1.8	632	2.0	490	2.0	820	3.0	613	3.2	641	2.8	1136	2.8
Butadiene	99	21	489	30.0	780	21.0	..	..	696	8.0	660	8.0	494	8.8	610	8.3	1222	14.8
All other C_4's	..	..	569	3.8	324	7.3	481	5.0	272	4.0	175	3.0	..	..	388	2.7	461	3.8
Xylenes	..	..	355	2.0	334	1.7	265	2.0	238	3.0	382	3.0	356	2.9	450	3.1	464	3.5
Toluene	..	..	..	..	..	..	69	3.0	198	2.0	358	3.0	331	3.1	329	3.1	403	3.9
C_5 hydrocarbons	..	..	..	..	..	..	42	6.0	13	11.0	12	8.0	..	..	..	..	..	..
Diisobutylene	..	..	..	..	..	..	..	..	..	..	9	5.0	11	..	20	..	22	..
Dodecene (propylene tetramer)	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	93	3.6
All others (benzene and other hydrocarbons)	201	1.4	674	..	792	..	427	..	387	..	371	..	567	..	943	..	801	..

[a] Figures from U. S. Tariff Commission Report (*16*).

Methane. On the average (*60*), methane makes up 85% of natural gas, 33% of the gas from thermal cracking, and about 18% of the gas from catalytic cracking. Average natural gas prices have been quoted from Bureau of Mines figures by Kuhn and Hutchison (*49*) and are summarized in Table XIV.

Ethylene. Ayres has reported (*2*) on the costs of ethylene production (based on 1950 construction costs) from propane at four cents per gallon, as shown in Table XV. The consumption of ethylene by the chemical industry has been reviewed by Aries and Copulsky (*1*).

Propylene. The consumption of propylene by the chemical industry and the dollar volume of the market have been surveyed by Aries and Copulsky (*1*).

Butenes. The consumption of butene and isobutene by the chemical industry and the dollar volumes of these olefins sold in the period 1940 to 1950 have been reviewed by Aries and Copulsky (*1*).

Butadiene. Plant investment and production costs for butadiene have been published by Gilliland and Lavender (*33*).

Benzene. The cost of benzene from petroleum has been estimated by Williams (*81*). He quotes a sales cost of 24 cents per gallon for benzene produced from a debutanized natural gasoline by the Platforming process.

Forecasts of benzene production from petroleum have been made by Egloff (*26*).

Xylene. Egloff states (*24*) that the annual production of phthalic anhydride from *o*-xylene is now 8,000,000 pounds, augmenting the inadequate supply from naphthalene.

Discussion

Despite its length, this paper cannot be considered to be a complete treatise on petroleum as a raw material for the production of chemicals. That is and has been the subject of books.

Petroleum refining for the production of fuels and lubricants remains "the dog that wags the tail" when chemicals from petroleum are considered. This does not mean that the dog never circles after his tail; witness the success of catalytic reforming processes, greatly stimulated by the need for aromatic hydrocarbons as chemicals. But it does mean that when petroleum or its frac-

Table XIV. Natural Gas Prices

Year	Cents/1000 Cu. Ft. At well	Industrial
1945	4.9	10.5
1946	5.3	10.8
1947	6.0	11.3
1948	6.5	12.5
1949	6.3	12.9
1950	6.4	...

tions are considered as chemical raw materials, there must be valid economic reasons for altering normal operations, installing new equipment, and entering chemical markets.

These reasons often occur, of course. Refineries produce many by-products whose value as chemical raw materials far exceeds their value as fuels, if there are chemical markets available. Proximity to chemical plants often affords such markets. Chemicals used by refineries may be producible from refinery by-products (e.g., sulfuric acid from hydrogen sulfide). Research may yield chemical extraction or chemical production processes which afford economic advantages.

Table XV. Ethylene Production Costs

Annual Capacity, Millions of Pounds	Ethylene Cost, Cents per Pound
10	6.8
30	4.9
60	4.1

In any event, petroleum and natural gas are chemical raw materials of great present value and growing future importance. In some future era of atomic and solar energy, who can say whether the petroleum then remaining may not be cherished exclusively for the chemicals produced from it?

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Basic Research on Hydrocarbons From Petroleum and Natural Gas

ALBERT E. MILLER

Sinclair Refining Co., 600 Fifth Ave., New York, N. Y.

Any symposium on the literature of chemicals derivable from petroleum would be incomplete without a paper on the basic research on hydrocarbons derivable therefrom. This paper is an attempt to assemble and evaluate the most important literature sources on this subject. The work of investigators in this field from the end of the eighteenth century to 1927 is reviewed. Most of our current, accurate knowledge of the hydrocarbons derivable from petroleum dates from the establishment of the API Fundamental Research Program in 1927. The major portion of the paper deals with the origin, purpose, organization, and accomplishments of this research work. The activities of API Research Projects 6, 42, 44, and 45, all of which are very much concerned with hydrocarbon composition of petroleum, are described. Similar hydrocarbon research work which has been carried out in some foreign countries is outlined. The paper is concluded with two sections; the first dealing with the present status of our knowledge of hydrocarbons derivable from petroleum, and the latter with future programs which have been suggested.

This paper is not complete with respect to the literature on the hydrocarbons derivable from petroleum. It is believed that the bibliography contains references to most of the important sources of information. To list all of the references would result in a work of several volumes.

Man has long wondered about the dark brown or almost black liquid which oozed from the earth in certain lands or sometimes floated on streams. He learned many centuries ago that this strange liquid would burn and give out great heat and light. Petroleum, or some portion thereof, referred to as bitumen, is mentioned in the Bible and has been described in the very early literature.

Abraham (1945) states that asphalt was used by the Sumerians certainly as early as 3800 BC (*1*). It was used considerably for building roads and in other construction in the ancient cities of Nineveh and Babylon. Herodotus (450 BC) (*58*), who has been called the Father of History, devotes considerable space to a description of petroleum, its products and uses. Although petroleum was known to exist in many parts of the world, and men used it as such or portions of it such as asphalt which occurred naturally, he did little to find out what it was made of until about 150 years ago. As man became more scientific and research minded, investigators began to use the tools at hand to determine the composition of the various crude petroleums available to them for study.

Work of Early Investigators

Some of the best research chemists of their day became intrigued with crude petroleum and endeavored to learn its composition and to find out what it was good for. This study began in certain European countries toward the end of the eighteenth century and is still going on. Outstanding scientists worked as individuals or in unrelated groups and achieved quite remarkable results in spite of inadequate methods and very crude apparatus. The early work centered in Austria-Hungary, France, Germany, Poland, Roumania, and Russia. Similar studies were carried out in the United States, beginning about the middle of the nineteenth century.

There are two outstanding works in the literature where this history is well recorded and where the efforts of these early investigators are presented in detail. The earlier source is the five-volume work by Carl Engler and Hans. v. Hoefer, "Das Erdöl," in German. Volume I covers the chemistry and physics of crude petroleum. In Part III, "Die Chemie des Erdöl" (The Chemistry of Petroleum), Engler (1913), has devoted 184 pages to the ultimate analysis, the classification, and the hydrocarbons of petroleum (*42*). The second source is a treatise of petroleum by Sir Boverton Redwood (4th ed., 1922), a three-volume work. Section III of Volume I is devoted to "The Physical and Chemical Properties of Petroleum and Natural Gas." Redwood (*143*) covers the subject of chemical composition in 47 pages of which 12 are on the subject of hydrocarbons in petroleum. The latter source is in English.

It is of interest to sketch briefly the progressive steps taken by the early investigators to learn the composition of petroleum and to designate those who played an important role in these researches. One of the earliest investigators of petroleum on record was Winterl (1788) (*212*). He distilled a sample of crude petroleum from Southern Hungary and obtained three overhead fractions and a coky residue, all of which he carefully investigated. A similar investigation was carried out by Von Martinovich (1791) (*186*), who obtained about the same results.

Ultimate Analyses. Much of the effort to determine the composition of petroleum in the nineteenth century was confined to making what today would be called ultimate analyses. De Saussure (1817) (*32*) seems to have been the first to make a quantitative elementary analysis of a crude petroleum. He determined that Amiano crude, which at that time was employed in street lamps in Parma, Italy, consisted of 87.6% carbon and 12.8% hydrogen. Prominent among the early research chemists who contributed to our knowledge of the elementary composition of crude oils were Bushong, Charitschkoff, Edeleanu and associates, Markownikoff, Mabery, and Peckham. Engler (*42*) summarized the work of these early investigators and listed the literature references to their original work on pages 222–4 inclusive in "Das Erdöl."

As early as 1833, Dumas (*37*) made the statement that, based on the results of the ultimate analyses of crudes, they consisted essentially of hydrocarbons, in spite of the fact that they had different sources. Mabery (*107*) after many years of arduous labor to determine the hydrocarbon composition of crude oils came to a similar conclusion in 1903. He concluded that petroleum from whatever source is one and the same substance, consisting of a mixture of a few series of hydrocarbons in variable proportions, and no matter what field the oil comes from, it only varies from oil from other fields in its content of these series of hydrocarbons, the members of the series varying from one crude to another. In the same paper, where Mabery summarized his work in 1903, he said in substance that he had been working with the financial assistance of the C. M. Warren Fund, but that lack of adequate money for research on the composition of petroleum was a serious handicap. He added that if $5,000 could be obtained from the Carnegie Institute, a really thorough analysis could be made.

Fractionation. Both Engler and Redwood refer to early attempts by certain investigators to separate the hydrocarbon constituents of various crude oils by fractional distillation. Reichenback (1830) (*187*) and Laurent (1837) (*91*) seem to have been the first on record to make such attempts. They were only partially successful, according to Redwood (*143*).

Redwood (*143*) writes on page 257 of his treatise on petroleum that B. Silliman, Jr. was the first to undertake the systematic examination of petroleum and of some of the commercial products obtained from it. Silliman fractionated Pennsylvania crude by distillation and on examining the distillates came to the conclusion that certain of the bodies which they contained were products of distillation and were not present in the crude oil. He also isolated wax. Paul H. Giddens in 1949 (*163*) printed a facsimile of Silliman's "A Report on the Rock Oil; or Petroleum," originally written in 1855.

Pelouze and Cahours are credited by Engler with having isolated the paraffin hydrocarbons from butane to hexadecane from American crude oils in the period 1862 to 1864. Another famous investigator who endeavored to separate petroleum into its constituent hydrocarbons by fractional distillation was Schorlemmer (1863–1866). This chemist, whom Engler described as "a master of the boiling art through fractional distillation," designated petroleum as a mixture of innumerable hydrocarbons incapable of being unravelled. Among other great research chemists who attempted to isolate hydrocarbons from petroleum by fractional distillation were, according to Engler, Mabery and Chandler in America, and Markownikoff and Zaloziecki in Russia. Engler (*42*) refers to the work of these pioneers and gives numerous citations in the literature to their original work on page 237 of "Das Erdöl."

The early investigators, by repeated fractional distillation, were able to determine that crude petroleum consisted principally of hydrocarbons. Ultimate analyses had shown that relatively small proportions of sulfur, nitrogen, and oxygen were usually present, probably in the form of derivatives. They were able to identify a number of hydrocarbon types such as paraffins, cycloparaffins, and aromatics, and even to isolate some members of these series in a qualitative way. The state of the art was very well summed up by Hoefer (1888) (*65*) when he wrote in his book "Das Erdöl" as follows: "It should be pointed out that up to the present no complete quantitative analysis has been carried out on any crude petroleum, that we must be content rather to discover which are the principal types of hydrocarbons present, which predominate and, qualitatively, to identify the individual members of such series."

It is of interest to note that Peckham (1900) (*133*) and Charitschkoff (1903) (*183*) attempted to classify the then known petroleum into certain classes. Charitschkoff suggested five classes—those containing paraffin (Pennsylvania type); those containing sulfur (Ohio type); paraffin-free (Russian, probably naphthene base); those containing nitrogen (Ventura, Calif.); and those containing oxygen (Caucasian, Russian).

Charitschkoff was apparently the first to fractionate petroleum with solvents at lower temperatures in order to obtain the higher boiling fractions as they exist in the crude. This was done to avoid the cracking incidental to distillation. This procedure, the solvents used, and the nature of the fractions obtained, as well as the literature references to this work appear on page 229 of Engler's "Das Erdöl" (*42*).

Work of Mabery. The tremendous amount of experimental work of Charles Frederick Mabery on the composition of petroleum and his position as the authority in this field entitles him, in the author's opinion, to special mention in this paper.

Dr. Mabery was head of the chemistry department of Case School of Applied Science at Cleveland, Ohio from its establishment in 1883 until his death in 1927, although he retired from active teaching in 1911. In 1892, during his address dedicating his new laboratory, Mabery stated: "No process involving chemical changes can be conducted intelligently and economically unless it is carefully controlled by a complete knowledge of the materials employed, the valuable products obtained, and all waste products as well." It was in this year that Mabery turned his attention to petroleum. His chief interest from 1892 until the end of his life was the separation and identification of the individual compounds in petroleum. His studies to establish scientific principles which would lead to intelligent and economical technology in the petroleum field extended over many years and resulted in numerous papers which have been widely quoted by other investigators in this field.

At the time that Mabery determined to separate and identify the individual compounds in petroleum, probably no more difficult line of work could have been undertaken. The methods of work, and even the apparatus, had largely to be developed. All his work in this field was done in his spare time, and it is doubtful if he ever worked for an oil company, excepting possibly on a retainer basis.

Mabery worked on the composition of crude petroleum from California, Canada, Japan, Ohio, Pennsylvania, Texas, and on some crudes from the Midcontinent field. He carried out repeated distillations to obtain very narrow boiling range fractions from a given crude. The molecular weight was determined for each such fraction obtained, and from these he derived his formulas. The formulas were checked by running ultimate analyses on all fractions to determine the percentages of carbon and hydrogen. By this means, Mabery identified a great many hydrocarbons up to $C_{125}H_{234}$. His analyses were primarily qualitative; his quantitative results were only approximate.

Mabery's work of interest in connection with this paper are cited in the bibliography. Attention is called to one of his early papers (1895) (*104*), as it contains an excellent summary of the work done by other investigators to isolate and identify various series of hydrocarbons from petroleum prior to his entrance into this field.

Literature of Early Work. For those interested in tracing the development of knowledge concerning the composition of petroleum from the early days up to perhaps 1927, a few of the books of particular interest are these of Brannt (1895), (*19*), Crew (1887) (*30*), Day (1922) (*31*), Deutsch (1894), (*33*), Goulichambaroff (1883) (*52*), Pawlewski (1891) (*132*), Sachanen (1945) (*156*), and Veith (1892) (*182*). These, and 25 other books including "Science of Petroleum" (*39*) are listed in the bibliography. Two of the best references found on the hydrocarbon composition of natural gas are "The Recovery of Gasoline from Natural Gas," by Burell (1925) (*25*), and "Natural Gasoline," by Oberfell and Alden (1925) (*128*).

Attention should also be called to some of the early foreign periodicals which may not be well known to Americans. Early investigators usually published their original work in the periodicals listed in Table I. A few American periodicals are included. The date of initial appearance and the language in which the periodical was published is indicated, if not apparent.

The very excellent paper, "Composition of Petroleum" by Rossini and Mair (*150*) prepared for the Symposium on Twenty-Five Years of Progress in Petroleum Technology held by the Division of Petroleum Chemistry of the AMERICAN CHEMICAL SOCIETY during the Diamond Jubilee Meeting at New York, 1951, deserves special mention. The authors list the more important investigators who endeavored to determine the composition of petroleum prior to 1900. They state that there was little additional work of real importance in the period from 1900 to 1920, but that a number of important investigations were made on the hydrocarbon constituents of petroleum in the period, 1920 to 1927. The literature references to these important investigations are listed on pages 5 and 6 of their paper, which is concluded with a list of 65 references cited by the authors. This paper is of great interest and value because of the authority with which these two authors can write on this subject.

API Fundamental Research Program

Most of our current accurate knowledge of hydrocarbons from petroleum followed the establishment of the API Fundamental Research Program.

Origin and Early History. The American Petroleum Institute Fundamental Research Program was started by a grant of $250,000 from John D. Rockefeller on November 1, 1925, to be spent on petroleum research over a period of 5 years. This grant was matched in January, 1926, by an equal sum from the Universal Oil Products Company. These two grants made $100,000 per year available for fundamental research for five years.

E. W. Washburn of the National Bureau of Standards, recognizing that there was actually little known on the hydrocarbons in petroleum in spite of considerable excellent scattered work that had been done on this subject, had set up a modest project in 1926 to study petroleum composition.

After funds had been placed at the disposal of the American Petroleum Institute, Dr. Washburn asked for financial support for the project which he had already established at the bureau. On January 10, 1927, the American Petroleum Institute placed funds at his disposal and established at the National Bureau of Standards the research investigation which has become internationally known as Project 6. Its present title is: "Analysis, Purification and Properties of Petroleum Hydrocarbons." It was one of the earliest of the API projects to be established, and the oldest one which is still operating. Facts pertinent to the setting-up of Project 6 are mentioned because of its importance in consideration of the subject matter of this paper.

A summary of the results obtained from the program supported by John D. Rockefeller and the Universal Oil Products Company for the period July 1, 1926 to June 30, 1931 was published by the API in 1932 in the form of "A Report on Fundamental Research in Petroleum." Hill (*62*) wrote the portion of the report pertaining to the composition and properties of Petroleum.

J. Bennett Hill (*64*) recently wrote a history of Project 6 in commemoration of the twenty-fifth year of continuous operation of the project. In commenting on this history, Frederick D. Rossini, who has been the director of Project 6 since January 1, 1935, stated that this history could have been prepared by anyone else only with great difficulty, if at all. Dr. Hill was chairman of the Advisory Committee of Project 6 from its organization in March 29, 1928 until December 31, 1949. He is still an active and valued member of that group.

As stated in Hill's history of Project 6 (*64*), the technical direction of the funds granted to the API for fundamental research was entirely in the hands of the Central Petroleum Committee for the first 2 years. This was a group of scientists appointed by the National Research Council at the request of the Board of Directors of the API. It soon became apparent that a group of petroleum technologists would be helpful in the selection of projects and in the proportionate allocation of funds. The Committee on Fundamental Research, with R. P. Anderson as chairman, was accordingly appointed and served jointly with the earlier committee until the API Fundamental Research Program was reorganized in 1931. Based on a recommendation from the joint committees, the API Board of Directors adopted a resolution endorsing the continuation of fundamental research, and approving "a plan for raising a special fund of $100,000 per annum to continue this research by requesting contributions from individual oil companies."

The projects were divided into two categories, one on the occurrence and recovery of petroleum, and the other on its composition and properties. Mr. Teagle, chairman of the Board of the API in March 1931, appointed two advisory committees to be known as the Advisory Committee on Fundamental Research on the Composition and Properties of Petroleum (ACFRCPP) and the Advisory Committee on Fundamental Research on the Occurrence and Recovery of Petroleum (ACFRORP). These committees replaced the two earlier joint committees.

ACFRCPP Session, Chicago, 1952. A Session on Fundamental Research, sponsored by the ACFRCPP, was held at Chicago, Ill., Nov. 10, 1952 during the 32nd Annual Meeting of the API. Papers were prepared jointly by the Chairmen of the Advisory Committees and the Director of each of the committee's six projects. These papers were presented at the session by the chairmen. Those presented by the Chairman of the Advisory Committees of Projects 6, 42, 44, and 45 are of special interest as literature references (*17*, *88*, *157*, *159*). Over a thousand copies of these papers have been distributed as preprints. The papers give the most authoritative up-to-date information available on these projects. This includes historical background, original purpose or scope, any changes that have taken place in the project since its establishment, administration and organization, the location as well as the physical facilities and staff of the project, accomplishments, publications, and future plans and program.

A brief description of each of these four projects and their relationship to each other is in order in this paper.

API Research Project 6 (Includes Project 46). The early background of Project 6 "Analysis, Purification, and Properties of Petroleum Hydrocarbons," has already been mentioned. Washburn directed the project at the Bureau of Standards until his untimely death February 6, 1934. Washburn (*193*) had made his first public report to the API on the accomplishments of the project at the Annual Meeting of the API, October, 1933. Following Washburn, M. R. Fenske of The Pennsylvania State College directed the project until Frederick D. Rossini was appointed, January 1, 1935. When Rossini left the National Bureau of Standards to become head of the Department of Chemistry at the Carnegie Institute of Technology, July 1, 1950, Project 6 moved with him. It must be said that, in no way detracting from the great work done by Washburn in the early formative years, Rossini's inspiring leadership, tireless energy, and courage have guided this research project to outstanding success in the face of many apparently insurmountable obstacles.

J. Bennett Hill, Director, Chemical and Engineering Division, Research and Development Department, Sun Oil Company, has given so much of his time and energy to make a success of Project 6 that he is almost "Mr. Project 6" himself. In addition he has been one of the most inspiring leaders in the work of the whole ACFRCPP. This author predicts that Hill's history of Project 6 will become a classic.

Sherman S. Shaffer of the Humble Oil & Refining Co., Baytown, Texas, became Chairman of the Advisory Committee of Project 6 when Hill resigned. The Advisory Committee consists of five members in addition to the Chairman.

The basic objective of the project is to learn the composition of petroleum in terms of its individual hydrocarbon compounds, or groups of related compounds. In order to carry out this basic objective, the project has developed, and now operates, fractionating equipment and processes having a degree of separating power previously unheard of.

STANDARD SAMPLES. The positive identification of the individual hydrocarbons isolated from petroleum created an early demand for known hydrocarbon compounds of the highest purity. An impetus was given to this need for pure hydrocarbons during World War II, when it became imperative to have standard samples for the calibration of spectrometers.

E. W. Thiele, Standard Oil Company of Indiana pointed out, on February 11, 1944, to T. G. Delbridge, then Chairman of the Technical Advisory Committee of the Petroleum Industry War Council, the great need for a supply of pure hydrocarbons for the calibration of mass spectrometers and infrared absorption spectrometers, which were then rapidly coming into use for analyzing hydrocarbon mixtures. He made a strong plea for the TAC to make the badly needed pure hydrocarbons available to petroleum and other laboratories. This proposal was considered at the meeting of the TAC Program Panel, March 3, 1944. The TAC studied the problem. Two very important meetings were held, one on March 22 and one on April 14 of that year. Some of those best informed in this field were present and contributed their ideas and made recommendations. It was decided to ask the API to take on this project under the sponsorship of the ACFRCPP, using the facilities of the API Hydrocarbon Research Committee at Ohio State University and the facilities of API Project 6 at the National Bureau of Standards.

A symposium held by the TAC in New York, May 12, 1944, devoted to "Newer Physical Methods of Analysis," brought out very forcefully that a most important element in the success of these "New Methods" was the availability of pure hydrocarbons required for the standardization and calibration of equipment and method. This was an important factor in persuading those interested to combine their efforts and to hasten the setting up of Project 46. The TAC report (*180*), containing the 7 papers presented at this symposium, was considered of such importance that it was reprinted by the API in 1950.

APIRP 46 was set up to handle this work July 1, 1944. W. J. Sweeney was Chairman of the Advisory Committee of this project, which was in existence until 1946, when its functions were taken over by Project 6.

The API Standard Samples now number 204 (as of January 1, 1953, they numbered 210); they are sold to the laboratories of the petroleum and other industries, and to colleges and universities, for use as standards. A similar number of API Research Samples, of exceptional purity, are available for loan to qualified investigators for the measurement of needed physical, thermodynamic, and spectral properties.

Inasmuch as the project uses the physical properties for the identification of hydrocarbons and the determination of their purity, one of the functions of the project is to make accurate measurements of the physical properties of the highly purified API Research hydrocarbons. Beginning with the very important property of the freezing point, determinations are made of the density, refractive index, boiling point, and vapor pressure.

The above paragraphs are quoted from the paper prepared by Shaffer and Rossini (*159*) as a report for APIRP 6 for the Session on Fundamental Research. Table 3 of their paper is a list of the API Standard Samples of hydrocarbons arranged by type of hydrocarbon. The formula, name, and purity of each hydrocarbon is shown.

VALUE OF METHODS. Many scientists and technologists feel that the methods of separation, purification, and analysis which have been developed during the course of the work of Project 6 are of as great or perhaps even greater value than the analytical results which have been obtained.

ANALYSIS OF SINGLE CRUDE. Hill (*64*), in his history of Project 6, states that at the first meeting of the Advisory Committee with Washburn and his staff, May 17, 1928, it was decided to embark on a systematic analysis of a single crude petroleum, beginning with the lightest fractions and working up through the boiling range. It was felt that crudes would differ quantitatively but not qualitatively in the hydrocarbons present, and that the analysis of a single crude, of average characteristics, would furnish the most valuable information. The Brett # 6 crude, on which Project 6 was already working, was considered to be a good choice. Accordingly, through the courtesy of the Marland Oil Company, 1000 gallons of this crude were procured. The most detailed description of this representative Mid-Continent crude is given in the paper by Rossini and Mair (*150*). The authors outline the general methods for isolating the individual hydrocarbons from the crude and for the identification and determination of the purity of the individual hydrocarbons obtained. See also Rossini (*146*).

In the Shaffer-Rossini paper, (*159*), Table 1 lists the 130 hydrocarbons that have been isolated and identified from this representative crude. This table lists the formula, name of compound, type of hydrocarbon, boiling point, purity of the best sample isolated, estimated amount in the crude petroleum, and the references to research paper in which the work is described. In Table 2, a summary is shown of the hydrocarbons isolated from this crude. The table is reproduced as Table I of this paper. Figure 10 is a diagrammatic sketch showing the relative amounts of different types of hydrocarbons in several broad fractions of one representative petroleum.

The appendix to the Shaffer-Rossini paper (*159*), is a list of the 139 publications of the project up to the time the paper was presented. The Shaffer-Rossini paper itself, becomes the 140th, and the "History of Project 6" by Hill (*64*), the 141st publication. These complete the list of publications of APIRP 6 to January 1, 1953.

Another joint paper by Rossini and Mair (1951) (*151*), entitled "Hydrocarbons in the Gasoline Fraction of Petroleum," was presented at a "Symposium on the Composition of Petroleum and its Hydrocarbon Derivatives" sponsored by the ACS at Cleveland, April, 1951. A number of the other papers presented at that symposium are also of interest (*174*).

A book entitled "Hydrocarbons from Petroleum" will be published in 1953 as a monograph of the ACS. It will be the most complete and detailed account of the accomplishments of APIRP 6 for the period 1927 to 1952, inclusive (*152*). The book will contain some 436 pages and hundreds of photographs and charts.

PROJECT 6 IN WARTIME. During World War II, the ACFRCPP placed the facilities of Project 6 at the disposal of the Technical Advisory Committee of the Petroleum Industry War Council and other groups working on problems of aviation fuels and other fuels in connection with the war effort. The author, then secretary of the TAC, was added to the Advisory Committee of the project to act as liaison between the two committees.

Project 6 greatly reduced its work with the one representative crude and concentrated its efforts on isolating and identifying the hydrocarbons present in alkylate, codimer, and other base stocks for aviation gasoline. Five of the reports (*176–180*) prepared and distributed by the TAC during the war are of sufficient interest for inclusion in the bibliography.

A paper by H. W. Field and D. W. Gould (*45*), entitled "Project 6 Spotlights Avgas Progress," was based on the information developed through the joint war efforts of Project 6 and the TAC. Dr. Field was chairman of the Synthesis Committee of the TAC during the war years.

Another paper by Glasgow, Streiff, Willingham, and Rossini, "Analysis of Alkylates and Hydrocodimers" (*51*), gives the results of this wartime joint work from the Project 6 point of view.

API Research Project 42. API Research Project 42 was established in 1940 at The Pennsylvania State College with Frank C. Whitmore as Director, and Leslie C. Beard, Jr., Socony-Vacuum Oil Co., Inc., as Chairman of the Advisory Committee. Its basic objective is to prepare pure hydrocarbons in the lubricating oil range. Further objectives are to develop new synthesis and purification methods for these hydrocarbons, to determine physical properties of the hydrocarbons prepared, and to develop correlations between hydrocarbon structure and physical properties. After the death of Dean Whitmore in 1947, his assistant, Robert W. Schiessler, was appointed Director of the project. Schiessler has proven to be an able and fitting successor to Whitmore, whose work in this field was outstanding.

The latest and most concise paper on API Research Project 42 was the one prepared by Professor Schiessler and Harry Sutherland (*157*) for the Session on Fundamental Research held at Chicago in November 1952. Dr. Sutherland, Shell Oil Company, Modesto, Calif., became Chairman of the Advisory Committee to Project 42 in 1951 after the resignation of Beard, who served with great distinction as Chairman of the project since its inception. The paper explains the seven objectives of the project in detail, the special equipment which had to be developed, and the analytical methods worked out in order to carry on the preparation of the hydrocarbons. Their purification and testing are described in the paper, which is well illustrated.

In all, 211 high molecular weight hydrocarbons have been prepared and purified by Project 42. For each of these hydrocarbons, as well as 9 additional ones supplied by Project 45, thirteen classes of properties have been determined. As explained in the Sutherland-Schiessler paper (*157*), these include viscosities at eight temperatures ranging from 32° to 450° F. Viscosities are included also at pressures ranging from 15,000 to 50,000 pounds per square inch at temperatures of 100°, 140°, 210°, and 275° F. The project's work on viscosity at elevated temperatures and pressures is considered outstanding. Another portion of the paper of particular interest is the section dealing with the relation of hydrocarbon structure to physical properties of hydrocarbons. This relationship is clearly explained. The authors concluded their paper (*157*) with 15 references published in connection with the work of the project.

A very interesting list, entitled: "Properties of Hydrocarbons of High Molecular Weight Synthesized by Research Project 42 of the API at Pennsylvania State College, School of Chemistry and Physics, State College, Pa," dated September 1952, and marked "Not for Publication," was distributed after the session at Chicago in November 1952. A notice on the fly leaf of the report states:

> Excepting the data which have already been recorded in the public literature, the physical properties or observations herein constitute a preliminary report to the American Petroleum Institute, subject to possible revision or correction. Until full publication has been made, this Laboratory should be consulted prior to making reference to or reproducing the preliminary data in the public literature. (Robert W. Schiessler, Director).

Copies of the list can probably be obtained from either the API or from Professor Schiessler.

API Research Project 44. API Research Project 44 was established in 1942 to collect, analyze, calculate, and compile data on the physical, thermodynamic, and spectral properties of hydrocarbons and related compounds. Prior to November 1949, the title of this project was "Collection, Analysis, and Calculation of Data on the Properties of Hydrocarbons." Its present title is "Data on Hydrocarbons and Related Compounds." Although Project 44 is sponsored and financed by the API and functions under the ACFRCPP, and was designed to serve the petroleum industry, it soon became worldwide in significance. There was no unquestioned, authoritative compilation of such data in existence prior to the establishment of this project 10 years ago.

Dr. Kuhn of The Texas Company, New York, N. Y. was the Chairman of the Advisory Committee of Project 44 from its inception in 1942 until January 1, 1953. His work was outstanding, and he gave unstintingly of his time and energy during his years as leader. Upon Dr. Kuhn's resignation, Arthur L. Lyman of the California Research Corporation was appointed chairman. Dr. Rossini has been the director of the project ever since it was established. The headquarters of the project was at the National Bureau of Standards in Washington, D. C. until July 1, 1950, when the project was transferred to the Carnegie Institute of Technology, Pittsburgh, Pa.

A report on Project 44, prepared jointly by Wayne E. Kuhn and Frederick D. Rossini entitled "A Decade of Progress in Selecting Data on Hydrocarbons and Related Compounds" was presented by Kuhn at the Session on Fundamental Research at Chicago on November 10, 1952 (*88*). It is by far the most exhaustive, informative, and authoritative paper on this project. The high quality and significance of the work is well brought out in the introduction to the paper. The 21 aims of the project with regard to compiling the tables of physical and thermodynamic properties, are explained in detail. The extent of this work and the many uses for the data are truly amazing.

Project 44 also collects infrared, ultraviolet, Raman, and mass spectral data from cooperating laboratories. These spectral data have been available for a number of years on loose-leaf data sheets; data are now being made available on IBM punch cards.

Appendix 16 of the Kuhn-Rossini paper (*88*) is a list with technical abstracts, of the 49 papers published by Project 44 up to November 1952. The Kuhn-Rossini paper itself brings the number of publications of Project 44 up to 50. One additional paper, published jointly with APIRP 50 has appeared (*136*) making the list of publications of this project complete for 1952.

The project published a book in 1947 entitled "Selected Values of Properties of Hydrocarbons". This book of 483 pages contained the material extant as of May 31, 1947 (*153*). APIRP 44 will publish a book in 1953 entitled: "Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds" (*149*). This will contain data for approximately 950 compounds that were on hand as of December 31, 1952. This book will be of inestimable value both to the petroleum industry and to the technical public.

Copies of data from Project 44 have had very wide distribution to gratis recipients abroad, to gratis recipients in the U. S., and to contributors to the API research fund. In addition, numerous copies have been sold (*88*).

The first decade of work of the project and a forecast of future efforts have been summed up by Kuhn and Rossini (*88*) in the last subject discussed in their paper—"Today and the Future."

APIRP 44 has, indeed, set a pattern for compiling physical, thermodynamic, and spectral data which is not only standing the tests of time and criticism but which will undoubtedly be used as a guide by others wishing to compile similar data in other fields. There is considerable agitation today to compile the physical properties and thermodynamic data on all types of organic compounds. It has been proposed that if this compilation is undertaken that it be done along lines similar to the pattern already set by Project 44.

API Research Project 45. API Research Project 45, the Synthesis, Purification, and Properties of Hydrocarbons of Low Molecular Weight, was established in the summer of 1944 when its predecessor, the API Hydrocarbon Research Committee, was reorganized. The original project was established August 15, 1938. It is the writer's understanding that the first suggestion to set up a Hydrocarbon Research Project came from E. W. Isom of the Sinclair Refining Company. Mr. Isom was a member of the original Committee on Fundamental Research, established in 1929, under the chairmanship of R. P. Anderson. This was a group of petroleum technologists appointed by the API Research Committee to assist the General Petroleum Committee in the selection of projects and in the proportionate allocation of funds (*64*). Isom suggested that setting up of the Hydrocarbon Research Project on the basis that the work contemplated was of a fundamental nature, the information was necessary to the petroleum industry, and the project was noncompetitive.

The project became active at The Ohio State University, September 1, 1938. It was financed by voluntary contributions from a group of from 24 to 38 industrial firms. Representatives from these sponsoring companies formed the Committee on Hydrocarbon

Research which administered the project. Six members from this committee were selected as an Advisory Committee to the main group. They maintained close contact with the project and followed its work in detail.

A paper entitled "The Synthesis, Purification and Properties of Hydrocarbons of Low Molecular Weight, a Report on API Research Project 45," prepared by Cecil E. Boord and Wheeler G. Lovell, was presented by Lovell at the Session on Fundamental Research at Chicago last November (*17*). Prof. Boord of The Ohio State University has been the Director of the project since its inception, 14 years ago. Dr. Lovell, of the Ethyl Corporation, Detroit, Michigan, has been Chairman of the Advisory Committee since the project was reorganized in 1944 and was officially made one of the projects under the supervision of the ACFRCPP. Their paper covers in detail the historical background, organization, objectives, accomplishments, techniques developed, and publications of the project.

APIRP 45 has three main objectives—the synthesis, purification, and properties of hydrocarbons; their engine combustion characteristics; and hydrocarbons for superpurification and physical-constants measurement.

The project has produced or synthesized 270 products; these hydrocarbons are produced in quantities of several gallons in a form pure enough for engine testing. All samples are studied at General Motors for engine performance, and a portion of those hydrocarbons that show unusual promise is sent to the Engine Research Laboratory of the Ethyl Corporation for testing under supercharged engine conditions. The information developed from the engine testing of hydrocarbons has been of inestimable value to the petroleum and automotive industries.

More than half of the synthetic hydrocarbon products made at Ohio State have been sent to APIRP 6 for purification to make the two series of high purity standard samples of hydrocarbons prepared, first at the National Bureau of Standards, now at the Carnegie Institute of Technology. Most of the hydrocarbon compounds that have been purified by APIRP 6 were prepared by APIRP 45.

The reader will be particularly interested in the portion of the Boord-Lovell paper devoted to the synthesis of low molecular weight hydrocarbons in the various series of hydrocarbons such as the paraffins, the olefins, the cycloparaffins, and the aromatics. Some of our best information on the engine knocking characteristics of various hydrocarbons has come from the work of this project. The lessons learned, and the relation between structure and knock, are very ably brought out in their paper. Another important phase of this work is the study of blends of hydrocarbons with respect to knocking. This study is an important part of the future program of the project. The paper is concluded by a list of 27 literature references pertinent to the work of APIRP 45.

Additional references of interest are "A Ten Year Summary" of APIRP 45, by Boord (*15*), and a recent revision of this summary entitled "Fourteen Years of Hydrocarbon Research," which covers the project to July 1, 1952, from the point of view of organization and administration (*15*).

The latest annual report (*3*), covering the period July 1, 1951 to June 30, 1952, lists the 270 compounds which have been synthesized or certified by the project during the 14 years of its existence. A cumulative tabulation of the physical constants of these compounds appears on page 115. Knock test data tables which contain all of the engine data accumulated up to July 1, 1952 constitute Tables I to IV inclusive. Appendix, Item F, starting on page 97, lists 15 annual reports, 53 serial bulletins, and 45 publications in scientific books and journals, which constitute the principal literature on the subject.

A book which will contain reprints of papers on the synthesis work of Project 45, will be obtainable in 1953, probably from the API (*2*).

Hydrocarbon Research in Some Foreign Countries

In addition to the very productive work carried out in this country on hydrocarbons derivable from petroleum and natural gas, several other countries have done research work in this field and secured significant results.

United Kingdom. Sir Boverton Redwood, (*143*) in his very complete treatise on petroleum, covered the early work on the identification of hydrocarbons in petroleum up to 1915. The treatise by Redwood is mentioned because it is the best early reference in English.

Fundamental research on hydrocarbons in the United Kingdom is conducted under the auspices of bodies such as the Institute of Petroleum, the Chemical Research Laboratory of the Department of Scientific and Industrial Research, and the universities. Published reports may be found in the journals of the Faraday Society, the Institute of Petroleum, and the Chemical Society.

Early in World War II, the problem of the rapid and certain identification and estimation of the hydrocarbons constituting gasoline and other liquid fuels became pressing in the U. K. as it did here in the U. S. Committees drawn from the oil industry were set up under the Petroleum Board, and later the Ministry of Aircraft Production, for the purpose of solving this problem. The history of this effort on the part of the U. K., which resulted in the establishment of the Hydrocarbon Research Group in 1944, is covered in detail by Bradford (*18*).

Liaison of the Hydrocarbon Research Group with the Institute of Petroleum is provided for by the Research Committee of the institute whose chairman sits as an ex-officio member of the group which is composed of the Hydrocarbon Synthesis Panel, the Spectroscopic Panel, and the Mass Spectrometry Panel. The earliest efforts in the U.K. were directed to absorption spectrometry, and (since 1949) to mass spectrometry.

Synthesis of pure hydrocarbons was also carried out from 1944 to some time in 1948 on selected paraffins in the C_7 to C_{11} range, particularly those with several branched chains, of cycloparaffins, and of substituted aromatics.

The Hydrocarbon Research Group of the Institute of Petroleum discontinued its work on synthesis of pure hydrocarbons in 1948. With the establishment of the Mass Spectrometry Panel in 1948, means had to be found to ensure a supply of pure hydrocarbons for calibration purposes. At that time the Chemical Research Laboratories at Teddington (operating under the Department of Scientific and Industrial Research) agreed to supply such hydrocarbons in collaboration with the members of the Hydrocarbon Synthesis Panel (*72*).

A recent summary (*129*) of the last report issued by the Chemical Research Board (which is advisory to the Chemical Research Laboratory) states that the Organic Group of the Chemical Research Laboratory works on preparation of pure hydrocarbons for chemical standards and determination of constants of these compounds. The report (late 1952) also states that 33 pure liquid hydrocarbons were prepared and are available as samples.

Many of the reports covering the work of the Hydrocarbon Research Group have been published in various journals. The papers published prior to September 1947 are listed in a report of the group published in that year (*74*). Many of the reports are unpublished but are on file at the library of the Institute of Petroleum and probably in other British libraries.

Fifteen references from the *Journal of the Institute of Petroleum* definitely a result of the work of the Hydrocarbon Research Group appear in the bibliography of this paper. In addition there are 7 references from that journal on the same subject but not apparently connected with the work of the Hydrocarbon Research Group.

Holland. There is no organization or official coordination of hydrocarbon research in Holland. However, workers in this field know each other well; there exists a kind of unofficial coordination. Some research is presently being carried out at the universities under the auspices of the Chemical Society. I. J. Smittenberg is the secretary. Most of this work is in a preliminary stage. Hydrocarbon research supported by industry is sometimes carried out at the universities. Much of the work has been done by individuals connected with the petroleum companies or the universities. Results have been published extensively in various chemical journals in Europe and can be located through *Chemical Abstracts* or *British Abstracts*.

The book by van Nes and van Westen, "Aspects of the Constitution of Mineral Oils" (1951) (*125*), is an outstanding work on the hydrocarbons. Although the primary object of the book was to introduce a new method for structural group analysis, it is also a quite comprehensive survey of present knowledge concerning the constitution of mineral oils. The stress of the book is on the heavier hydrocarbons occurring in petroleum fractions boiling above 200° C.

Of interest also is the book by Wibaut entitled "Chemistry in Wartime in the Netherlands" (*196*) with sections on hydrocarbons, dissociation of aryl ethane derivatives, and structure of the benzene nucleus.

Over 80 references representing a survey of investigations in the field of hydrocarbon chemistry carried out by the Dutch research workers and reported in the last 15 years are included in the bibliography. This list is not complete, but it seems to include the principal contributions pertinent to this paper. Papers presented at the Third World Petroleum Congress held at The Hague, 1951, which are pertinent to the subject matter of this paper, appear in the bibliography.

France. Apparently, very little organized work has been done in France on pure hydrocarbons. There, the work is carried out at L'Institute Francais du Petrole. According to L. Robert of that institute (*145*), a "Group of Applied Physics" at the institute has undertaken the study of pure hydrocarbons to determine their physical constants. Incidentally, L'Institute Francais du Petrole collaborated with API Research Project 44 in determining the Raman spectra of five pure hydrocarbons.

Four French papers pertinent to the consideration of hydrocarbons derivable from petroleum are cited. Messrs. Jacque, Givaudon, Schmit, and Delion obtained a number of paraffin hydrocarbons in pure form by the superfractionation of synthetic gasoline (*75*). Laurent studied the possibilities of producing isobutane and isooctane for aviation gasoline in France (*92*). Souillard and Jungers investigated, in particular, the preparation of cyclohexane (*171*). Cologne and Berthous did research on the preparation of six normal and two cycloparaffins in pure form (*26*).

During the discussion of hydrocarbon research as reported in the proceedings of the Third World Petroleum Congress (*213*), it was stressed that there was a need for international exchange of fundamental data on hydrocarbons (especially in Europe). Fundamental data obtained through ACFRCPP is being sent to many countries. Exception are those listed in "Subgroup-A Destinations" (considered to be under Russian domination).

Present Status of Our Knowledge

Where do we stand after 25 years of a well-coordinated attack on the problem of determining what hydrocarbons are derivable from petroleum. Hill has summed this up very well in his paper: "Petroleum-What Is It?" presented at the Unsolved Problems Symposium, sponsored by the Division of Petroleum Chemistry, American Chemical Society (*63*). Hill points out that, except for normal paraffins, no individual hydrocarbon beyond C_{12} has as yet been isolated from petroleum and identified. Our knowledge has been extrapolated into the higher molecular weight range, guided by general information from what Hill called "hydrocarbon-type analysis." By these methods, the average distribution of the carbon atoms between aromatic rings, naphthene rings, and paraffin side chains can be estimated, and indications can be obtained as to the type of ring structure. Hill advises that our extrapolations are of doubtful value; however, they have had a real value in estimating what hydrocarbons of higher molecular weight are present in crude petroleum, and have been useful as a guide in selecting what hydrocarbons in this category should be synthesized by API Research Projects 42 and 45.

Shaffer and Rossini in their recent paper (*159*), brought out strikingly our limited knowledge of this subject. One important task undertaken by APIRP 6 was to isolate and identify the individual hydrocarbons in one representative crude petroleum. Table 1 of their paper lists the hydrocarbons isolated from this crude with the formula, name of compound, type, boiling point in °C. at atmospheric pressure, purity of the best sample isolated (mole per cent), estimated amount in the crude (volume per cent), and references for each hydrocarbon listed. Table 2 of their paper, reproduced here as Table I, summarizes the hydrocarbons isolated from this crude by boiling range fractions. Note that the compounds isolated to date only account for 42.5% of the crude.

Table I. Summary of the Hydrocarbons Isolated from One Representative Crude Petroleum

API Research Project 6—Carnegie Institute of Technology

	Boiling Range, °F.					
	Below 104	104 to 356	356 to 446	446 to 572	Above 572	Entire Petroleum
Total number of compounds	7	92	21	9	1	130
Estimated percentage of the entire petroleum constituted by the number of compounds isolated	4	27.2	4.7	5.7	0.9	42.5
Estimated percentage of the original petroleum occurring in the given boiling range	4	33	14	17	32	100
Estimated percentage of the original petroleum constituted by the number of compounds isolated in the given boiling range	99	83	33	34	3	42.5

Rossini (1938) (*146*) presented a paper, "Hydrocarbons in the Lubricant Fraction of Petroleum." This, with his recent paper with Mair (*150*), gives a very good resume of our present knowledge of the lubricant fraction of the one crude petroleum selected by APIRP 6 for study.

Until recently, it was generally believed that olefins and acetylenes were not present in crude petroleum and that they were formed by decomposition during the fractionation of the crude by distillation. Rossini, in his joint paper with Mair (*150*), states that no olefin or acetylene hydrocarbons appear to exist in naturally occurring petroleum in any significant amount. Hill, in his paper (*63*) points out that we used to state categorically that crude petroleum contained no olefins. Recent evidence that certain crude petroleums do contain molecules with olefinic linkages is too strong to be ignored. Hill refers in this connection to two recent papers: one by Fred and Putscher (1949) (*46*) entitled, "Identification of Pennsylvania Lubricating Oils by Infrared Absorption," and another by Haak and Van Nes (1951) (*55*), "Investigation into the Olefinic Components of a Pennsylvania Crude Oil."

The effort, in this country alone, to determine the hydrocarbons derivable from petroleum, has cost considerable money. API funds allocated to Project 6 since 1927 will total slightly more than $1,000,000 at the end of the current fiscal year. The annual budget of this project is at present $96,000. A total of over $1,200,000 has been allocated to the Projects 42, 44, and 45 up to July 1, 1953. Much of this total has been spent on problems related in some way to the general objective of learning more definitely the composition of petroleum, or some portion thereof. The effort so far has been costly, but much progress has been made in knowledge of petroleum composition, particularly in regard to processes and equipment for carrying out this type of research.

Future Program

In their paper, "Composition of Petroleum" (*150*), Rossini and Mair state that it is planned that the work of API Project 6 on the exhaustive examination of one representative crude petroleum will be continued into those portions not yet fully investigated. Improvements in fractionation, extraction, crystallization, and other separating techniques are being studied to cope with the more difficult problems ahead. It is planned to continue the purification of additional API Standards and Research Samples, giving priority to those most in demand.

Rossini, Hill, and others have pointed out the great difficulties which will be encountered in isolating and identifying the hydrocarbon in the gas oil, lubricating oil fraction, and wax cut of the crude. Hill, in his paper (*63*), lists the following means at our disposal for tackling this problem:

Actual isolation and identification of hydrocarbons in this range. (This looks a long way off).

The isolation and identification of compounds in a lower range, but enough higher than we have been working on to make extrapolations more plausible.

Correlations between physical properties and constitution.

Spectroscopic data.

Synthesis of possible structures and comparison of properties with isolated narrow fractions.

Conclusion

The total effort to learn the hydrocarbon composition of crude petroleum has been tremendous. One hundred thirty hydrocarbons definitely and quantitatively have been isolated from one crude petroleum and positively identified. These compounds, representing 42.5% by volume of that crude are mostly confined to the lower boiling portion. A great many more hydrocarbons are derivable from crude petroleum. Although a considerable number of these have been synthesized, they have not as yet been isolated from crude petroleum itself in anything like a positive, quantitative manner.

The use of spectrometers for analyzing mixtures of hydrocarbons is increasing all the time. The need to know the hydrocarbons present in the higher boiling fractions of petroleum is becoming more pressing from year to year. The analysis of the representative crude petroleum will be continued with every available tool. The immediate emphasis will be on the isolation and identification of several representative hydrocarbons in the gas oil boiling range. Further efforts will then most likely be directed toward obtaining similar information on the lubricant fraction of the crude.

Table I. Periodicals Containing Works of Early Investigators

American Chemical Journal, Baltimore, 1879.
Annales scientifiques de l'université de Jassy, Roumania, 1900. (Text in French).
Berichte der deutschen chemischen gesellschaft, Berlin, 1868.
Bitumen, Wiesbaden, 1902. (Text in German).
Bulletin de la societe chimique de Paris, Paris, 1863.
Chemical News, London, 1860.
Chemiker-Zeitung, Cöthen, 1877.
Chemische Revue über die Fett-und Harzindustrie, Hamburg, 1894.
Chemische Zeitschrift, Berlin, 1901.
Chemisches Zentralblatt, Berlin, 1856.
Comptes rendus hebdomaires des séances de l'academie des sciences, Paris, 1835.
Dinglers Polytechnisches Journal, Berlin, 1820.
Gornyi Zhurnal, Leningrad, 1825. (Text in Russian).
Industrial and Engineering Chemistry, 1909.
Journal of the American Chemical Society, 1879.
Journal of the Chemical Society, London, 1849.
Journal of the Franklin Institute, Philadelphia, 1826.
Journal für praktische Chemie, Leipzig, 1834.
Journal of the Russian Physical-Chemical Society, Leningrad, 1869. (Text in Russian).
Journal of the Society of Chemical Industry (London), 1882.
Liebigs Annalen der Chemie, Leipzig, 1832.
Memoirs of the American Academy of Arts and Sciences, Boston, 1833.
Monitorul Petrolului Român, Bukarest, 1900. (Text in Roumanian).
Naphta, Leipzig, 1893. (Text in German).
Neftyanoe Dielo, Baku, 1898. (Text in Russian).
Petroleum Industrial and Technical Review, London, 1899.
Petroleum Review, London, 1903.
Petroleum: Zeitschrift für die gesamten Interessen der Petroleum-Industrie, Vienna, 1905. (Text in German).
Philosophical Transactions of the Royal Society, London, 1665.
Proceedings of the American Academy of Arts and Sciences, 1846.
Proceedings of the American Philosophical Society, 1838.
Proceedings of the Royal Society (London), 1854.
Transactions of the Baku Section of the Imperial Russian Technical Society (Trudy Baku), Baku, 1886. (Text in Russian).
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Commercial Development of Hydrocarbons From Petroleum and Natural Gas

GUSTAV EGLOFF, MARY ALEXANDER, and CATHERINE ZIMMER

Universal Oil Products Co., Des Plaines, Ill.

The literature of the commercial development of hydrocarbons derivable from petroleum and natural gas is meager until about 1935. Since 1945, the literature has become extensive. This study includes the paraffins, olefins, alicyclics, aromatics, acetylene, and separation processes. Journals and sections of journals of value are discussed. The main subject heads to be consulted in *Chemical Abstracts* are given. There is considerable overlapping of subject matter in the U. S. patent classification system; pertinent classes are listed. References in the bibliography were selected to show the various types available.

The quantity of literature available on the commercial development of hydrocarbons from petroleum and natural gas is indicative of the increasing interest in this subject as well as of the vast expansion of the petrochemical industry over a period of relatively few years. Published information on the commercial development is meager until about 1935. During the late thirties, the growing interest in hydrocarbons which have high wartime significance became apparent. During the war, publications on these hydrocarbons increased, but the information therein is somewhat limited because of security regulations. Since 1945, the literature has become extensive on manufacture, separation, and purification of all classes of hydrocarbons produced commercially. While the primary interest immediately after the war was in the field of aliphatics, producing aromatics began to receive increasing attention, and the literature since 1950 has been voluminous.

The present study of the literature includes that relating to the paraffins of which propane and the butanes are the principal commercial products for manufacture of chemicals, to olefins of which ethylene and butadiene are most important, to alicyclics, to aromatics of which toluene, benzene, and the xylenes are of commercial interest, to acetylene, and to separation processes.

Paraffins

The commercial production of propane and the butanes has been the subject of technical articles since the beginning of the liquefied petroleum gas industry in the early 1920's. The number of articles appearing has increased with advances in technical knowledge. Most of these articles relate to the design and operation of natural gasoline plants and recovery of the gases therefrom. Much information is also available in articles on separation processes. Isobutane, which is present in comparatively small quantities in natural gas, was produced by isomerization of normal butane during World War II. The isomerization processes have been discussed in the literature, and descriptions of them are still given in the process sections of some oil journals. Selected references are given under Propane-Butanes in the bibliography.

There is very little information in the literature on commercial production of the individual higher paraffins. A number of these, however, are marketed by petroleum companies for use in research, and announcements of their availability are made in the oil journals. References to these compounds are listed under Paraffins, Miscellaneous.

Olefins

Although utilized for chemical manufacture in some short-lived ventures prior to World War I and continuously since the early 1920's, ethylene manufacture and separation were the subjects of relatively few publications outside of patents before the end of World War II. Since that time numerous articles have been published on ethylene production by cracking C_2-C_3 gas fractions and selected oil fractions and on its separation by adsorption processes. Its production is the greatest of any of the hydrocarbons from petroleum, and much literature is available on its utilization. A selected list of references is given in the bibliography under Ethylene.

Inasmuch as sufficient quantities of propylene to meet demands have been available from conventional thermal and catalytic cracking processes and from ethylene manufacture, there is very little literature on the specific subject of propylene manufacture. Information on its extraction is to be found in articles on separation processes. The butylenes are also obtained as by-products of conventional cracking, but the large demand for them for gasoline and synthetic rubber brought about the commercial development during World War II of dehydrogenation processes for their production. Selected references to the butylenes and propylene are cited under Olefins, Miscellaneous in the bibliography.

With the advent of the synthetic rubber industry at the beginning of World War II, articles began to appear on the commercial production and separation of butadiene. Articles on the progress of butadiene production appeared, but security regulations limited the amount of technical information given. More specific information was divulged after the war, and improvements in the processes, catalysts used, and equipment continue to appear in the literature. Selected references are listed under Butadiene in the bibliography.

Alicyclics

There is very little information available on the commercial production of pure cycloparaffins. Although feed stocks composed of this class of hydrocarbons are used in the manufacture of aromatics, chemical-grade cycloparaffins have not been produced extensively. Highly purified cyclohexane is being used in production of nylon. References to the cycloparaffins are listed under Miscellaneous.

Aromatics

Toluene was produced commercially from petroleum during World War I at the rate of 3,000,000 pounds per month, and a limited number of articles on its production appeared during this period. No chemical grade aromatics were produced from that time until World War II, when large scale commercial production was initiated to meet requirements for TNT. Both the extractive process and the catalytic reforming processes used were discussed in the literature. Its production by the newer catalytic reforming processes has been discussed recently. References are listed under Toluene.

Although chemical-grade benzene was not produced commercially prior to 1949, potential interest became increasingly apparent after the end of World War II. With the unprecedented demands brought about by the Korean War and the rapid growth of such markets as plastics, detergents, and nylon, commercial production was rapidly increased. The major portion of petroleum benzene is produced by the newer catalytic reforming processes such as platforming and an increasing number of articles have been appearing since 1950 on this subject. The separation and purification of petroleum-produced benzene has also necessitated new adsorption and extraction processes which are discussed in the literature. Selected references are listed under Benzene.

The commercial utilization of *o*-xylene for phthalic anhydride in 1945, of *p*-xylene for synthetic fibers more recently, and the numerous applications of isophthalic derivatives from *m*-xylene have brought about intense interest in the production and separation of the xylenes. These compounds are produced by the catalytic reforming processes used for benzene and toluene and are discussed in articles on these processes. Fractionation processes for separation of *o*-xylene and fractional crystallization for separation of *p*-xylene are discussed in the recent literature. References to the xylenes are listed under Aromatics, Miscellaneous.

The commercial production of styrene attained high importance during World War II in connection with the synthetic rubber program, and demands have continued to increase because of new developments in and requirements for plastics. The literature appearing during the war was limited by the security regulations, but rather extensive information in aviation gasoline, was another hydrocarbon of importance during the war. It was not produced for a number of years thereafter, but interest has recently been renewed because of its utilization in a process for making phenol and acetone simultaneously. The literature to date on its manufacture is rather sparse, although considerable has been published on its utilization. References to styrene and cumene appear under Aromatics, Miscellaneous.

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Acetylene

Although much has been published over the past 30 years in reference to semicommercial production of acetylene from methane, acetylene has only recently been produced commercially from natural gas in the United States. After the cessation of hostilities in Europe in 1945, a number of articles were published on production in Germany. While only the Huels plant utilized natural gas and for only a short time, the technical information is applicable. These articles were based on PB (Publication Board), or TIIC (Technical Industrial Intelligence Committee) and FIAT (Field Information Agency, Technical) and BIOS (British Intelligence Objectives Subcommittee) reports which should be consulted in any extensive study of the subject. An increasing number of articles is appearing on commercial production in the United States, and on separation processes which are of primary importance in successful commercial production. A number of recent articles discuss the utilization of acetylene and compare it with ethylene as a starting material for chemical products. Selected references appear under Acetylene.

Separation Processes

It should be emphasized that the development of separation processes has, to a large extent, made possible production of the hydrocarbons from petroleum and natural gas. Large volumes of many of these hydrocarbons are naturally present in the raw materials or in the gases produced by refining operations, and separation is the only problem. For those hydrocarbons requiring special manufacturing processes such as benzene and acetylene, processes for purification are also necessary. Separation process articles are listed under Separation Processes in the bibliography except for those articles which relate to only one compound.

Types of Information Available

The types of information on hydrocarbons from petroleum and natural gas vary widely. The patent literature on manufacture and separation of the hydrocarbons is voluminous. Articles in chemical, engineering, and oil journals include reviews, descriptions of processes, descriptions of entire plants, discussions of construction materials for these plants, discussions of the adaptation of conventional facilities for production of specific hydrocarbons, discussions of utilization, enumeration of plants operating, analyses of present requirements, and predictions of future demands. Many of these journals also publish news items announcing the availability of new hydrocarbons and the construction of new plants. Recently a number of journals have established the practice of publishing staff reports on a specific product or group of products. These give the present status of processes from a technical standpoint and often discuss the economics of various processes and utilization of the product. Although the actual technical information included is brief, good comparisons of processes and source materials are often found in this type of article.

The selected references listed under the names of individual hydrocarbons, classes of hydrocarbons, and Separation Processes are principally articles giving technical information on processes and plant design and the staff-report type of review. Some articles have been included because of their historical significance in the long-range development of modern processes. The amount of detail given in the technical articles varies. In general, simplified flow diagrams, operating conditions, specifications on starting materials, analyses of products, and a discussion of various phases of the process are included. In some instances a discussion of plant costs, uses, and historical background is also given. Articles relating to pilot plant operation of processes which have been commercialized are cited as well as those on full scale operation. Under Review Articles, some comprehensive reviews of various phases of the production of hydrocarbons from petroleum are cited. A number of these are particularly valuable because of the lengthy bibliographies which have been included.

Principal Journals

The principal journals in which information on the commercial production of hydrocarbons from petroleum and natural gas is found include *Industrial and Engineering Chemistry, Chemical Engineering, Chemical Engineering Progress, Chemical and Engineering News, Chemical Week, Petroleum Processing, Petroleum Refiner, Oil and Gas Journal,* and *Petroleum Engineer.*

Articles and news items also appear frequently in *Petroleum World* and *World Petroleum,* the *Proceedings of the American Petroleum Institute,* gas journals such as *LP Gas* and the *American Gas Association Monthly,* and publications of some private companies such as *Heat Engineering* and the *Standard Oil of California Technical Review.*

The chemical engineering journals have carried rather complete descriptions of most of the processes used in the manufacture and separation of hydrocarbons. Articles in *Industrial and Engineering Chemistry* and *Chemical Engineering Progress* very frequently contain a discussion of theoretical considerations and engineering calculations. *Industrial and Engineering Chemistry* has published a Unit Operations Review section, which reviews the status of processes used for hydrocarbons as well as for other chemicals, annually since January, 1946. *Chemical Engineering Progress* includes the discussions of papers at American Institute of Chemical Engineers' meetings which often bring out interesting details. *Chemical Engineering* (*Chemical and Metallurgical Engineering* prior to August, 1946) publishes a special type of articles called the Commodity Survey on specific products. These evaluate different processes used in production and the markets for a given product.

The news magazines publish announcements of plants, which include such information as location, processes used, cost of plant, and date of initial production. In *Chemical and Engineering News,* the latest items are usually found under "conCENtrates." This magazine publishes, in addition to news items and articles of general interest in the petrochemical field, excellent staff reports on the technical and economic status of various products of widespread interest at the time. *Chemical Week* (*Chemical Industries Week* prior to June, 1951 and *Chemical Industries* prior to January 20, 1951) is one of the best magazines for keeping up-to-date on the commercialization of new processes. The articles therein usually include only brief technical descriptions of plants, and discussion is usually concerned with the significance of processes and products. The technical type of articles which appeared in *Chemical Industries* are now carried by *Chemical Engineering.*

The oil journals carry both news items and technical articles. The technical articles frequently relate to the operations in a specific plant rather than to the general operation of the process. These journals also carry timely staff reports on products and processes which are particularly good from a comparative viewpoint. *Petroleum Processing* (Section R of *National Petroleum News* prior to 1946) now has a Petrochemical Processing

Section, which appears every month. It also has a special section on Patents which lists new patents according to their classification. The Process Issue of the *Petroleum Refiner* is now carrying a special section on Petrochemical Processes. In the September 1952 issue for example, Extractive Distillation for Aromatic Recovery, Modified SO_2 Extraction for Aromatic Recovery, Udex Extraction, Ethylene Manufacture by Cracking, Ethylene Production, Hypersorption, Hydrocol, Dehydrogenation (for butadiene), and Butadiene Process, were described. These descriptions include the main essentials of the process, simplified flow diagrams, and the name of the company offering it. Formerly these processes were described under the Process Section.

The Oil and Gas Journal carries a process section in its Annual Refinery Number under the Annual Refining Section-Processing Details. Most of the processes in current use can be found in these special sections. The *Oil and Gas Journal* has recently been carrying a special type of article called Petrochem Report which usually gives a timely discussion of specific commercial plants. In the *Petroleum Engineer*, articles on hydrocarbons from petroleum and natural gas are found under Section C, Refining and Gas Processing. This journal publishes a Reference Annual which usually contains more technical articles on hydrocarbon production than do other issues.

European developments are covered in the *Petroleum Times*, *Petroleum* (London), and the *Institute of Petroleum Review*. *Canadian Chemical Processing* is carrying an increasing number of articles as a result of the rapidly growing petrochemical industry and the vast new petroleum and gas fields which have been discovered in that country. There are many Japanese and Russian articles referring to possible commercial production of hydrocarbons from petroleum. In the case of Russian references, it is not known whether processes described have actually been used commercially.

Because of the relative newness of the petrochemical industry, very few books have been published which have chapters on the commercial development of hydrocarbons from petroleum and natural gas. A list of miscellaneous books and pamphlets of interest is given in the bibliography.

Indexes

No attempt will be made to outline a clear-cut index-to-article procedure inasmuch as individual searches will vary with the specific information wanted and will require some ingenuity on the part of the searcher.

In reviewing the literature for the present paper, about 600 references were considered. These were located by checking *Chemical Abstracts* Indexes, bibliographies prepared for the use of our research men, clipping files maintained by our library staff, and perusal of the tables of contents of recent issues of chemical engineering and oil journals. It is also helpful to check the author indexes for the names of the principal contributors to a given field and to look into the publications of private companies which are available in some libraries.

In searching the subject indexes to *Chemical Abstracts*, the main subject headings to be consulted are chemicals; gases; gas, fuel; gas, natural; gasoline; hydrocarbons; the individual hydrocarbons—i.e., acetylene, benzene, butadiene, butane, butene, and toluene; oils; petroleum refining, and the processes—i.e., adsorption, alkylation, distillation, fractionation, isomerization, and polymerization. There are many subheadings under each of these general subject headings. In general, the subheadings, "formation of," and "preparation of," refer to laboratory syntheses. Under "manufacture of" and "separation of" individual compounds or classes of hydrocarbons, references are mainly to patents.

Petroleum refining is perhaps the most important main heading in *Chemical Abstracts* to be consulted if a comprehensive but nonexhaustive search is being made. The subheadings "cracking- to aromatic and saturated hydrocarbons," "gas manufacture," "gases from," and "reviews" are important. Under "gases from" the headings are more specific—"fuels and chemicals for petroleum industry," "hydrocarbon extraction in liquid phase from," "hydrocarbon recovery from," "CH_4 recovery therefrom," "olefin recovery from," "C_3H_8 recovery from," "purification of," "pyrolysis and polymerization," and "sepn."

When investigating the abstracts, an article should not be eliminated on the basis of a title alone for these are often deceptive. For example an article entitled "The Utilization of Benzene" may contain detailed information on its commercial production. An article entitled "XYZ Company produces 180,000,000 million lbs. of ethylene" may simply be an announcement that the plant is operating, but again, it may contain a highly detailed description of the plant itself, construction materials used therein, and results of operations. "More Propane Recovery" may be merely a half-column story stating that more propane is being recovered from a specific plant, but it could also be a highly technical article on how the result is accomplished.

U. S. Patent Classes

The principal United States patent classes which should be searched in a survey of the manufacture of paraffinic, olefinic, and aromatic hydrocarbons include the main classes 196, mineral oils, and 260, chemistry, carbon compounds. There is considerable overlapping of subject matter in the United States patent classification system because no attempt is made to cross index or cross file patents on many different topics. The classes suggested for search will many times contain a great deal of subject matter which is not pertinent to the search being conducted. For example class 196 has about 50 subclasses dealing with distillation of petroleum, and at the same time class 202 deals with distillation from a broad standpoint. Similarly many cracking processes are directed to olefin and aromatic production and many subclasses of class 260 are directed to hydrocarbon production by thermal or catalytic processes. The United States patent classification is rather inflexible and much cross searching is necessary to find all of the patents on any given subject. This is illustrated by the following pertinent classes.

I. Lower Paraffins

Class 196, Mineral oils
- Subclasses 7, Mineral oils from hydrocarbons gases
  - 11, Weathering or rectification of "wild gasoline"
  - 47–70, Distillation, vaporizing processes, with cracking
  - 61, Vapor phase cracking
  - 71, Distillation without cracking

Class 260, Chemistry, carbon compounds
- Subclasses 676, Acyclic
  - 683.4, Alkylation or condensation
  - 683.5, Isomerization
  - 683.6, Hydrogenation

II. Lower Olefins

Class 196, Mineral Oils
- Subclasses 47–70, Distillation, vaporizing processes, with cracking
  - 52, With Catalysts

Class 260, Chemistry, carbon compounds
- Subclasses 677, Acyclic, unsaturated
  - 678, Acyclic, unsaturated, triple bond
  - 679, Acetylene
  - 680, Diolefins, including butadiene
  - 683.3, by dehydrogenation
  - 676, dehydrogenation process

III. Aromatic Hydrocarbons

Class 196
- Subclasses 47–70, Cracking processes

Class 260, Chemistry, carbon compounds
- Subclasses 668, Aromatic
  - 671, Alkylation
  - 671, Alkylation
  - 672, Dealkylation
  - 673, From acyclic hydrocarbons
  - 673.5, Six or more C Atoms in Molecule
  - 669, Vinyl, styrenes
  - 674, Purification or recovery

IV. Hydrocarbon Solvents

Class 196, Mineral oils
- Subclass 14.46, Hydrocarbon solvents

Class 252, Compositions
- Subclass 364, Solvents

V. Azeotropic Distillation

Class 202, Distillation
Subclasses 41, Two component
42, Azeotropic mixtures

VI. Sorption Processes

Class 196, Mineral oils
Subclasses 4, Dehydration with chemicals, adsorbent, or filtering material
147, Treatment with filtering material

Bibliography

A list of patents has not been given in the bibliography inasmuch as specific searches would be necessary for any project. In selecting articles for the bibliography, an attempt was made to represent the various types of information available. News items, however, have not been cited. Some references are included on processes which have been offered but have never been put into operation and on processes which have been in commercial operation but are currently not being used. Under miscellaneous headings, the specific subject matter is noted after the reference unless the article includes discussion of a number of hydrocarbons or processes.

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Oxygen-Containing Hydrocarbon Derivatives From Petroleum and Natural Gas

MARTIN M. PADWE

Jefferson Chemical Co., Inc., Box 4128, North Austin Station, Austin, Tex.

Derivatives of petroleum and natural gas which contain oxygen are obtained primarily by oxidation, hydration, hydrolysis, and esterification, and the general literature on these processes, as well as on the Oxo, Synol, and Fischer-Tropsch processes, is presented. The literature concerning individual classes of oxygen-containing compounds and specific, important members of each class is next described. Catalytic operations are an inextricable part of many of the processes involved; attention is therefore directed to the literature on catalysis. Pertinent class numbers of the U. S. Patent Office are discussed. The literature presented is restricted to material published after 1936, although on occasion important earlier references are given.

Those derivatives of petroleum and natural gas which contain oxygen are obtained directly or indirectly from these basic hydrocarbons primarily by oxidation, hydration, hydrolysis, esterification, alkylation, and by hydrogenation of carbon monoxide. These processes either are generally applicable to the synthesis of many members of a specific class of oxygenated compounds, such as the synthesis of alcohols by hydration of olefins, or more frequently, give a mixture of oxygenated compounds of more than one class, e.g., oxidation and carbon monoxide hydrogenation. It is for this reason that the process literature is to be emphasized rather that the literature on individual compounds. An attempt will also be made to present selected literature on some individual compounds as well as on some groups of compounds. However, before considering the latter types of literature, attention must be directed to the general basic literature.

Basic Literature

The comprehensive treatment given the subject compounds by Ellis (*26*) has restricted the literature which is to be presented to material published after 1936, although on occasion important earlier references will be given. Emphasis has been placed on those publications which contain fairly extensive bibliographies, e.g., review articles and monographs.

Perhaps the most satisfactory method of quickly obtaining information on, and literature references to the desired oxygenated compounds is to refer to Kirk and Othmer's "Encyclopedia of Chemical Technology" (*58*). Although not yet complete, most of the oxygenated compounds and the processes used in their preparation are described in the volumes published. The importance of this work cannot be overemphasized. By consulting Thorpe (*113*) one can supplement information obtained from Kirk and Othmer. A new edition of Houben-Weyl (*49*) is in the process of publication and promises to be another important source of information.

Individual works of importance are Brooks (*11*), which appears to be the most complete single volume in the field with respect to the oxygenated and other derivatives of aliphatic and naphthenic hydrocarbons; Goldstein (*40*); Faith, Keyes, and Clark (*31*), in which brief descriptions of commercial methods of preparation of many oxygenated compounds from hydrocarbons are given, although no literature references are cited; and finally Brooks and Dunston (*12*), which supplements information on old processes and deals also with subjects and processes which are new since 1937.

Review publications give considerable attention to the desired products. *Reports on the Progress of Applied Chemistry*, is published annually by the Society of Chemical Industry, London (*91*). Two sections of *Reviews of Petroleum Technology* (*95*), are of special interest—the section on derived chemicals and the section on petroleum literature. The latter section is concerned primarily with the nonperiodical literature, such as books and pamphlets. This first volume of *Progress in Organic Chemistry* contains a section, "Chemicals from Petroleum," which emphasizes the oxygenated derivatives (*89*).

A special guide to the publications known as PB, FIAT, and BIOS reports, many of which are included in references to the literature, is provided in the *Bibliography of Technical Reports* (*115*). Lederman and Green (*64*) give a more detailed explanation of such publications.

Many other encyclopedias, books, and review publications could be mentioned, but the above-mentioned publications are deemed essential to the location of the desired literature on the oxygenated compounds.

Process Literature

The process literature is presented in some detail in the work by Shreve (*105*), and especially by Groggins (*42*). Earlier work on oxidation processes is adequately dealt with in the AMERICAN CHEMICAL SOCIETY Monograph by Marek and Hahn (*69*).

The September 1948 issue of *Industrial and Engineering Chemistry* contained the first Unit Processes review. This first review embraced developments in unit processes reported in the literature since approximately the start of World War II. Among the the pertinent processes covered by the first review were oxidation, hydration and hydrolysis, esterification, alkylation, halogenation, and sulfonation. Thereafter, these reviews appeared annually with the exception of the hydration and hydrolysis section which appeared biennially. The section on hydrogenation and hydrogenolysis first included the hydrogenation of carbon monoxide in 1951. The literature surveyed by these process reviews is very extensive and considers not only the journal literature, but the patent and PB literature as well. These reviews, in addition to providing the most expedient method for keeping abreast of the current literature for the processes involved, serve as a fairly comprehensive literature source for the time period covered by all the reviews.

Much of the literature through 1947 on the preparation of oxygenated compounds by the hydrolysis as well as by the dehydrochlorination of organic chlorine compounds is contained in a work by Huntress (*51*).

Variations in the conditions employed in the hydrogenation of carbon monoxide have led to a group of processes all of which yield important quantities of oxygenated materials, either as by-products or as the main product, the initial carbon monoxide and hydrogen mixture (synthesis gas) being derivable from paraffin gases, especially methane. Two of these processes, although directed primarily to the manufacture of synthetic fuels, have always given considerable amounts of by-product oxygenated materials. These are the Fischer-Tropsch process and the American hydrocarbon process (Hydrocol process). Those processes concerned directly with the production of oxygenated compounds are the methanol and higher alcohol syntheses, the Synol process, and the recent Oxyl process. A recent paper describes a British process in which the amount of oxygenated compounds obtained is intermediate to that obtained in the processes mentioned above. The Oxo process, that is, the catalytic addition of carbon monoxide and hydrogen to olefins to give aldehydes followed by reduction of the latter to alcohols, is almost invariably associated with carbon monoxide hydrogenation in the literature and will be similarly treated here.

Publications by Storch, Golumbic, and Anderson (*110*), U. S. Naval Technical Mission (*118*), Schmidt (*99*), Martin and Weingaertner (*70*), Anderson (*4*), Weil and Lane

(*123*), and Komarewsky, Riesz, and Estes (*60*) include discussions of the majority of the above-mentioned processes except the Oxyl.

Recent papers by Eliot (*25*), Steitz and Barnes (*109*), Cain, Weitkamp, and Bowman (*15*), Weitkamp and Frye (*124*), and Morrell (*78*) are concerned with the distribution of oxygenated compounds in the Hydrocol products; a paper by Gall, Gibson, and Hall (*36*) discusses the British counterpart.

Considerable literature, especially patent literature, deals with processes for the isolation of oxygenated products present in the mixture of hydrocarbons and oxygenated compounds obtained from synthetic fuel processes. An excellent source for such literature, as well as for much carbon monoxide hydrogenation and Oxo process literature, is the U. S. Bureau of Mines, "Synthetic Liquid Fuel Abstracts," now discontinued (*114*). Although general and patent literature are included therein, probably the greatest importance of this work lies in the fact that abstracts are given for German work—that is, the PB reports, the TOM (Technical Oil Mission) reels, etc., whereas *Chemical Abstracts* has not abstracted such material, and the *Bibliography of Technical Reports* abstracts are often inadequate and poorly indexed by comparison.

Special references on the methanol and higher alcohol syntheses are Ellis (*27*), Hirst (*45*), Kastens (*54*), and Giesen and Hanisch (*38*). The Oxyl process is described by Roelen and Beery (*96*). The Synol process literature is covered in references (*4, 38, 110, 118*). Oxo synthesis literature is reported on in some detail by Holm (*46*), Schuster (*100*), and Orchin and Schroeder (*83*).

Recent research on acetylene as the basic hydrocarbon in the synthesis of a number of important oxygen-containing compounds has centered on the work of Walter Reppe and his associates of Germany. Prior to Reppe's work, the most important oxygen-containing derivatives of acetylene were acetaldehyde and acetone.

Three important processes have evolved from Reppe's work. Vinylation, the formation of vinyl derivatives by reaction of such compounds as acids, glycols, and alcohols with acetylene, produces the important vinyl esters and vinyl ethers. Ethinylation is defined as the reaction of acetylene with the carbon atom of a reactant without loss of the triple bond. A major application of the ethinylation reaction is to aldehydes and ketones to give alkynols and alkyndiols—e.g., the reaction of acetylene with formaldehyde to give propargyl alcohol and butyn-2-diol-1,4. Carboxylation (also referred to as carbonylation), the reaction of acetylene with carbon monoxide in the presence of metal carbonyls, has been applied to the production of acrylic acid, acrylates, and hydroquinone.

The polymerization of acetylene to cyclooctatraene and oxygenated derivatives obtainable from the latter is also described (*17, 44, 84, 92, 93, 94*).

The general acetylene literature up to 1938 is reported on by Nieuwland and Vogt (*81*). In addition to a translation of Reppe's own work (*92*), two excellent reviews in the English language of Reppe chemistry are Owens and Johnson (*84*) and Copenhaver and Bigelow (*17*). Several other important works on Reppe chemistry are Reppe (*93, 94*), Hecht and Kröper (*44*), and Piganiol (*86*).

The Diels-Alder reaction (diene synthesis) is the addition of compounds containing double or triple bonds (dienophiles) to the 1,4 positions of conjugated dienes with the formation of six-membered hydroaromatic rings. Hydrocarbons most often used in the reaction are 1,3-butadiene, cyclopentadiene, and isoprene, and dienophiles used include maleic anhydride, acrolein, and acrylic acid. The literature on this process is thoroughly reviewed by Alder (*1*), Kloetzel (*59*), Holmes (*48*), and Norton (*82*).

The reaction of olefins with aldehydes to form 1,3-glycols has recently been reviewed by Arundale and Mikeska (*5*).

Considerable literature exists on the mechanism of hydrocarbon oxidation and autoxidation. The more important of these works are by Waters (*122*), the Faraday Society (*23, 32*), and Frank (*33*).

Organic peroxide formation by the oxidation of hydrocarbons and the reaction of these compounds is especially emphasized by Frank (*33*), Criegee (*18*), Hawkins (*43*), and Kharasch (*57*).

The literature on the use of organic per acids for the oxidation of olefins, especially higher olefins, to epoxides and glycols has been surveyed by Swern (*112*).

Oxidation of hydrocarbons with selenium dioxide can result in the formation of dialdehydes, ketones and diketones, and unsaturated alcohols, depending upon the hydrocarbon used. Such oxidations have been summed up by Rabjohn (*90*).

Since so many of the processes involved are catalytic in nature, a few of the more important publications in the field of catalysis should be mentioned. These are Berkman, Morrell, and Egloff (*6*), Burk (*14*), Griffith (*41*), Schwab (*101*), the Faraday Society (*22*), and Frankenburg (*34*).

A guide to the analysis, as well as to the ordinary physical properties of pure oxygenated compounds is provided for in a work by Huntress and Mulliken (*52*). The physical constants (n_D^{20}, b.p., and m.p.) with references to the original literature for a selected number of organic peroxides are given by Mesrobian (*71*).

Literature on Individual Compounds or Groups of Compounds

The following literature has been selected as a guide to information on a few individual members and groups of oxygenated compounds. These compounds have been chosen either because special literature is available or because of their importance. The German reports included have been chosen since they give detailed information not generally obtainable. For many of the individual members and groups of compounds, the existing literature is almost exclusively patent literature. The pertinent classes of the U. S. patent system will be described later.

Formaldehyde. Oxidation with air or oxygen of natural gas or propane and butane yields not only formaldehyde but also acetaldehyde, propionaldehyde, acetone, methyl ethyl ketone, tetrahydrofuran, methanol, propanol, butyl alcohols, and formic, acetic, and propionic acids. Such literature is covered by Walker (*120, 121*). Two reports on German processes for oxidation of methane to formaldehyde are given by Sherwood (*104*), and by Holm and Reichl (*47*). One of these processes indicates the almost exclusive formation of formaldehyde; it is also indicated that the process was applied to ethane and propane with similar results.

Acetaldehyde. The manufacture of acetaldehyde in Germany by hydration of acetylene is described by Alexander (*2*) and by Brundrit, Taylor, and Ellis (*13*). Acetaldehyde preparation by hydrolysis of lower vinyl ethers is briefly indicated in the latter reference as well as by Leaper and Direnga (*63*). For complete coverage of the literature on these methods, see references (*17, 44, 81, 84, 86, 92, 93, 94*).

Ethyl Alcohol and Higher Alcohols. Two general processes exist for hydrating olefins to alcohols. The first is by absorption of olefins in inorganic acids, primarily sulfuric acid, followed by hydrolysis of the intermediate ester. The second process is the direct catalytic hydration of the olefin. The literature on these processes, especially as applied to ethanol and 2-propanol manufacture, is well covered in the general works listed above, and especially by Brooks (*11*). German work on the catalytic hydration of olefins is described by Kammermeyer and Carpenter (*53*). The preparation of amyl alcohols via chlorination of pentanes and hydrolysis of the halides is described by Kenyon (*56*).

Epoxides and Glycols. The literature on the important aliphatic epoxides and glycols, especially ethylene and propylene oxides and ethylene and propylene glycols, is given by Curme and Johnston (*20*). Detailed descriptions of German processes for the manufacture of ethylene oxide by direct oxidation of ethylene and via chlorohydrination of ethylene are given by Goepp (*39*) and by Vaughan and Goepp (*119*). Brief descriptions of the direct and chlorohydrination processes as well as of the manufacture of ethylene glycol from ethylene oxide by hydration and from ethylene dichloride by hydrolysis are given by Morley (*77*). The hydration of ethylene oxide to ethylene glycol and higher glycols is also described by Brandner and Goepp (*9*).

Allyl Alcohol and Glycerol. These two products are treated together since both involve the chlorination of propylene to allyl chloride. The Shell allyl alcohol process is described by Fairbairn, Cheney, and Cherniavsky (*30*). This same process and the glycerol process are described by Williams (*125*). The German counterpart of these processes is briefly described by Sheely (*102*). Allyl alcohol preparation by isomerization of propylene oxide is given by Lunsted (*68*). The Shell Chemical Co. has published a booklet (*103*), which describes the properties and reactions of this alcohol. Further literature on synthetic glycerol is to be found in the new AMERICAN CHEMICAL SOCIETY Monograph by Miner and Dalton (*73*).

Acetone, Methyl Ethyl Ketone, Acetic Acid, and Propionic Acid. Oxidation of the lower hydrocarbons in the gas phase catalyzed by hydrogen bromide gives carboxylic acids, ketones, and hydroperoxides, depending on the hydrocarbon used. Ethane gives acetic acid; propane gives acetone plus a significant amount of acetic and propionic acids; *n*-butane yields methyl ethyl ketone and acetic acid. Oxidation of branched-chain hydrocarbons such as isobutane and isopentane gives peroxides and hydroperoxides as major products and alcohols as coproducts. This literature is reviewed by Rust and Vaughan (*97*). For information on acetone from 2-propanol, see the general introductory literature. For literature on acetone via cumene oxidation, see below under phenol from cumene.

Carboxylic Acids and Esters. The literature on German methods for the preparation of unsaturated acids and their esters via acetylene, carbon monoxide, and water or alcohol, as well as the application of this reaction to olefins, carbon monoxide, and water or alcohol to give saturated acids and esters, is to be found in references (*17, 44, 84, 92, 93, 94*). Other references on these methods are Blair-McGuffie (*7*) and Natta (*80*). The preparation, properties, and reactions, especially polymerization, of products from the acetylene–carbon monoxide reaction, such as acrylic acid and its esters, are given by Blout and Mark (*8*) and by Schildknecht (*98*). Similarly treated therein are the vinyl esters from acetylene and carboxylic acids, and other vinylation products such as vinyl ethers. The esterification of organic acids with olefins is reviewed by Morin and Bearse (*76*).

Higher Fatty Acids. Oxidation of higher paraffins can give mixtures of acids, alcohols, and carbonyl compounds, although fatty acids may be obtained as the principal product. Publications by Wittka (*126*), Stossel (*111*), Allen (*3*), Lanning (*62*), Zabel (*128*), and Gall (*35*) are of importance in this field.

Adipic Acid. The German process for the preparation of this compound is described by Smith (*108*).

Maleic Anhydride. The preparation of maleic anhydride from C_4 hydrocarbons is given by Bretton (*10*). The preparation of maleic anhydride from benzene is described in Faith, Keyes, and Clark (*31*). Maleic anhydride is an important by-product in the phthalic anhydride process.

Phthalic Anhydride. The preparation of phthalic anhydride from xylene is described by Parks and Allard (*85*) and Levine (*65*). Phthalic anhydride from naphthalene is discussed by Downs (*24*), Shreve and Wilborn (*106*), Ellis (*28*), Hunter (*50*), Young (*127*), and Nash (*79*).

Phenol. The manufacture of phenol by the oxidation of benzene is described by Denton (*21*) and by Simons and McArthur (*107*). The literature on phenol by the oxidation of cumene is partly covered in the reports of Frank (*33*), Hawkins (*43*), and Kharasch (*57*), mentioned earlier. A brief description and flow sheet of the process is given in *Chemical Engineering* (*16*). The patents in this field are mainly held by The Distillers Co., Ltd., Hercules Powder Co., and Allied Chemical and Dye Corp. In this phenol process large amounts of acetone are obtained as a coproduct. It should also be noted that the process may be directed to the production of cumene hydroperoxide and α,α-dimethylbenzyl alcohol. Krieble (*61*) and Kenyon and Boehmer (*55*) describe the preparation of phenol by the chlorination and sulfonation processes.

Alkyl Phenols. The literature on the alkylation of phenols with olefinic hydrocarbons has been reviewed by Price (*88*).

Aromatic Aldehydes. The preparation of aromatic aldehydes from benzene or monoalkyl and polyalkyl aromatic compounds by means of carbon monoxide and hydrogen chloride has been reviewed by Crounse (*19*).

Acetophenone. The oxidation of ethylbenzene to acetophenone is described by Emerson (*29*) and by Pinkernelle and Kroning (*87*).

Aromatic Acids by Oxidation of Side Chains. German work on this subject is briefly reported on by Mittag (*74, 75*) and by Michel and Krey (*72*).

Cresylic Acids. These compounds are discussed by Gallo (*37*).

Naphthenic Acids. Important literature on these acids includes Littmann and Klotz (*66*) and Lochte (*67*). Dr. Lochte is preparing a book entitled "Petroleum Acids and Bases"; publication is expected in late 1953 or early 1954.

U. S. Patent Literature

The U. S. Patent Office provides several guides for obtaining those patents of interest. These are the "Manual of Classification of Patents" (*117*), the index to said manual, plus a series of classification bulletins which define the classes and subclasses listed in the manual. Once having determined the subclasses of interest, one may obtain from the Patent Office, at a charge of about 20 cents a page, separate numerical lists of both the original references and cross references in each subclass. Furthermore, the Patent Office will supply these lists of subclasses and cross-reference lists upon receiving a request which fully describes the subject matter of interest. The subclasses of Class 260, "The Chemistry of Carbon Compounds," are the subclasses of main interest, and these have been recently revised. The definitions for Class 260 are in *Classification Bulletin* No. 200 (*116*). It may be noted at this time that a revised copy of this bulletin, as well as a new index to the "Classification Manual," is scheduled for publication in the near future.

Specific important subclasses of Class 260 are listed.

Heterocyclic compounds

341	Polycarboxylic acid anhydrides
342	Polycarboxylic acid anhydrides by oxidation of aromatic compounds, e.g.—phthalic anhydride from naphthalene or *o*-xylene and also maleic anhydride from benzene
342.6	Anhydrides of acyclic polycarboxylic acids
348	Epoxy compounds, general
348.5	Epoxy compounds by oxidation of olefins—e.g., ethylene oxide by oxidation of ethylene
348.6	Epoxy compounds by dehalogenation (actually dehydrohalogenation)—e.g., ethylene oxide from ethylene chlorohydrin

Carbocyclic or acyclic compounds

449	Hydrogenation of carbon oxides to give mixtures of hydrocarbons, alcohols, esters, and acids
449.5	Methanol synthesis from CO and H_2. Higher alcohol synthesis from CO and H_2 are also included in this subclass
449.6	Hydrogenation of carbon oxides with iron, cobalt, or nickel catalysts (Fischer-Tropsch process). Hydrocarbons are the main products
450	Recovery and separation of oxygenated products obtained from CO and H_2
451	Partial oxidation of nonaromatic hydrocarbon mixtures, e.g., petroleum, paraffins, and natural gas, to produce a mixture of products, such as esters, acids, aldehydes, ketones, and alcohols. This also includes higher fatty acids from petroleum and patents on formaldehyde production
452	Subclass 451, in which the recovery or purification of the products is especially emphasized
460	Sulfuric acid esters from olefins by direct sulfation
468	Carboxylic acid esters
478	Acyclic carboxylic acid esters
497	Acyclic carboxylic acid esters from olefins; this includes esters from olefins + alcohol + CO and from olefins + acids
498	Acyclic carboxylic acid esters from acetylene; this includes esters from acetylene + acid
514	Carboxylic acids; this includes naphthenic acids
515	Aromatic carboxylic acids
524	Aromatic side chain alkyl group oxidation—e.g., toluene oxidation to benzoic acid and *p*-xylene oxidation to terephthalic acid
526	Acyclic carboxylic acids, general
530	Acyclic carboxylic acids by oxidation of aldehydes
533	Acyclic carboxylic acids from single or mixed hydrocarbons of known constitution; this includes reaction of acetylene with CO and water, reaction of olefin with CO and water, and also dibasic acids from cycloalkanes
537	Acyclic polycarboxylic acids, e.g., from cycloalkanols and/or cycloalkanones
540	Saturated lower fatty acids, general

542 Formic acid from CO and water
546 Carboxylic acid anhydrides, general
586 Carbocyclic or acyclic ketones—e.g., by oxidation of cycloalkanes
590 Aromatic ketones
592 Acetophenone
593 Acyclic ketones
596 Dehydrogenation or dehydration of alcohol to form ketones, e.g., acetone from isopropyl alcohol
597 Acyclic ketones from hydrocarbons; this includes ketones prepared by the Oxo process
598 Carbocyclic or acyclic aldehydes
599 Aromatic aldehydes
601 Acyclic aldehydes
604 Acyclic aldehydes from hydrocarbons—processes where definite hydrocarbons are employed as starting material; this includes Oxo process, formaldehyde processes and acrolein from propylene
605 Acyclic aldehydes from acetylene—e.g., acetaldehyde from acetylene
610 Organic carbocyclic or acyclic peroxides—e.g., cumene hydroperoxide
611 Carbocyclic or acyclic ethers
614 Acyclic ethers
617 Carbocylic or acyclic hydroxyl compounds, general
618 Aromatic hydroxy compounds
619 Phenols
621 Phenol by benzene oxidation
624 C-polycarbon alkyl or alkylene phenols
626 C-isopropyl or isopropylene phenols; both 624 and 626 include patents on alkylation of phenols
628 Phenols from aryl sulfonates
629 Phenols by hydrolysis of aryl halides
631 Cyclohexanols
632 Acyclic hydroxy compounds (see also 638); this includes Oxo process patents which go beyond the aldehyde stage by reduction
634 Acyclic chlorohydrins from olefins
635 Polyhydric acyclic compounds; this includes oxidation of cycloalkanes, cycloalkanols and cycloalkanones to such products
636 Polyhydric acyclic compounds by hydrolysis of alkyl polyhalides or halohydrins—e.g., the glycerol process and ethylene glycol from ethylene dichloride
637 Purification of acyclic polyhydric compounds
638 Acyclic hydroxyl compounds directly from carbonyl containing compounds; this seems to overlap Subclass 632 as far as the Oxo process alcohols are concerned
639 Acyclic hydroxy compounds by hydrolysis of alkyl esters of polybasic inorganic acids—e.g., alcohols via olefins + inorganic acid + hydrolysis
640 Acyclic hydroxy compounds by hydrolysis of alkyl halides
641 Acyclic hydroxy compounds by hydration of olefins (direct hydration)
643 Purification or recovery of acyclic hydroxy compounds

Processes
686 Sulfonation or sulfation
687 Oxidation
690 Hydrogenation
692 Etherification by alkylation of an alcoholic or phenolic hydroxyl group
693 Fusion with alkalies to convert sulfonic group to OH group
694 Halogenation

Close examination of the above list will reveal that both the original subclass and the cross references in each of several subclasses must be consulted in order to find all the art on a given subject. It should also be noted that frequent changes in the classification scheme are made.

General Sources

To obtain references to the foreign patent literature one must search through either *Chemical Abstracts*, *Chemisches Zentralblatt*, or *British Abstracts*. To obtain literature on other pertinent German processes, the *Bibliography of Technical Reports* must be searched. It is hoped that the literature which has been presented will provide a background for such searches and also indicate some of the more numerous headings which will have to be used to obtain a more complete picture of the literature of the oxygen-containing hydrocarbon derivatives obtainable from petroleum and natural gas.

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Halogen-Containing Hydrocarbons from Petroleum and Natural Gas

BARBARA PFAHLER

Shell Development Co., Emeryville, Calif.

A survey of the literature of halogen-containing hydrocarbons obtainable from petroleum and natural gas is given. Various reviews are pointed out. Methods of preparation, with emphasis on the chlorine and fluorine compounds, are indicated as a guide to the literature. The uses of these compounds are considered from the same standpoint. A bibliography, composed chiefly of reviews and technological articles, is arranged by section for convenient reference. Suggestions for intensively and extensively searching the field by the use of abstract volumes are included.

Halogenated hydrocarbons represent one of the most important chemical groups. The production of these compounds increases every year. In 1951 the total for the whole group was 2,690,000,000 pounds against 2,089,000,000 in 1950 and 1,856,000,000 in 1949, according to the U. S. Tariff Commission.

One of the reasons for the importance of halogen-containing hydrocarbons in petroleum chemistry is that the halogens, with the exception of iodine, are among the few chemical substances which react readily with paraffins. Thus, besides the numerous uses to which these compounds themselves are put, they provide a starting point for making many of the other chemical products.

Until fairly recently, chlorinated hydrocarbons dominated the halogenated hydrocarbon field. This was undoubtedly due to the cheapness and availability of chlorine and the ease with which it reacted with paraffinic compounds. Recently fluorine compounds have received a great deal of attention. In reviews of the general field up to about 1947 or 1948, the attention is largely on chlorine; since then, it has been about equally distributed between chlorine and fluorine.

Halogenation and Halogen Compounds

With this in mind a discussion of some of the reviews which have been published on halogenations and on halogen compounds in general is in order. The processes for making the compounds are considered along with the compounds themselves because the two are really not separable.

Groggins includes in his book (*6*) of unit processes a chapter on halogenations which covers mechanisms and theory. In Grignard's summary of organic chemistry are found chapters (*13*) by Swarts on the aliphatic, cyclic, and aromatic halogenated hydrocarbons. Halogenation is one of the processes considered in *Industrial and Engineering Chemistry's* yearly reviews of unit processes (*8, 9*). A number of chapters on halogenations and halogen compounds are included in Ellis's "Chemistry of Petroleum Derivatives" (*5*). Several reviews (*3, 4, 10–12*) have been published which are limited to the halogenations of aliphatic hydrocarbons. Even narrower in scope are a number of studies and reviews (*1, 2, 7, 14*) on the addition of halogens to olefinic bonds.

Chlorination and Chlorine Compounds

There is an abundance of literature on chlorinations and chlorine compounds; general reviews will be discussed first. Brallier (*17*), in a study of the economics of chlorination processes, gives one table showing the chronology of important developments in the chlorine industry and another depicting the industrial applications of these processes and their products. An Italian review by Justoni (*47*) deals with modern processes and commercial progress in the chlorination of hydrocarbons. Based chiefly on the literature, a Russian discussion (*51*) covers the mechanism of chlorinations of simple organic compounds in the presence of catalysts. Another Russian contribution (*71*), published in 1947, summarizes advances in the chlorination of hydrocarbons for the previous 10-year period. McBee and Hass (*37, 54*) have surveyed the recent progress in chlorination a couple of times. A study of mechanisms in the chlorination of petroleum hydrocarbons was reported in an article by Hearne (*41*). Treatment of the individual chlorine compounds is presented by Huntress (*43*) and the Kirk-Othmer encyclopedia (*49*).

The chlorination of paraffinic hydrocarbons has received more attention than that of any of the other groups. An excellent review of this phase was presented by Asinger (*15*). Several other surveys (*36, 42, 72*) are available.

Free chlorine is the principal chlorinating agent. It may be used with light, heat, or catalysts as promoters. Photochemical reactions are economically possible for commercial chlorinations because of the high quantum yield (*42*).

The chlorination of pentanes in 1929 by the Sharples Solvent Corporation (*20*) represented the first commercial venture into the use of petroleum hydrocarbons as the raw material for organic synthesis. About 10 years earlier, extensive studies (*45, 46*) had been made of the chlorination of natural gas, but not of the pure compounds contained in it, so the experiments were not of as much value as they might have been. In 1935, McBee and Hass with their coworkers (*37, 38, 39*) started a series of studies of the chlorination of paraffins. Their experimental results and a consideration of the prior literature led to their drawing up a set of rules regarding the manner in which the reactions proceed. These investigations were the starting point for further investigations at high temperatures and pressures to obtain primary substitution products (*58*). These authors were also successful in mixing the reactants by passing the hydrocarbons through jets spaced along the reactor, thus keeping the momentary concentrations below those of explosive mixtures (*57*). Recently, in attempts to utilize the hydrogen chloride formed during chlorination reactions, some experiments have been carried out (*26, 32, 61*) using a mixture of hydrogen chloride and oxygen to produce chlorine. A couple of these investigations were concerned with carrying out the reaction in a copper chloride melt (*26, 32*).

Several papers discussing industrial processes for the manufacture of individual chlorinated paraffins may be of interest. Hirschkind (*42*) gave flow diagrams and an outline for the continuous process for the chlorination of methane in which all the chlorinated methanes are produced. Wilson and Howland (*78*) discuss the effect of different variables on methane chlorination. Detailed drawings of equipment and an outline of the process for the chlorination of ethane in both the liquid and the gaseous phase are given by Sergeys (*67*).

The reaction of olefinic compounds with chlorine whereby addition takes place at the double bond has been known for some time. Ethylene dichloride and propylene dichloride are produced by reaction of ethylene or propylene with chlorine (*27*). A number of articles (*23, 24, 31*), which review the methods of production of ethylene dichloride, are available. The manufacture of dichloropropane in Germany by reaction of propylene with chlorine in the presence of light was reported by Sergeys (*68*). High yields of dichlorobutene may be obtained by the vapor phase chlorination of butadiene (*73*).

About 1937, Shell Development investigations (*19, 34, 35, 76*) of the chlorination of olefinic hydrocarbons led to the discovery that high temperatures induced substitution rather than addition to the double bond. A commercial-scale manufacture (*25*) of allyl chloride was based on this discovery. A book (*70*) has been published summarizing the known properties and uses of allyl chloride.

Chlorination of benzene may lead to the formation of various chlorinated products. Commercial chlorination is generally carried out in tall cast-iron or steel tanks which have been lined with pure lead, then tile (*33*). The process is regulated so that chlorobenzene is the chief product. Wiegandt and Lantos (*77*) developed a process for improved yields of *p*-dichlorobenzene. Hexachlorocyclohexane is generally obtained by photochemical chlorination of benzene (*40, 63*).

Aromatic hydrocarbons can be chlorinated in the side chain in either the liquid or vapor phase. In the liquid phase, the chlorine is generally bubbled into the boiling hydrocarbon in the presence of light (*65, 69*). With temperatures as high as 300 to 400° C. no light is necessary. Nuclear substitution occurs in the presence of halogen carriers such as iron, aluminum, or iodine (*28*) at low temperatures. In the vapor phase, nuclear chlorinations occur at high temperatures and in the absence of a catalyst.

Hydrogen chloride may be used as a chlorinating agent. It is sometimes employed in such a manner that it adds to the double bond as in the preparation of ethyl chloride from ethylene (*75*) or in the synthesis of vinyl chloride from acetylene (*16*). Kainer (*48*) has surveyed the patents dealing with the preparation of vinyl chloride. A review (*21*) of the patent literature and the application of the Deacon reaction, which uses hydrogen chloride and air, has also been published. Some of the material on this reaction has been mentioned before (*26, 32, 61*).

The use of sulfuryl chloride instead of chlorine as a chlorinating agent eliminates the danger of explosion. It reacts readily with paraffins in a manner similar to that of chlorine. With unsaturated compounds, it forms the chlorine derivatives. It is also used for the chlorination of aromatic compounds but does not react readily in the absence of a catalyst. Halogen carriers are used as catalysts. In the presence of organic peroxides, sulfuryl chloride selectively chlorinates the side chain. Several reviews on the use of sulfuryl chloride as a chlorinating agent are available (*18, 22, 66*).

Polychlorinated products may be obtained by further chlorination of chlorine-containing compounds (*29, 62*). McBee and Hass (*53, 55, 56, 59*) devised a process for chlorinating an organic compound in such a way that rupture of the carbon-to-carbon bond takes place, and polychloro compounds with fewer carbon atoms than the starting material are obtained. They used the term chlorinolysis to define this process. Further chlorinations of polychloro compounds may lead to the formation of unsaturated compounds. For example, high-temperature chlorination of polychloropentanes and polychlorobutanes, led to production of hexachlorocyclopentadiene (*52*) and hexachlorobutadiene (*60*), respectively.

Prins has published a series of articles (*64*) on the synthesis of higher molecular polychlorinated compounds from lower molecular ones by condensation reactions in the presence of aluminum chloride.

Dehydrochlorination of polychlorinated compounds produces unsaturated compounds (*44*). Allyl chloride is prepared from propylene dichloride in this way (*30*).

Several reports dealing with the equipment that may be used for chlorination processes may be of interest (*50, 74, 79*).

Fluorination and Fluorine Compounds

The number of recent books and reviews on various phases of fluorine chemistry is astounding. Moissan, after completing his classical pioneering work on fluorine about 1900, published a book (*102*) on fluorine chemistry, chiefly inorganic. Worth-while contributions in the next 25 years were limited almost entirely to the investigations of Swarts (*116*). Bockemüller (*84*) published a book on organic fluorine compounds in 1934. Several years later, he summarized (*83*) recent progress in the preparation of organic fluorine compounds. About the same time, Mayor (*100*) reviewed the subject historically. Having become enmeshed in the field, Henne (*95, 96*) contributed chapters on aliphatic fluorine compounds for two books. The use of hydrogen fluoride in organic chemical reactions was surveyed by Weichert (*121*). In connection with their contract with the Naval Research Laboratory, the University of North Carolina conducted an enormous survey of the chemical literature dealing with fluorine-containing organic compounds (*103*). A limited number of copies of this volume were published. A critical review of the methods of introduction of fluorine into organic compounds was published in Russia about 1946 (*97*). An excellent review of the preparations and properties of organic fluorine compounds was included in the 1947 *Annual Reports of the Progress of Chemistry* (*114*). Four books (*94, 108, 110, 113*) were published in 1950 and 1951 on various aspects of fluorine chemistry. Several other reviews (*86, 87, 93, 105, 109, 111, 115*) may be of interest.

Three symposia on fluorine chemistry (*118–120*) have been held in the United States and Great Britain. The first is largely covered in the March, 1947 issue of *Industrial and Engineering Chemistry* (*117*).

Various methods may be used to introduce fluorine into hydrocarbons. A discussion of these methods, indicating principal studies of each, may be of interest.

The action of elementary fluorine on organic compounds has been reviewed by Bigelow (*81, 82*). The chemical changes which can be brought about are addition, substitution, fragmentation, dimerization, and polymerization.

The electrochemical production of fluorocarbons was developed by Simons (*112*) and is the method applied by the Minnesota Mining and Manufacturing Co. A pilot plant study of this method was reported in Simon's book (*110*).

Fluorides may be prepared by replacing other halogens with fluorine by means of inorganic fluorides or hydrofluoric acid (*95, 96, 116, 121*). Swarts (*116*) discovered this method and used antimony halides as the reagents. It was the method used by Midgley and Henne (*101*) for preparing the organic fluorides which they found could be used as refrigerants, and has been used extensively by Henne in his painstaking experiments on fluorine compounds. Whalley (*85, 122*) has made studies of this method with anhydrous hydrogen fluoride.

Higher fluorides, such as cobalt fluoride and silver fluoride, are used to replace hydrogen in organic compounds. Fluorinations using cobalt fluoride (*80, 89, 90*), are sometimes referred to as "Fowler" fluorinations, because Fowler was responsible for developing the method. The process is generally carried out in two steps, first converting the fluoride to its highest-valent state with elementary fluorine, then passing the vapors of the organic compound through the reactor over the fluoride. A reactor has been described for carrying out this reaction (*99*). Silver fluoride (*98*), cerium fluoride (*88*), and manganese fluoride (*88*) have been found useful for the reaction.

The process of adding hydrogen fluoride to olefins or acetylene (*91, 92*) has not received much attention industrially (*95, 96, 121*).

The Balz-Schiemann reaction for the introduction of fluorine into an aromatic nucleus involves forming the amine, then the diazonium fluoborate, which in turn decomposes into an aromatic fluoride (*104, 106, 107*). One of the reviews (*104*) of this reaction gives tables of the compounds prepared by this method.

Bromination and Bromine Compounds

Brominations are, in most cases, carried out by methods similar to those for the preparation of chlorine derivatives. Sampey (*127*) gives a history of the photobromination of benzene and toluene. Davis (*123*) made a thorough examination of the relative rates of bromination of the olefins, concentrating particularly on ethylene. An unusual method for producing bromine compounds is by the use of bromosuccinimide or related compounds. This method is called the Wohl-Ziegler reaction and causes allylic bromination. It has been the subject of a couple of reviews (*124, 126*).

Although a large number of bromine compounds are known and described in the literature, they are used mainly in the synthesis of other compounds and have little commercial significance. In the Kirk-Othmer Encyclopedia (*125*) a chart is given of a number of bromine compounds, most of which have some industrial importance. This chart includes condensed information on preparations, methods, properties, and uses.

Iodination and Iodine Compounds

Iodinations generally differ from other halogenations because the weak carbon-to-iodine bond makes permanent direct union of carbon to iodine by replacement of hydrogen possible only in exceptional cases. The reaction is reversible, so the hydrogen iodide must be removed immediately by oxidation or absorption in alkali. Iodine-containing compounds may be formed by the addition of iodine to an olefin or replacement of chlorine or bromine by iodine.

Organic iodine compounds are used in relatively small amounts in industry, although they are used to a considerable extent in the laboratory for organic synthesis. The relatively important organic iodine compounds and their methods of manufacture are listed in the Kirk-Othmer Encyclopedia (*130*). Many publications on iodine compounds have been issued by the Chilean Iodine Educational Bureau (*128, 129*), formerly the Iodine Educational Bureau. Since July, 1949, they have been publishing *Iodine Abstracts and Reviews*, which is issued quarterly and is broken down into five sections, one of which covers organic chemistry. There have been a couple rather extensive reviews on organic compounds containing polyvalent iodine (*131, 132*).

Polymerization and Polymers

The polymerization of unsaturated halohydrocarbons has been studied most extensively in the case of vinyl chloride and closely related compounds. Kainer (*136*) published a book recently on polyvinyl chloride and mixed polymers of vinyl chloride. In addition to chlorovinyl polymers, Schildknecht includes fluorovinyl polymers in his book (*141*). Books covering plastics generally include material on the halohydrocarbon polymers (*142, 144*). Several papers (*133, 134, 135, 143*) have been published in the last couple of years dealing with the polymerization of fluorine-containing compounds. Articles on polymerization of chloroprene (*145*), fluoroprene (*138*), chlorotrifluoroethylene (*140*), tetrafluoroethylene (*139*), vinylidene fluoride (*137*), and dichlorodifluoroethylene (*137*) have appeared in recent years.

Use as Intermediates

The use of organic halogen compounds as the starting products for the synthesis of other organic chemicals is too immense a field to do more than indicate some of the commercial applications. In his book (*148*) on the chemistry of petroleum derivatives, Ellis includes a chapter on the production of alcohols and esters from alkyl halides, and also one on miscellaneous reactions of halo-paraffins and cycloparaffins. The manufacture of amyl alcohols and related products from the chlorides has been well covered (*146, 153*). A two-step process for the synthesis of cyclopropane by chlorinating propane from natural gas and dechlorinating with zinc dust was devised in 1936 (*152*). A critical review of syntheses from 1,3-dichloro-2-butene was published in Russia in 1950 (*154*). The products obtainable from the allylic chlorides are covered in a number of articles (*147, 149, 157*).

Chlorobenzene is one compound that has been used extensively for syntheses; the preparation of phenol (*151, 155, 156*), DDT, and various dyestuffs (*150*) from it are probably among the most important commercially.

When considering the use of halogenated hydrocarbons as reactants, the review article by Wilson (*158*) on the effect of structure on the reactivity of organic halogen compounds might prove valuable.

Use as Solvents

Examination of the fields in which halohydrocarbons find use sometimes yields a great deal of information. This is true in the case of solvents.

Jordan (*162*) and Durrans (*160*) included chapters on chloro compounds in their books on solvents. They both list the individual compounds and give data about each.

Mellan (*164*) treats the subject in a similar manner but covers more compounds and includes bromo and fluoro compounds. Another book (*161*), published in France in 1948, covers only the chlorinated hydrocarbons but gives quite an extensive list. McGovern (*163*) discusses the commercially important groups of chlorinated hydrocarbons and properties affecting their applications. A detailed discussion of the methods and apparatus used by the German manufacturers of chlorinated solvents is reported by Brundit and Taylor (*159*). Two earlier reviews (*165, 166*) with extensive bibliographies may also be helpful.

Use as Insecticides

Halogenated hydrocarbons have been used a great deal for the control of insects. They were first used as fumigants (*187*). During the second world war chlorinated hydrocarbons came to the fore as insecticides, with DDT contributed by Switzerland and benzene hexachloride by the United Kingdom and France. Their subsequent development in the United States was followed by the appearance of toxaphene, chlordan, aldrin, and dieldrin. Brown (*170*) and Shepard (*186*) in recent books give a fairly complete listing of chemicals, including halogenated hydrocarbons, used for insect control. A number of other books (*173, 175, 191*) have been published recently which cover the subject quite well. Frear's catalog (*174*) of insecticides and fungicides is particularly well arranged for checking through the halohydrocarbons. A book by Truhaut (*189*) is limited to organic halogen compounds. For reviews even more limited in scope, Summerford (*188*) covers organofluorine insecticides and Bowen (*167*), the organic iodine insecticides. The United States Bureau of Entomology and Plant Quarantine has put out a number of bibliographies and digests of the literature on specific compounds, including DDT (*178, 179, 180, 183, 184, 185*), benzene hexachloride (*168, 172*), chlordan (*182*), toxaphene (*181*), and methyl bromide (*171*). DDT and a few of the better-known insecticides are the subject of a book by West and Campbell (*190*). Other works, which may be of interest, are a study of methallyl chloride (*169*) and one of aldrin and dieldrin (*177*). A review (*176*) of the methods of analysis of insecticides by Haller covered chlorinated hydrocarbons.

Use as Refrigerants

Halogenated hydrocarbons are used extensively as refrigerants (*192, 194, 196*). Since the discovery by Midgley and Henne (*195*) that fluoro-halo derivatives of aliphatic hydrocarbons could be used as refrigerants with certain advantages, and the completion of a comprehensive study (*193*) of the thermodynamic properties of dichlorodifluoromethane, these Freon-type compounds have been successfully applied as refrigerants. Park (*197*) discusses the Freon-type compounds, giving nomenclature, and a bibliography of Freon refrigerants.

Use as Fire Extinguishers

Halogenated hydrocarbons serve also as fire extinguishers. Fryburg (*201*), after a study of the literature pertinent to fire-extinguishing agents, concluded that the organic halogen compounds appeared to be the most promising. Downing and coworkers (*200*) studied halogenated extinguishing agents in general and concluded that chlorobromomethane was not the perfect agent. [A method for the commercial preparation of chlorobromomethane has been reported (*199*).] In an early study (*198*) chlorinated hydrocarbons were tested against methane-air flames.

Use as Lubricants and Lubricant Additives

Some chlorine-containing organic compounds are viscous, oily liquids which may be utilized as lubricants, either alone or admixed with petroleum oils. Typical materials of this type are chlorodiphenyls, chloronaphthalenes, and chlorinated paraffin wax (*205*).

The chlorinated paraffins have been used chiefly as extreme pressure additives (*207*, *209*). Lincoln (*206*) has investigated the addition of both aliphatic and aromatic chlorine compounds to lubricants. Several fundamental studies of the extreme pressure lubricating properties of halogenated compounds have been made by Davey (*203*, *204*). Wiggins and coworkers (*210*) investigated lubricating oils synthesized by condensing chlorinated paraffin wax with aromatic hydrocarbons. The production of fluorocarbon oils, which may be classed as lubricating oils, was studied by Cady (*202*) and Smith (*208*), but their manufacture is not economically feasible at present.

Hazards

Hazards involved in the use of halogenated hydrocarbons must not be overlooked when considering these compounds. In the discussions of the various specific uses these problems are generally considered (*216*). It has become almost standard practice to include along with the properties of a given halogen-containing compound, such information as the toxicity and explosibility. The toxicity of solvents is the subject of a couple of books (*211*, *213*) which include chapters on halogenated compounds. Various hazards of common refrigerants are indicated in a book by Nuckolls (*214*). A review by von Oettingen (*215*) covers the potential dangers of the lower-membered halohydrocarbons and includes an extensive bibliography. Smith (*217*) has compiled a bibliography on the pharmacology and toxicology of fluorine compounds. A book by Jacobs (*212*), which gives the analytical chemistry of industrial poisons, hazards, and solvents, includes a chapter on halogenated hydrocarbons.

Abstracts and Indexes

It is fortunate, since the literature of halogen compounds is so extensive, that many books and reviews are available. These alone should be adequate for some purposes. When more extensive or intensive literature surveys are required, the abstract journals or indexing volumes must be consulted, and here a familiarity with subject headings is helpful.

Generally, *Chemical Abstracts* would be one of the first abstract journals to be consulted. Specific halohydrocarbons are indexed, of course, under the hydrocarbons of which they are derivatives, with the exception of several of the more common ones. A number of general headings must also be considered for a general survey. For example, for chlorinated hydrocarbons, entries under chlorides, alkyl chlorides, aralkyl chlorides, aryl chlorides, chlorination, chlorine compounds, hydrocarbons (chlorinated), and paraffins (chlorinated), should be considered, and in addition the corresponding entries for the all-inclusive halogen class. In some cases, it might also be advisable to examine reactions under the various agents used for chlorinations.

Chemisches Zentrallblatt is especially well arranged for searches in which all the halogenations or halogen compounds are to be considered or, indeed, when any of the individual cases is involved, because here, all the halogenations are indexed under that one heading. Likewise, the halogen compounds are included in general headings, such as organic halogen compounds, alkyl halides, aryl halides, and hydrocarbons (halogenated). For specific compounds, as in all cases, the formula index should be checked.

For the technological literature, *Engineering Index* should be consulted for the sake of completeness. Entries and cross references should be checked under chlorine, fluorine, and hydrocarbons (chlorinated).

Industrial Arts Index may also prove helpful. Some of the general headings are the same as those indicated for *Chemical Abstracts*. Checking the individual compounds is a little more difficult from the chemist's viewpoint, because some of the compounds appear under uninverted names, while others appear, for example, as alkyl derivatives.

If it is considered desirable to check the abstracts of the Institute of Petroleum, entries under the sections special processes, special hydrocarbon products, derived chemical products, and miscellaneous products should be scanned. In their *Reviews of Petroleum Technology*, one should check in the section on special products under halogen derivatives.

Patents are included in most of the reviews and abstract journals. However, if one wishes to make a thorough search, the patent classes may be checked. The main class is 260-648 and specific products or processes are considered from this number through to 260-664.

It is hoped that this attempt to summarize the more important literature on the halogen-containing hydrocarbons obtainable from petroleum and natural gas will prove of aid and save time for those considering some aspect of this field.

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Nitrogen-Containing Compounds from Petroleum and Natural Gas

G. MALCOLM DYSON

Loughborough, England

Nitrogen-containing compounds are obtained from petroleum and natural gas primarily by three processes—i.e., nitration, direct amination, and direct cyanidation of hydrocarbons. The author has listed review articles containing numerous references and the subject headings for searching indexes, in order to give the individual insight into the approach necessary in this field.

The nitrogen-containing compounds of organic chemistry represent approximately one third of that subject, and since the number of organic compounds known at present is about 500,000, it follows that those containing nitrogen will number about 166,000. It is also probable that each and every member of this group can be obtained by a route from a petroleum hydrocarbon, either natural or synthetic; it is clear that some restrictive process must be applied in this paper. A logical way is to discuss only the literature of such nitrogen compounds as may be made economically from petroleum or natural gas and which have some practical application, or, in other words to discuss only those compounds which are now being produced in bulk from natural gas, and petroleum, or which might be so produced in the immediate future.

Even so, it would be improper to include in such a discussion certain groups of chemicals such as nitrobenzene or aniline, despite the fact that the aromatic hydrocarbons which give rise to them are now substantially obtained by the reforming of petroleum hydrocarbons. However, there is always the possibility that the catalytic processes can give supplies of nearly every aromatic hydrocarbon, and since the latter are easily nitrated there is thereby a means of obtaining in two or three steps the nitro compounds, amines, hydroxylamines, hydrazines, etc., of the whole aromatic field.

Since the advent of vapor-phase nitration in the aliphatic series it has been possible to contemplate the aliphatic nitro compounds as a similar wide group for synthetic purposes.

The interrelations of these compounds are shown in Figure 1.

The three main divisions of this subject are nitration and the nitro compounds, the direct amination of petroleum hydrocarbons, and the direct cyanidation of hydrocarbons to nitriles. The production of amines by reduction of nitro compounds or by amination of chloro compounds are subsidiary interests which involve petroleum hydrocarbons only in the second step. It may be added that hydroxylamine itself and its salts are almost exclusively prepared from nitropropane and may be thus considered a petroleum chemical (*2*).

Nitroparaffins

The first dinitroparaffin was prepared in 1864, and simple mononitro compounds were made in 1872 by Victor Meyer.

The literature from 1864 to 1937 is summarized by Taylor and Baker in "Sidgwick's Organic Chemistry of Nitrogen" (*13*) which contains 91 references. No mention of the direct nitration of petroleum hydrocarbons is made in this summary. The literature up to 1940 is summarized by Hass and Riley in a paper containing 420 references, of which 22 deal with the direct production of nitroparaffins from hydrocarbons by vapor-phase nitration (*9*). Another review, covering the period to 1946, by Levy and Rose (*10*) includes 214 references. Indications of usage and potential usage are given. A later, but somewhat less extensive review of the nitroparaffins is given in Goldstein's "The Petroleum Chemicals Industry" (*3*).

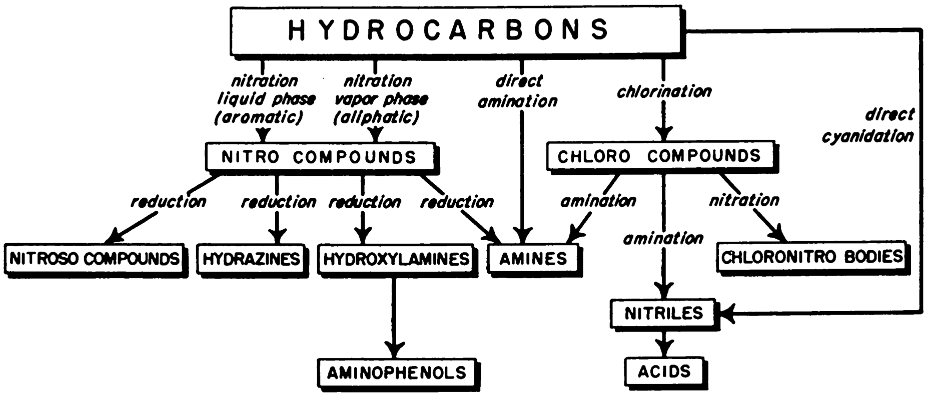

Figure 1. Derivation of Nitro Compounds from Hydrocarbons

The main index headings for search other than the names of specific compounds are *Paraffins, nitration of; Paraffins, nitro; Paraffins, from nitration of—; Paraffins, dinitro; Hydrocarbons, nitration of; Nitration of hydrocarbons; Nitration of paraffins; Petroleum, nitrogen compounds from; Olefins, nitro derivatives;* and *Acetylenes, nitro derivatives.* These items are not mutually inclusive, e.g., references under *Paraffins, nitration of* are not necessarily to be found under *Nitration of paraffins.* In *Chemical Abstracts* collective index for 1937 to 1946, there are 19 entries under the first heading and 12 entries under the second; only 10 are common to both lists.

Amines

There are no very extensive reviews on the direct reaction between petroleum hydrocarbons and ammonia; some references of a general character are made to the direct amination of unsaturated hydrocarbons by Goldstein (*5*).

The only sources of information are to be found under the index headings, *Hydrocarbons, amination of; Hydrocarbons, amines from,* and *Olefins, amination of,* and, of course, the individual amines themselves.

A review of amination by catalytic reduction of nitro compounds was made by Groggins (*6*), who points out that refinery hydrogen is suitable for this purpose; it may also be added that ammonia itself can be produced from the hydrogen of natural or cracker gas.

Nitriles

There is considerably more information about nitriles from natural gas or petroleum; this is to be expected since there are two distinct routes to these substances—from hydrogen cyanide and a hydrocarbon ($C_6H_6 + HCN \rightarrow C_6H_5CN + H_2$); and from the pyrolysis of ammonia and hydrocarbons, particularly low-carbon number hydrocarbons, as in $CH_4 + NH_3 + C_6H_6 \rightarrow C_6H_5CN + 4H_2$. The latter process is reviewed by Groggins (*7*), and is extended to unsaturated hydrocarbons. Both acetonitrile and acrylonitrile are so obtained industrially.

An excellent review of this field can be obtained in an article by Mowry (*11*) on preparation of nitriles. This contains 624 references.

General References

In addition to the sources names, the following have good accounts of some phases of nitroparaffin formation, of amination, and of the formation of nitriles. "The Chemistry of Petroleum Derivatives" by Ellis (*1*), in two volumes, was published in 1934 and 1937. The first volume is becoming somewhat incomplete, owing to the march of time, but a new edition is in progress. "Thorpe's Dictionary of Applied Chemistry" (*14*) has several important articles on the subjects of this field. Goldstein's "The Petroleum Chemicals Industry" (*4*) has a section dealing with nitriles and their formation. The Kresge-Hooker Science Library's publication, *Record of Chemical Progress* (*12*), should not be overlooked in a search for general reviews. In that journal there is a compact survey of nitroparaffins by H. B. Hass (*8*).

In this short paper the author has deliberately refrained from giving long lists of individual reference citations but has rather attempted to give an insight into the approach necessary in this field of chemical literature.

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Sulfur Compounds from Petroleum Fractions

J. H. KARCHMER

Humble Oil & Refining Co., Baytown, Tex.

In considering the sulfur-containing compounds obtainable from petroleum and its fractions five principal topics are discussed—sulfur compound types that occur in petroleum and its fractions; methods of identifying, determining, and naming sulfur compounds; the chemical and physical properties of the sulfur compounds likely to be found in petroleum fractions; the effect of the various refinery processes upon the constituent sulfur compounds; and processes for segregating and manufacturing sulfur compounds from petroleum fractions. Included in this discussion are a number of key literature references which provide additional information and leads for continuing the search. In addition to specific references, general reference sources are given, such as the U. S. Patent Class and Subclasses, the work of the Bureau of Mines and API Project 48, a list of periodicals that generally publish articles on sulfur petroleum chemistry, and the names of those organizations that are actively engaged in the field.

In searching for information on the sulfur compounds obtainable from petroleum, the most inclusive single guide is the *Chemical Abstracts*. Very few fields of human endeavor can boast such a comprehensive, well-organized source of knowledge. However, it is this completeness that presents an obstacle to the searcher who has but a limited amount of time to spend on a subject that may embrace several different categories of the *Abstracts*. The chemistry of the sulfur compounds derivable from petroleum is such a case, since the sheer number of all the published reports on sulfur make the task of the literature searcher who is selecting the pertinent references monumental. Almost limitless amounts of time are required to locate each promising lead in the index, ferret it out in the *Abstracts*, and follow through, if necessary, to the original article. The examination of the abstracts alone requires large amounts of time. Of necessity the wording in the indexes must be brief, and many false leads are obtained from those clipped and sometimes cryptic phrases. Promising references which appear to contain the desired information in many cases turn out to be valueless.

While there is no short cut method of examining all of the published information on sulfur, any systematic division of the subject into smaller topics should aid in reducing the time spent to obtain fruitful results. It is, therefore, the object of this paper to subdivide the problem into its component parts and to acquaint the searcher with the key points of each subdivision by summarizing some of the most important work published in the field and presenting a bibliography with the appropriate subject category. Typical and significant references are included. The intent has been to include many references which contain large bibliographies and which give leads to other information in that subject. It is hoped that with these summaries and lists of references as a background, the searcher will be aided in making his own study of his particular problem.

In considering the subject of the sulfur-containing chemicals obtainable from petroleum fractions, the questions that are encountered are: what sulfur compounds are present in the various petroleum fractions; how can these materials be detected or identified; what are the chemical and physical properties and modes of preparation of each of these sulfur compounds or compound types; what happens to these sulfur compounds as they are subjected to the various refining processes; and lastly, what processes are available for segregating the sulfur compounds?

Following each of the brief discussions of the five topics, a list of general references is included which will yield more detailed information on the respective subjects. The full title of the article has been included and in many cases when the title is not sufficiently descriptive a brief statement in parenthesis covering information given in the publication is provided. Interspersed in these general lists are the publications specifically referred to in the text.

In addition to these general subjects, in a sixth section of this report certain reference sources which will yield additional information on all five of the discussed topics are discussed.

Sulfur Compound Types Occurring in Petroleum Fractions

Sulfur Compounds in Crudes. The presence of sulfur compounds in petroleum products is principally due to the sulfur originally present in the crude; treatment with sulfuric acid and other refining agents accounts for relatively minor quantities. While the source of the sulfur in the crude has never been definitely determined, and a number of interesting theories have been advanced, it is generally assumed that sulfur was present in the original organic material from which the petroleum was derived. The sulfur contents of crudes vary from very low values, 0.04 wt.% sulfur in Pennsylvania crudes, for example, to about 5 wt.% in the case of certain West Texas, California, Middle East, and Mexican crudes. A comprehensive study of the sulfur contents of crudes in the United States is presented by Smith and Blade (*40*) in which all fields of the United States having a daily production of over 2500 barrels are classified according to their sulfur content.

There is still a great deal of indefiniteness in the knowledge of what sulfur compounds are actually present in the crudes. This is due to the fact that chemical reactions may take place converting one type of sulfur compound to another (*16*, *41*, *133*, *134*) during the distillation step which is a commonly used method of initiating the analysis. Studies of the chemical activities of sulfur compounds likely to be present in crudes indicate that it is possible for many known chemical reactions to take place (*33*). Generally, however, sulfur in crude oil is present as hydrogen sulfide, mercaptans, aliphatic sulfides, sulfides, cyclic sulfides (thiophanes), aromatic sulfides, polysulfides, and free sulfur. The concentration of the compounds in the crudes vary considerably, depending upon the conditions of temperature and pressure to which the crude was subjected while in the ground, which would cause varying degrees of reaction between the sulfur compounds and between the sulfur compounds and hydrocarbons.

Additional references are cited (*4*, *5*, *6*, *7*, *15*, *32*, *35*, *36*, *38*, *43*, *136*).

Sulfur Compounds in Petroleum Gases. The principal sulfur compounds present in natural petroleum gas, refinery effluent gas, and liquefied petroleum gas are hydrogen sulfide, carbonyl sulfide, and the lower molecular weight mercaptans, thiophenes, and sulfides. The presence of carbon disulfide in other than trace amounts is generally not encountered; however, its formation is thermodynamically possible as a result of the interaction of sulfur or hydrogen sulfide with hydrocarbon at very high temperatures (*14*, *42*). Sulfur dioxide is commonly encountered in stack gases obtained when hydrogen sulfide–containing gases are burned as fuels. Sulfur dioxide and sulfur trioxide are liberated in some acid regeneration processes.

Additional references are cited (*9*, *37*).

Sulfur Compounds in Naphthas. In the distillation of crudes, a larger portion of the sulfur in the petroleum is concentrated in the higher boiling fractions, if the analysis of the cuts obtained by simple distillation may be regarded as an accurate representation, For example, Sachanen (*35*) shows the distribution of sulfur in the various distillate cuts from four crudes, and from the examination of his data it may be observed that as the boiling points of the cuts increase, the concentration of the sulfur in the fractions increases. This same pattern has been observed in crude assay results obtained at other refineries. It should be pointed out that not only does the per cent sulfur increase in the distillates, but also the amount of sulfur based upon the total sulfur in the crude charge also increases. The sulfur balance on data of this type is generally low, probably because hydrogen sulfide is evolved during the distillation. The formation of this hydrogen sulfide may be attributable to the decomposition of some of the high boiling sulfur fractions or to the combination of elemental sulfur with certain hydrocarbons. The thermal degradation of the sulfur compounds is well known (*41*, *118*) and can be illustrated with information recently presented in the literature (*2*, *38*), which shows that distribution of sulfur compounds is affected by the distillation conditions. In a study by the API Project 48, it was shown that the distillation of the higher boiling petroleum fractions under atmospheric conditions yielded a considerably greater breakdown of the sulfur compounds than a corresponding vacuum distillation carried out at low temperatures (*21*, *174*). Attendant to this breakdown, marked variations in the type of sulfur compounds were encountered.

In straight-run gasoline a variety of sulfur compounds may be present, such as hydrogen sulfide, mercaptans, sulfides, disulfides, polysulfides, and cyclic sulfides. It is also possible that sulfonic acids and alkyl sulfates can be present because of their incomplete removal after refinery treating operations. Likewise there can be a polysulfide content as a result of doctor sweetening. Alkyl sulfates, which are hydrocarbon soluble, can form through the action of sulfuric acid upon olefins.

The sulfur compounds present in some typical straight-run gasolines are presented in an API Project 48 publication (*20*). In another investigation carried out by the Bureau of Mines some additional material is presented on sulfur contents of straight-run gasolines and of cracked gasolines (*21*). From this latter work it may be observed that mercaptans are more prevalent in the straight-run gasolines than in the cracked gasolines; while the more stable sulfur compounds, such as thiophenes predominate in the cracked gasolines. The distribution of sulfur in the petroleum fractions as obtained by straight distillation is ultimately altered when the gas oil is cracked in order to secure a greater amount of gasoline. The gas oil fraction is comparatively rich in sulfur content, and in subsequent cracking to gasoline a disproportionate amount of sulfur finds its way into the gasoline fraction; this is an expected consequence of the fact that cracking favors the decomposition of the less stable sulfur compounds and causes rearrangements to the more stable aromatic forms at the higher temperatures.

Sachanen (*34*) compiled a long list of crudes found throughout the world showing the sulfur content of the crude as well as that of the straight-run gasoline and cracked gasoline. Examination of 35 of the listed crudes revealed that the sulfur concentration in the straight-run gasoline averaged about 13% of the sulfur concentration in the crude, while the sulfur concentration of the cracked gasolines averaged approximately 41% of the sulfur concentration in the crude. The higher proportion of sulfur in cracked gasolines than in straight-run gasolines is a consequence of the aforementioned fact that the higher molecular weight sulfur compounds decompose under thermal stress to more volatile compounds which are found in the gasoline boiling range or slightly above.

There is some difference in the distribution of sulfur compounds in catalytically and thermally cracked stocks. In catalytic gasoline the sulfur content is slightly lower. This difference is probably due to the susceptibility of the carbon-sulfur bond to cleavage by acid type catalyst (*24*); consequently, in catalytic cracking more hydrogen sulfide may be produced than by thermal processes carried out at the same temperature. This difference in the sulfur content, although small in many cases, may be observed by comparison of the data obtained by Barron, *et al.* (*3*) on thermally cracked stocks with that of Healy and Hertwig (*124*) on catalytically cracked stocks. At high cracking levels, however, evolution of hydrogen sulfide may be less than that observed at lower levels, although the sulfur content of the gasoline may continue to decrease (*28*). This may be explained by the reaction of sulfur with the heavy products of cracking. This reaction product is withdrawn with the coke or residuum. The nature of this reaction is rather obscure.

In the study of sulfur distribution in catalytic cracking, Healy and Hertwig (*124*) state that although the amount of sulfur in the gasoline is primarily dependent upon the sulfur content of the cracking stock, the method of operation also has an appreciable influence. In general, high conversions and high feed partial pressures lead to catalytic gasoline of low sulfur content. Also, the use of lower temperatures lowers the sulfur content of the gasoline. The pretreatment of the sulfur-bearing charge stock is also an important factor in the distribution of the sulfur in the products of cracking.

Additional references are cited (*1, 13, 16, 18, 19, 31, 34, 39, 44, 137*).

Sulfur Components in Higher Boiling Fractions. It is generally thought that the sulfur compounds in kerosene are much the same type as those in gasoline except that they are of a higher molecular weight. Because of the difficulties inherent in the analysis of sulfur compounds in the fractions boiling higher than gasoline, the sulfur constituents of kerosene, jet fuels, diesel oils, and heating oils are not as well established as those of gasoline. Velikovsky in "The Science of Petroleum" (*10*) has reported the composition of a straight run Ural kerosene which appears to be very much like a straight run naphtha except for the presence of a sizable amount of disulfides. The largest single compound type was the sulfides. Project 48A of the API is systematically studying the sulfur constituents of petroleum and as yet is still engaged in identifying the compounds in the gasoline range. It is expected that their studies will reveal more information on the higher boiling components than has hitherto been available.

Work carried out at the University of Birmingham (*11*), in England, by Dr. Emmott on middle distillates has revealed the presence of large amounts of sulfides in virgin stocks. As one ascends the boiling range scale the information on the types of sulfur compounds present becomes more limited. Hoog (*26*) has examined some Middle East gas oil and has deduced from the results of the several experimental techniques employed that essentially no sulfides, di- or polysulfides, or mercaptans were present and that the sulfur compounds of that specific gas oil were preponderantly of the thiophene and thiophane type.

It has been thought that asphaltenes contain some type of oxygen sulfur linkage but beyond this the structure has not been established. It is also postulated that sulfur compounds with thioaldehyde structures may function as additives and be responsible for certain desirable lubricating characteristics of some lube oils (*8*).

Additional references are cited (*15, 29, 30*).

Sulfur Compounds Present in Refining Solutions. Acid and alkaline derivatives are discussed separately.

Alkaline Solutions. Many of the acidic sulfur compounds such as hydrogen sulfide and the mercaptans may be adsorbed in alkaline treating solutions such as sodium hydroxide and alkylolamine solutions. Sodium phenyl mercaptan is commonly found in many caustic solutions along with other mercaptans in the lower boiling ranges. In many cases disulfides may be found in these solutions as a consequence of the oxidation of the alkaline mercaptides. References are cited (*22, 23, 25, 27, 43, 45, 114*).

Acid Derivatives. When sulfuric acid is used as the treating agent; it is possible that sulfates, bisulfates, sulfonates, sulfones, polysulfones, and sulfoxides may be formed. The most important of the sulfuric acid derivatives are the sulfonic acids which are formed when the various oils are treated with this reagent. These acids are generally classified as green acids and mahogany acids. The green acids are those sulfonic acids of lower molecular weight and are generally found in the acid phase. The mahogany acids on the other hand are high molecular weight sulfonic acids and are oil soluble. References are cited (*17, 43, 113*).

Identification, Analysis, and Nomenclature of Sulfur Compounds

Chemical Analyses. Analysis of gases and analysis of naphthas are involved.

Analyses of Gases. Many analytical schemes have been proposed to determine hydrogen sulfide, sulfur dioxide, carbonyl sulfide, and the lower molecular weight mercaptans in gases (*46, 65, 71, 77*). A commonly used procedure is to conduct the gas through trains containing a succession of selective absorbing solutions and determine the total sulfur after absorption in each step or to determine the total sulfur in each absorbing solution.

Hydrogen sulfide (*58, 59, 68, 71*) is precipitated as cadmium sulfide from an acidified cadmium chloride solution. Mercaptans (*68, 71*) are absorbed in aqueous alkaline solutions, while other organic sulfide gases (*57, 68*) may be catalytically reduced to hydrogen sulfide in which form it may be determined iodometrically or colorimetrically (*59, 76*). Carbonyl sulfide may be absorbed in alcoholic alkali or ammoniacal peroxide solutions. This compound may also be determined in the presence of carbon disulfide and thiophene by the ultraviolet method recently proposed by Brady (*57*). Thiophene may be detected colorimetrically with isatin (*46*). The homologs of thiophenes can in some cases be detected with ceric nitrate (*62*). Optical and mass spectrometric measurement may be made using data presented by Hartough (*63*). The total sulfur determination of gaseous sulfur compounds has recently been carried out instrumentally (*73*) by an automatic titration of naphthas with bromine which oxidizes sulfur compounds. Optical and mass spectrometric methods are also available for many sulfur gaseous compounds provided the concentration is sufficiently high (*63*). The usefulness of these latter procedures has been considerably enhanced by the development of recent techniques in concentrating sulfur compounds.

ANALYSES OF NAPHTHAS. The determination of sulfur compounds in naphtha has been worked out by Faragher, Morrell, and Monroe (*56*), and was later modified by Ball (*49*). In these procedures the sulfur compounds are determined by an initial determination of the total sulfur by the lamp method, and in subsequent steps various sulfur compounds are removed by a variety of reagents; and after each step the total sulfur content is obtained. Thus, the sulfur content of any specific type of sulfur functional group can be obtained by subtraction. The sulfur compounds failing to react with any of the above-mentioned reagents are classified as residual, and in many cases (especially cracked naphthas) the residual sulfur content is as high as 70%. This analytical scheme suffers from the following limitations: a large percentage of the sulfur is unidentified; small errors in the early removal steps of analysis are likely to effect adversely the accuracy of the remaining portion of the analysis; and the method is restricted to naphthas.

In addition to this comprehensive scheme, other determinations may be carried out by utilizing specific properties of the sulfur compound types (*34, 72*). Sulfur may be determined by removal with elemental mercury (*51, 70*), or by reaction with a mercaptan. In the latter case the sulfur determination is made by measurement of the excess mercaptan after the sample has been treated with litharge, sodium hydroxide, and a known excess of butyl mercaptan (*78, 81*). A qualitative method of detecting elemental sulfur in gasoline is by the addition of sodium hydroxide to a pyridine solution of the gasoline which turns blue if sulfur is present (*67*). Free sulfur can also be determined polarographically (*60*).

Mercaptans are determined either by their removal with silver nitrate or by a direct titration with this reagent (*53, 66*). Hydrogen sulfide, which interferes, may be first removed from the sample by treatment with an acidified cadmium chloride solution. Mercaptans have also been determined by a direct titration with ammoniacal copper sulfate or copper oleate (*52*), the end point being reached when a solution retains its blue or green color. An excellent means of determining mercaptans is by the potentiometric procedure reported by Tamele and Ryland (*74, 75, 79*) which has the added advantage that hydrogen sulfide, if not present in too great a quantity, can be determined at the same time. Amperometric procedures for the determination of mercaptans have likewise proven successful.

Certain sulfides may be determined by treatment of the naphtha with iodine and measurement of the absorptivity of the resulting complex in the ultraviolet (*64*). Sulfides (*56, 151*) are removed with powdered mercurous nitrate monohydrate which readily reacts with aliphatic sulfides and thiophanes but not with thiophenes nor aromatic sulfides (*49*).

Disulfides are generally determined by reduction to mercaptans by refluxing with zinc and hydrochloric acid (*49*). The mercaptans are then determined by any of the methods described above. This reduction can also be carried out in the cold by using aluminum and alcoholic potassium hydroxide (*69*). A polarographic method for determining primary and secondary alkyl disulfides has been described (*61*).

Additional references are cited (*55*, *80*).

Optical Methods. Mercaptans and thiophenes are the only sulfur compound types that exhibit an absorption band, in the 2 to 15μ region, characteristic of their respective functional groups. Mercaptans have such an absorption band at 3.83μ which is attributed to the S-H vibration, while thiophenes usually exhibit an absorption band at 14.5μ. The intensity of the aliphatic mercaptan absorption band is weak except for the lower molecular weights while it is strong for aromatic and cyclic mercaptans. The intensity of the thiophene absorption bears no relation to the molecular weight. The position of the substitute groups in the substituted thiophene is of significance since, when the substituent is in the 3 position, a band appears at 13.1μ which has a greater intensity than the 14.5μ band. Because of the over-all low intensity of these bands, it is usually necessary to concentrate the sulfur compounds prior to optical inspections. In this same region (2 to 15μ) sulfides, disulfides, and polysulfides exhibit no unique bands which can be used for their respective identification.

Ultraviolet examination of the sulfur types indicates broad overlapping bands of relatively low intensity in the extreme lower end of the spectrum which makes ultraviolet analysis impractical.

Raman studies on sulfur compounds indicate that, in general, their means of determination is seriously limited by the excessive fluorescence exhibited by the majority of the compounds examined. It was found, however, that disulfides and thiophenes could be identified if the proper separation and concentration were obtained.

Some references are cited (*47*, *48*, *63*).

Physical Separation of Sulfur Compounds. In order to make several types of determinations feasible it is frequently necessary to isolate or to concentrate the sulfur compounds. Various means such as distillation, extraction, and absorption have been employed to affect the separation because these operations are closely related to those processes which may be employed to segregate sulfur compounds on a commercial scale. The discussion of these topics will be undertaken in the section, Processes for Segregating Sulfur Compounds.

Nomenclature. In any discussion of sulfur compounds in petroleum fractions the nomenclature (*50*, *91*) and the structural relationship of the sulfur compounds commonly encountered should be elucidated in view of the large number of compound types and the several methods that now exist for naming sulfur compounds. Following is a list of sulfur compound types presented and arranged in such a manner as to show how the name of a compound can serve to indicate its structure. This tabulation is not intended to be comprehensive, but is offered as a guide for readily classifying the more common types of sulfur compounds generally associated with refining operations.

In this tabulation it may be noted that the sulfur compounds are classified in three categories: first, those compounds of sulfur which are analogous to oxygenated compounds having the sulfur atom substituted for the oxygen; second, sulfur compounds in which the sulfur atom forms the nucleus of a compound (in a similar manner to phosphorus in phosphorium compounds); third, cyclic compounds of sulfur.

Sulfur Compounds Analogous to Oxygen Compounds. The compounds in this group may be regarded as oxygen compounds in which one or more atoms of sulfur has been substituted for the oxygen atoms; consequently, the sulfur compounds can be named by prefixing the parent oxygen compound with the affix "thio." In those cases where a distinction is needed to indicate whether the sulfur has been substituted for an oxygen atom in alcohol or in a carbonyl group, the affixes "thiol" and "thion" are respectively used. The prefix "thia" is used to denote an ether-type linkage; however, when thia is used, the parent compound is named as though the sulfur were substituted for a carbon atom—i.e., the position that the sulfur atom occupies is indicated by the number preceding the name, but named as though it were substituted for a carbon atom occupying that position (for example, —C—C—S—C—C— is called 3-thiapentane).

The use of these affixes are briefly summarized. Thio denotes sulfur in place of of any oxygen; thiol denotes sulfur in place of alcohol oxygen; thion denotes sulfur in place of carbonyl oxygen; and thia denotes sulfur in place of ether oxygen. Examples illustrating this usage are shown in Table I.

Table I. Sulfur Compounds Analogous to Oxygenated Compounds

(In which oxygen has been replaced by sulfur)

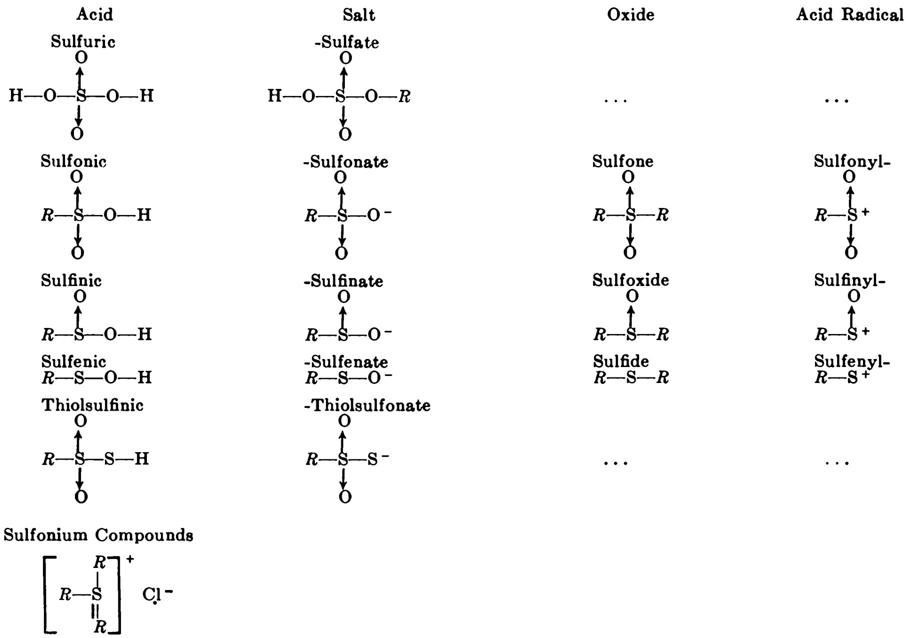
Sulfur Compound Type and Synonyms	General Skeletal Formula	Specific Example: Skeletal formula	Specific Example: Names
Mercaptan, Thiol, Thioalcohol	*R*SH	C—SH	Methane thiol Methyl mercaptan Methyl thioalcohol Thiomethanol
Sulfide, Thioether	*R*SR	C—S—C	2-Thiapropane Dimethyl sulfide Dimethyl thioether
Disulfide	*R*SS*R*	C—S—S—C—C	2,3-Dithiapentane Methyl ethyl disulfide
Thioaldehyde	$R\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}H$	$C\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}H$	Thionacetaldehyde (or thioacetaldehyde)
Thioketone	$R\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}R$	$C\text{—}C\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}C$	Methyl ethyl thionketone
Thioacids			
Carboxyl derivatives	$R\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}H$	$C\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}H$	Thionacetic acid[a]
	$R\text{—}\overset{\overset{O}{\Vert}}{C}\text{—}S\text{—}H$	$C\text{—}\overset{\overset{O}{\Vert}}{C}\text{—}S\text{—}H$	Thiolacetic acid[a]
	$R\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}S\text{—}H$	$C\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}S\text{—}H$	Thionthiolacetic acid
Carbonic derivatives	$R\text{—}O\text{—}\overset{\overset{O}{\Vert}}{C}\text{—}S\text{—}H$	$C\text{—}O\text{—}\overset{\overset{O}{\Vert}}{C}\text{—}S\text{—}K$	Potassium methyl thiolcarbonate
	$R\text{—}O\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}H$	$C\text{—}O\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}K$	Potassium methyl thioncarbonate
	$\mathrm{R}\text{—}S\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}H$	$C\text{—}O\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}S\text{—}K$	Potassium methyl xanthate
	$R\text{—}S\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}S\text{—}H$	$C\text{—}S\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}S\text{—}C$	Dimethyl trithiocarbonate
Carbamic derivatives	$N\text{—}\overset{\overset{O}{\Vert}}{C}\text{—}S\text{—}R$	$N\text{—}\overset{\overset{O}{\Vert}}{C}\text{—}S\text{—}C\text{—}C$	Ethyl ester thioncarbamic acid Thionurethan
	$N\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}R$	$N\text{—}\overset{\overset{S}{\Vert}}{C}\text{—}O\text{—}C\text{—}C$	Ethyl ester thiolcarbamic acid Thiolurethan

[a] Actually only the resonance form of these two acids is found.

SULFUR COMPOUNDS IN WHICH SULFUR IS THE CENTRAL ATOM. Although sulfur compounds may resemble oxygen compounds in their formulas, they differ in many ways. One of the principle differences is that the sulfur atom can be oxidized whereas generally the oxygen atom cannot. This property of sulfur gives rise to the multivalent series of sulfur compounds which includes sulfoxides, sulfones, sulfonic acid derivatives, and sulfuric acid derivatives. Table II shows the relationship of these compounds to each other, their names, and their structural formulas.

Table II. Sulfur Compounds in Which Sulfur Is the Central Atom

Organic Sulfur Acid Derivatives



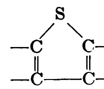
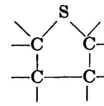
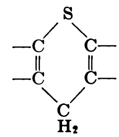
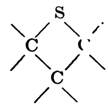
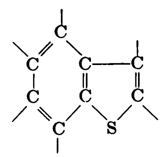
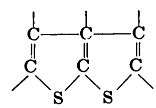
Cyclic Sulfur Compounds. The names of the cyclic sulfur compounds may be derived from specific names such as thiophene or from other names relating the structure to the corresponding oxygen compound. A summary of some of the more common compounds is shown in Table III.

Physical and Chemical Properties of Sulfur Compounds

Physical Properties. While the physical properties of the lower molecular weight sulfur compounds may be secured from any of the standard chemical handbooks, some difficulty may be encountered in finding information on the higher molecular weight compounds. This is primarily due to the fact that many of these compounds have not been prepared or have not been purified so that accurate measurements may be made. For this reason one of the objectives of the API Project 48 is to prepare and purify sulfur compounds so that more physical tests may be made. This project has developed several new techniques and has modified existing ones in order to solve the problems imposed by the unique properties of some of the sulfur compounds (*92, 97*). A number of papers describing experimental work have been published by this group, as well as several compilations of existing data on physical properties. These materials include data on boiling points, refractive indices, densities, freezing points (*20, 95*), and thermodynamic values (*97, 104, 105, 108*). One of the most comprehensive sources of the physical properties of the types of sulfur compounds that may be encountered in petroleum fractions is the literature survey "Physical Properties of Sulfur Compounds," prepared by Haines, Helm, and Ball (*93*).

In addition to the abovementioned thermodynamic data prepared by the API Project 48 and the thermodynamic values of the sulfur compounds given in API Project 44 (*82, 102*), and data from other miscellaneous sources (*99, 109*), a valuable summary of the available or readily calculated thermodynamic properties of sulfur compounds of

Table III. Summary Table of More Common Cyclic Sulfur Compounds

Compound	Structural Formula
Thiophene	
Thiophane (Thiacyclopentane)	
Thiapyran	
Thiacyclobutane	
Benzothiophene	
Thiophthene	

interest to the petroleum industry has been prepared by Barrow and Pitzer (*83*). Entropy, free energy function, heat content function, heat capacity, heat of formation, and free energy of formation for mercaptans, sulfides, sulfones, hydrogen sulfide, and sulfur trioxide are given. Data for methyl substituent groups of the organic compounds are presented as being representative of each homologous group. Some of these data may be extrapolated for the higher molecular weight compounds by use of the method of group equivalence described by Franklin (*89*). Using the electron impact method, Franklin and Lumpkin have obtained some values for the bond energies of C—S, H—S, and S—S (*90*).

The azeotrope formation between sulfur compounds, thiols, alkane disulfides, and thiophenes, and petroleum hydrocarbons have been extensively studied by the Anglo-Iranian Oil Co.; the results have been published in several papers (*87*, *88*). Research workers of this company have also secured data on vapor-temperature relationships of sulfur compounds (*110*).

Chemical Properties and Preparation of Sulfur Compounds. As in other branches of organic chemistry, there is a similarity in the reactions of a given homologous series; thus reasonable generalizations can be made regarding the property of a given reaction by knowing the molecular weight of the compound, the configuration of the hydrocarbon position of the molecule, and having some knowledge of how the sulfur functional group reacts. Since there is a diversity of response of the sulfur functional groups to the various reagents, a series of equations illustrating the typical reactions of certain sulfur compounds and means of preparation is herewith presented. The number in the guide table (Table IV) refers to the numbered equations following in Table V.

Detailed information is available on certain compound types, for example, on thiophene (*94*), thiols (*101*), thiols and thions (*86*), mercaptans, hydrogen sulfide and olefin reactions (*96*), sulfenic acids (*98*), sulfides and sulfones (*106*), sulfides and disulfides (*100*), cyclic sulfides (*111*), and mercuric chloride complexes with sulfur compounds (*157*). For reactions not covered by the above summary, the searcher is advised to try, in addition to the regular reference sources on organic chemistry and organic preparations, the "Science of Petroleum" (*182*), Carlton Ellis's "Petroleum Derivatives" (*184*), Theilheimer's "Synthetic Methods of Organic Analysis" (*107*), and Gilman's "Organic Chemistry" (*91*). Some additional references are cited (*84, 85, 92, 103*).

Effect of Various Refining Processes on Sulfur Compounds

Processes Involving the Application of Heat. In any refinery process employing heat, whether it be distillation or cracking, there is the possibility that some sulfur compounds will be converted to other types. Friedmann (*122*) has shown that heating elemental sulfur with paraffins produces thiophenes, thiophanes, sulfides, and polysulfides. The well-known method for the laboratory preparation of hydrogen sulfide by simply heating paraffin wax, asbestos, and elemental sulfur should be recalled when the thermal effect on sulfur compounds is considered. If elemental sulfur is present in petroleum as it comes from the ground, as soon as it is subjected to heat, hydrogen sulfide may be evolved. This hydrogen sulfide could react with olefins to produce mercaptans (*96*). The effect of heat has been studied by API Project 48 (*133, 134, 174*), and it was concluded that much of the hydrogen sulfide present in petroleum is due to thermal effects. As previously pointed out, only a comparatively small portion of the total sulfur present in crude oil is in the fractions distilling below 500° to 600° F., but thermal effects causing the decomposition of sulfur compounds are the reason why there are more sulfur compounds below the boiling range than would be expected if heat were not applied. Several investigators (*116, 118*) have reported that mercaptans and thiophenes are the most stable of the organic sulfur compounds. Sulfides and disulfides under thermal cracking conditions form hydrogen sulfide, thiophenes, and mercaptans. More severe thermal cracking of the mercaptans yields hydrogen sulfide and olefins. Thiophenes are favored under the more severe thermal cracking conditions (*122*).

The order of increasing thermal stability of sulfur compounds is sulfides, disulfides, mercaptans, and thiophenes, which is consistent with the fact that mercaptans predominate in petroleum products that have been thermally treated and that increasing concentrations of thiophenes are found as the thermal conditions become more severe (*117*). This same order may be observed, for three of the sulfur compound types, in the average bond energy data presented by Remick (*130*):

Table IV. Key to Equations for Reactions of Sulfur Compounds

(Numbers refer to equation numbers in Table V)

Chemical Operation or Reagent	Sulfur Compounds: Mercaptans	Disulfides	Polysulfides	Sulfides	Thiophene	Elemental sulfur	Hydrogen sulfide	Sulfur dioxide
Oxidation								
Halogens	9, 16	23, 24, 34, 35	..	42, 43, 44	55	64	67	74
Other oxidizing agents	6	26	38	43, 44	56		66	75, 76, 77, 79
Alkalies	1	25				8	68	73
Reduction								
Reducing agents		22, 28	39	49				
Catalytic hydrogenation	7		40	48	53			
Heavy metals								
Elements			37					
Salts	2, 3, 4			45, 46	54		69	
Others								
Olefins	5	29			48	63, 62, 61	65	
Sulfur	3, 8, 10, 58	27	27	47				78
Sulfuric acid	14, 15			50	58, 57	14	71	
Miscellaneous	11, 12, 13, 17, 18, 19, 20	11, 30				10, 62, 63	70	77
Preparation or formation	21, 28, 30, 40, 49, 65	3, 6, 15, 36	10, 12, 13, 14, 27, 41, 47, 62	5, 29, 51, 52	59, 61, 63	66, 67, 70, 71	7, 40, 48, 53, 72	15, 31, 32 33, 50, 71 80

Linkage	Energy required to break linkage, kcal./mole
C—S	54.5
S—S	63.8
S—H	87.5

In the presence of cracking catalysts all the sulfur compounds, even thiophenes, are converted to hydrogen sulfide, hydrocarbons, and coke. This difference in the behavior of sulfur compounds at high temperatures in the presence of and in the absence of cracking catalysts explains the difference in the amount and the types of sulfur in catalytic and thermal gasolines.

Additional references are cited (*119, 120, 121*).

Catalytic Cracking. In a previous section of this paper, it was pointed out that although the sulfur content of catalytic gasoline and cycle oil was primarily dependent upon the sulfur content of the cracking stock, the mode of operation has an appreciable effect. High conversions and high feed partial pressures result in gasolines of low sulfur content and cycle oils of high sulfur content; lowering the temperature lowers the sulfur content in both the gasoline and the cycle oil. Natural catalysts produce gasoline of lower sulfur content than do synthetic catalysts. According to Healy and Hertwig (*124*) (for Mid-Continent, West Texas, and Wyoming crudes), the type of pretreatment given a sulfur-containing charge stock prior to catalytic cracking is of extreme importance in that gas oils which have been previously subjected to catalytic or thermal cracking conditions are harder to desulfurize than virgin gas oils. See also (*119*).

Processes Involving Hydrogenation. Refining processes such as hydroforming and platforming which improve the product quality of naphthas also greatly affect the sulfur content. In fact, these hydrogenation processes are capable of almost completely desulfurizing naphthas, gas oil, and crudes provided the appropriate catalyst and conditions are selected. Under optimum conditions, such hydrogenation processes are deliberately used for desulfurization. This special type of hydrogenation (also referred to as hydrogenolysis) differs from the catalytic desulfurization (*137*) in that hydrogen is employed with a selective catalyst (*112*) and a higher pressure is used to effect the decomposition of sulfur compounds. Catalytic desulfurization does not appreciably affect the more stable sulfur compounds such as the thiophenes and certain sulfides; however, destructive hydrogenation is capable of converting even thiophene to hydrogen sulfide and butane. The conditions must be carefully selected so that hydrogenation of the olefins will not occur before the hydrogenolysis of the sulfur compounds. When using a cobalt molybdate catalyst, the conditions are generally 700° to 750° F. with a pressure varying from 200 to 300 pounds per square inch. It is the susceptibility of sulfur compounds to this mild hydrogenation that makes this process feasible. An outstanding bibliography of petroleum desulfurization complete with abstracts has been compiled by Rakoff (*210*) which adequately covers all phases of this operation and excellent reviews of desulfurization and sweetening processes have been given by Tait (*132*) and Kalichevsky (*190*). In hydrogenolysis the catalysts employed are cobalt molybdate, molybdenum sulfide, nickel or cobalt thiotungstates, vanadium trioxide, and nickel tungsten sulfide; they are not poisoned by sulfur. Hydrogenolysis is by far the most efficient method of removing sulfur compounds from petroleum stocks: crudes (*123, 126*), gas oil (*125, 135*), gasoline (*115*), and gases. (So complete is this sulfur removal that methods employing alumina or platinized asbestos catalysts at atmospheric pressure have been used to determine analytically organic sulfur (*10, 57*) in light petroleum products.) High molecular weight polycyclic sulfur compounds such as resins and asphaltenes are hydrogenated in the first stages of the process and undergo gradual decyclization. The result is that the resinous and asphaltic materials are converted to hydrocarbons of lower molecular weight.

A variation of hydrogenolysis is autofining (*129*) in which sulfur compounds are catalytically decomposed by hydrogen furnished from naphthenes which are in turn converted to aromatics.

Acid Treatment. Although sulfuric acid is primarily employed to remove undesirable diolefins, peroxides, gums, gum-forming hydrocarbons, and resinous materials, it is also capable of removing certain sulfur compounds. Fuming sulfuric acid will completely remove mercaptans, monosulfides, disulfides, and thiophenes. However, fuming sulfuric acid is not employed in gasoline treating as it also reacts with the aromatics which are a desirable constituent of gasoline. With small amounts of commercial sulfuric acid (93%), the reaction with aromatics is prevented, and monosulfides, disulfides, and thiophenes are partially removed. Mercaptans can also be removed by virtue of their oxidation to disulfides which are soluble in the sulfuric acid. Dilute acid (66%), however, has little action on sulfur compounds. The concentration and the temperature at which the sulfuric acid is employed is of importance as a variety of side reactions can take place (*131*); for example, the use of sulfuric acid to treat gasoline not only causes the formation of alcohols and polymers as a consequence of the reaction with olefins but also causes the introduction of sulfuric acid esters, $R\text{HSO}_4$, and $R_2\text{SO}_4$, into the gasoline. While the alkyl bisulfate may be acid soluble, the dialkyl sulfate is usually more soluble in the gasoline and thus would have to be removed after the sulfuric acid treatment. An excellent review of the reactions of sulfuric acid on various sulfur compounds found in petroleum is presented by Mapstone (*127*).

Additional references are cited (*113*, *128*).

Table V. Equations for Reactions of Sulfur Compounds

1. $R\text{SH} + \text{NaOH} \longrightarrow R\text{SNa} + H_2O$
   low molecular weights dissolve in aqueous alkali; high molecular weights insoluble

2. $2\,R\text{SH} + \text{Pb}(CH_3CO_2)_2 \longrightarrow \underset{\text{insoluble}}{\text{Pb}(\text{S}R)_2} + 2CH_3COOH$
   also Hg, Zn, Cu, Ag, Au, Pt, Ni, Fe, Co, Zn, and Cd mercaptides are known

3. $\text{Pb}(\text{S}R)_2 + \text{S} \longrightarrow R\text{SS}R + \text{PbS}$

4. $R\text{SH} + \text{HgCl}_2 \xrightarrow[\text{alcohol}]{} R\text{SHgCl} + \text{HCl}$

5. $(H_3C)_2\text{—C=CH—CH}_3 + R\text{SH} \longrightarrow (CH_3)_2\text{CH—}\underset{\displaystyle \text{S}R}{\overset{}{\underset{|}{\text{CH}}}}\text{—CH}_3$
   adds counter Markownikoff

6. $2R\text{SH} + 1/2\ O_2 \longrightarrow R\text{SS}R + H_2O$
   also other oxidizing agents such as halogens, hypohalites, nitric acid, potassium permanganate, air, ferric chloride

7. $R\text{SH} + 2\text{H} \xrightarrow[V_2O_5]{400°\text{ C.}} R\text{H} + H_2S$

8. $2\,R\text{SH} + \text{S} + 2\,\text{NaOH} \longrightarrow R\text{SS}R + Na_2S + 2H_2O$

9. $t\text{-}R\text{SH} + I_2 \longrightarrow t\text{-RSI} + \text{HI}$

10. $2\,\text{NaS}R + 2\text{S} \longrightarrow Na_2S + R\text{S}_3R$

11. $R\text{SH} + R_1\text{SS}R_1 \longrightarrow R\text{SS}R_1 + R_1\text{SH}$
    Heated in borosilicate glass under N_2 with Na in *sec.*-C_3H_7OH as a catalyst.

    $R\text{SS}R + R'\text{SS}R' \longrightarrow 2\,R'\text{SS}R$
    trace of RSH as a catalyst

12. $4\,R\text{SH} + \text{SOCl}_2 \longrightarrow R\text{SS}R + R\text{SSS}R + H_2O + 2\,\text{HCl}$

13. $2\,R\text{SH} + S_2Cl_2 \longrightarrow R\text{SSSS}R + 2\,\text{HCl}$

14. $2\,R\text{SH} + H_2SO_4 + \text{S} \longrightarrow R_2S_3 + SO_2 + 2\,H_2O$

15. $2\,R\text{SH} + H_2SO_4 \longrightarrow R\text{SS}R + SO_2 + 2\,H_2O$

16. $R\text{SH} + Cl_2 \longrightarrow R\text{SCl} + \text{HCl}$

17. $t\text{-}R\text{SH} + CS_2 + \text{NaOH} \longrightarrow \underset{\text{aliphatic trithiocarbonate}}{t\text{-}R\text{S}\overset{\overset{\displaystyle S}{\|}}{\text{C}}\text{SNa}} + H_2O$

18. $R\text{SH} + n\underset{\diagdown\,\diagup \atop O}{CH_2CH_2} \longrightarrow R\text{S}(CH_2CH_2O)_n\text{H}$

19. $RSH + R'CHO \xrightarrow{HCl} R'CH(OH)SR$ hemimercaptal

$R'CH(OH)SR + RSH \xrightarrow{HCl} R'CH(SR)_2 + H_2O$ mercaptal

20. $3\,RSH + PCl_3 \longrightarrow P(SR)_3 + 3\,HCl$ alkyl trithiophosphites

21. $RCl + S{=}C(NH_2)_2 \longrightarrow \left[R{-}S{-}C(NH_2){=}NH_2\right]Cl$

$\left[R{-}S{-}C(NH_2){=}NH_2\right]Cl + NaOH \xrightarrow[\text{hydrolysis}]{} RSH + NH_2CN + H_2O + NaCl$

22. $RSSR + H_2 \xrightarrow[\text{Zn + acetic acid}]{} 2\,RSH$

23. $ArSSAr + Cl_2 \longrightarrow 2\,ArSCl$
anhydrous
true for aromatics only

24. $RSSR + 5\,Cl_2 + 4\,H_2O \xrightarrow{\text{room temp.}} 2\,RSO_2Cl + 8\,HCl$
also true for aromatic disulfides

25. $RSSR + KOH\text{(dilute)} \longrightarrow$ no reaction
$RSSR + 2\,KOH\text{(concd.)} \longrightarrow RSK + RSOK + H_2O$

26. $RSSR \xrightarrow[\text{acetic acid}]{H_2O_2} RSO_2SR$ thiolsulfonate

27 $RSSR + xS \xrightarrow{\Delta} RSS_xSR$
catalyzed by NH_3

28. $2\,RSSR + LiAlH_4 \longrightarrow (RS)_4LiAl + 2\,H_2$

$(RS)_4LiAl \xrightarrow[HCl]{H_2O} RSH$

29. $-C-C-S-S-C-C- + -C{=}C- \xrightarrow[\text{catalyzed}]{\text{acid}} -C-C-S-C-C-S-C-C-$

30. $RSSR + H_2 \xrightarrow{\text{catalytic}} 2\,RSH$

31 $RSSR + 2\,H_2SO_4 \longrightarrow RSSO_2R + 2\,H_2O + 2\,SO_2$ monosulfone

32. $RSSR + 4\,H_2SO_4 \longrightarrow RSO_2SO_2R + 4\,H_2O + 4\,SO_2$ disulfone

33. $RSSR + 5\,H_2SO_4 \longrightarrow 2\,RSO_3H + 4\,H_2O + 5\,SO_2$

34. $RSSR + Cl_2 \longrightarrow 2\,RSCl$

35. $RSSR + Cl_2 \xrightarrow{0^\circ\text{ F.}} RSSCl + RCl$ alkyl thiosulfenyl chloride

36 $RSI + RSH \longrightarrow RSSR + HI$

37. $RSSSR + 2\,Hg \longrightarrow RSSR + Hg_2S$

38. $RSSSR + 16\ HNO_3 \longrightarrow H_2SO_4 + 2\ R\!-\!\underset{\underset{O}{\downarrow}}{\overset{\overset{O}{\uparrow}}{S}}\!-\!OH + 16\ NO_2 + 6\ H_2O$

39. $2\ RSSSR + 2\ LiAlH_4 \longrightarrow (RS)_4LiAl + LiAlS_2 + 4\ H_2$

$LiAlS_2 \xrightarrow[HCl]{H_2O} H_2S$

40. $RSS_xSR + (x + 1)H_2 \xrightarrow{\text{catalytic}} 2\ RSH + xH_2S$

41. $2\ RCl + Na_2S_3 \longrightarrow RS_3R + 2\ NaCl$

42. $\underset{\text{anhydrous}}{RSR + Cl_2} \longrightarrow \left[R\overset{\overset{Cl}{\uparrow}}{S}\!-\!R \right]^+ Cl^-$

43. $RSR + Cl_2 + H_2O \xrightarrow{\text{aqueous}} R\overset{\overset{O}{\uparrow}}{S}R + 2\ HCl$

44. $RSR + 2\ Cl_2 + 2\ H_2O \longrightarrow R\!-\!\underset{\underset{O}{\downarrow}}{\overset{\overset{O}{\uparrow}}{S}}\!-\!R + 4\ HCl$

45 $RSR + HgCl_2 \longrightarrow R\underset{\underset{HgCl_2}{\downarrow}}{S}R$

46. $RSR + \underset{\text{dry powder}}{Hg_2Cl_2} \longrightarrow R\underset{\underset{HgCl}{\downarrow}}{S}R$

47. $RSR + S \xrightarrow[\text{24 hr.}]{180^\circ\text{ C.}} RSSR$ (reaction very poor)

48. $RSR + 4\ H \longrightarrow 2\ RH + H_2S$

49. $-\underset{|}{\overset{|}{C}}-\underset{\underset{R}{\underset{|}{S}}}{\overset{|}{C}}-\underset{|}{\overset{|}{C}}- \xrightarrow{\text{Raney Nickel}} -\underset{|}{\overset{|}{C}}-\overset{|}{C}=\overset{|}{C}- + RSH$

50. $R_2S + 2\ H_2SO_4 \longrightarrow \underset{\text{sulfone}}{R_2SO_2} + 2\ H_2O + 2\ SO_2$

51. $RSNa + RX \longrightarrow RSR + NaX$
more rapidly than corresponding Williamson synthesis of ethers

52. $2\ RSH \xrightarrow[\text{metallic sulfide}]{\text{high temperature}} RSR + H_2S$

53. $\underset{\text{thiophene}}{C_4H_4S} + 6\ H_2 \xrightarrow[\text{1 atmos., } V_2O_5]{400^\circ\text{ C.}} C_4H_{10} + H_2S$

54. $C_4H_4S + HgCl_2 \longrightarrow C_4H_3S{\cdot}HgCl + HCl$

55. $C_4H_4S + Cl_2 \longrightarrow C_4H_3ClS + HCl$

56. $C_4H_4S + HOCl \xrightarrow{\text{pH 4.0}} H_2SO_4 + \text{derivatives}$

57. $C_4H_4S + H_2SO_4 \longrightarrow \underset{\text{sulfonic acid}}{C_4H_3SSO_3H} + H_2O$

58. $C_4H_4S + C_xH_{2x} \xrightarrow[\text{alkylation}]{H_2SO_4\ \ \text{sulfonic acid}} C_xH_{2x+1}\,C_4H_3S$

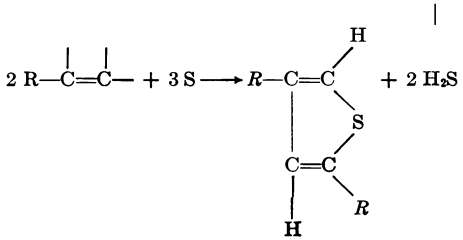
59. $C_4H_{10} + 4\,S \xrightarrow{\text{high temp.}} \underset{\text{thiophene}}{C_4H_4S} + 3\,H_2S$

60. $S + Hg \longrightarrow HgS$

61. $\underset{\text{butadiene}}{C_4H_6} + S \xrightarrow{\text{high temp.}} C_4H_4S + H_2S$

62. $R-C=C-\underset{H}{C}-R_1 + xS \xrightarrow[\text{catalyst}]{250\text{–}325^\circ\text{ F.}} R-C=C-\underset{Sx}{C}-R_1$

$R-C-C-C-R_1$

63. 

64. $Cl_2 + 2\,S \longrightarrow S_2Cl_2$

65. $-C-C=C- + H_2S \xrightarrow[\text{catalyst}]{100\text{–}300^\circ\text{ C.}} -C-\underset{SH}{C}-C-$

adds according to Markownikoff's rule

66. $H_2S + O \longrightarrow H_2O + S$

67. $H_2S + I_2 \longrightarrow 2HI + S$

68. $H_2S + NaOH \longrightarrow NaSH + H_2O$
$NaSH + NaOH \longrightarrow Na_2S + H_2O$

69. $H_2S + Hg(NO_3)_2 \longrightarrow HgS + 2\,HNO_3$

70. $H_2S + 1^1/_2\,O_2 \longrightarrow SO_2 + H_2O$
$2\,H_2S + SO_2 \longrightarrow 3\,S + 2\,H_2O$

71. $H_2S + H_2SO_4 \xrightarrow{\text{hot}} S + 2\,H_2O + SO_2$

72. $C_xH_{2x+2} + S \longrightarrow C_xH_{2x} + H_2S$

73. $2\,NaOH + SO_2 \longrightarrow Na_2SO_3 + H_2O$

74. $SO_2 + I_2 + 2\,H_2O \longrightarrow 2HI + H_2SO_4$

75. $5\,SO_2 + 2\,KMnO_4 + 2\,H_2O \longrightarrow K_2SO_4 + 2\,MnSO_4 + 2\,H_2SO_4$

76. $3\,SO_2 + 2\,CrO_3 \longrightarrow Cr_2(SO_4)_3$

77. $SO_2 + PCl_5 \longrightarrow \underset{\text{thionyl chloride}}{SOCl_2} + POCl_3$

78. $S + SO_2 \xrightarrow[\text{10 mm. press.}]{\text{electric arc}} 2\,SO$

79. $2\,SO_2 + O_2 \longrightarrow 2\,SO_3$

80. $S_2Cl_2 + 2\,H_2O \longrightarrow SO_2 + H_2S + 2\,HCl$

Processes for Segregating Sulfur Compounds

Distillation. Distillation cannot be relied upon to furnish a sharp separation of sulfur compounds from hydrocarbons since the sulfur compounds are pretty well dispersed throughout all boiling ranges; furthermore, sulfur compounds form many azeotropes with the various classes of hydrocarbons usually present in petroleum with the exception of the lower boiling aromatics (*88*). A comprehensive study of the azeotropes of alkane sulfides, alkane disulfides, thiophenes, and thiols with paraffins, naphthenes, and olefins has been recently reported (*87*) and from the constants obtained in these investigations it is possible to predict the mol per cent of a given sulfur compound in the azeotrope formed with hydrocarbons in the 50° to 250° F. boiling range. It was also shown that there was a straight line relationship existing between the boiling points of a series of azeotropes and the log of the mol per cent sulfur compound in the mixture. A relative order of azeotrope-forming tendencies was established in which it was shown that paraffins > naphthenes > olefins > aromatics. The relative order of azeotrope formation was obtained by determining the maximum and minimum boiling points of hydrocarbons in a given homologous series that would form azeotropes with a given sulfur compound. The range of the spread between maximum and minimum was used as an index to the azeotrope-forming power of that homologous series; the greatest spread being considered as indicative of the greatest azeotrope-forming power. In a like manner the azeotrope-forming power of the sulfur compounds was considered and it was found that the following order is generally followed: straight chain disulfides > cyclic sulfides > thiophenes > thiols > straight chain sulfides.

While distillation does not appear to be a very potent tool in the direct separation of sulfur compounds from hydrocarbons, it is nevertheless very important, as in many processes it may be necessary to fractionate a stock prior to or after treatment in order to secure the maximum efficiency. Thus, fractionation techniques as an auxiliary to other processes are still most necessary.

Additional references are cited (*110, 126*).

Adsorption. Adsorption techniques offer a possible route for separating sulfur compounds from the associated hydrocarbons (*145*) as sulfur compounds in general are adsorbed on silica gel to a greater extent than aromatic and paraffin hydrocarbons.

The relative order of increasing adsorptivity of the various sulfur compounds and associated hydrocarbon to be adsorbed on silica gel, given by Haresnape, Fidler, and Lowry (*151*), is aromatic hydrocarbons, thiophenes, alkanethiols, alkane disulfides, aromatic and cycloalkanethiols, alkane sulfides, and cyclic sulfides. (The more polar sulfur compounds such as sulfoxides, sulfones, and sulfonic acids would be expected to be more readily adsorbed and therefore would fall at the end of the list.)

Haresnape, Fidler, and Lowry also state that it is possible to separate aromatic hydrocarbons sharply from any sulfur compound more strongly adsorbed than a disulfide. In this list the influence of the hydrocarbon portion of the molecule is apparent and causes a displacement of the sulfur functional groups. Because the order of adsorption is a function of the molecular weight, and the configuration of the substituent groups, as well as the sulfur functional group, a more detailed representation of the adsorptive order of the lower molecular weight sulfur compounds is presented in an API. Project 48A report (*144, 174*). In this study it was noted that the lower the molecular weight, the greater was the adsorption of sulfur compounds with the same functional group. The functional group order of increasing adsorption is thiophenes, thiols, disulfides, sulfides, and cyclic sulfides, which is in good agreement with the order established by Haresnape, Fidler and Lowry.

Adsorption with silica gel is an extremely useful tool in sulfur compound analysis. Since sulfur compounds are more tightly adsorbed than aromatics, unsaturated compounds, naphthenes, and paraffins (in that order), a ready means of separating the sulfur in a given boiling range, is available. Compounds more polar than the sulfur compounds, such as amines, alcohols, and acids (in increasing order) are capable of replacing them from the column; alcohols are used to replace the sulfur compounds in most chromatographic schemes. Sulfur compounds, after being displaced from the silica gel column, can be identified by their refractive indices, and if the prior fractionation is sufficiently narrow, individual sulfur compounds can be obtained. A plot of the refractive indices of successive adsorption cuts from a silica gel column *vs.* the order in which these cuts were displaced is called an "adsorptogram" and is useful in identifying pure compounds. Many investigators have used silica gel in connection with other techniques as a means of isolating and identifying sulfur compounds in various naphthas (*144, 167*).

Although other adsorbents such as activated carbon, bauxite, and Fuller's earth have been used to desulfurize naphtha, their adsorptiveness is generally thought to be inferior to silica gel with respect to their use for analytical purposes. Recent investigations have revealed that H-41 alumina (available from Aluminum Company of America, Chemicals Division) is superior to silica gel for concentrating the sulfur compounds in a Wasson distillate; 82% of the total sulfur was concentrated into 1.8% of the naphtha (*174*).

Additional references are cited (*120, 121, 156, 164*).

Extraction. Sulfur compounds may be segregated by solvent extraction, by removal of acidic sulfur constituents with alkaline reagents, and by acid extraction.

SOLVENT EXTRACTION. It is well known that cold sulfur dioxide dissolves sulfur compounds, but processes based on this solubility suffer from the lack of selectivity, as aromatics are likewise extracted. Many other solvents, such as aniline, propylene, glycol, and furfural, have been proposed but are not completely satisfactory. Extraction of individual organic sulfur compounds with anhydrous hydrogen fluoride shows an orderly progression with changes in sulfur type, in molecular weight, or in configuration of substituent groups (*154*). This order is roughly the same as the order of adsorption observed for silica gel.

An additional reference is cited (*168*).

REMOVAL OF ACIDIC SULFUR CONSTITUENTS. The common sulfur acidic materials like hydrogen sulfide and the mercaptans may be removed from gases and naphthas by the use of an alkaline solution such as sodium hydroxide, alkaline phosphates, and alkylolamines. In the Mercapsol, Solutizer, and Unisol processes the reactivity of the alkali with the mercaptan is enhanced by the incorporation of various additives. Naphthenic acids and isobutyric acid, which are used in the Mercapsol and Solutizer processes, respectively, improve the reactiveness of the alkali with the higher molecular weight mercaptans over that when caustic is used alone. The reactivity of the sodium hydroxide, with and without additive, toward mercaptans of varying carbon atoms is presented by Happel, Cauley, and Kelly (*150*). In the Unisol process, however, the caustic solution which has methyl alcohol incorporated in it reacts with all mercaptans equally. In the gas purifying processes there is no concern for the various degrees of reactivity the mercaptans exhibit toward alkalis, since the major sulfur components of a gas are usually limited to hydrogen sulfide and the lower molecular weight mercaptans which are very easily combined with the alkanolamine or the alkali phosphate which is employed in these processes. The gas purifying processes employ an alkaline solution which forms compounds with the acidic constituents that are unstable at high temperatures; thus, the solution may be easily regenerated.

The mercaptans may be regenerated by acidification of the caustic solutions, or these solutions may be deliberately oxidized to yield disulfides (*37*). It should be pointed out that, just as in the case of the gas purifying processes, hydrogen sulfide reacts with all the other alkalis in the aforementioned processes. Because the amount of hydrogen sulfide is usually large and because of its activity toward ordinary caustic solutions, a common refinery practice is to remove a major part of the hydrogen sulfide with inexpensive caustic so as not to overload the subsequent sweetening processes.

Additional references are cited (*9, 113, 143, 153, 158, 160, 169, 170*).

The hydrogen sulfide content of some natural gases in West Texas and in Wyoming and some of the other western states is frequently sufficiently high to make the erection of a plant for producing elemental sulfur economically attractive. Likewise, in some of the larger refineries in the United States the amount of hydrogen sulfide produced per day is in the order of 30 to 60 tons, which amount is sufficiently large for installation of sulfur recovery facilities. While there have been several different processes proposed for the production of elemental sulfur from hydrogen sulfide, the ones in use in the United States at the present time are generally based on the Claus process. In this process the hydrogen sulfide is first concentrated by absorbing it in an alkaline solution so that the gas when regenerated will be approximately 70% or more hydrogen sulfide. A portion of this hydrogen sulfide is burned to form sulfur dioxide which is mixed with some of the hydrogen sulfide concentrate and passed over a bauxite-type catalyst at elevated temperatures. This reaction produces elemental sulfur.

Additional references are cited (*136, 139, 141, 147, 152, 159, 162, 156, 171*).

ACID EXTRACTION. Strong sulfuric acid not only reacts with many sulfur compounds in gasolines at room temperature, but also with aromatic and unsaturated compounds; however, when the temperature is dropped to 15° to 20° F., the acid is capable of dissolving the sulfur compounds while its activity toward unsaturates and aromatics has been diminished considerably (*113, 131*), thus making a selective removal of the sulfur compounds feasible. Dilution of the acid with water regenerates the sulfur compounds; however, these compounds may not necessarily be the same as were originally present in the naphtha, particularly if the acid treatment was not maintained at the low temperature.

Sulfonic acids may also be classified as sulfur compounds derivable from petroleum although the sulfur functional group is derived from the sulfuric acid treating agent. As previously mentioned, generally two types of sulfonic acids are obtained, the oil-soluble acids and the oil-insoluble acids. However, Sperling (*161*) has recently set up a classification system which divides the sulfonic acids into eight subgroups. This classification is shown in Table VI. In common refinery practice the oil-soluble acids are obtained by treating the oil with sodium hydroxide to convert the acids to the sodium salt which may be extracted with dilute ethyl or isopropyl alcohol. The inorganic salts are precipitated by adjusting the alcohol content. After filtration the sodium sulfonates are deoiled by extraction with petroleum ether. The sulfonic acids may be removed from the acid layer by treatment with an equal volume of water. This divides the acid sludges into two layers: an upper, tarry, rich layer containing organic material and a lower layer, mostly containing the spent sulfuric acid. Sulfonic acids of different types may be recovered if the upper and lower layers are treated separately. This treatment is carried out by adding caustic, dehydrating, extracting with alcohol, removing inorganic salts, and deoiling.

Sulfonic acids may also be made by direct treatment of the oils with sulfur trioxide (*163*).

An additional reference is cited (*149*).

Table VI. Classification of Petroleum Sulfonic Acids[a]

Group and Subgroup	Radical	Characteristic Property	Source
Oil-soluble monosulfonic acids			
Hydrocarbon sulfonic acids	Aromatic - naphthenic nucleus attached to long paraffinic chains	Soluble in hydrocarbon oils	Oil layer
Resin sulfonic acids	Oxygenated compounds derived from above	Soluble in hydrocarbon oils	Oil layer
Oil-insoluble monosulfonic acids			
Hydrocarbon sulfonic acids	Aromatic - naphthenic nucleus with short paraffinic chains	Insoluble in hydrocarbons and mineral acids, soluble in benzene	Acid sludge upper layer on water dilution
Resin sulfonic acids	Oxygenated compounds derived from above		
Asphaltene sulfonic acids	Oxygenated polymers of high molecular weight	Insoluble in dilute mineral acids and benzene, sol. in $CHCl_3$	
Oil-insoluble disulfonic acids			
Less aromatic disulfonic acids	Aromatic - naphthenic nucleus with short paraffinic chains	Soluble in dilute mineral acids, and $C_6H_{11}OH$ barium salt soluble in water	Acid sludge, upper layer on water dilution
Highly aromatic dilsulfonic acids	Highly aromatic nucleus, no paraffinic chains	Soluble in dilute mineral acids; insoluble in $C_6H_{11}OH$	Acid sludge, lower layer on water dilution
Corresponding resin and asphaltene disulfonic acids	Corresponding oxygenated and polymerized compounds derived from above two hydrocarbon types	Similar to disulfonic acids of parent compound	

[a] According to Sperling (*161*).

Miscellaneous Methods for Manufacture of Sulfur Compounds. The current trend toward synthetic detergents and the fact that sulfonic acids have been found to possess many attributes desirable for a detergent has led to the development of hydrocarbons which upon sulfonation yield a superior type of detergent. One of the most satisfactory types of product for general household application is the alkyl aryl sulfonates. This field is adequately discussed by Griesinger and Nevison (*148*).

In addition to the processes discussed for segregating sulfur compounds, other means have also been employed by refiners to produce certain sulfur compounds. Some refineries have installed facilities for recovering the sulfur dioxide obtained from the burning of acid sludges and using it to manufacture sulfuric acid (*166*), while other refiners manufacture acid utilizing the recovered hydrogen sulfide (*140, 146*). Mercaptans and disulfides have been produced from the catalytic reaction of hydrogen sulfide and olefins (*138*). Thiophene may be produced from the reaction of elemental sulfur, sulfur dioxide, or hydrogen sulfide with hydrocarbons (*142, 155*); and carbon disulfide may be made from elemental sulfur and methane (*14*). Having a supply of these sulfur compounds it is possible for refiners to produce polysulfides by reaction of disulfides with elemental sulfur at elevated temperatures (*91*); trithiocarbonates by reaction of aliphatic mercaptans with carbon disulfide and sodium hydroxide (*103*); aliphatic tertiary sulfenyl chlorides and their derivatives by the reaction of aliphatic tertiary mercaptans to with chlorine (*103*); and surface active alkylmercapto polyether alcohols from the addition of ethylene oxide to a mercaptan. Mercaptols and mercaptides may also be prepared by reacting mercaptans with aldehydes and heavy metals respectively.

General References

Bibliographies. In addition to the foregoing specific references, there are other books and articles which are too general to be listed in any single one of the previous categories of this subject. Borgstorum, Bost, and Brown's "Bibliography of Organic Compounds" (*179*) is a valuable aid in securing information published about organic sulfur compounds prior to 1929. It lists brief abstracts of patents and literature articles dividing the field into 34 groups according to the type of sulfur compound. Rakoff's "Bibliography on Petroleum Desulfurization" (*201*) is not as limited as its title implies, since it contains abstracts not only pertaining to desulfurization but many other phases of sulfur petroleum chemistry as well. Many important references on sulfur compounds derived from petroleum can be found in its well-organized index. A literature article by Fookson and Bell (*13*), although entitled "Sulfur Compounds in Gasoline," has many references to sulfur compounds in general and contains an excellent bibliography. In the December, 1949 issue of *Industrial and Engineering Chemistry* there is a collection of articles devoted to the sulfur compounds in petroleum (*188*) and in the November, 1950 issue of this same periodical there is a symposium on sulfur (*189*). While the latter symposium is not necessarily concerned with the specific subject of sulfur compounds derivable from petroleum, it nevertheless contains articles having many pertinent references. In the November, 1950 issue of *Petroleum Refiner*, Kalishevsky initiated a series of eight articles (*190*), "Sweetening and Desulfurization of Light Petroleum Products," which not only describes essentially all of the desulfurization processes but also includes many references on sulfur compounds in general.

API and Bureau of Mines Projects. Some of the most important current work on the sulfur compounds present in petroleum is being carried out under the auspices of the American Petroleum Institute under Project 48 which was organized in 1948 to conduct fundamental studies on the synthesis, properties, and identification of sulfur compounds in petroleum. At present, Project 48 consists essentially of four phases: (1) production and purification of sulfur compounds and the determination of their common physical properties; (2) measurement of thermodynamic properties of pure sulfur compounds; (3) identification and measurement of sulfur compounds in crude oil; and (4) development of methods of synthesis and identification of sulfur compounds. Work on the first three phases, combined as Project 48A, is being conducted at the U. S. Bureau of Mines under the supervision of H. M. Smith as project director. Work on the fourth phase designated as Project 48B is being conducted at Northwestern University under the direction of F. G. Bordwell. The API Advisory Committee for the entire project consists of W. D. Seyfried, R. G. Capell, W. H. Claussen, F. E. Frey, H. D. Hartough, G. P. Hinds, G. R. Lake, A. P. Lien, L. T. Lorne, and F. P. Richter. Mr. Seyfried, chairman of the Advisory Committee, outlined the scope and activities of this project in the *Chemical and Engineering News* (*38*).

Prior to the formation of the API Project 48, the Bureau of Mines initiated research on the problem of sulfur in petroleum. For this reason the Advisory Council of Project 48 after its formation elected the Bureau of Mines to carry out a portion of its program because such an arrangement was to their mutual interest and would eliminate duplication of work. There are some phases of the Bureau's work on sulfur in petroleum that API Project 48 does not support. Some of the publications on this type of work and on Bureau of Mines work on sulfur in petroleum before the establishment of Project 48 are as follows: (*2, 20, 40, 49, 50, 112, 124, 133, 134, 144*). Other Bureau of Mines publications may be found by consulting the *List of Publications of the Bureau of Mines* (*194*).

While some of the completed research produced by the joint effort of the Project and the Bureau of Mines has appeared in the technical literature (*21, 92, 93, 97, 104, 105, 108, 177*), the bulk of the work of this Project, which is now being reported in progress report type publications (*173, 174, 175, 176*), is still preliminary in nature and is not ready for general release. The information contained in these progress reports is not regarded as confidential and further advice regarding the availability of these reports and the information therein may be obtained from the Project or the Bureau of Mines. Recently an excellent summary of Project 48's history, program, accomplishments, and conclusions drawn from their work has been presented at an American Petroleum Institute Session and is available as a preprint (*177*).

Petroleum Companies. Some of the major petroleum companies are carrying on extensive research programs on problems associated with the presence of sulfur in petroleum and as a product of this research some information on the availability of sulfur compounds derivable from petroleum has been obtained. While much of this information is of necessity confidential, some portion of it is eventually presented at AMERICAN CHEMICAL SOCIETY meetings or is published in the chemical literature. Although no attempt can be made to name all the companies carrying on work of this sort, there have been recent contributions by research workers from Phillips Petroleum Company, Standard Oil Development Company, Anglo-Iranian Oil Company, Union Oil Company, and Standard Oil Company (Indiana).

Books and Publications. Some of the general references that should not be overlooked in a search of this sort designed to yield information on sulfur compounds is that material that can be obtained from some of the standard encyclopedias and reference texts, for example, "The Science of Petroleum" (*182*); Ellis, "The Chemistry of Petroleum Derivatives" (*184*); Sachanen, "The Chemical Constituents of Petroleum" (*34*); Sachanen, "Conversion of Petroleum" (*202*); Kalichevsky and Stagner, "The Chemical Refining of Petroleum" (*191*); Egloff, "The Reactions of Pure Hydrocarbons" (*183*); Nelson, "Petroleum Refining Engineering" (*196*); Gruse and Stevens, "The Chemical Technology of Petroleum" (*149*); and Goldstein," The Petroleum Chemicals Industry" (*187*).

Some technical publications such as *Petroleum Refiner* (*200*), *Petroleum Processing* (*199*), and the *Petroleum Engineer* (*198*) frequently publish information of a practical nature regarding sulfur chemistry and review principal processes involving sulfur in refinery operations. *Soap and Sanitary Chemicals* (*204*), being concerned with detergents of all kinds, frequently carries articles about the uses and properties of sulfonic acids. The *Petroleum Refiner* and the Universal Oil Products Co.'s *Library Bulletin of Abstracts* (*193*) publish abstracts on desulfurization processes, and *Soap and Sanitary Chemicals* abstracts current patents pertaining to detergents, many of which are sulfonated petroleum products. This latter publication also abstracts in a news-reporting style articles of interest in the detergency field.

Patents. No literature search can be complete without consideration of the patent literature. Since it is outside the scope of this survey to undertake any comprehensive search on the subject of sulfur in petroleum, it may be desirable to herewith include a brief set of instructions of how a search of the U. S. patents may be conducted. The U. S. patents are divided into 300 classes which in turn are divided into about 43,000 subclasses. The United States Patent Office issues a "Manual of Classification" (*205*) and various classification bulletins (*180*) which provide a key to the numerous patents issued by that office. The manual contains a subject index of the various search classes and an arrangement of the classes and subclasses in numerical order. Knowing the class and subclass of a given subject, the definition of each subclass may be sought in the appropriate classification bulletin. There is a classification bulletin for each class. With the aid of these definitions, one may select the subclasses that most nearly fit the subject which he is seeking. Having the appropriate subclasses, one may obtain from the Patent Office a list of the numbers of all patents contained in each subclass. The title and abstracts can be obtained by using the numerical patent index in the chemical abstracts; or the claims of the individual patents may be looked up in the *Official Gazette U. S. Patent Office* (*197*). Consulting the abstracts or the claims will enable the searcher to determine whether he desires to examine the complete patent. If so, the patent may be obtained by number from the United States Patent Office at a cost of twenty-five cents per patent.

A few of the most important U. S. patent classes and subclasses for obtaining information on sulfur compounds obtainable from petroleum are listed below. All those patent subclasses which would yield references to desulfurization have been omitted in view of the excellent coverage of patent abstracts on this subject given in Rakoff's bibliography (*201*). References to the sulfur compounds themselves may be found by searching many of the patent classes such as 196 for mineral oils, 202 for distillation processes, 183 for gas separations, 210 for liquid separations, and 260 for organic carbon compounds. In this last class are listed the most important references to the sulfur compounds and for that reason there is included below a selected list of those subclasses which may contain pertinent information on sulfur compounds.

Class 260: Chemistry of Carbon Compounds

Subclass	Title
125	Sulfurized Carbon Compounds of Undetermined Composition
327	Hetero-sulfur atoms
329	Thiophenes
329.3	Diarylene sulfides
330.5	Arylene thiophenes
332.8	Preparation, purification or recovery of thiophene
454	Thiocyanic acid
455	Thiocarbonic acid
459	Unsubstituted alkyl acyclic sulfoxy acids
460	Unsubstituted alkyl acyclic sulfoxy acids produced by sulfation of olefins
470	Aromatic compounds wherein the acid radical contains sulfur
481	Acyclic compounds wherein the acid radical contains sulfur
503	Sulfonic acids
504	Sulfonation products of nonaromatic hydrocarbon mixtures
505	Aromatic sulfonic acids
513	Acyclic sulfonic acids
552	Thioureas
567	Thiocarbamyl compounds
608	Disulfides, persulfides (two or more atoms of sulfur joined together)
609	Mercaptans, mercaptides and thioethers
685	Sulfurization processes
686	Sulfonation or sulfation processes

Universities. The work on theses and dissertations carried on by universities is largely inaccessible. It has been estimated that 50% of the doctoral dissertations and probably most of the master theses are never published (*195*). The possibility of obtaining information from university theses on a systematic basis is not bright since only few countries publish union lists of dissertations which present titles (the United States, however, is one of those countries in which union lists are available.) Then the accessibility of the dissertation itself is another source of trouble since no one library has a complete file nor is there an international depository where theses can be obtained. The problem of securing lists of theses and obtaining the thesis itself is discussed in detail by Marr, "Theses and Dissertations" (*195*). Also included in this article are sources whereby one can obtain information on how to secure lists of theses from the universities of the United States, France, Switzerland, Germany, Netherlands, Sweden, and Canada.

Searching the Literature. As previously stated, this survey of the literature of sulfur compounds derivable from petroleum is of necessity limited. It is limited both from the standpoint that very little emphasis has been placed upon foreign reference and also from the fact that only a small percentage of the U. S. sources have been mentioned. While it is hoped that this brief survey will be of assistance to the searcher, there will nevertheless arise situations when it is necessary to examine the literature more closely. In such an event the recent publication of the AMERICAN CHEMICAL SOCIETY's series on ADVANCES IN CHEMISTRY, "Searching the Chemical Literature" (*172*) will be of great assistance to a searcher. Among the numerous topics discussed are the use of chemical abstracts (*181*), foreign (*186*) and U. S. patents (*185*), German scientific literature (*203*), theses and dissertations (*195*), government documents (*178*), and house organs (*192*). Inasmuch as this booklet not only presents background information on library science but also contains many lists of references, it should be a valuable handbook for one about to embark upon a comprehensive search.

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Sources of Market Information On Petrochemicals

RICHARD M. LAWRENCE, *Monsanto Chemical Co., St. Louis, Mo.*
JONATHAN H. SPRAGUE, Jr., *Freeport Sulphur Co., New York, N. Y.*
RAYMOND H. EWELL, *Stanford Research Institute, Stanford, Calif.*

Most organic chemicals are now made wholly or in part from petroleum or natural gas. Therefore, the markets for petrochemicals are virtually the same as the markets for organic chemicals in general. This paper presents a bibliography of the key sources of information on the markets for petrochemicals, and organic chemicals in general, including general sources, chemical-consuming industries, and chemicals and chemical end products.

Petroleum chemicals or "petrochemicals" are chemicals derived from petroleum, liquefied petroleum gases, or natural gas. These raw materials are the major sources of organic chemicals today, and the term petrochemicals is virtually synonymous with "organic chemicals." Therefore, the markets for petrochemicals are the same as the markets for organic chemicals in general. Even a few inorganic chemicals—for example, sulfur, sulfuric acid, ammonia, and hydrogen cyanide—are made from petroleum and natural gas.

Virtually all organic chemicals are made wholly or in part from petroleum and natural gas. Methane, ethane, propane, butane, ethylene, propylene, butylenes, cyclohexane, and other nonaromatic hydrocarbons and their derivatives are made entirely from petroleum and natural gas. Toluene, xylenes, cresylic acids, ammonia, cyclopentadiene, and their derivatives are made principally, although not entirely, from petroleum and natural gas. Benzene, acetylene, hydrogen cyanide, sulfur, and their derivatives are made in part from petroleum and natural gas, although other sources are more important. As a matter of fact, there are very few organic chemicals which are not made wholly or in part from petroleum or natural gas. A few examples of chemicals not made from petroleum or natural gas are naphthols, regenerated cellulose, fatty acids, toxaphene, furfural, glutamic acid, and sorbitol.

However, petrochemicals are so synonymous with organic chemicals that the sources of market information can be considered to be the same as those for organic chemicals in general.

Market Potentials

What are the markets for petrochemicals or organic chemicals in general? The sale of most chemicals will come under one of four categories:

Sales to other chemical companies to make other chemicals or chemical end-products.

Sales to chemical-consuming industries (other than the chemical industry) to use in processing or to make into consumer products.

Sales directly into wholesale and retail trade channels.

Export sales.

Sales to Other Chemical Companies. This comprises the sale of intermediates from one chemical company to another, such as acetone, phenol, formaldehyde, glycerin, ammonia, and phthalic anhydride. The purchasing chemical companies use the chemicals to make other chemicals and ultimately to make chemical end-products, such as plastics, fibers, medicinals, fertilizer, synthetic rubber, antiknock agents, pesticides, and lubricating oil additives. Virtually all of the chemicals sold by one chemical company to another are intermediates rather than chemical end-products. Chemical end-products, such as plastics, fibers, and pesticides, are rarely sold from one chemical company to another.

Sales to Chemical-Consuming Industries. This comprises sales to (1) manufacturing industries, such as the textile, rubber, paint, plastics fabricating, petroleum, pharmaceutical, food processing, mining and smelting, metal fabricating, paper, and leather industries; (2) service industries, such as laundry, dry cleaning, transportation, and communications; and (3) agriculture. These industries use the chemicals they purchase for processing or for making consumer products. They do not use purchased chemicals to make other chemicals, except in a few rare instances.

Sales Directly into Wholesale and Retail Trade Channels. Comparatively few chemical products are sold directly into wholesale or retail trade channels. A few examples are household insecticides, some fertilizers, soil conditioners, antifreezes, and cellulose sponges.

Export Sales. Chemicals used in the export trade are, of course, consumed in foreign countries in the same categories just discussed. However, exported chemicals are in a special class because, regardless of their use in the foreign country, they are removed from the channels of trade in the United States.

Bibliography

On the basis of the above analysis of chemical sales categories, the bibliography given below is divided into three principal sections.

General Sources. Sources of general economic data, sources which give data on many industries and commodities, compendia of market research data, and bibliographies are listed in this section.

Chemical-Consuming Industries. This section contains sources of data on chemical-consuming industries, including agriculture.

Chemicals and Chemical End-Products. Sources of data on all organic chemicals and those inorganic chemicals which have some relationship to petrochemicals are included.

The bibliography of 150 references includes the key references relating to markets for petrochemicals and organic chemicals in general. However, it is not exhaustively complete, and there are numerous additional less important sources which will be found mentioned in some of the sources listed. Important industries not mentioned specifically are covered in references given in General Sources. Important chemicals and chemical end-products not mentioned specifically are covered in references given in General Sources or in the General list under Chemicals and Chemical End-Products.

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Stanford Research Institute, Stanford, Calif., "Chemical Economics Handbook" (looseleaf), annual, 1950-. Issued in several installments per year. Graphical and tabular data on economic indicators; production, sales and sales value of major industries and commodities; economic data on chemical and allied process industries; production, sales, sales value, consumption pattern, foreign trade, and prices of major raw materials, chemicals, and chemical end-products.

U. S. Government Publications

Bureau of the Census, "Census of Manufactures," 1899, 1904, 1909, 1914, biennially 1919–1939, and 1947. Production, sales, employment and other data on all major industries. Among chemical products, data are given on all major organic and inorganic chemicals, including acids, alkalies, salts, pigments, compressed and liquefied gases, fertilizers, plastics, synthetic fibers, synthetic rubber, explosives, medicinal chemicals, synthetic detergents, glycerin, wood distillation products, naval stores, fatty acids, carbon black, etc. Basic data on many chemical-consuming industries, such as rubber, paint, petroleum, pharmaceutical, metal, food and other industries. Considerable breakdown by states. "Annual Survey of Manufactures" gives abridged supplemental data for intercensal years 1949 to date.

Bureau of the Census, "Historical Statistics of the United States 1789–1945," 1949. Supplement and historical summary of "Statistical Abstract of the United States." Continuation data, 1946 to date, given in appendices of "Statistical Abstract of the United States."

Bureau of the Census, "Statistical Abstract of the United States," annual, 1880-. General economic data and basic data on all major industries and commodities.

Bureau of the Census, "United States Exports of Domestic and Foreign Merchandise," Rept. No. **FT 410**, monthly and annual, 1820–. Quantity and value of U.S. exports by commodity by country of destination. Formerly "Foreign Commerce and Navigation of the U.S.," 1820–1946.

Bureau of the Census, "United States Imports of Merchandise for Consumption," Rept. No. **FT 110**, monthly and annual, 1820–. Quantity and value of U. S. imports by commodity by country of origin. Formerly "Foreign Commerce and Navigation of the U. S.," 1820–1946.

Bureau of Mines, "Minerals Yearbook," annual, 1910-. Data on production, sales, consumption, foreign trade, and prices of minerals and mineral products, including chemicals derived from coal and petroleum, nonferrous metals, sulfur, and other mineral raw materials. Data for 1950 for many items now available in preprint form, and many preliminary annual and monthly data for 1951 and 1952 available in "Mineral Industry Surveys." Formerly "Mineral Resources of the United States," 1910–1931.

Department of Agriculture, "Agricultural Statistics," annual, 1927–. Crop data and statistics on production, production value, prices, and uses of agricultural raw materials and end-products. Formerly "Yearbook of Agriculture," 1927–1935.

Department of Commerce, "Basic Information Sources," 1948–1950. Series of over 100 bibliographies on various chemicals and commodities. Subjects include rubber industry, plastics materials, synthetic fibers, and others.

Department of Commerce, "Market Research Sources," 1950. Guide to information on domestic marketing. Lists sources published by U.S., state, and local governments, colleges and universities, chambers of commerce, professional, technical and trade associations, commercial organizations and publishing companies.

Department of Commerce, *Survey of Current Business*, monthly with annual summaries and biennial historical supplements, 1929-. (Supplements not published during war.) Data on finance, wages, expenditures, and on production, sales, and prices of agricultural, mining, and manufacturing industries.

Department of Commerce, "Synopses of Information" (later called "Commodity Reviews"), 1940–1950. Series of over 100 leaflets on various chemicals, drugs, and commodities.

National Production Authority, *Defense Production Record*, weekly, May 3, 1951–Jan. 1, 1953. Summarizes activities of Defense Production Administration and related federal agencies. Includes certificates of necessity issued by D.P.A. for rapid amortization of new chemical facilities.

President's Materials Policy Commission, "Resources for Freedom," 5 vol., June, 1952. Study of raw material requirements of the United States, 1950–1975. Major sections on chemicals, metals, minerals, fuels, agriculture, forest resources, water, and ocean resources. Forecasts demand for major chemicals and raw materials up to 1975.

Tariff Commission, "Summaries of Tariff Information," 16 vol., 1948–1950. Production, foreign trade, tariff rates and general information on major commodities and raw materials. Includes volumes on "Chemicals, Oils and Paints" and on other, related products.

Tariff Commission, "War Changes in Industry," 1943–1949. Series of 29 booklets on various chemicals and commodities. Subjects include wool, alcohol, rubber, magnesium, magnesia, aluminum, petroleum, dyes, plastics products, *et al.*

PERIODICALS

Chemical and Engineering News, weekly with annual review issue (usually middle of January). Frequent surveys of major chemicals. Price data on chemicals and related materials.

Chemical Engineering, monthly with annual review issue (usually January or February issue). Frequent surveys of major chemicals. Annual review issue gives data on production and consumption pattern of major chemicals. Formerly *Chemical and Metallurgical Engineering.*

Chemical Week, weekly. Frequent surveys of major chemicals. Formerly *Chemical Industries* (monthly).

Industrial and Engineering Chemistry, monthly with biennial review issue (June of even-numbered years). Occasional surveys of major chemicals.

Journal of Commerce, daily. Special section on chemicals and developments in chemical industry.

Oil, Paint and Drug Reporter, monthly with annual review issue. Price data on chemicals and related materials.

Wall Street Journal, daily. Occasional review articles on chemicals and developments in chemical industry.

PAPERS PRESENTED AT TECHNICAL MEETINGS (frequently published afterwards, but sometimes available only in mimeographed form).

Chemical Market Research Association. Meetings four times a year. Papers frequently published in *Chemical and Engineering News.*

Commercial Chemical Development Association. Meetings four times a year. Papers frequently published in *Chemical and Engineering News.*

Division of Chemical Marketing and Economics, American Chemical Society. Meetings twice a year. Papers usually published in *Industrial and Engineering Chemistry* or *Chemical and Engineering News.*

Division of Petroleum Chemistry, American Chemical Society. Meetings twice a year. Papers usually published in *Industrial and Engineering Chemistry* or *Chemical and Engineering News.*

Chemical-Consuming Industries

Agriculture

U. S. GOVERNMENT PUBLICATIONS

Bureau of Agricultural Economics, "Agriculture's Capacity to Produce," Agricultural Information Bull. No. 88, June 1952. Production of all major crops in 1950 and 1951 with projections for 1955, and other data.

Bureau of Agricultural Economics, *Crop Production*, monthly with annual summaries, 1942-. Production data on all major crops.

Bureau of Agricultural Economics, *Farm Income Situation*, bimonthly, 1940-. Data on cash receipts, home consumption, net farm income, government payments, indexes of farm production, and outlook for farm income.

Department of Agriculture, "Agricultural Statistics." Described under General Sources.

Food and Food Processing

U. S. GOVERNMENT PUBLICATIONS

Bureau of Agricultural Economics, "Consumption of Food in the United States," Misc. Publ. **691** (1948). Statistics for 1909 to 1948 on food supply and utilization, prices and per capita consumption and on shipments of major food commodities for civilian relief in areas occupied by armed forces. 1949 Supplement gives revisions and 1949 data. No supplemental data since 1949.

Bureau of Agricultural Economics, *The Dairy Situation*, bimonthly. Data on farm production, factory production, cold storage and manufactures, stocks, prices, and utilization of dairy products.

Bureau of Agricultural Economics, "Dairy Statistics and Related Series," Stat. Bull. **100**, (June 1951). Summary of statistics contained in bimonthly issues of *The Dairy Situation*.

Bureau of Agricultural Economics, *The National Food Situation*, quarterly, 1941–. Per capita consumption of major food commodities and supply and distribution of major foods.

Leather

BOOKS AND PAMPHLETS

Leather Production Data, Tanners' Council of America, 100 Gold St., New York monthly, with annual summary, 1922–. Production of leather and leather products.

U. S. GOVERNMENT PUBLICATIONS

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources.

Department of Commerce, *Leather Industry Report*, monthly, January 1946–February 1950. Production of leather, leather products, and tanning materials.

Metal Fabricating Industries

BOOKS AND PAMPHLETS

American Bureau of Metal Statistics, 33 Rector St., New York, "Yearbook," annual, 1921–. Production of certain copper and brass products. Consumption of copper, lead, and zinc by fabricators.

American Iron and Steel Institute, 350 Fifth Ave., New York, *Statistical Reports*, monthly and annually, 1912–. Production of rolled iron and steel products, sheets, strips, bars, pipes, tubes, and steel wire.

U. S. GOVERNMENT PUBLICATIONS

Bureau of the Census, "Census of Manufactures," and "Annual Survey of Manufactures." Described under General Sources. Production of many fabricated metal products including ferrous and nonferrous metal products. Data on consumption of various metals and alloys by fabricators.

Mining and Smelting

BOOKS AND PAMPHLETS

American Bureau of Metal Statistics, 33 Rector St., New York, "Yearbook," annual, 1921–. Production, consumption, foreign trade, and prices of copper, lead, zinc, and other nonferrous metals.

American Iron and Steel Institute, 350 Fifth Ave., New York. *Statistical Reports*, monthly and annually, 1912–. Production, shipments, and employment of iron and steel industry and data on iron and steel products.

Bituminous Coal Institute, Washington, D. C. "Bituminous Coal Annual Facts and Figures," annual. Statistical survey of coal industries, including data on reserves, production, transportation, marketing, and labor conditions.

U. S. GOVERNMENT PUBLICATIONS

Bureau of the Census, "Census of Manufactures." Described under General Sources. Production of all metals and minerals.

Bureau of Mines, "Minerals Yearbook," annual, 1910–. Production of all metals and minerals.

Bureau of Mines, *Mineral Industry Surveys*, monthly. Reports on aluminum, bauxite, cadmium, chromite, copper, fluorspar, gold, lead, silver, tin, and zinc.

Paint

Books and Pamphlets

Hercules Powder Co., Wilmington, Del., "A Survey of the Paint, Varnish and Lacquer Industry," 1945. Production of surface coatings by type and materials used in manufacture of surface coatings.

National Paint, Varnish and Lacquer Association, Washington 5, D. C., *Coatings*, weekly. Statistical data, largely reprints of U. S. Government data. Annual summary gives historical data on sales of paint industry.

National Paint, Varnish and Lacquer Association, Washington 5, D. C., "Paint, Varnish and Lacquer Statistical Handbook," 1950. Data on production of paint, varnish and lacquer; consumption of raw materials; exports; labor statistics; wholesale price indexes; and market research. Supplement issued 1953.

U. S. Government Publications

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources.

Bureau of the Census, *Paint, Varnish, Lacquer and Filler*, Facts for Industry, Series M 19J, monthly, 1928–. Monthly and annual totals of sales value of paint, varnish and lacquer, breakdown by trade channel.

Bureau of the Census, *Sales of Lacquers*, Facts for Industry, Series M 19L, quarterly 1930–June 1948. Monthly, quarterly, and annual data on lacquer sales by type.

Paper

Books and Pamphlets

U. S. Pulp Producers' Association, 122 East 42nd St., New York, "Wood Pulp Statistics," annual, 1936–. Supply, consumption, sales, inventories, and foreign trade of pulpwood, pulp, and paper in the U. S. and world.

U. S. Government Publications

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources.

Bureau of the Census, *Pulp, Paper and Board*, Facts for Industry, Series M 14A, monthly, October, 1945 to date and annual, 1949 to date. Production, by grades, of paper and board.

Department of Commerce, *Pulp and Paper—Industry Report*, monthly and quarterly, January 1944–October 1950. Production, imports, exports, inventories, and consumption of wood pulp and production of paper and board by grades.

Petroleum

Books and Pamphlets

Advances in Chem. Ser., 5 (1951). Progress in Petroleum Technology, 1951. Collection of papers presented before the Division of Petroleum Chemistry. Mostly technological, but includes some economic data.

American Gas Association, Inc., 420 Lexington Ave., New York 17, N. Y., "Gas Facts," annual, 1947–. Energy reserves, production, sales and employment of natural gas and liquefied petroleum gas industries.

American Petroleum Institute, 50 West 50th St., New York 20, N. Y., "Petroleum Facts and Figures," annual, 1934 to date (except 1941–1946). Utilization, production, refining, transportation, and marketing of petroleum and petroleum products. Includes some world data.

American Petroleum Institute, 50 West 50th St., New York 20, N. Y., *Statistical Bulletin*, weekly with annual summaries in June. Issue of June 21, 1951 reports data on production, consumption, foreign trade, and stocks of crude oil and petroleum products for 1918–1950.

Sweeney, W. J., "Petroleum and Its Products," 24th annual Priestly lectures, Pennsylvania State University, 1950. Production and refining of petroleum, chemical production from petroleum and utilization of petroleum products.

U. S. Government Publications

Bureau of the Census, "Census of Manufactures." Described under General Sources. Production and consumption of petroleum products. Only source of detailed data on production of lubricating oil and greases.

Bureau of Mines, *Crude Petroleum and Petroleum Products*, Mineral Industry Surveys, monthly and annual. Production, demand, stocks, and foreign trade of petroleum and petroleum products.

Bureau of Mines, *LP-Gases*, Mineral Industry Surveys, annual. Sales of LP-gases, by hydrocarbon, by use, and by district.

Bureau of Mines, "Minerals Yearbook," annual, 1910–. Extensive data on production and consumption of petroleum, petroleum products, natural gas, and liquefied petroleum gases.

Bureau of Mines, *Natural Gas*, Mineral Industry Surveys, monthly and annual. Regional data on marketed production, storage and consumption of natural gas.

PERIODICALS

Oil and Gas Journal, weekly with annual survey issues on natural gas, petroleum refining, and international petroleum, plus annual review and forecast issue (January).

Petroleum Processing, monthly.

Petroleum Refiner, monthly.

Petroleum World, monthly, with annual review issue (October).

World Oil, monthly, with annual review issue (usually February).

World Petroleum, monthly, with annual review issue (July).

Rubber

See Chemicals and Chemical End Products.

Soap

See Chemicals and Chemical End Products.

Textiles

BOOKS AND PAMPHLETS

Textile Organon, Textile Economics Bureau, 10 East 40th St., New York, monthly with annual review issue, 1930–. Production, consumption, foreign trade, and prices of natural and synthetic fibers and textiles. Formerly *Rayon Organon* (1930–1951).

U. S. GOVERNMENT PUBLICATIONS

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources.

Bureau of the Census, *Cotton and Synthetic Woven Goods Finished*, Facts for Industry, Series M 15G, quarterly October, 1946–March 1948 and annual 1948 to date. Cotton and synthetic fabric finishing by type of fabric, by type of finish, and by end use.

Bureau of the Census, *Cotton Broad Woven Goods*, Facts for Industry, Series M 15A, quarterly, January 1943 to date. Production by type of goods, production of tire cord and fabrics and machinery used in manufacture of these products. Formerly Series 32-2 (January 1943–July 1947).

Bureau of the Census, *Synthetic Broad Woven Goods*, Facts for Industry, Series M 15C, quarterly, March 1944–. Production of rayon, acetate, nylon, and other synthetic fibers by type of fabric. Also consumption of yarns in fabrics. Formerly Series 32-3 (March 1944–December 1946).

Bureau of the Census, *Wool Manufactures*, Facts for Industry, Series M 15H, monthly, July 1919–. Production of woolen and worsted woven fabrics and consumption of fibers in woolen fabrics. Formerly Series 32-1 (January 1944–December 1944).

Wood Preserving

U. S. GOVERNMENT PUBLICATIONS

Forest Service, "Wood Preservation Statistics," annual, 1910–. Statistics on wood-preserving plants, consumption of preservatives and materials treated, compiled in cooperation with American Wood Preservers' Association.

Wood Products

BOOKS AND PAMPHLETS

National Lumber Manufacturers' Association, 1319 18th St., Washington, D. C., "Lumber Industry Facts," annual. Production, uses, prices, and foreign trade of lumber, by grades and types and by states.

U. S. GOVERNMENT PUBLICATIONS

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources.

Bureau of the Census, *Hardwood Veneer and Plywood*, Facts for Industry, Series M 13A, monthly, March 1944–. Production, shipments, consumption, and stocks of hardwood plywood. Formerly Series 16-3 (March 1944–January 1946).

Bureau of the Census, *Lumber Production and Mill Stocks*, Facts for Industry, Series M 13G, annual, 1921 to date; monthly, September 1946 to date. Lumber production, by type and by region.

Bureau of the Census, *Softwood Plywood*, Facts for Industry, Series M 13B, monthly January 1944–. Annual and monthly data on production, shipments, and stocks of softwood plywood and on consumption and stocks of plywood materials. Formerly Series 16-1 (January 1944–December 1945).

Department of Commerce, *Lumber, Plywood and Allied Products—Industry Report*, quarterly, with annual supplement, May 1944–September 1950. Production, consumption, and stocks of lumber industry. Includes data on softwood and hardwood plywood.

Chemicals and Chemical End Products

General

Books and Pamphlets

Faith, W. L., Keyes, D. B., and Clark, R. L., "Industrial Chemicals," New York, John Wiley & Sons, Inc., 1950. Technology and economic trends in production, sales, consumption and prices on 106 major chemicals.

Manufacturing Chemists' Association, Washington, D. C., "Chemical Facts and Figures." Described under General Sources.

Stanford Research Institute, "Chemical Economics Handbook." Described under General Sources.

U. S. Government Publications

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources. (These figures are often in disagreement with those published by the Tariff Commission in "Synthetic Organic Chemicals—U. S. Production and Sales.")

Bureau of the Census, *Chemicals in the War Program*, Facts for Industry, Series 6-8. Sixty-two issues published 1946–1947. Description of wartime end-use patterns of major organic and inorganic chemicals.

Bureau of the Census, *Inorganic Chemicals—U. S. Production*, Facts for Industry, Series M 19A, monthly with annual summary, November 1943–. Production and quantity and value of shipments of inorganic chemicals. Formerly Series 6-1 (November 1943–December 1945).

Bureau of Mines, "Minerals Yearbook," annual, 1910–. Data on coal and coal-tar distillation chemicals, petroleum wax, liquefied petroleum gases, bromine, lead to make tetraethyllead, sulfur, and sulfuric acid.

Department of Commerce, *Chemicals and Drugs—Industry Report*, monthly, July 1945–September 1950. Production, sales, value, and foreign trade of major organic and inorganic chemicals and chemical end-products. Formerly *Chemicals and Allied Products* (July 1945–February 1947).

Tariff Commission, *Production of Specified Synthetic Organic Chemicals in the United States*, Facts for Industry, Series 6-2, monthly. Preliminary monthly and annual figures comparable with those reported in "Synthetic Organic Chemicals—U. S. Production and Sales."

Tariff Commission, "Synthetic Organic Chemicals—U. S. Production and Sales," annual, 1917 to date (except 1931–1932). Production, sales, and unit values of dyes, lakes, and toners, medicinal chemicals, flavor and perfume chemicals, plastics and resins, elastomers, rubber-processing chemicals, plasticizers, surface active agents, pesticides, and many individual organic chemicals. Lists producers of all commercially important organic chemicals. Formerly "Dyes and Other Synthetic Organic Chemicals" (1917–1937).

Carbon

U. S. Government Publications

Bureau of the Census, "Census of Manufactures" and "Annual Survey of Manufactures." Described under General Sources.

Bureau of Mines, *Coke and Coal Chemicals*, Mineral Industry Surveys, monthly and annual. Production and consumption of coke.

Bureau of Mines, *Carbon Black*, Mineral Industry Surveys, monthly and annual. Production, consumption, stocks, sales, foreign trade, and sales value of carbon black.

Bureau of Mines, "Minerals Yearbook." Described under General Sources.

Department of Interior, Pacific Northwest Field Committee, "Carbon," June 1949. Industrial carbon requirements of the Pacific Northwest.

Coal Chemicals

U. S. Government Publications

Bureau of Mines, "Minerals Yearbook." Described under General Sources.

Bureau of Mines, *Coke and Coal Chemicals*, Mineral Industry Surveys, monthly, with annual summaries. Production and consumption of coke and coal chemicals by states.

Tariff Commission, *Production of Specified Synthetic Organic Chemicals in the United States*, Facts for Industry, Series 6-2.

Tariff Commission, "Synthetic Organic Chemicals—U. S. Production and Sales," annual, 1917–.

Ethyl Alcohol

BOOKS AND PAMPHLETS

Arnold, L. K., and Kremer, L. A., *Iowa State Coll. Agr. and Mech. Arts, Eng. Expt. Sta.*, Bull. **167** (1950). "Corn as a Raw Material for Ethyl Alcohol." An economic study of the past and future demand of corn as a raw material for industrial alcohol as well as for distilled spirits.

Tousley, R. D., "The Economics of Industrial Alcohol," Pullman, Wash., Washington State College, 1945. Survey of production, consumption and prices of industrial alcohol.

U. S. GOVERNMENT PUBLICATIONS

Bureau of Internal Revenue, "Annual Report of the Commissioner of Internal Revenue." annual, 1916–. Production, withdrawals, imports, and raw materials of ethyl alcohol by states and by months. Data for 1927–1933 reported in "Statistics Concerning Intoxicating Liquors," Bureau of Industrial Alcohol, Department of Justice.

Bureau of Internal Revenue, *Comparative Statistics on Ethyl Alcohol*, monthly, with annual summary. Preliminary data for "Annual Report of the Commissioner of Internal Revenue."

Bureau of Internal Revenue, "Statistics on the Uses of Specially Denatured Alcohol," annual, 1936 to date (except 1938 and 1939). Detailed end-use data on specially denatured alcohol.

Department of Agriculture, *Misc. Publ.* **695** (1950). "Industrial Alcohol." Chemical, technological, and industrial aspects of alcohol in relation to agriculture.

Production and Marketing Administration, "Sugar Reports, Molasses Issue," annual, 1948–. Supply and utilization of ethyl alcohol.

Explosives

U. S. GOVERNMENT PUBLICATIONS

Bureau of Mines, *Consumption of Industrial Explosives*, Mineral Industry Surveys annual, 1944–.

Bureau of Mines, "Production of Industrial Explosives in the U. S. 1912–1943," (1944).

Fatty Acids

BOOKS AND PAMPHLETS

Association of American Soap and Glycerine Producers, Fatty Acid Division, 295 Madison Ave., New York, *Fatty Acid Monthly Report*, monthly, October 1951–. Production, sales, stocks, and disposition of fatty acids.

U. S. GOVERNMENT PUBLICATIONS

Bureau of the Census, *Animal and Vegetable Fats and Oils*, Facts for Industry, Series M 17-1, quarterly, 1919 to July 1942; monthly, June 1942 to date with annual issue 1919 to date. Production, supply, stocks, and consumption of fatty acids.

Bureau of the Census, *Fats and Oils*, Facts for Industry, Series M 17-2, annual, 1919 to 1942; quarterly, 1943 to June 1949; and monthly, July 1949 to date. (Annual data for 1943 to date given in annual issues of Series M 17-1.) Consumption of fatty acids.

Fertilizers

BOOKS AND PAMPHLETS

Mehring, A. L., *Am. Fertilizer*, **106**, No. 5 (March 8, 1947). "Materials Used as Fertilizers." Comparison of sources of various nutrients contained in fertilizers for period 1910 to 1945 with emphasis on change of balance among materials used as fertilizers during these years.

Moore, H. C., "Dictionary of Fertilizer Materials and Terms," published by *The American Fertilizer*, 1950. Defines fertilizer and related materials according to their origin, composition, and properties.

National Fertilizer Association, Washington, D. C., "Fertilizer Use at the Half-Century Mark," 1951. Detailed data by regions and by crops for 1950.

Stanford Research Institute, Stanford, Calif., "Chemical Economics Handbook." Described under General Sources.

U. S. Government Publications

Bureau of Agricultural Economics, "Agriculture's Capacity to Produce," Agr. Information Bull. No. 88 (June 1952). Consumption of plant nutrients by states and by crop for 1950 and projections for 1955.

Bureau of Census, *Superphosphate*, Facts for Industry, Series M 19D, monthly, July 1946–. Production, receipts, disposition, and stocks of superphosphate by type.

Bureau of Plant Industry, Soils and Agricultural Engineering, "Consumption of Commercial Fertilizers in the United States," annual, 1925–. Fertilizer consumption, chemical content of fertilizers consumed, and consumption of plant food, by states. This report is reprinted in several trade journals shortly after it is issued each year.

Department of Agriculture, "Agricultural Statistics." Described under General Sources.

Federal Trade Commission, "Report of the Federal Trade Commission on the Fertilizer Industry," 1950. An economic study of the fertilizer industry, including statistics from Department of Agriculture and individual company reports.

Production and Marketing Administration, "The Fertilizer Situation," annual, 1943– Current and historical data on production, supply and use of fertilizers.

Periodicals

Agricultural Chemicals, monthly, with annual review issue (January).
Agronomy Journal, monthly.
American Fertilizer, monthly.
Better Crops with Plant Food, monthly.
Commercial Fertilizer, monthly, with annual yearbook.
Journal of Agricultural and Food Chemistry, semimonthly.
National Fertilizer Review, quarterly.
Plant Food Journal, quarterly.

Fibers

Books and Pamphlets

Textile Organon, Textile Economics Bureau, 10 East 40th St., New York, monthly, with annual summaries, 1930–. Production, consumption, supply, and prices of fibers in the U. S., and world production of all natural and synthetic fibers. Formerly *Rayon Organon* (1930–1951).

U. S. Government Publications

Bureau of Agricultural and Industrial Chemistry, "Trends in the Consumption of Fibers in the U. S. 1892–1948." Consumption of raw fibers and foreign trade and consumption by ultimate consumers of cotton, wool, silk, flax, rayon, and other synthetic fibers, and industrial fibers.

Bureau of Agricultural Economics, *The Cotton Situation*, bimonthly, 1941–. Each issue emphasizes a particular aspect of the cotton industry—i.e., foreign trade prices, production, etc.

Bureau of Agricultural Economics. "Statistics on Cotton and Related Data," 1951. Acreage, production, prices, consumption, supply, distribution, and international trade of cotton.

Bureau of Agricultural Economics. *The Wool Situation*, quarterly, 1948–. Each issue presents an historical survey of a specific phase of the wool industry—i.e.. production, prices. world consumption. etc.

Bureau of Agricultural Economics. "Wool Statistics," 1949. Historical survey of the economics of the wool industry, including production, consumption, supply, and prices of wool.

Bureau of the Census, "Cotton Production and Distribution," annual, 1914–. Production, consumption, stocks, and foreign trade of cotton, cottonseed, linters, and other cottonseed products.

Department of Commerce, "World Study of Hard Fibers and Hard Fiber Products," 1949. Production, consumption, external trade of hard fibers and hard-fiber products for the world. Data given for all major producing countries.

Glycerin

U. S. Government Publications

Bureau of Agricultural Economics, *Fats and Oils Situation*, bimonthly, with annual summaries, 1935–. Production and consumption of glycerin.

Bureau of the Census, *Animal and Vegetable Fats and Oils*, Facts for Industry, Series M 17-1, quarterly, 1919 to July 1942; monthly, June, 1942 to date, with annual issue 1919 to date. Production and supply of glycerin.

Bureau of the Census, *Fats and Oils*, Facts for Industry M 17-2, annual, 1919–1942; quarterly, 1943 to June 1949; and monthly, July 1949 to date. (Annual data for 1943 to date given in annual issues of Series M 17-1.) End-use data on glycerin.

Pesticides

Books and Pamphlets

Frear, D. E. H., "Pesticide Handbook," State College, Pa., Commercial Printing, Inc., 1951. A guide and index to trade names, active ingredients, uses, and manufacturers of commercial insecticides, fungicides, herbicides, rodenticides, and pesticide equipment sold in U. S.

U. S. Government Publications

Bureau of the Census, *Inorganic Chemicals—U. S. Production*, Facts for Industry, Series M 19A. Production of arsenical insecticides.

Bureau of the Census, "United States Imports of Merchandise for Consumption," Rept. No. **FT 110,** monthly and annual, 1820–. Imports of pyrethrum and rotenone.

Department of Agriculture, "Agricultural Statistics," annual, 1927–. Production, foreign trade, and prices of insecticides, fungicides, and weed killers.

Tariff Commission, "Synthetic Organic Chemicals—U. S. Production and Sales," annual, 1917 to date (except 1931–2). Production and sales of synthetic organic insecticides, fungicides, fumigants, and herbicides.

Periodicals

Agricultural Chemicals, monthly.
Journal of Agricultural and Food Chemistry, semimonthly.

Plastics and Resins

Books and Pamphlets

Plastics Catalogue Corp., "Modern Plastics Encyclopedia and Engineer's Handbook," annual, S/B1937–. Plastics materials, engineering and methods, fabricating and finishing, machinery and equipment. Also directory of plastics manufacturers, plastics fabricators, etc.

Stanford Research Institute, Stanford, Calif., "Chemical Economics Handbook." Described under General Sources.

U. S. Government Publications

Bureau of the Census, "United States Imports of Merchandise for Consumption," Rept. No. **FT 110,** monthly and annual, 1820–. Imports of natural resins, shellac, etc.

Tariff Commission, *Production and Sales of Plastics and Resin Materials*, Facts for Industry, Series 6-10, monthly with annual summaries, May 1945 to date. Includes data on both synthetic and cellulosic resins. Formerly Series M 19H (May 1945–September 1948).

Tariff Commission, "Synthetic Organic Chemicals—U. S. Production and Sales," annual, 1917–.

Tariff Commission, "Summaries of Tariff Information," 16 vol., 1948–50. Statistics and general information of natural resins.

Rubber

Books and Pamphlets

International Rubber Study Group, Brettenham House, 5-6, Lancaster Place, Strand, London, *Rubber Statistical Bulletin*, monthly, 1946–. U. S. and world historical data on production, consumption, and supply of natural and synthetic rubber.

Rubber Manufacturers' Association, 444 Madison Ave., New York, *U.S.A. Rubber Statistics*, monthly with annual summaries. Production, consumption, and supply of natural and synthetic rubber and shipments of rubber tires and casings.

U. S. Government Publications

Department of Commerce, "Rubber—Annual Report by the Secretary of Commerce," annual, 1948–. Monthly and annual data on natural and synthetic rubber production, consumption, supply, and stocks. Also data on manufacture of tires.

Department of Commerce, *Rubber—Industry Report*, monthly, March 1947–September 1950. Production, consumption, and stocks of natural, reclaimed, and synthetic rubber.

Reconstruction Finance Corporation, Synthetic Rubber Division, ***Production Records,*** monthly. Production of butadiene, styrene, and synthetic rubber in government plants.

Rubber Reserve Company, "Report on the Rubber Program 1940–1945." Covers activities of Rubber Reserve Company from June 1940 to February 1945. Data on government-owned plants in the synthetic rubber program.

Tariff Commission, "Synthetic Organic Chemicals—U. S. Production and Sales," annual, 1917–. Production of synthetic rubber.

Sulfur and Sulfuric Acid

Books and Pamphlets

Stanford Research Institute, Stanford, Calif. "Chemical Economics Handbook." Described under General Sources.

U. S. Government Publications

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Basic Principles of Literature Searching

JULIAN F. SMITH, *5715 Crawford Drive, Rockville, Md.*

CHARLOTTE M. SCHALER, *Sinclair Refining Co., New York, N. Y.*

Initially, the literature searcher should have a clear conception of the precise subject of his search, the time interval and sources to be covered, and the ultimate use of the information. Use of prior bibliographies often simplifies a search. Headings to be checked in subject indexes must be selected with care for each index examined, as subject headings vary in different indexes. The searcher must be discriminating in the selection of references and in establishing the point at which the search should be terminated. Presentation of results may vary depending on what form will be of most value to the reader.

Some of the fundamental rules for searching technical literature may seem so obvious that any searcher would surely heed them. Yet beginners often ignore them. Even experienced searchers sometimes neglect them, perhaps from overconfidence. The fundamental rules are presented, not as a sermon with a stern decalog of thou-shalt-nots, but as a pentalog which searchers might well engrave on a jeweled breastplate, worn even in sleep.

Draw clear boundary lines, and work within them.

Seek first the work of prior bibliographers.

Fit word-keys in advance to the locks guarding information.

Stay on the beam of actual (rather than apparent) pertinence, persisting only as long as persistence is profitable.

Adapt the presentation to the intended use.

Establishment of Boundary Lines of Subject

Boundary lines are essential, not only for subject coverage but also for the time period, source coverage, and even the uses the information is to serve. The searcher must discipline himself to formulate his interests exactly. When he is instructing a professional searcher as to the requirements, accurate statement is all the more important. The temptation to proceed from quick-and-easy but fuzzy premises is strong and must be resisted. Professional searchers should question inquirers patiently until the boundary is clear. Inquirers should respond with equal care and patience, making sure the record is straight before the search begins. Often an inquirer is not clear in his own mind until the question-and-answer session blows away the mists.

As to time period, patent searches set the most exact limits. To find what U. S. patents are now in force the search goes back exactly 17 years. For anticipation it starts with the beginning of the art, but ends one year before the filing date of the questioned application or patent, since the inventor has a year after the disclosure date in which to file. Other considerations permit or impose other time limits. Searchers are sometimes asked to consider only the live literature, which may mean anything from a year to a generation in age, according to whether the art is burgeoning or slow-moving.

Among sources, a single prior bibliography may free the searcher up to the point where his predecessor stopped, or it may merely spur him to do the job better. Often using *Chemical Abstracts* suffices, but for borderline subjects or when thoroughness outweighs cost, it should be checked (especially in the early years) against other sources. Abstract periodicals are not good hunting grounds for academic dissertations, government technical reports, or industrial bulletins.

The objective of the search itself may set sharp boundaries for subject, or source, or time, or all three. In patent searching it makes a great difference whether the interest is in anticipation, or novelty, or interference, or infringement. The fuzziest of all objectives, a comprehensive bibliography, may be sharply clarified by limits on funds or manpower.

Working within the defined boundaries is as important as drawing them, but they are guidelines, not stockades. They allow short side sorties for tracking down clues, and the better the searcher knows his subject, the better he can emulate Sherlock Holmes. The Princes of Serendip had a technique which is not recommended for systematic searching, but it had its points; they made their greatest discoveries while looking for something else. Good searchers allow themselves a little serendipic browsing now and then, but they keep it within reason.

Use of Prior Bibliographies

Prior bibliographies help, even when they are so poorly done that it is cheaper to build a new one than to rebuild the old one. Too often the compiler does not say what sources he used, nor how thoroughly he combed them.

Take heed when horrible examples cross your path; preface your own bibliographies by telling what sources you consulted, and how, and why. Then your successors can judge whether your toil was for demands of the moment, or for posterity.

Circumstances may justify doing a hasty job for immediate needs, but they do not justify leaving later readers in the dark about it.

The searcher, having found prior bibliographies, should make the best estimate of their dependability for the task. He should never lean on broken reeds or pass by strong props which might have saved him weariness of flesh and spirit.

Many otherwise excellent literature reviews are heavily overweighted with homeland references. Probably this stems much more from convenient propinquity than from willful neglect of foreign literature. Americans sometimes think German and Russian reviews are the worst offenders, but actually this yielding to the easy way is more or less world-wide.

Old bibliographies which exactly fit the subject are rare. Usually the old and new subjects overlap in part, each having an area of interest not shared by the other. But searchers can often save much work by skillful gleaning in pertinent portions of earlier bibliographies.

Selection of Index Headings for Examination

The right word-keys can make a search shine; the wrong ones can easily wreck it. The right words may or may not be found in standard subject-heading lists, almost certainly not in any list compiled without benefit of technical knowledge. Skilled searchers make up their own lists, changing from index to index and giving no unearned credence to standard lists. The perfect list for *Chemical Abstracts* will be imperfect for *British Abstracts* and may need complete revamping for *Biological Abstracts*. None of the three would do for searching a library card catalog.

When searching foreign-language indexes, the searcher must exercise care in his choice of word-keys. For some years the Nazi regime banned Latin and Greek words; by decree, "Emulsion" became "Milch" and "emulgieren" became "vermilchen." The German word for enzyme is "Ferment," and any fungus from molds to mushrooms is a "Pilz." The searcher should not have any mushrooms fermenting sugars and rotting telegraph poles, as a well-meaning German did.

Fortunately, the nomenclature of identifiable chemical compounds is fairly well internationalized. Chemical nomenclature presents enough problems in English; searchers should be duly grateful for any language-to-language sameness. The path to international agreement has often been hard; searchers should watch progress, and utilize it, on the long road that still lies ahead.

There is nothing static about the word-key game. The searcher makes up a list which seems to cover his field, and plunges into an index. One word leads to another, such as "distillation" suggesting "fractionation," and he adds a word. A word that looked useful may prove barren, so he shelves it for possible use in another index. Skillful first choices minimize backtracking, but in complicated searches even the seasoned professionals have to retrace some steps through an index now and then.

Selection of References, Termination of Search

Once the search is started, staying on the beam calls for judgment and will power. Tempting side paths lead into greener-looking pastures, and sometimes they are worth following. So judgment is needed to pick the true path, and will power is needed to shun the specious. Suppose a search is being made on dimerization of acetylene, and the searcher finds under 1-buten-3-yne a synthesis from ethene. Will it pay to track down the mechanism? The ethene might have been cracked to acetylene, then dimerized, or it might have been dimerized, then dehydrogenated. Again, will the heading "acetylene reactions" conceal any dimerization references? Probably yes in a sketchy subject index, whereas thorough ones will have all references listed under dimerization. The searcher should not let an index lead him up the garden path; he should check and choose his paths with care.

Staying on the beam is not solely a question of deviations to right or left. How far does the searcher go? Some searchers stop too soon; others go far past the point where results cease to justify effort. Inquirers and searchers alike should learn to set a reasonable goal, accepting a feasible standard of completeness. Then searchers should persist to an acceptable result as gaged by the standards adopted. There is no profit in going further.

Presentation of Results

Presentation of search results, to be most effective, requires as much skill and care as correct defining of the subject area. Reading lists need only bibliographically adequate citations; bibliographies for publication need only brief annotations; but a search for a research unit may demand expert slanting to specific interests. Comments on individual references may vary, in one search, from skeleton bareness through brief (but instructive) comments to detailed abstracts or digests.

Choice of arrangement also depends on what the reader needs, which in turn depends on whether he is John Q. Public or a little band of dedicated men who know what they want and why. There are alphabetical, chronological, source-wise, subject-classified, and hybrid arrangements in endless variety; the best one is the one from which readers get the most help with the least effort.

There are standards of presentation, such as accepted abbreviations for periodical titles, or sequences for citation data (volume, page, and date) which sacrifice one freedom in return for another. Rugged individualists who object to any shackles of standardization are right on one point; misguided or excessive standardizing can do serious harm. National and international committees find it so hard to agree on bibliographical matters that overstandardization does not seem imminent. Searchers can only hope the committees are protecting them from misguided standards.

All the commandments, the prophets, and the evangelism of the new bibliographic day can be summed up in three shining words which run through an old engineering song: judgment, skill, and care. When all searchers plan and execute all their jobs with these three in ample supply and in perfect balance, the bibliographic millennium will be here.

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Sound and Unsound Short Cuts in Searching the Literature

CHARLOTTE M. SCHALER, *Sinclair Refining Co., New York, N. Y.*

JULIAN F. SMITH, *5715 Crawford Drive, Rockville, Md.*

Sound short cuts in literature searching evolve from thorough application of searching principles and thorough acquisition of technical knowledge and nomenclature on the subject. The time spent on a search can be reduced for the professional searcher by planning the search routine and by using nontechnical help in some steps. An administration supporting a literature unit which maintains a collection of references on topics of interest is the greatest time saver for the searcher. A bibliography on the technique of searching, which accumulated in such a unit, is appended.

Short cuts in searching must be approached with caution and with a clear understanding of the difference between sound and unsound procedure. A sound short cut does not break any of the basic rules of searching, and is, in some instances, based on a more intensive application of them; it is a better, faster, or more direct way of making a search, with no loss, and often an improvement, in quality.

Reliable short cuts in searching may be divided into five types: those dependent on thorough application of searching principles or a better acquisition of technical knowledge on the search subject, those accruing from planning the search routine to save operations, those based on the use of carefully supervised nontechnical help, those resulting from maintaining a multipurpose literature unit, and mechanical aids in searching (punched cards and searching machines).

Only the first four will be discussed here, as the fifth, mechanical aids in searching, is better handled by specialists in that particular field. This paper deals with short cuts applicable without the use of specially designed equipment.

Intensive Application of Searching Principles or Better Acquisition of Technical Knowledge

Defining the Problem. The careless searcher may take an unsound short cut by failing to define the search subject and search problem adequately. The average searcher, however, will not make this mistake. He will set up a fairly accurate definition or will accept the one given him by those requesting the search. The literature searcher with imagination and foresight will, at this point, go a step further. He will not be satisfied to accept either the definition given him or the first definition he himself may develop, for he will realize that a problem usually lends itself to more concise definition than is at first evident.

The first reliable short cut open to a searcher is to attempt to limit the search problem beyond the first acceptable definition. Often those who want a search are so familiar with their own ideas and wishes that they are unaware that they are not expressing them completely. A searcher should test any search aim and problem definition by continuing to question those who want the search, beyond the point where most searchers leave off. Such questions may be put indirectly and tactfully, as an expression of interest and a desire for more knowledge, but they should be carefully selected by the questioner with the express object of further limiting the search scope, if this should prove possible. For example, a search may be needed on the effect of catalysts on the oxidation of lubricating oils. The experienced searcher will recognize this search problem as not as well bounded as it might be. Which lubricating oils—petroleum, synthetic, compounded or blended? What catalysts—some particular group, perhaps, of the periodic table of elements? What temperature range and what other conditions are of interest? If the searcher can find out what this man is working on and why he wants the search, a more concise and better search will result in less time. A good searcher will dig out the answers he needs. The revised search problem definition will produce a search where all references listed will be of real interest.

The inept searcher can, however, vitiate this procedure by improper questioning and faulty understanding. This may result in limiting the search aim too narrowly, with consequent omission of significant references. No revised search problem definition should ever be used unless it is approved by those who requested the search.

Search type must also be established; this refers not to the subject matter but to the purpose of the search. Is the search to find out whether invention novelty is present for patent application, or is someone suing the company for infringement? Is it suspected that a competitor's patent is invalid? Or does the company need data for building a new plant? Most searchers perform this task, but the exceptional searcher goes along further. Besides determining the reason for making the search and establishing limiting dates, it is wise to get the technical and, for certain types of searches, the legal viewpoint of those interested in the search. Without this the searcher will be unable to use any native ingenuity he may have to apply the indirect method of using a combination of two or more references to establish a technical point, where no adequate single reference can be found.

To illustrate, suppose a company wishes to anticipate a patent on a composition used in metal cutting, this composition containing certain fatty acids. The literature reveals no pertinent statement prior to the date in question. The searcher who has not established a viewpoint will turn in a negative result.

If several statements indicating that tall oil was used for metal cutting at an early date were found, the searcher who has established the necessary technical and legal viewpoint will start looking for the composition of tall oil, not in modern, but in old books, realizing that if he can find a book published, for example, in 1925 or before, stating that tall oil contains the fatty acids in question, his problem will be solved. While he has not found any early statement that the composition in question was used for metal cutting, he has established that tall oil was so used, and that it was general knowledge at the time of the published statement that tall oil contained the fatty acids in question. This searcher, through ingenuity, will have proved patent anticipation by an indirect method, where the other failed.

An unsound short cut develops from this when a superficial searcher tries to use the indirect method as a substitute for the direct method. It is necessary, of course, to find references definitely stating the ideas sought if available; the indirect method should be resorted to only when the direct method fails.

A searcher who does not establish what type of search he is making will collect material that seems pertinent to him but which actually contributes little or nothing to the search purpose. Not determining date limits will cause inclusion of references on the subject that are valueless for other reasons.

Consulting Experts. Consulting experts on the search subject is a valuable short cut which can supply considerable information quickly and may even make further search unnecessary.

Using Existing Bibliographies and Previous Searches. To begin the search where existing bibliographies and previous searches leave off is a standard short cut that has become a rule of searching. However, both consulting experts and using existing bibliographies and past searches can become a trap for the lazy searcher. Because he has had a few lucky breaks he may thereafter expect suitable information to drop into his lap and neglect finding references that must be tracked down.

Preparing Subject Heading List and Reviewing Nomenclature. Instead of setting up a list of subject headings for searching as soon as possible, time can be saved by delaying this a little. Before making the list it is better to browse through suitable books, to go from there to review articles and bibliographies, and even to begin abstracting material already available for the search. The object of this delay is to avoid preparation of an unrealistic list needing much revision, to make possible a quick solution that might make the search proper unnecessary, and to acquire a background of technical knowledge and nomenclature without taking time away from the search to do so. The subject list itself will be improved by this knowledge. This postponement in listing subject headings, however, should not be construed as a suggestion to slur over this task, as slackness may result in several false starts. Also, it should not be taken as justification for making a rigid list requiring no subsequent revision. The object is simply to cut the need for this revision to a minimum.

The searcher should inform himself not only on scientific nomenclature and terminology, but also on popular usage and trade names. For chemical compounds, particularly complicated ones, all synonyms and correct and incorrect terms should be listed. It cannot be assumed that authors and indexes use orthodox terminology, especially where industrial or trade journals are involved. An inadequate knowledge of unscientific nomenclature and terminology is just as likely to cause a searcher to miss references as a lack of knowledge of proper nomenclature.

Evaluating Journals. Awareness of the varying viewpoints, aims, audiences, and policies of different journals is a rewarding time saver, as is awareness of how an individual journal varies over the years. This awareness may be acquired by comparing and contrasting journals with titles which indicate a similarity of content, having editorial policies which make them differ. For example, the application of chemistry industrially is implied in the titles of four dissimilar journals: *Chemical Processing*, *Journal of Applied Chemistry*, *Industrial and Engineering Chemistry*, and *Chemical Engineering*. *Chemical Processing* is a trade journal, giving small news items of processing developments and control. *Industrial and Engineering Chemistry* contains highly technical articles. Though *Petroleum Processing* and *Chemical Processing* may sound like sister journals in different fields, this is far from the case. *Petroleum Processing* prints excellent articles on the development of the petroleum chemicals industry, as well as on the processing of petroleum, with little space for the type of small news item featured in *Chemical Processing*. However, in looking for information on drilling, geology, and production techniques, *Petroleum Engineer* or *Journal of Petroleum Technology* should be consulted.

A search will proceed faster, if the searcher, whenever possible, will examine first the familiar journals. By the time he has done this, he will have collected bibliographical material containing references to less familiar journals. In looking up these references in the less familiar journals, he will become familiar to some extent with them. Bibliographies located will also aid him in setting up or revising his list of sources to be searched.

As in the case of index topics, the making of a list of journals to be searched should also be postponed a little, in this instance to the time when the more familiar journals have been searched. A better list will result. However, the searcher who begins with the sources he knows and never gets around to the less familiar sources is taking an unsound short cut. If he omits listing suitable sources, he may find himself painstakingly looking through *Chemical Abstracts*, for material not covered there.

Searching trade journals can be very time-consuming, as they frequently have sketchy indexes or none. A page by page search may become necessary. An aid, especially helpful in searching the trade journals, is to make a list of authors and companies known to have worked on the subject. Previous search through abstract and other journals, consultation with experts, review articles, and bibliographies form the basis for such a list.

Unsound Short Cuts. Giving up a source simply because it does not yield immediate results is especially tempting in the case of journals with inadequate indexes, no indexes, or poor arrangement of material. Other pitfalls include not looking up cross references, using titles only where titles do not suffice, not properly digesting the contents and thus overlooking significant references, and omitting annotations where needed. Some searchers do not know when a search is finished; with a passion for completeness, they lose sight of the search goal and do not recognize its attainment. Neglecting to get enough background information to make an intelligent search can make the search valueless. In fact, any short cut dependent on careless work, the breaking of searching principles, or lack of proper technical knowledge is unsound.

Planning the Search Routine

The routine of recording references, writing abstracts, and making search indexes may be cumbersome or efficient. Looking up references may be haphazard or arranged to save energy.

The first principle in saving search time is to use single operations to serve multiple purposes. For example, references listed on sheets of paper can serve only one purpose, if one reference is listed right under the other. Lists on cards or sheets, with one reference per card or sheet, can serve several purposes. Abstracts can be added under each reference, and the cards can be rearranged by subject content, so that the typist can copy, entering items in the desired order on the final copy. A rearrangement of the cards by author can be used to produce an author index without extra work.

Longer searches usually require a breakdown by special technical points; one reference frequently contains information on two or three points. Each point can be designated with a number like 1, 2, or 3, which can be added on the cards as subjects indicate. For instance, in a search on separating low boiling olefins from hydrocarbon gases, point 1 may be separation by adsorption methods; point 2, separation by absorption methods; and point 3, separation by cold fractionation. The typist can copy all cards bearing number 1, then all bearing number 2, and so on. A breakdown by special interests results.

This illustrates also a second principle for saving time on search routine—namely, the use of symbols or code designations when feasible to save writing the same words over and over. It is certainly simpler to write "1" than to write "separation by adsorption methods."

If the initial compilation of references is on a set of cards or sheets of a loose-leaf notebook, these cards or sheets can be rearranged by journal titles. Then all references in one journal may be examined by the searcher at one time, instead of his running about in the library or from one outside library to another, in search of different journals on the same day. This illustrates a third principle of saving time—searchers should arrange the routine to save needless walking about and unnecessary trips to outside libraries.

If several searches are being made, one person may look up references in a certain set of journals for more than one search at one sitting more quickly than several searchers, each one on a different search. Many companies order Photostats, Microfilms, or other copies of important references for the file. If articles are recognized as important enough to be Photostated, they can be covered after their arrival.

Use of Supervised Stenographic and Clerical Help for Nontechnical Steps

Short cuts based on the use of nontechnical help, when misused, can produce fatal results. For instance, a stenographer who had typed up many searches, was once asked to make a list of patents dealing with windshield cleaning compositions, listed in the annual U. S. patent indexes. She spent several days doing this. Unfortunately, without proper supervision, her list turned out to be a collection of mechanical gadgets—windshield wipers—a subject of no interest whatever for the search.

Index work cannot be carried out by nontechnical people in a reliable way. A searcher may, however, obtain help from a stenographer who is intelligent and willing; the searcher may go through indexes and mark references for copying; the stenographer follows, copying what is marked. The searcher must supervise the copying carefully, to see that right forms and entries are made. He may also turn to the original references and mark statements along the margin for entry in the abstract. These may be copied by a stenographer. The searcher can dictate his abstracts for the search in a comparatively short time, provided he has digested and marked them so that he knows what he wants to say. An intelligent stenographer can also learn the set form for recording the journal, patent, or book references in the search, so that the searcher is spared the work of writing them out, and need only check her finished work.

For a spot information search, a stenographer may be asked to see if she can find some references on a subject, and what she finds may satisfy the person wanting the information, but a searcher must tell her where to look and must be ready to take over if she does not find what is wanted. Sometimes people ask for general information that is not hard to locate. Here a stenographer is useful to assist with general reference work. At no time should she be left to flounder on her own without guidance. Clerks with several years of library experience can be useful in the same way. Clerical help can also assist in arrangement of cards and sheets for the search work, and an intelligent clerk in a library can locate articles in journals and place these references on a table where the searcher can look through them. If some errors are made, this is unimportant, for the searcher will note them, and simply help himself to the right journals from the library shelves.

The principles of using nontechnical help to save time in searching may be summarized as follows: Only intelligent and willing help can be used, all the work done by nontechnical help must be carefully planned and supervised by the searcher, no steps requiring technical knowledge should be carried out by nontechnical help, and all work done must be carefully checked.

Maintaining a Multipurpose Literature Unit

A far-sighted company policy can do more to save time in making searches than individual searchers can possibly save. When a company develops its own tailored subject index system of classification, covering its entire field of interest, and feeds into this its current literature abstracts and reviews of currently issued patents, the over-all saving of search time will be from 50 to 70%, after the system has been in effect for 20 or more years. When such a procedure is used, the time saved in searching is directly proportional to the number of years covered and the quality of the classification system. For the first year or so, the time saved is small, but it mounts yearly. In time, files of articles and patent references are built up on all subjects likely to interest the company. These files constitute searches in themselves and are kept up to date by the routine abstracting and patent indexing.

The importance of the quality of the classification system is obvious. It should have simple basic classes so broad that no subject of possible interest to the company can arise outside its totality; under these main headings, increasingly specific subclasses and subsubclasses are placed. A form of decimal or combination decimal and symbol (letter) system seems best suited. Alphabetical word systems are too cumbersome.

New scientific and technical developments can be inserted as they arise, as new subclasses or new subsubclasses, without disturbing the basic framework of the system, the date of the new entry being included; this date will be an indication of the time the development gained significance or notice. Old developments that are outmoded cease to acquire new references and, in time, the subclasses can be closed out. In this way the classification system can be kept up to date in a period of advancing science and technology.

However, a sound classification system will be so arranged that new classes seldom need be added, and old classes seldom dropped, because the classes represent basic ideas of which new developments are generally modifications or applications. For example, cracking in the oil industry is a basic idea. New cracking processes will be developed, but they are still on cracking, and so fall into this main class. There are also certain subdivisions of cracking that remain basic. If this class and its subdivisions are set up on sound principles, changes that have to be made are rare. Chemical treatment of petroleum products is another such basic class. There are also certain standard types of chemical treatment under this class as subdivisions. Applications may vary, but the classes should stand up.

To illustrate the use of such a classification system and its coordination with the work of abstracting to produce time saving in making searches, the attached bibliography was compiled from references which accumulated under class 1.03 "Technique of Searching" at the Sinclair Refining Co. Not all references found in this class, but selected references, with emphasis on the past 15 years, have been included. No attempt has been made to supplement it by material from journals not regularly abstracted or to add material not already there. These references, therefore, represent a bibliography on searching collected with a minimum of effort in less than an hour.

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Standards and Specifications

CEDRIC R. FLAGG, *Research and Development Board, Washington, D. C.*

ROBERT P. WARE, *National Paint, Varnish & Lacquer Association, Washington, D. C.*

Standards are issued by individual companies, associations, and government agencies, and are used in connection with purchases as well as manufacture of products. The American Society for Testing Materials is interested in standardizing methods of testing and specifications for materials of engineering. The American Standards Association is a federation of national organizations interested in standards. A selective list of groups and government agencies that issue standards of chemical interest gives information on subject matter covered, type of standards, designations used, and forms of publication. Standards are an excellent source of definitions, of information on materials and test methods, formulas for computations and calculations, and bibliographical material.

The terms "standards" and "specifications" may have slightly different meanings to various individuals or groups, and they are often confused and mistakenly used interchangeably. Therefore, any discussion should begin with the definition and clarification of these two terms.

Definitions

There are 23 definitions listed for the noun "standard" in Webster's Unabridged Dictionary. One of these is "that which is established by authority, custom, or general consent, as a model or example." In this sense, standard means anything which is accepted. Thus, we have living standards, social standards, and business standards. Because, under various conditions, different authorities may be recognized, standards may change and two or more conflicting standards dealing with the same subject may exist at the same time.

Standards used in connection with technology, industry, and business cover both material objects and procedures.

Standards on material objects include those of measurement and of composition. These standards are usually material objects themselves, such as a weight, a color chip, or a chemical. For example, the National Bureau of Standards prepares, certifies, and distributes nearly 500 different standard samples of chemicals, metals, ores, and ceramics. They are materials which have been carefully analyzed or whose physical properties have been precisely determined. They are used in controlling chemical processes and in maintaining the accuracy of apparatus and equipment.

Standards on procedure include those on administration and operation. Those standards are usually written documents outlining an approved method, technique, or process.

Another definition of standards is: "In business, . . . carefully drawn specifications covering material or equipment." Therefore, standard may be considered a generic term and specifications a form of standards used primarily for buying and selling. In everyday usage, a specification is usually a written document describing a material in terms of composition, dimension, or performance or combinations of these, so that the same meaning is conveyed to a buyer and a seller.

Standards of Companies and Groups

Standards are issued and maintained by a number of diverse organizations, including individual companies, societies, associations, and government agencies.

Most industrial concerns use some form of standards not only for the purchasing of materials but also for their own processes and products. For example, they are engineering standards which deal with designing a product, specifying the materials used in making the product, and determining how the product shall operate. A company may have one or more departments, whose sole function is to plan and issue standards. In some cases, these company standards may be copies or modifications of nationally recognized standards. However, particularly in the chemical industry, special company standards may be needed. The success of a process may well depend upon the use of very special materials of construction or very specific operating temperatures and pressures. This type of information may be confidential and its distribution limited.

For some procedures and materials, it is advantageous if a number of companies collectively develop group standards. For example, the American Society for Testing Materials is interested in the standardization of methods of testing and specifications for materials of engineering. The membership of this society may be roughly classified into three groups: (1) producers of raw materials and semifinished and finished products, (2) consumers of materials, and (3) a general interest group comprising engineers, testing experts, research workers, etc. These members working in technical committees sponsor and carry out research work. This work, in the form of papers, reports, and discussions, is published in the annual *Proceedings* and the *ASTM Bulletin* (issued eight times a year). From this work, the committees develop tentative specifications and methods of test. On recommendation of the committee, the tentatives are published. On formal adoption by the society, which includes a letter ballot approval by the entire membership, these tentatives become standards. Tentatives and standards are published in separate pamphlet form, in collected form as a book of ASTM standards, and in special compilations. An annual numerical and subject index to the tentative and standard specifications and methods of test is also published.

In turn, these various groups, societies, and associations may combine for the purpose of issuing standards on a national or international scale. One such combination is the American Standards Association, which is a federation of national organizations interested in standards. They include engineering societies, trade associations, and government departments. There are also a number of company members. The "American standards" approved by the American Standards Association may be of a wide variety of types: dimensional standards, specifications of materials, performance specifications, definitions of technical terms, methods of test, methods of analysis, industrial safety codes, industrial health codes, of building codes. An "American standard" may be an existing standard already in general use, a proposed standard which is generally accepted, or an entirely new standard. Approved standards are published by the American Standards Association or by sponsor organizations. These standards, a list of them, and standards issued by the government and foreign standardizing bodies are available from the American Standards Association. In addition, the association publishes a monthly magazine—*Standardization*—and maintains a library of over 25,000 standards with related books and material.

Standards of Government Agencies

In addition to the standards of companies and groups, such as societies and associations, a large number of standards are issued by city, county, state, and federal government agencies. A great percentage of such standards are procurement specifications.

The Department of Defense, Office of Standardization, may be used as an example of a government agency that develops such specifications. This agency was established on May 11, 1948, as a successor to the Joint Army and Navy Specifications Board. It is responsible for the standardization of specifications and of common use items for the three military departments. The agency provides for the avoidance of duplication both in the military series and between the military and federal series. When adopted, MIL specifications are mandatory for use by the military departments. The principle of adoption by consensus is followed. Besides specifications, this agency puts out MIL standards. Two forms are used—the book form and the sheet form. The sheet form in many respects is a drawing depicting standardized items rather than a word description. A four-volume Military Index to this material is available. Volume I lists all MIL specifications and standard; the other volume lists the specifications and standards used by the three military departments—Volume II, Army; Volume III, Navy; Volume IV, Air Force. Monthly supplements keep these volumes current and a new issue of the basic volume is to be published semiannually.

Locating Specific Standards

It is the written standards of these various organizations on industrial and technical procedures and materials that are of interest to the Division of Chemical Literature. Each of these organizations has set forms for its own standards. In general, material specifications contain various combinations of the following: scope, definition or description of the terms used, requirements of the material, methods of sampling and testing, classes of the material, basis of purchase, shape, size, and dimension of the material, workmanship, finish, packing, marking, shipping, storing, and inspecting. Test methods may contain the following: scope, definition or description of terms, sampling and size of sample, apparatus (including calibration), reagents to be used, procedure, calculations, records, accuracy, and reproducibility.

Literature specialists may use standards in a number of ways. The most common requests, of course, are for specific standards. If sufficient information—the name of the issuing organization and the title and/or designation of the standard—is given, no great difficulties are encountered. Also, because most organizations furnish adequate indexes to their own standards, few problems arise in locating a specific organization's standard on a particular subject. However, two types of questions can be extremely troublesome: where a standard on a certain subject is required with no idea of what organization issued it, and where the only information is the standard designation—a jumble of numbers and/or letters—and the standard and issuing organization are to be found.

These two types of questions are troublesome because, although most organizations have lists and indexes of their own material, there is no over-all list or index to standards. Standards are not, as a general rule, abstracted for abstract journals. There have been a few compilations of standards. One of these is the "National Directory of Commodity Specifications" issued by the National Bureau of Standards. Another is Circular 751 of the Scientific Section of the National Paint, Varnish, and Lacquer Association. This circular contains abstracts of all U. S. government specifications on paints, varnishes, lacquers, and their raw materials.

As a possible aid in answering such questions, a list has been prepared of a number of the groups and federal government agencies which issue standards of chemical interest. This list contains information on name and address of issuing organization, subject matter covered by the standards, type of standards, designation used, and forms of publication.

Information Provided by Standards

A close study of standards will show that they contain much information useful in general chemical reference work.

Standards are an excellent source for definitions. Because standards should convey the same meaning to different groups, a great deal of care is exercised in the use and definition of terms. Examples of standards dealing entirely with definitions include ASTM D 16-47 and D 16-48T covering terms relating to paint, varnish, lacquer, and related products and D 123-45 covering terms relating to textile materials. The last named contains an appendix which gives not only definitions of various defects in woven fabrics, but also photographs illustrating each defect.

Standards naturally contain a great amount of information on materials and test methods. They may offer the easiest method of finding data on composition, physical and chemical properties, manufacture, handling, and uses of chemicals and other materials. For example, the "Pharmacopeia of the United States," which is a book of standards, gives the official Latin name, the official English name, synonyms, chemical formula, molecular weight, description, physical properties, tests for identity and purity, assay, storage, preparations, and dosage for drugs and medicines of therapeutic usefulness or pharmaceutic necessity used in the United States or its possessions.

Standards are a recognized source for test methods, including sampling, qualitative and quantitative analyses, reagents, testing apparatus and equipment, calibration, procedure, calculations, accuracy, and reproducibility.

Particular attention should be paid to the fact that standards contain various formulas for computations and calculations, conversion factors, and correction factors. For example, a method of test for calorific value of gaseous fuels by the water-flow calorimeter (ASTM D 900-46T) has tables showing corrections for reduction of observed barometric heights to standard conditions. These corrections include those of temperature, latitude, and altitude. A standard method of testing and tolerances for woolen yarns (ASTM 403-44) has formulas for computing yarn numbers and a yarn number conversion table.

Certain standards also contain bibliographical material. The "Methods of Analysis" of the Association of Official Agricultural Chemists, for example, gives 40 references in the section dealing with coloring matters and 155 references in the section on drugs.

Familiarity with standards will reveal many other ways in which they may be helpful.

Standards of Chemical Interest

The following list includes groups and federal government agencies which issue standards of possible chemical interest. This list is selective and is intended to be representative and not complete. The omissions include a large number of organizations which do not issue standards themselves but may sponsor standards in other groups.

Organization and Address	Type of Standards	Form	Designation
American Association of State Highway Officials, 1220 National Press Bldg., Washington, D. C.	Specifications and methods of test for highway materials	Book	M 1, 2, or 3 digits–2 digits T 1, 2, or 3 digits–2 digits
American Association of Textile Chemists and Colorists, Lowell Textile Institute, Lowell, Mass.	Methods of test	Part of technical manual and yearbook, also separates	None
AMERICAN CHEMICAL SOCIETY, 1153 16th St., N. W., Washington 6, D. C.	Descriptions, properties, and methods of test of reagent chemicals	Book	None
American Iron and Steel Institute, 350 Fifth Ave., New York 1, N. Y.	Materials and methods of test	Manual, separates	Pamphlets numbered
American Leather Chemists' Association, University of Cincinnati, Cincinnati, Ohio	Methods of test	Book	....
American Oil Chemists' Society, 35 East Wacker Drive, Chicago 1, Ill.	Methods of test, including oil products, such as soap	Book (loose-leaf)	Capital letter, possibly small letter–1 or 2 digits, possibly small letter 2 digits
American Petroleum Institute, 816 Rio Grande National Bldg., Dallas 2, Tex.	Equipment and methods of test	Separates	Std. 1 or 2 digits capital letter; 2 digits capital letter

American Pharmaceutical Association, 2215 Constitution Ave., N. W., Washington, D. C.	Methods of test (drugs)	Book	None
American Public Health Association, 1790 Broadway, New York 19, N. Y.	Methods of test (*a*) Water and sewage with American Water Works Association (*b*) Dairy products, chemical part, with Association of Official Agricultural Chemists	Books	(*a*) None (*b*) Chapter and paragraph
American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.	Specifications and methods of test for engineering materials	Book, special compilations, and separates	Capital letter (A, B, C, D, or E)–1, 2, 3, or 4 digits–2 digits; possibly T (for Tentative)
American Standards Association, 70 East 45th St., New York 17, N. Y.	All types	Separates	Capital letter 1 through 6 digits (decimals and small letters possible)–if approved, year of approval
Association of American Railroad Operating-Transportation, Engineering, Mechanical, and Freight Claim Divisions, 59 East Van Buren St., Chicago 5, Ill.; Purchases & Stores Division, Transportation Bldg., Washington 6, D. C. Bureau of Explosives, 30 Vesey St., New York 7, N. Y.	Many types, including methods of test, material specifications, equipment (maintenance and installation), and recommended practices and instructions	Manuals and separates	Various, including 1 or 2 digits–capital letter–1, 2, or 3 digits; digits; M–1 digit (O–T Div.) 2 or 3 digits–2 digits (Eng. Div.), M or EM–3 digits–2 digits (Mech. Div.)
Association of Official Agricultural Chemists, P. O. Box 540, Benjamin Franklin Station, Washington 4, D. C.	Methods of test, including drugs, cosmetics, fertilizer, vitamins, residues in food, and economic poisons	Book	Chapter and paragraph number
Institute of Radio Engineers, 1 East 79th St., New York, N. Y.	Methods of test, equipment, and materials	In Proceedings, reprints and special compilations	....
Manufacturing Chemists' Association of the United States, 264 Woodward Bldg., Washington 5, D. C.	Recommended practices, including air and water pollution, tables, warning labels, and safety data	Separates and manual	SD, T, L, TC, C, W, P–number
National Board of Fire Underwriters, 85 John St., New York 7, N. Y.	Recommended practices and equipment	Separates	2 or 3 digits
National Electrical Manufacturers Association, 155 East 44th St., New York 17, N. Y.	Equipment and materials	Separates	2 digits–2 or 3 digits
National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass.	Recommended practices and equipment	Book (codes) and separates	Separates–L or A 1, 2, or 3 digits small letter possibly
National Safety Council, 20 North Wacker Drive, Chicago 6, Ill.	Recommended practices, instructions, and equipment	Separates	Numbers; abbreviations (Chem., Cem., Au.)–numbers; D–abbreviations numbers

Society of Automotive Engineers, 29 West 39th St., New York 18, N. Y.	Materials and methods of test	Handbook	
Technical Association of Pulp and Paper Industry, 122 East 42nd St., New York 17, N. Y.	Materials and methods of test	First published in TAPPI; book (loose-leaf)	M, E, O, T 1, 2, or 3 digits p, s, r [illegible] sm–2 digits
United States Pharmaceutical Convention	Drugs and medicines (including methods of test)	Book	
United States Government			
Department of Agriculture			
Production and Marketing Administration, Washington 25, D. C.	Materials (some on color testing)	Separates, some in handbooks, reprints	None
Department of Commerce			
Office of Industry and Commerce, 14th and Constitution Ave., N. W., Washington 25, D. C.	Materials and simplified practice recommendations	Separates	CS or R 1, 2, or 3 digits–2 digits
Department of Defense			
Defense Supply Management Agency, Office of Standardization, Pentagon, Washington 25, D. C.	Materials, methods of test, and recommended practices	Separates	MIL capital letter 1 to 5 digits; MIL–STD 1 to 4 digits; MS 3 to 5 digits; some still with JAN capital letter 1 to 3 digits; JAN-STD 1 to 3 digits
Department of Interior			
Bureau of Mines, Publications-Distribution Section, 4800 Forbes St., Pittsburgh 13, Pa.	Equipment and methods of test	Separates	Schedule number
Bureau of Reclamation, Chief Engineer, Denver Federal Center, Denver, Colo.	Materials and methods of test	Separates	
Federal Security Agency			
Food and Drug Administration, Washington 25, D. C.	Materials (may include methods of test)	Book also separates and reprints from *J. Assoc. Offic. Agr. Chemists*	Chapter and paragraph
General Services Administration			
Federal Supply Service, Standards Division, Washington 25, D. C.	Materials and methods of test	Separates	1, 2, or 3 capital letters (A to MMM)–capital letter–2 or 3 digits; interims have 00 before last digit; FED-STD 1 digit; some still GSA–3 digits

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Domestic Sources of Foreign Information On Trade, Statistics, and Scientific Activities

HAROLD OATFIELD
Chas. Pfizer & Co., Inc., Brooklyn, N. Y.

DORIS J. LOWE
Bristol-Myers Co., New York, N. Y.

An evaluative survey has been attempted of the numerous offices of foreign governments and subsidiary agencies maintained within the United States, from which scientific and technical information pertinent to the parent country is disseminated here, or which give assistance in obtaining trade information and statistics. A source list is appended.

Just as the validity of chemical principles does not stop at national borders, the chemist cannot limit his horizon in seeking information. During recent years it has become apparent that much potentially valuable trade, statistical, and scientific information is being accumulated in obscure offices without necessarily becoming accessible to scientists throughout the world. The men of the press seem to have found their way to it. The bulk of this growing mass of heterogeneous information is neither cataloged nor recorded in standard technical publications, although it may exist in a documented form. The purpose of the authors' efforts has been the organization of a source list of places in the United States to seek supplemental information of this character on a world-wide basis. They had no concern with information of a restricted nature from any source.

Problems

When a need arises for scientific, trade, or statistical information concerning foreign countries which is not supplied through normal channels of publication, a personal, time-consuming search becomes incumbent upon the scientist or statistician seeking the information. The problems prompting that search might conceivably require export and import trade figures on finished or raw materials which are not available in usual sources—e.g., the U. S. Bureau of Foreign and Domestic Commerce tables. Other instances may require technical data on products, equipment, or processes involved in the manufacture of given materials, or may concern location of institutions conducting specialized types of research, or foreign directories. Such a search necessitates seeking out and screening possible new sources rather than the checking of standard foreign bibliographic reference sources, as was discussed by Spitzer (*10*).

Attack

The authors approached by letter or personal visit approximately 200 official and non-official representatives of foreign governments that maintain offices in the United States, in order to ascertain and evaluate the reference assistance that they make available in this country. As a point of departure a list issued by the Chamber of Commerce of the United States was used (*3*). Many of the offices cited in this guide did not cooperate, failing to answer the inquiry. Others were vague or uncertain even as to sources of information available in their own countries. In contrast, numerous agencies showed a genuine willingness to cooperate within the limitations of their particular spheres of activity. In a number of cases, special efforts are made by the various consulates or diplomatic missions to secure direct information from their countries for reputable investigators. The authors made no attempt to circumvent political barriers to their efforts wherever encountered. At the present time there is no free flow of information from certain areas of the world.

Information Offices

Two important sources of information are the embassies and the consulates. A third class of organization handles data on an international basis—e.g., the United Nations and the Pan American Union, the International Monetary Fund (which has both Washington and New York outlets), and the International Labor Organization. Beyond this, the National Foreign Trade Council in New York is most helpful on matters of foreign legislation, and issues bulletins concerning it at frequent intervals. The National Association of Manufacturers has an active international section. The U. S. Council of International Chambers of Commerce and purely trade associations like the Pan American Coffee Bureau and the Metals Statistics Bureau are special sources not to be neglected.

The fifth source to consider is the government bureau. Outstanding among them is the Office of International Trade, Department of Commerce. Other bureaus of the Department of Commerce, such as the Pan American Bureau and the Pan American Health Organization, may also be of assistance. The Department of Labor and the Federal Security Administration also have sections dealing with certain foreign conditions.

A sixth type of organization serving as a general information source is the bank. In New York City, the Chase National Bank issues a monthly *Bulletin of Pan American Affairs*, and the National City Bank, Guaranty Trust Co., Bankers Trust, Irving Trust, and others are cooperative and reliable sources of data on foreign countries. Information can usually be obtained more quickly from these banks than from a government bureau. The First National Bank of Boston and large banks in other major cities can undoubtedly be drawn upon for similar assistance. The Federal Reserve in Washington, D. C., and its district branches are also available for consultation. The check list appended does not include banks nor some of the trade councils cited above. The telephone book is invaluable in finding new leads in all these categories.

Several of the larger and more trade-conscious nations have established offices prepared to cope with inquiries about their homeland, either within the embassy's commercial or scientific attaché office or as an information bureau. An example of the first sort is the Commercial Counselor's Office of the Turkish Embassy, and of the latter, the Republic of Indonesia Information Office. Both of these are located in New York City, although there is also a Turkish commercial attaché active in Washington.

The consulate system of information exchange is an older type, but has been expanded by a number of countries following World War II. Not only are there consulates in New York, Boston, Philadelphia, Baltimore, New Orleans, Houston, Los Angeles, San Francisco, Portland, and Seattle, but many non-coastal trading centers like Chicago, St. Louis, Minneapolis, Denver, Atlanta, and Cleveland possess such offices.

In this connection, it is well to consult the classified section of the telephone directories of large cities, wherein entries are of three types:

1. Governments—foreign, representatives
2. Consulates
3. Consulates and other foreign government representatives

Private companies concerned with trade in a specific country are in general less willing and less competent to advise.

Services

Library Reference. A limited number of these information offices maintain libraries whose resources may be drawn upon by outsiders. The library maintained by the Australian Information Office is an outstanding example of this kind. It is of additional interest because it is a branch of the Australian National Library (of Canberra). Other agencies maintaining libraries are the Belgian Government Information Center, the Brazilian Government Trade Bureau, the Norwegian Information Service, the Peruvian Embassy, the Philippine Consulate General of New York, and the Swedish Chamber of Commerce of the U.S.A. A list of these libraries is given in Table I. Several information offices—for example, those of Austria, Indonesia, and the Dominican Republic—maintain research files of information.

Table I. Agencies Maintaining Libraries

1. Australian News and Information Service
2. Austrian Consulate General, Information Department
3. Belgian Government Information Center
4. Brazilian Government Trade Bureau
5. British Information Services
6. Chilean Iodine Educational Bureau
7. Danish Information Office
8. Royal Egyptian Embassy
9. French Embassy, Press and Information Service
10. Government of India Information Service
11. Republic of Indonesia Information Office
12. Legation of Lebanon
13. The Netherlands Information Service
14. New Zealand Government Trade Commissioner
15. Norwegian Information Service
16. Pakistan Consulate General
17. Peruvian Embassy
18. Philippine Consulate General (New York City)
19. Polish Research and Information Service
20. Swedish Chamber of Commerce of the U. S. A.

Trade Data. Most of these agencies can provide statistics on imports and exports, production, tariffs, and other legal regulations for their countries. Many offices issue periodic statistical bulletins—for instance, the *Ceylon Trade Journal*, the *Economic Survey* (of Helsinki), and the Addis Ababa *Monthly Report on Economic Conditions*. A separate list of the seriallike publications mentioned in the source list, but not restricted to the trade field, appears in Table II.

Scientific Information. Only a few offices are prepared to provide information concerning scientific activity. When unable to answer a request, the usual procedure in the information office is to refer it to a suitable home ministry. The British Information Services and those of the commonwealths are well qualified to supply information bearing on research. The Pakistan Association for the Advancement of Science offers a good select bibliography concerning scientific progress there. Several countries (Sweden, Union of South Africa, etc.) have stationed in the United States science attachés whose function is to channel notice of American scientific advances to their countries. The technical adviser to the Swedish Embassy can advise United States inquirers about scientific matters in Sweden, and the French National Center for Scientific Research (C.N R.S.) maintains a New York office which supplies information on French science. Offices possessing library or reference files occasionally contribute scientific data from those sources.

Key to Check List

In the source list, the countries of the world are arranged alphabetically, and all the sources for a specific country are grouped under that entry. The Office of International Trade of the U. S. Department of Commerce, the Pan American Union, and the United

Table II. Quasi-Serial Publications Cited

1. Austria and the ERP
2. *Brazilian Bulletin* (semimonthly)
3. *Ceylon Trade Journal* (monthly)
4. *Iodine Abstracts*
5. *Iodine Reviews*
6. *Dominican Republic* (bimonthly)
7. *Monthly Report on Economic Conditions and Market Trends* (Ethiopia)
8. *Monthly Bulletin of the Bank of Finland*
9. *Finnish Paper and Timber*
10. *Unitas* (bulletin of economic conditions in Finland)
11. *Economic Survey* (Finland)
12. *Economic Review* (Finland)
13. *Facts about Finland*
14. *Indonesian Economic Review* (quarterly)
15. *Berita Ekonomi* (weekly) (Indonesia)
16. *Report on Indonesia* (weekly)
17. *Economic Trade Notes* (Indonesia)
18. *Economic Review of Indonesia*
19. *Indonesian Affairs*
20. *OSR News* (Organization for Scientific Research in Indonesia)
21. *Facts about Indonesia*
22. *The Java Bank* (Indonesia)
23. *Irish Trade Journal and Statistical Bulletin* (quarterly)
24. *Trade Statistics of Ireland* (monthly)
25. *Bulletin of the Research Council of Israel*
26. *Monthly Bulletin of the Bank of Tokyo*
27. *Statistical Bulletin* (Lebanon)
28. *Current News on the Lithuanian Situation*
29. *T.N.O. Guide* (The Netherlands)
30. *News of Norway*
31. *Bulletin* (Norway)
32. *Norwegian American Commerce* (monthly)
33. *Pakistan Trade Journal*
34. *Information on Portuguese-American Trade*
35. *Statistical News* (Poland)
36. *Venezuela Up-to-Date* (monthly)
37. *Commercial Information* (monthly) (Yugoslavia)
38. U. S. Trade with the Latin American Republics (semiannual) (U. S. Department of Commerce)
39. *Foreign Commerce Weekly* (U. S. Department of Commerce)
40. International Trade Statistics Series (U. S. Department of Commerce)
41. *Current Export Bulletin* (irregular) (U. S. Department of Commerce)
42. World Trade in Commodities (irregular) (U. S. Department of Commerce)
43. Foreign Trade Statistics Notes (U. S. Bureau of Census)
44. Inter-American Review of Bibliography (Pan American Union)
45. *Panorama* (Pan American Union)
46. *Estadistica* (Pan American Union)
47. *Conservation in the Americas* (quarterly) (Pan American Union)
48. United Nations Documents Index

Nations follow the listing of countries. Sources that excel in usefulness have been marked with an asterisk preceding the title.

A third column describes the type of service or information offered. Branch offices are usually indicated, plus other sources suggested for reference. No attempt has been made to list every consulate, but rather to draw attention to consular offices as sources and to remind the user that they are situated in geographically diverse spots. There may be some closer to home than is realized. The consulates listed have been found to be of distinct service. Data for colonies must be sought from offices of the parent country. The Portuguese Commercial Office, for example, is prepared to handle inquiries concerning Angola, Goa, Macao, Mozambique, and other Portuguese dependencies. The French Information Office has separate divisions for its North African colonies and for overseas territories. For some of the less developed areas of the world, the United Nations is the only source of reliable information. In large measure, the United Nations agencies collect data for their own use rather than that of the public.

Sources other than those mentioned and listed herein no doubt exist where helpful information could be obtained. The responsibility of broadening and maturing our initial effort rests with all of us.

Check List of Domestic Sources of Foreign Information on Trade, Statistics, and Scientific Activities

Asterisk indicates sources that excel in usefulness.

Abyssinia (*See* Ethiopia)

Aden
- Consult: United Nations Division of Information from Non-Self-Governing Territories, United Nations, New York, N. Y. British Information Service

Afghanistan
- Afghanistan American Trading Co., Inc., 120 West 30th St., New York 1, N. Y. — Has no information. Refers to embassy.
- Royal Afghanistan Embassy, 2001 24th St., N.W., Washington, D. C.

Albania

Algeria (*See* France)

Argentina
- Embassy of Argentina, 1600 Massachusetts Ave., N.W., Washington, D. C. — Scientific, technical, and trade information not available at this office.
  - Refers to: Statistical Department, Argentine Ministry of Technical Affairs: Ministerio de Asuntos Técnicos de la Nacion, Dirección General del Servicio Estadístico Nacional, Avenida General San Martín 665, Buenos Aires, República Argentina

Australia
- Australian News and Information Bureau, 630 Fifth Ave., New York 20, N. Y. — Provides library and information division to serve people in U.S. and Australian government agencies in America (Branch of Australian National Library). Australian books, periodicals, official documents, annual reports (federal and state) and patents. Maintains press, radio, photograph, and film divisions.

Austria
- Austrian Legation, 1344 Connecticut Ave., Washington 6, D. C.
  - Refers to: * Information Department, Austrian Consulate General, 509 Fifth Ave., New York 17, N. Y. — Maintains small library. Collection includes economic data. Reference publications in both English and German. Clippings from United States and Austrian newspapers and periodicals available for inspection.
  - Suggests for trade and statistical information: Federal Chancellory, Central Bureau for ERP-Affairs, Vienna, Austria — Issues "Austria and the ERP."
- Austrian Trade Delegate, 25 Broad St., New York 4, N. Y. — Has no information. Agency of Austrian Federal Chamber of Commerce.
  - Refers to: Oesterreichisches Dokumentations-Zentrum, P.A. Technische Hochschule, Karlsplatz 13, Vienna IV, Austria

Belgium
- Commercial Services Office, Embassy of Belgium, 1780 Massachusetts Ave., N.W., Washington, D. C. — Has trade statistics.

Refers to: Commissioner of Information,
Belgian Government Information Center,
630 Fifth Ave.,
New York 20, N. Y.
For trade and technical information refers to:
Belgian Chamber of Commerce,
50 Rockefeller Plaza,
New York 20, N. Y.
Belgian Consulate General,
630 Fifth Ave.,
New York 20, N. Y.

For Belgium and Belgian Congo. Has export and import figures. Office primarily concerned with cultural affairs and maintains library chiefly on cultural subjects.

Bolivia
Embassy of Bolivia,
Continental Building,
Washington, D. C.

Brazil
Embassy of Brazil,
3007 Whitehaven St., N.W.,
Washington, D. C.
Refers for trade information to: * Director,
Brazilian Government Trade Bureau
Department of Industry and Commerce of Brazil,
551 Fifth Ave.,
New York 17, N. Y.

Office of Commercial Attaché of Brazilian Embassy. Has library and file of special information as well as statistical data on Brazil; issues *Brazilian Bulletin* semimonthly (in English)

Also refers for scientific and technical information to:
Fundaçao Getulio Vargas,
186 Praia do Botafogo,
Rio de Janeiro, Brazil
Conselho Nacional de Pesquisas,
Avenida Marechal Camara 350, 6° Andar,
Rio de Janeiro, Brazil

Bulgaria

Burma
*Embassy of Burma.
2228 Massachusetts Ave., N.W.,
Washington, D. C.
Burmese Consulate,
829 Madison Ave.,
New York, N. Y.

These agencies provide trade information only.

For scientific information refers to:
Ministry of Information,
Rangoon, Burma

Byelorussian S.S.R. (Consult United Nations)

Canada
Embassy of Canada,
1746 Massachusetts Ave., N.W.,
Washington, D. C.
Refers to: * Information Office,
Canadian Consulate General,
620 Fifth Ave.,
New York, N. Y.

Cites: (1) Canadian Information Service Publ. 20 (of Department of External Affairs, Ottawa), comprising information sources in Canada: official sources, other national sources, standard reference material.
(2) Dominion Bureau of Statistics, "Sources of Official Statistical Information Relative to Canada" reprinted from Canada Year Book

Suggests scientific inquiries be addressed to:
General Secretary,
Public Relations and Research,
National Research Council of Canada,
Sussex St.,
Ottawa, Canada

Council operates very closely with universities and provincial governments, as well as large commercial organizations.

Ceylon
* Embassy of Ceylon,
2148 Wyoming Ave., N.W.,
Washington, D. C.

Can supply statistics relating to imports and exports from Ceylon, and other trade information. When unable to answer specific inquiries, will obtain scientific and technical information from appropriate agency in Ceylon.

Direct inquiries suggests: Information Officer,
Colombo, Ceylon
Director, Department of Commerce,
P. O. Box 500,
Colombo, Ceylon

Publishes *Ceylon Trade Journal*, containing statistics relating to imports and exports. Maintains a library.

All publications issued by government departments are available for sale at:
Government Publications Bureau,
Secretariat,
Colombo 1, Ceylon

The following Singhalese institutions also issue journals and reports of technical interest:
Central Bank of Ceylon,
Colombo 1, Ceylon

Tea Research Institute,
St. Coombs, Talawakelle, Ceylon

Rubber Research Institute,
Dartonfield,
Agalawatte, Ceylon

Coconut Research Institute,
Lunuwila, Ceylon

Chile

Office of Commercial Counselor,
Embassy of Chile,
1736 Massachusetts Ave., N.W.,
Washington 6, D. C.

No information

Corporation de Fomento de la Producción de Chile,
37 Wall St.,
New York, N. Y.

Chilean Iodine Educational Bureau, Inc.,
120 Broadway,
New York 5, N. Y.

Maintains library of bound volumes, abstracts, relating to iodine in chemistry, industry, medicine, surgery, nutrition, and related fields. Open to research workers. Published *Iodine Abstracts*, *Iodine Review*, supplied gratis to chemists and other technical workers; also special bulletins and bibliographies. Service agency on iodine rather than on Chile.

Chilean Nitrate Educational Bureau, Inc.,
120 Broadway,
New York 5, N. Y.

Chilean State Railways,
United States Office,
120 Broadway, New York 5, N. Y.

Information on Chilean state railways.

Pacific International Corp.,
42 Broadway,
New York 4, N. Y.
Refers to: Pan American Union

No data.

China

Embassy of China (Nationalist),
2311 Massachusetts Ave., N.W.,
Washington 8, D. C.
For scientific information refers to:
China Institute in America,
125 East 65th St.,
New York, N. Y.

Has contact with academic organizations.

Colombia

Embassy of Colombia,
2118 Leroy Place, N.W.,
Washington 8, D. C.
Refers for statistics on imports and exports to:
Contraloría General de la Republica,
Bogotá, Colombia, S. A.

Costa Rica

Embassy of Costa Rica,
2112 S St., N.W.,
Washington 8, D. C.

Can supply limited trade data.

Suggests also: Pan American Union, United Nations, United States Embassy in San José, Costa Rica	
Camara de industrias de Costa Rica, Apartade III, San José, Costa Rica	Private industrial association. Publications of internal interest only. Willing to act as intermediary.
Cuba	
Office of Commercial Attaché, Embassy of Cuba, 2060 16th St., N.W., Washington 9, D. C.	
Czechoslovakia	
Embassy of Czechoslovakia, 2349 Massachusetts Ave., N.W., Washington, D. C.	No data.
Denmark	
Embassy of Denmark, 2374 Massachusetts Ave., N.W., Washington, D. C.	No data.
Royal Danish Consulate General, Commercial Section, 17 Battery Place, New York 4, N. Y.	
*Danish Information Office, 588 Fifth Ave., New York 19, N. Y.	Maintains small library.
Dominican Republic	
Embassy of Dominican Republic, 4500 Sixteenth St., N.W., Washington 11, D. C.	Publishes bimonthly bulletin, *Dominican Republic*, containing items of social, political, cultural, commercial, and economic interest.
Refers to: * Dominican Republic Information Center, 507 Fifth Ave., New York 17, N. Y.	Extensive files, mostly of nontechnical content.
For statistical data suggests writing to: Dirección General de Estadística, Ciudad Trujillo, R.D., West Indies	
For scientific information: Rector, Universidad de Santo Domingo, Ciudad Trujillo, R.D., West Indies	
Ecuador	
Embassy of Ecuador, 2125 Leroy Place, N.W., Washington, D. C.	Pleased to submit on request periodical information concerning literature, technical, and scientific developments of Ecuador.
Suggests direct inquiries to: Casa de la Cultura Ecuatoriana, Quito, Ecuador	
Egypt	
Bureau of Egyptian Commercial Counsellor, Royal Egyptian Embassy, 2310 Decatur Place, N.W., Washington 8, D. C.	Maintains small library, open to qualified persons.
Refers to: Department of Statistics, Ministry of Finance, Cairo, Egypt	
England (See Great Britain)	
Estonia	
Consulate General of Estonia, 9 Rockefeller Plaza, New York 20, N. Y.	No information.
Ethiopia	
Embassy of Ethiopia, 2134 Kalorama Road, N.W., Washington, D. C.	State Bank of Ethiopia, Addis Ababa, Ethiopia, issues *Monthly Report on Economic Conditions and Market Trends*.

Finland

Legation of Finland,
1900 Twenty-fourth St., N.W.,
Washington 8, D. C.

Following publications are available for distribution:
Monthly Bulletin of Bank of Finland (statistical data on commerce)
Finnish Paper and Timber
Unitas (bulletin of economic conditions)
Economic Survey
Economic Review
Facts about Finland

Consulate General of Finland,
53 Broadway,
New York, N. Y.

France

* Press and Information Service,
French Embassy,
610 Fifth Ave.,
New York 20, N. Y.

Established to provide American public with information on political, economic, and social conditions in French Union—Metropolitan France and overseas territories. Maintains small library with reference, documentation, publication, and photograph divisions.

République Française Centre National de la Recherche Scientifique,
934 Fifth Ave., New York, N. Y.

Supplies scientific information from this office or from Paris principals to whom inquiry may be relayed.

For trade information refers to:
French Commercial Counselor,
610 Fifth Ave.,
New York 20, N. Y.

Service de l'Afrique du Nord provides information and statistics on imports and exports of all countries from French Morocco, Algeria, and Tunis. Overseas Territories Division does same for other French colonies.

Germany

* Consulate General of German Federal Republic,
745 Fifth Ave.,
New York, N. Y.

Consult Office of International Trade,
U. S. Department of Commerce

Great Britain

British Embassy,
Washington, D. C.

United Kingdom Scientific Mission,
Washington, D. C.
Refers to: * British Information Services,
30 Rockefeller Plaza,
New York 20, N. Y.
(branches in Washington, Chicago, San Francisco, and Los Angeles)

Superseded (1942) British Library of Information. Comprises: Reference Division (contains economic section and library), Press and Radio Division, and Films and Publications Division. Latter has available classified catalogs of:

(1) British government publication documents: Department of Science and Industrial Research, Meteorological Office, Board of Trade, Medical Research Council, Aeronautical Research Council

[See *Science*, **116**, 11 (July 4, 1952) for data concerning Headquarters, Technical Information Service of DSRI merger with TIDU (corresponding to U. S. Department of Commerce's OTS.]

(2) Films from Britain and film strips. All publications listed are available at this office.

Greece

Information Service,
Royal Greek Embassy,
2211 Massachusetts Ave., N.W.,
Washington 8, D. C.

If unable to answer queries, will refer to appropriate authority in Greece.

Guatemala

Embassy of Guatemala,
1614 Eighteenth St., N.W.,
Washington 9, D. C.

For economic, commercial, and statistical information: Banco de Guatemala, Guatemala City, Guatemala

Dirección General de Estadística, Guatemala City, Guatemala

For scientific information:
Universidad Autónoma de San Carlos, Guatemala City, Guatemala

Haiti
Embassy of Haiti,
4400 Seventeenth St., N.W.,
Washington, D. C.

Suggest consulting: Bissainthe, Max, "Dictionaire de Bibliographie Haitienne," Scarecrow Press, Washington 7, D. C. (director of Bibliothèque Nationale, Port-au-Prince, Haiti)

Suggest:
Pan American Union
Bureau des Statistiques et du Recensement,
Port-au-Prince, Haiti

Départment des Finances et de l'Economie Nationale,
Port-au-Prince, Haiti

Bibliothèques de l'Institution St.-Louis de Gonzague et du Petit,
Seminaire Collège St.-Martial,
Port-au-Prince, Haiti

Possess rich and varied collections of publications.

Hedjaz (*See* United Nations)
Holland (*See* The Netherlands)
Honduras
Embassy of Honduras,
4715 Sixteenth St., N.W.,
Washington, D. C.

For scientific, technical, and trade information refer to:
Ministerio de Fomento, Agricultura y Trabajo, Tegucigalpa, Honduras

For trade statistics:
Ministerio de Haciendo y Comercio,
Tegucigalpa, Honduras

Banco Nacional de Fomento,
Tegucigalpa, Honduras

For library facilities:
Director,
Biblioteca Nacional,
Tegucigalpa, Honduras

Hungary
Legation of Hungarian People's Republic,
2118 Leroy Place, N.W.,
Washington, D. C.

Iceland
Legation of Iceland,
909 Sixteenth St., N.W.,
Washington 8, D. C.

India
* Government of India Information Services,
2107 Massachusetts Ave., N.W.,
Washington 8, D. C.

Information on imports and exports as well as scientific, technical, and industrial progress can be obtained from:
Embassy of India,
2107 Massachusetts Ave., N.W.,
Washington 8, D. C.

Small reference libraries are maintained at all these posts.

Consulate-General of India,
3 East 64th St.,
New York 21, N. Y.

Director, India Information Services,
3 East 64th St.,
New York 21, N. Y.

Consulate-General of India,
25 Beale St.,
San Francisco, Calif.

Indo-china (*See* France and United Nations)

Indonesia

Economic Division,
Embassy of Indonesia,
2020 Massachusetts Ave., N.W.,
Washington, D. C.

Has import, export and production statistics, and miscellaneous data on products, price indexes, etc. Receives: *Indonesian Economic Review* (quarterly) and *Berita Ekonomi* (weekly, partly in English) (a bulletin of current economic aspects, labor questions, finance, regulations concerning imports, exports, and foreign exchange)

Refers to:
Office of Consul General of Indonesia,
10 Rockefeller Plaza,
New York 20, N. Y.

Material almost identical with that at chancery.

* Republic of Indonesia Information Office,
10 Rockefeller Plaza,
New York 20, N. Y.

Issues weekly bulletin *Report on Indonesia.* Office of Trade Commission (same address) issues *Economic Trade Notes*, and export-import statistics. Research files of Information Office contain publications in English, issued by various ministries in Indonesia:

Economic Review of Indonesia, Ministry of Commerce and Industry, Djakarta, Indonesia
The Java Bank, Djakarta, Indonesia
OSR News, Organization for Scientific Research in Indonesia, Merdeka Selatan 11, Djakarta. (free to scientific institutions which are members of OSR)
Facts about Indonesia, Ministry of Information, Djakarta, Indonesia

All these publications are maintained for reference.

Iraq

Baghdad Chamber of Commerce,
Baghdad, Iraq

Trade and statistical information from:
Principal Bureau of Statistics,
Ministry of Economics,
Baghdad, Iraq

National Bank of Iraq,
Baghdad, Iraq

Iran

Embassy of Iran,
3005 Massachusetts Ave.,
Washington, D. C.

Consulate General of Iran,
30 Rockefeller Plaza,
New York, N. Y.

Ireland

Embassy of Ireland,
2234 Massachusetts Av., N.W.,
Washington, D. C.

Statistical information also available from:
Irish Consulate General,
33 East 50th St.,
New York, N. Y., and consulates in Boston, Chicago, and San Francisco

Central Statistics Office, Dublin, Ireland	Issues: *Irish Trade Journal* and *Statistical Bulletin* (quarterly) which contains information regarding industrial, financial, agricultural, transportation, labor, and social situations in Ireland, and *Trade Statistics of Ireland* (monthly) These and other publications available for purchase from: Government Publications Sales Office, G.P.O. Arcade, Dublin, Ireland
Israel Israel Office of Information, 11 East 70th St., New York 21, N. Y. For detailed scientific information: Council, Office of Prime Minister, Jerusalem, Israel	*Bulletin of Research Council of Israel*, Vol. 1, No. 1, March 1951 (in English), includes various fields of science.
Italy Office of Commercial Counselor, Embassy of Italy, 1601 Fuller St., N.W., Washington 9, D. C. Refers to: Commercial Attaché, United States Embassy, Rome, Italy	Office not in position to furnish information.
American Chamber of Commerce for Trade with Italy, Inc., 105 Hudson St., New York 13, N. Y.	Can furnish specific information on trade with Italy, particularly statistics on imports and exports. Will route inquiries for scientific information to proper sources in Italy.
Japan Embassy of Japan, 2514 Massachusetts Ave., N.W., Washington 8, D. C. SCAP Foreign Trade Mission (no longer active since signing of peace treaty) Embassy suggests writing directly to: Secretariat, Ministry of International Trade and Industry, Kasumigaseki, Tokyo, Japan Public Information Section, Secretariat, Ministry of Agriculture and Forestry, Hibiya, Tokyo, Japan Secretariat, Ministry of Education, Kasumigaseki, Tokyo, Japan Secretariat, Ministry of Welfare, Kasumigaseki, Tokyo, Japan	Some monthly publications on foreign trade and general economic situation in Japan.
Japanese Consulate General, 350 Fifth Ave., New York 1, N. Y. Suggests direct inquiry to: Ministry of International Trade and Industry Committee, Toramomon, Tokyo, Japan Scientific and Technical Advisory Committee, Nagata-cho, Tokyo, Japan	Limited amount of trade information.

Jordan
Arab Chamber of Commerce,
Jerusalem, Jordan

Not in position to furnish information.

Refers to:
Ministry of Trade and Customs,
Hashemite Kingdom of Jordan,
Jerusalem, Jordan

Has information on statistics and trade.

Korea
Embassy of Korea,
2322 Massachusetts Ave.,
Washington, D. C.
Consult United Nations

Laos (Consult United Nations)

Latvia
Legation of Latvia,
1346 Connecticut Ave., N.W.
Washington, D. C.

Lebanon
Secretary,
Legation of Lebanon,
Washington, D. C.

Trade information available in reference library. Receives quarterly *Statistical Bulletin*. Has data on prices, production, currencies, population, public health, weather. No scientific information.

Refers to
American University of Beirut,
Université St. Joseph,
Ministry of Health, and
Ministry of Agriculture,
Beirut, Lebanon

Liberia
Embassy of Liberia,
5201 Sixteenth St., N.W.,
Washington, D. C.

Liberian Commercial Attache's Office,
220 Broadway,
New York, N. Y.

Firestone Plantations, Inc.,
120 Wall St.,
New York, N. Y.

Libya (Consult United Nations)

Lithuania
Legation of Lithuania,
2622 Sixteenth St., N.W.,
Washington, D. C.

Issues *Current News on the Lithuanian Situation.* No scientific or trade information.

Luxembourg
Legation of Luxembourg,
2622 Sixteenth St., N.W.,
Washington, D. C.

Mexico
Embassy of Mexico,
2829 Sixteenth St., N.W.,
Washington 9, D. C.
Refers to:
Dirección General de Estadística,
Secretaría de Economia,
Calle de Balderas Número 71,
México, D.F., México
Over 80 Mexican consulates in United States.

Mongolian People's Republic (*See* United Nations)

Nepal
Legation of Nepal,
12A Kensington Palace Gardens,
London W. 8, England

No information.

Refers to:
The Secretary,
Department of Information,
Government of Nepal,
Katmandu, Nepal via India

The Netherlands
Director,
*The Netherlands Information Service,
10 Rockefeller Plaza,
New York 20, N. Y.

If answer not known here, office will try to obtain from home sources. Maintains small library of books and newspapers (some printed in Dutch only), including data for Netherlands West Indies and Surinam (Dutch Guiana). Publishes digest of news, review of Dutch press comments.

Refers for scientific information to:
Central National Council for Applied Scientific Research in Netherlands (T.N.O.),
12 Koningskade,
The Hague, Netherlands

Publishes *T.N.O. Guide* (2nd ed., November 1950). Lists all branch councils. T.N.O. is composed of branch councils working independently in fields of industrial research, agriculture, defense, health, and nutrition, but controlled by Central Council.

Netherlands Information Service,
Western Division,
Mills Building,
San Francisco 4, Calif.

Branch office.

Netherlands Chamber of Commerce in United States, Inc.,
41 East 42nd St.,
New York, N. Y.

Statistics on imports and exports.

Netherlands Chamber of Commerce in United States (for the Pacific Coast States), Inc.,
417 Market St.,
San Francisco 5, Calif.

New Zealand
Embassy of New Zealand,
19 Observatory Circle,
Washington 8, D. C.

Has library with trade and general commercial information. Will direct specific inquiries to appropriate government office in New Zealand.

Refers to:
New Zealand Scientific Attaché,
1800 K St., N.W.,
Washington, D. C.

New Zealand Trade Commissioner,
1346 Connecticut Ave.,
Washington, D. C.

New Zealand Government Office,
Suite 526,
630 Fifth Ave.,
New York 20, N. Y.

No information.

Refers to:
Counselor,
Embassy of New Zealand,
Washington, D. C.

Nicaragua
Embassy of Nicaragua,
1627 New Hampshire Ave., N.W.,
Washington, D. C.

Norway
Embassy of Norway,
3401 Massachusetts Ave., N.W.,
Washington 7, D. C.

Refers to:
* Norwegian Information Service,
3516 Massachusetts Ave., N.W.,
Washington 7, D. C.

Limited library services. Will refer inquiries for scientific, technical, and trade information to proper sources in Norway. Publishes *News of Norway*, stories related to scientific and technical developments (distributed free of charge on request).

Norwegian Information Service,
Norway House,
290 Madison Ave.,
New York 17, N. Y.

Distributes:
Bulletin (of general trade information),
Norwegian American Commerce (*monthly* trade publication)

Suggests contacting:
Norwegian Export Council, and
Norwegian American Chamber of Commerce,
Norway House,
New York 17, N. Y. (Branch offices in Chicago, San Francisco, New Orleans, Oslo)

Publishes:
Bulletin (of general trade information), and
Norwegian American Commerce (monthly trade publication)

Pakistan
Embassy of Pakistan,
2201 R St., N.W.,
Washington, D. C.
Refers to:
*Pakistan Consulate General,
Pakistan House,
12 East 65th St.,
New York, N. Y.

Maintains small library of current Pakistan publications. Has commercial and technical data. Issues monthly statistics on imports and exports between Pakistan and U. S. There is time lag in compilation of these data. *Pakistan Trade Journal* printed in Karachi is a subscription publication, usually a month or two late in reaching U. S. Gives comprehensive statistical report on Pakistan's overall imports and exports.

For scientific information:
Pakistan: A Select Bibliography, compiled by A. R. Ghani, published by Pakistan Association for Advancement of Science, University Institute of Chemistry, Lahore, Pakistan, 1951. (Will answer direct inquiries)

Panama
Embassy of Panama,
2862 McGill Terrace,
Washington, D. C.

No information.

Refers to:
Panama Ministry of Agriculture, Commerce and Industry,
Panama City, Panama

Oficina de Estadistica,
Contraloría General,
Panama City, Panama

Consult Pan American Union

Paraguay
Embassy of Paraguay,
5500 Sixteenth St., N.W.,
Washington, D. C.

Peru
Secretary,
Embassy of Peru,
1320 Sixteenth St., N.W.,
Washington 6, D. C.

Has library of official books and statistics. No scientific information.

Refers to:
Oficina de Informaciones,
Palacio de Gobierno,
Lima, Peru (S. A.)

Camera de Comercio,
Lima, Peru

Philippines
Embassy of the Philippines,
1617 Massachusetts Ave., N.W.,
Washington, D. C.

Philippine Consulate General,
350 Fifth Ave.,
New York 1, N. Y.

Refers to embassy. Limited library facilities.

Poland
Embassy of Poland,
2640 Sixteenth St., N.W.,
Washington 9, D. C.

No information.

Refers to:
Wiodomosci Statystyczne
"Ruche",
Pl. 3 Krzyzy 16,
Warsaw, Poland

This is address of *Statistical News*.

* Polish Research and Information Service, 250 West 57th St., New York 19, N. Y.	Maintains small library. Economic data available.
Polish American Supply Corp., 151 East 67th St., New York 21, N. Y. Refers to: Panstwowa Konisja Planowania Gospodarczego, Warszawa, Plac Trzech Krzyzy, Poland	In process of liquidation.
Portugal	
* Portuguese Commercial Office, 630 Fifth Ave., New York 20, N. Y.	Will give information on trade and refer scientific inquiries to appropriate home ministries. Provides pamphlet *Information on Portuguese-American Trade.*
Suggest: Embassy of Portugal, 2125 Kalorama Road, N.W., Washington 8, D. C Consulates General in New York, Boston, San Francisco.	
Ruanda-Urundi (Consult United Nations)	
Rumania	
Legation of Rumania, 1601 Twenty-third St., Washington, D. C.	
Saudi Arabia	
Embassy of Saudi Arabia, 2800 Woodland Drive, N.W., Washington 8, D. C.	
El Salvador	
Embassy of El Salvador, 2400 Sixteenth St., N.W., Washington 9, D. C.	Upon request will route limited scientific literature issued by government of El Salvador.
Consulate General of El Salvador, 55 West 52nd St., New York, N. Y. Refers to:	No information.
Ministerio de Cultura, San Salvador, El Salvador, Central America	Scientific, technical, and cultural information
Ministerio de Economica	Economics, finance, etc.
Dirección General de Estadística	Export and import data.
Somaliland (Consult United Nations, Division of Information from Non-Self-Governing Territories.)	
Spain	
Commercial Office, Embassy of Spain, 2558 Massachusetts Ave., N.W., Washington, D. C. Refers to: Bureau of Census, Department of Commerce, Washington, D. C.	No points of distribution of trade or scientific intelligence from Spain in United States.
Jefe de Estadística, Dirección General de Aduanas, Calle de Magdalena 10, Madrid, Spain	Statistical data regarding domestic and international trade of Spain.
Consejo Superior de Investigaciones Cientificas, Serrano 119, Madrid, Spain	Information about scientific research.
Sweden	
Embassy of Sweden, 2249 R St., N. W., Washington 8, D. C.	

Refers to: Royal Swedish Academy of Engineering Science, Room 863, 630 Fifth Ave., New York 20, N. Y.	
American Swedish News Agency, 630 Fifth Ave., New York 20, N. Y.	Maintains small library with special collection of Swedish yearbooks, periodicals, and encyclopedias.
Swedish Chamber of Commerce of U. S. A., 45 Rockefeller Plaza, New York 20, N. Y. (Branch office in San Francisco)	Attempts to solve any kind of problem in commercial field between United States and Sweden. Will refer to home sources if necessary. Has extensive library which includes special resources of: Swedish Export Directory Directory of Swedish Manufacturers Current Swedish Tariffs
For scientific and technical information refers to: * Technical Adviser to Swedish Embassy, 630 Fifth Ave., Room 863, New York 20, N. Y.	Functions in principle along same lines as Swedish Chamber of Commerce.
Switzerland	
Legation of Switzerland, 2900 Cathedral Ave., N.W., Washington 8, D. C.	
Swiss Office for Development of Trade, Place de la Riponne 3, Lausanne, Switzerland Refers to: Swiss National Library (Schweizerische Landesbibliothek), Hallwylstrasse 15, Berne, Switzerland Swiss Economic Archives (Schweizerisches Wirtschaftsarchiv), University Building, Petersgraben, Basle, Switzerland	Will try to furnish data it may possess or be able to obtain.
Syria	
Legation of Syria, 2215 Wyoming Ave., N.W., Washington, D. C.	
Chamber of Commerce, Damascus, Syria Refers to: * Syrian Consulate General, 350 Fifth Ave., New York, N. Y.	Can give economic information.
Thailand	
Royal Thailand Embassy, 2490 Tracy Place, N.W., Washington 8, D. C. Refers to: Secretary-General, Economic Affairs Council, The Government House, Bangkok, Thailand	Does not possess data or library.
Department of Foreign Trade, Ministry of Commerce, Bangkok, Thailand Refers to: Department of Commercial Intelligence, Ministry of Economic Affairs, Bangkok, Thailand	Does not publish or distribute statistics or scientific information.
Tibet	
Turkey	
Turkish Embassy, Office of Press Attaché, 2021 Hillyer Place, N. W., Washington 9, D. C.	No information.

Refers to:
Turkish Information Office,
444 East 52nd St.,
New York 22, N. Y.
Turkish Embassy,
Office of Commercial Counselor,
3511 Ordway St., N. W.,
Washington 16, D. C.
Refers to:
Statistical Administration
(Istatistik Umum Mudurlugu),
Ankara, Turkey
Turkish Embassy,
Commercial Counselor's Office,
20 Exchange Place,
New York 5, N. Y.
Refers to:
Chamber of Commerce
(Ticaret ve Sanayi Odasi Baskanligi),
Istanbul, Turkey,
and Izmir, Turkey

Ukrainian S.S.R.

Union of South Africa
Union of South Africa,
Government Information Office,
655 Madison Ave.,
New York 21, N. Y.
Refers to:
* South African Scientific Liaison Office,
1800 K St., N.W.,
(P. O. Box 680
Benjamin Franklin Station),
Washington 6, D. C.,

Office is responsible for distributing publications of South African Council for Scientific and Industrial Research in United States and Canada. Copies of all current technical reports and publications are available. Files go back to 1948, with few publications prior to this date. Office acts as technical information office. Staff answers questions or refers inquiries concerning scientific research and technology in Union of South Africa to parent organization in Pretoria.

Refers to:
South African Consul General,
655 Madison Ave.,
New York 21, N. Y.

Trade information.

Commercial Counselor,
South African Embassy,
Washington, D. C.

South African Government,
Information Office,
655 Madison Ave.,
New York 21, N. Y.

General information and publicity matter.

Union of Soviet Socialist Republics
Embassy of U.S.S.R.,
1125 Sixteenth St., N.W.,
Washington, D. C.
Refers to:
Information Bulletin,
Embassy of U.S.S.R.,
2112 Massachusetts Ave., N.W.,
Washington 8, D. C.

Cannot supply information.

Refers to:
Four Continent Book Corp.,
38 West 58th St.,
New York, N. Y.

Has listing of publications obtainable from U.S.S.R.

Consultants Bureau,
152 West 42nd St.,
New York 18, N. Y.

J. Applied Chem. U.S.S.R. offered in English translation for 1952 [See *Chem. Eng. News*. 30, 2964 (1952)].

Uruguay
Counselor,
Embassy of Uruguay,
Room 303,
1025 Connecticut Ave., N.W.,
Washington 6, D. C.

Has industrial and trade publications.

Refers to:

Biblioteca Nacional,
Ave. 18 de Julio y Tristán Narvajas,
Montevideo, Uruguay

Venezuela
Embassy of Venezuela Information Service,
2437 California St., N.W.,
Washington, D. C.

Supplies free on request: *Venezuela Up-to-Date*, which reports business, industrial, and cultural developments. Will refer inquiries or suggest appropriate sources.

For imports and exports refer to:
Ministerio de Fomento,
Dirección de Estadística,
Caracas, Venezuela, S. A.

For scientific data refer to:
Academia de Ciencias Naturales,
San Francisco a Bolsa,
Caracas, Venezuela, S. A.

Instituto de Medicina Experimental,
Caracas, Venezuela, S. A.

Ministerio de Obras Públicas,
Laboratorio de Resistencia de Materiales,
Caracas, Venezuela, S. A.

For library facilities refer to:
Biblioteca Nactional,
San Francisco a Bolsa,
Caracas, Venezuela, S. A.

Yemen
Legation of the Mutawakelite Kingdom of Yemen,
3554 Albemarle St., N.W.,
Washington, D. C.

Not yet in position to supply information, but expects to add this service.

Yugoslavia
Commercial Counselor,
Embassy of Federated People's Republic of Yugoslavia,
1600 Massachusetts Ave., N.W.,
Washington 6, D. C.

Refers to:

Yugoslav Information Center,
816 Fifth Ave.,
New York 21, N. Y.

Will make contacts with proper sources. Has *Commercial Information*, monthly bulletin, which contains articles in English on industry and trade. Issued by: Chamber of Commerce of Yugoslavia, P. O. Box 47, Beograd, Yugoslavia

For scientific information refer to:

Council of Science and Culture,
Yugoslav Government,
Kneza Milosa Br. 20,
Beograd, Yugoslavia

Yugoslav National Commission for UNESCO,
Bozidara Adzije Br. 11,
Beograd, Yugoslavia

Will contact scientists in that country.

Sources Handling Data on International Basis

Office of international trade, United States Department of Commerce, Washington 25, D. C.
Refers to:
New York Regional Office,
Office of International Trade,
2 West 43rd St.,
New York, N. Y.
(Maintains 42 other field offices in major cities of United States.)

Publishes:
U. S. Trade with Latin American Republics (semiannual bulletin)
Foreign Commerce Weekly
International Trade Statistics Series
"Foreign Commerce Yearbook." Annual volumes reporting on trade of American Republics with the world. Latest ed. 1949. Volume carrying statistics through 1950 is in press
Current Export Bulletin (irregular)
World Trade in Commodities (irregular)
Suggest consulting bulletins of other bureaus within Department of Commerce: *Foreign Trade Statistics Notes* (Bureau of Census). See *Monthly Catalog of Government Publications*, Superintendent of Documents, Washington, D. C.

Pan American Union
Pan American Union,
19th St. and Constitution Ave., N.W.,
Washington 6, D. C.
Department of Economic and Social Affairs
Division of Economic Research. Prepares statistical compilations and summary analyses of foreign trade and other subjects of interest to American republics.
Statistics Division. Provides medium for professional collaboration among statisticians of Americas. Publishes quarterly, *Estadística.*
Division of Agriculture and Conservation. Prepares and distributes publications on agricultural industries of American republics, crop studies for growers, and technical conservation studies. Publishes quarterly *Conservation in the Americas* (English and Spanish).
Department of Cultural Affairs
Division of Philosophy, Letters, and Sciences. Edits, translates, and prepares for publication selected works of outstanding authors and scientists.
Stimulates and coordinates preparation of manuals, specialized glossaries, and reference works.
Promotes publication of outstanding inter-American works by university and private processes.
Carries on research for preparation of specialized monographs and bibliographies.
Edits *Inter-American Review of Bibliography,* a journal containing articles, reviews, notes, selected subject bibliographies, and information about authors, publications, and libraries.
Prepares for publication reviews in various cultural fields containing original articles or reprints of selected articles of lasting interest (*Panorama*).
Undertakes preparation of indexes and directories of writers, scientists, philosophers, and scholars, and lists of specialized institutions.
Provides information by means of bulletins (*Boletin de Ciencia y Tecnologia, Boletin de Ciencias Sociales*) and news services, establishes contact between scientists and institutions in the various fields, and assists in coordination of technical and scientific developments.
Division of Education. Conducts inquiries and surveys, and prepares for publication and distribution technical reports, information bulletins, pamphlets, bibliographies, and study guides.
Columbus Memorial Library. Collection particularly strong since 1889, particularly in economics and international relations. Offers interlibrary loan services. Provides reference and document distribution services. Current bibliography is a specialty.
Publications and Promotion Section. Issues catalogs of publications. For documents issued by Pan American Union write to this section.
United Nations
United Nations Information Center,
2000 Massachusetts Ave., N.W.,
Washington, D. C.
UN Headquarters,
United Nations, New York, N. Y.
A partial outline of UN Secretariat subdivisions selected to indicate possible useful auxiliary information sources for particular purposes follows:
United Nations Headquarters Library
Reference and Documentation Section. UN and Specialized Agencies Documents Collection.
Documents Index Unit (not reference source, but publication unit). Lists and indexes systematically documents of United Nations and of specialized agencies in a monthly publication, *United Nations Documents Index* (Vol. 3, 1952). The subject index (Vol. 3, No. 4, Pt. 2) gives a consolidated list of depositories of UN and Specialized Agencies documents and of sales agents for their sales publications.

League of Nations Documents (Woodrow Wilson Memorial Library).
Map Collection.
Department of Economic Affairs
Statistical Office. Chief Statistician, Production and Prices.
Department of Social Affairs
Division of Narcotic Drugs. Bulletin and Publications Unit. Section II. Research.
Division of Social Welfare. Social Reference Center.
Function of these two departments is primarily accumulation and analysis of data for UN representatives, rather than dissemination of information.
Department of Trusteeship and Information from Non-Self-Governing Territories
Division of Information from NSG Territories. Africa Section, Caribbean Section, Pacific-Asia Section, and Specialists' Unit.
Department of Public Information. Serves as UN public relations office. It is zealous in disseminating information about UN as an organization, but cannot be thought of as a source of information about individual countries or clearinghouse for information from abroad on any subject.
Sales and Circulation Section. Distributes certain UN documents. (International Documents Service, Columbia University Press, is also official sales agency for United Nations Documents.)
Technical Assistance Administration
Information Officer.
Directorate of Operations. Reports Division.
United Nations International Children's Emergency Fund
Reports and Proceedings Office.
Technical Assistance Board
Public Information Officer.
United Nations Korean Reconstruction Agency
Office of Public Information Department.
Division of Reports and Statistics.
Commissions, Committees and Councils
Committee on Information from Non-Self-Governing Territory.
United Nations Field Operations Service (Information). UN maintains in connection with various commissions, councils, and committees, field representatives who make intelligence reports to N. Y. headquarters office for India, Pakistan, Greece, Somaliland, Indonesia, Korea, Eritrea, Palestine, Germany, Libya, but not for Cameroons, Togoland, Tanganyika, and other African trust territories; Nigeria, Ruanda-Urandi, Falkland Islands, Aden, Tunisia, Morocco, Tangier (see Department of Trusteeship for latter places).
Specialized Agencies
FAO Food and Agricultural Organization, 1325 C St., S.W., Washington 25, D. C., and Secretariat Building. United Nations, New York, N. Y.
FAO documents are listed and indexed in *UN Documents Index* and may be purchased from: International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N. Y. A list of depository libraries appears in UN Documents Index 3, No. 4, Pt. 2 (April 1952). This is a consolidated list of depositories of UN and Specialized Agencies.
ITO, International Trade Organization. For information: UN Secretariat Building, United Nations, New York, N. Y.
Interim Commission for International Trade Organization (ICITO) is responsible for publication of its documents, which are unrestricted, and those of Contracting Parties to General Agreement on Tariffs and Trade (GATT) (nearly all restricted at time of issue). ICITO and GATT unrestricted documents may be purchased from I.D.S. There are no depository libraries as such, but some libraries receive documents free on request.
UNESCO, United Nations Educational. Scientific, and Cultural Organization. For information: UN Secretariat Building, United Nations, New York, N. Y.
Documents and publications of UNESCO are listed and indexed in *United Nations Documents Index*. A description of the documentation system used therein appears in Vol. 2, No. 1, January 1951. These documents may be consulted in depository libraries selected by UNESCO, a list of which can be obtained on request, or purchased individually. All documents intended for distribution to the public may be received on a blanket annual subscription for $30, placed with: International Documents Service, Division of Columbia University Press, 2960 Broadway, New York 27, N. Y.
Comprehensive Periodicals Subscription Service offers combined annual subscription to all UNESCO periodicals for $10. An over-all standing book order scheme also exists. Separate orders for individual items are possible. Subject lists are obtainable from I.D.S. One of publications of wider interest is *Index Translationum* now in Vol. 3 (1952).
UNESCO has also been responsible for creation of World Braille Council, and an active Arid Zone Program.
WHO, World Health Organization. For general information and for public relation information: UN Secretariat Building, United Nations, New York, N. Y.
Documents of WHO are published or summarized in *Official Records of WHO*.
Reports of its expert committees and other technical advisory bodies are published in *WHO: Technical Report Series*.

The Division of Pubic Information distributes at irregular intervals articles in series, *Special Features*, and publishes a monthly, *WHO Newsletter*, either of which may be obtained on application to: WHO, Division of Public Information, Palais des Nations, Geneva, Switzerland.

WHO has established, among others: Expert Committee on Insecticides, Expert Committee on Cholera, International Centers of Biological Standardization, Expert Committee on the International Pharmacopoeia, International Plant Protection Convention, International Shigella Center, International Salmonella and Escherichia Center.

Has compiled EB 9/94 List of: (1) National Salmonella Centers, and (2) National Control Centers, 5 pp, Geneva, January 25, 1952. EB 9/105. Production of Antibiotics and Insecticides, 2 pp, Geneva, January 31, 1952.

Publications of WHO may be purchased from : International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N. Y.

WMO, World Meteorological Organization. For information: Information Office, UN Secretariat Building, United Nations, New York, N. Y.

Orders for its publications should be addressed to: The Secretariat, World Meteorological Organization, Geneva, Switzerland. No depository libraries have been established.

Bibliography

(1) Braschi, A. A., "Export Guide for Latin America," Chicago, Export Guide Publishing Co., 1951. Contains documentation, shipping regulations, packing, consular information, export requirements, trade-mark and patent data, etc.
(2) *Bibliographic Index*, Vols. 1–4 (1937–51).
(3) Campbell, K. H., "Guide to Foreign Government Information Service," Washington, D. C., Foreign Commerce Department, Chamber of Commerce of the United States, 1st ed. 1949, rev. ed. 1951.
(4) Carter, P. G., "Sources of Statistics on Chemicals in Latin America," Washington, D. C., Library of Congress, 1951.
(5) *Industrial Arts Index*, 1951–June 1952.
(6) Library of Congress, Washington, D. C., "Library and Reference Facilities in the Area of the District of Columbia," 3rd ed., 1948.
(7) New York City Telephone Directory, 1952. Classified section: Governments—foreign, representatives. Also directories of other U. S. metropolitan centers: Boston, Chicago, Los Angeles, Minneapolis, New Orleans, Philadelphia, St. Louis, San Francisco, Washington.
(8) *Public Affairs Information Bulletin*, current issues, 1952.
(9) Special Libraries Association, New York, "Directory of Greater New York City, 1950."
(10) Spitzer, E. F., "Foreign Sources of Pharmaceutical Information," paper presented before Pharmaceutical Section, Sci-Tech. Division, Special Libraries Association, 42nd annual meeting, St. Paul, Minn., June 18, 1951.
(11) United Nations, New York, "United Nations Documents Index."
(12) United Nations, New York, "United Nations Handbook."
(13) U. S. Department of Commerce, International Reference Service.
(14) U. S. Department of Commerce, Office of International Trade, *Foreign Commerce Weekly*, 1952; International Trade Statistics Series, "U. S. Trade with Latin America," 1950 and 1951.
(15) Vormelker, Rose, ed., "Special Library Resources," New York, Special Libraries Association, 1941–47.
(16) "World of Learning," 4th ed., London, Europa Press, 1952.

RECEIVED October 14, 1951. Presented before the Division of Chemical Literature, at the 122nd Meeting of the AMERICAN CHEMICAL SOCIETY, Atlantic City, N. J.

Searching the PB Collection for Chemical Information

LORNA F. LEDERMAN, *Monsanto Chemical Co., Dayton, Ohio*

JOHN GREEN and DOROTHY GRAF, *Office of Technical Services, Department of Commerce, Washington, D. C.*

A large part of the PB collection, which consists of data seized by the Allies after World War II and declassified reports of government-sponsored research, is not indexed in standard chemical indexes. Much of the PB collection relates to the chemical industry, and often details of chemical manufacture are disclosed. The prime source for searching the reports is the index to the *Bibliography of Technical Reports* issued by the Office of Technical Services. Other indexes and search sources are listed in the bibliography and evaluated.

The PB (Publication Board) report collection, maintained by the Office of Technical Services (OTS), U. S. Department of Commerce, includes all the technological data seized by the Allies after World War II from the conquered European and Asian enemy countries, particularly Germany; it also includes a large number of declassified reports of U. S. federal-sponsored research carried on during and after World War II, and British and Canadian reports of government-sponsored research.

The PB reports were made available to the public in the form of pamphlets and photoreproductions. Since these forms of reproduction do not fall into the types of publications covered by the standard chemical abstracting and indexing sources, it requires the use of special indexes to the PB collection to find PB reports.

There are over a quarter of a million reports in the PB collection today, after less than 10 years of operation of the PB publication program. A large proportion of the PB reports relate to the chemical industry. It was decided at the outset of the PB publication program that it would be impossible for *Chemical Abstracts* to undertake the abstracting and indexing of such a huge collection. This decision was based, at least in part, on the contention that the truly original information in the PB reports would very rapidly be republished in the existing technical journals; and it may be seen that this has been the case with such developments as the oxo synthesis, and Reppe's acetylene chemistry. However, not all, or nearly all of the chemical information in the PB collection has been republished in journal literature which would be indexed in *Chemical Abstracts* or other standard chemical indexes. That the original detailed laboratory data captured and copied from research records in Germany would not be republished in U. S. journals *in toto* will be readily appreciated. Perhaps less widely realized is the significance of PB reports consisting of manufacturing plant blueprints and operating records, which received even less coverage in journal articles than did research records. Details of chemical processes and formulations are trade secrets; journal articles usually describe laboratory techniques, and patents are customarily uncooperatively vague with respect to operating plant conditions. A PB report may often be the only place in which details of manufacture are actually published for well-known chemicals. For these and for other types of chemical information, a search of the PB reports is of importance.

Subject Indexes and Subject Search Sources

U. S., General. The PB reports were listed by the Office of Technical Services (OTS) as issued, in its publication, *Bibliography of Scientific and Industrial Reports* (BSIR), later renamed the *Bibliography of Technical Reports* (*3*). The listing of each PB report includes bibliographical data, a brief abstract, and price. The abstracts are arranged by broad subject classes.

A subject index was prepared by the OTS for each volume of the *Bibliography* (*4*), and, since almost every PB report of any kind is listed in the *Bibliography*, these indexes are the prime source for searching for PB reports. A word of caution is necessary with respect to their use, however, for no subject-heading authority list was used in their preparation. As a result, related reports are indexed under widely varying headings. For example, in the index to the first volume, only one PB report is listed under the heading, "Styrene, polymerization," but under "Polystyrene," there is an entry for the same report, plus entries for 12 more. "Polystyrene" also refers to "Plastics, polystyrene," where seven PB reports are listed, two of which have already been found under the heading "Polystyrene." Reference to one of the PB reports found via the index informs the user that commercial names for styrene polymers in Germany include "Styroflex" and "Polystyrol," and in the BSIR index four new reports may be found under the former heading, and under the latter, one new report reference plus two more found previously.

Another typical example of the indexing in the *Bibliography* is furnished by a search for vinylacetylene. In the index to the first volume of the *Bibliography*, entries for this subject are found under "Monovinylacetylene." In the second volume, pertinent entries occur under both "Monovinylacetylene" and "Vinyl acetylene." The subject index of Volume 3 switches to the form "Acetylene, vinyl-." In the fourth volume, the compound is indexed as "1-Buten-3-yne"!

In addition to presenting difficulties in searching, the indexes to the BSIR are not complete, because they were largely prepared from the abstracts of the reports, rather than the reports themselves. As a result, a complete search of the PB report collection must supplement a search of the *Bibliography* indexes by reference to other, specialized indexes.

In addition to the BSIR subject indexes issued by OTS, a subject index to chemical information in the BSIR was prepared by a private publisher, Technical Information Service (*2*). An index volume was projected for each of 12 broad subject fields, under the general heading, "Chemicals and Allied Products." After publication of the first two indexes, covering respectively agricultural and analytical chemistry, the series was apparently discontinued.

The Technical Information Service subject indexes refer to the PB number and the volume and page of BSIR where an abstract of the PB report occurs. Each volume also contains a numerical list of PB reports indexed, a correlation of PB with other series identification numbers, and author, agency, and company indexes. The indexes appear to be supplementary to the OTS BSIR subject indexes, in that reports found via one index may not be listed in the other, and vice versa.

Foreign, General. The other Allied countries participated in the program of copying captured German documents along with the U.S. The British collection of such documents is organized under the designation of FD (foreign document) reports. The collection is held by the Technical Information and Documents Unit (TIDU), Department of Scientific and Industrial Research.

No systematic catalog of the German documents corresponding to the BSIR was published in England; instead, the emphasis was put on summaries of the information in the documents, written by British experts. These summaries will be discussed below. The chemical documents were listed, however, by the Association of British Chemical Manufacturers (ABCM), in lists distributed to their members. In addition to the FD reports, which are the copies of German documents or Allied microfilms relating to captured German technical information, the ABCM lists included FDX and ORR report listings. The former also correspond to German captured material, but are distinguished from FD reports by the fact that summaries of these reports have been made; the latter are U. S. government-sponsored research reports. The FD reports are all available through the OTS, which has a large number of FD reports already in the PB collection, and will acquire any not held, if a request is received. The FD reports are difficult for U. S. readers to find, however, since the ABCM lists give only title and number, and in any case, the lists are available only to ABCM members. TIDU maintains a card index of the FD reports at its offices; eventual publication of this index is planned.

The French post-war investigating teams in Germany produced some 20,000 copies of German documents relating to chemistry, under the authority of the Ministère de l'Industrie et du Commerce, Direction des Industries Chimiques. The dissemination of these documents was put into the charge of l'Association pour l'Utilisation et la Diffusion de la Documentation (UDD), which issues abstracts of the documents in periodically published catalogs (*1*). The catalogs are arranged by a broad subject classification; each issue, after number 11, contains a subject index. It is expected that about 30 catalogs will be issued, and on completion of the series, the UDD plans to issue a cumulative index. The indexes particularly emphasize analytical chemistry. The reports include some German material not available in other collections. Reports, as well as the catalogs, may be obtained through the UDD.

BIOS, CIOS, FIAT, and JIOA. The American and British technical investigators sent into Germany and into Japan after the close of World War II were, for the most part, under the supervision of one of the following agencies: Joint Intelligence Objectives Agency (JIOA), which was the U. S. agency to supervise combined Allied terms of investigators; Field Intelligency Agency, Technical (FIAT), which was responsible for teams consisting of U. S. men only; Combined Intelligence Objectives Subcommittee (CIOS), which was the British counterpart of the JIOA, and British Intelligence Objectives Subcommittee (BIOS), the British equivalent of our FIAT.

Each of these agencies issued its own series of reports—some, a number of different series. The reports varied from interrogations, designed, for example, to evaluate plant operating conditions and war damage, to scholarly and detailed surveys of the state of technical progress in the whole area of a field of German industry. Although the reports are secondary sources, they may incorporate original data copied from the German records. The following types of reports were issued: CIOS: (Roman Numeral Series) and Evaluation Reports (E/R); BIOS: Final, Evaluation (E/R), /JAP, Overall (or Survey—one numerical series with two alternative designations), and Interrogation Reports; FIAT: Final Reports and Technical Bulletins (T/B); and JIOA Reports.

The most extensive index to these reports available has recently been issued by the Association of British Chemical Manufacturers together with TIDU (*5*). This index is a microfilm copy of handwritten cards, prepared by page-by-page indexing of the original reports. A semiclassified arrangement is used, the entries being grouped under general headings, such as "Resins, synthetic." A separate subject index of references to dyestuffs is included in the second microfilm reel of the index.

An American counterpart to this British index of FIAT, CIOS and BIOS reports was prepared by FIAT (*8*). The FIAT index covers fewer reports—because it was issued several years earlier—but is equally detailed.

A subject index is included in a numerical title list of FIAT reports compiled by A. Blackburn (*6*). The subject index primarily consists of catch-words from titles. This report also includes correlations of PB and FIAT numbers to each other, BSIR references where abstracts of the reports may be found, and an author index.

BIOS issued a "Technical Index of Reports on German Chemical Industry" (*7*), in 6 parts, which indexes BIOS and FIAT Final, CIOS Roman Numeral Series and JIOA reports. Each part of this publication is a separate subject index for the reports issued in the period covered; there is no cumulative index. The indexing is apparently chiefly derived from report titles.

Less convenient for subject searching are the classified lists of FIAT, CIOS, and BIOS reports. In "Reports on German and Japanese Industry" (*13*), a series of classified lists issued by TIDU, the cumulated issue published late in the series divides the title listings under the heading, "Chemical Industry" into only four subgroups. CIOS, CIOS E/R, BIOS, BIOS E/R, BIOS/MISC, BIOS/JAP/PR, BIOS Overall (or Survey), FIAT, FIAT T/B, and JIOA reports are listed by title in this publication.

"The JIOA Subject Index of Scientific and Technical Reports" (*9–11*), volumes under this title being issued separately for BIOS, CIOS, and FIAT Final Reports, is not a subject index in the library sense; each volume is a catalog of abstracts, arranged by a very broad subject classification.

A classified arrangement is also used in a list of reports by TIIC, TIIB, and TIID investigators issued in 1946 (*12*). The Technical Industrial Intelligence Committee (TIIC) was the civilian counterpart of JIOA in Europe. After hostilities ceased, the overseas branch was given the designation of FIAT, and the U. S. group became the Technical Industrial Intelligence Branch (TIIB), and later, the Technical Industrial Intelligence Division (TIID) of the OTS. This list includes chiefly CIOS and FIAT reports, listed by author, and classed by TIID units; the corresponding PB number is given in some cases.

British Abstracts has also listed and subject-indexed the reports written by Allied teams of investigators.

Technical Oil Mission. The petroleum industry cooperated closely with the U. S. Government during the war; at the close of the war, a Technical Oil Mission (TOM) appointed by the Petroleum Administration for War (PAW), was sent to Europe to operate under CIOS. German documents relating to petroleum chemistry were microfilmed by this group. In addition, a number of reports written by members of TOM were filed with CIOS. Tables of contents in English to the TOM microfilm reels were prepared under the auspices of PAW, and later, the U. S. Bureau of Mines (*14*). Abstracts and translations of selected portions of these reels were prepared by the Technical Advisory Committee of the Petroleum Industry War Council, and subsequently by the TOM Study Group of the American Petroleum Institute. The U. S. Bureau of Mines, as successor to the PAW, prepared and distributed a subject index to TOM reels (*15, 16*); a more detailed card index, not published, is also available at the U. S. Bureau of Mines office. The subject indexes are semiclassified, but provided with extensive subheadings. Much chemical material is included, as well as information on petroleum technology and synthetic liquid fuels. The TOM reels are available through the Photoduplication Service of the Library of Congress.

Indexes to German Industrial Reports. The major portion of the German chemical industry was controlled by I. G. Farbenindustrie. Not only did FIAT members prepare indexes to some of the I. G. Farben material copied (*18–21*), but FIAT also copied I. G. Farbenindustrie's own extensive card index files, which include structure, trade name literature, and I. G. Farbenindustrie report references, and cover such subjects as dyes, plastics, and organic chemicals. A list which includes the 45 PB reports comprising this series, and their prices, is available from OTS (*17*).

German Patents. Approximately 200,000 patent applications deposited during the war and not yet issued or published were seized and microfilmed in the German Patent Office by the Allies, immediately following the close of hostilities. These patent applications and abstracts of the applications were published as part of the PB report series, and the processes described were placed in the public domain in Allied countries. Despite this fact, the German Patent Office subsequently began to process these same applications, and to issue the patents, which then appear in the regular chemical literature index sources. However, since the U. S. Patent Office recognizes PB reports as a form of publication, the date of issue of these German patents is considerably later than the legal date of the disclosure. This point can be of importance for prior art searches.

The abstracts of the patent applications, comprising 22 volumes, were published, in

German, in 1947. A list of the PB numbers of these 22 volumes is available from the OTS (*22*). The abstracts are grouped by the German Patent Office classification in very broad classes. A subject outline of the classification correlated with the PB volumes and pages on which the abstracts of the patents occur has been prepared (*23*). The German patent classification is also given in an index published by the Special Libraries Association (*36*).

A partial subject index, in German, of I. G. Farbenindustrie patent applications submitted to the German Patent Office from 1939 to 1945 is available for consultation at the OTS office.

Some issued and published German patents were also microfilmed and included in the PB collection.

Office of Technical Service Publications. The Office of Technical Services issues a number of publications which are search sources. The *OTS Press Releases* are mimeographed lists of reports, usually on the same or related topics—i. e., a selected bibliography. This series was initiated when the office was started, and is still being published.

OTS also compiles mimeographed informal bibliographies of PB reports on subjects of general interest, and special bibliographies, which are similar to the informal bibliographies but include literature references. Lists of the informal and special bibliographies are available from the OTS.

Review Reports. Many of the FIAT, BIOS, and CIOS final reports discussed above are comprehensive reviews of the state of a particular German industry, and some include references to other relevant PB reports. Such reports are useful for purposes of orientation in starting a literature search. A few examples may be mentioned.

A detailed description of plastics manufacture in Germany was prepared under the auspices of the Quartermaster Corps (*25*). Synthetic fiber developments in Germany are covered in a review which also includes information on plastics and synthetic organic chemicals (*29*). A review of German dyestuffs and dye intermediates was published as a FIAT final report (*28*). The BIOS survey report series includes many review reports of this type; a list of these BIOS reports published and planned is available (*24*).

The "FIAT Review of German Science" includes a number of references to unpublished work carried out in Germany during the war. This was issued in German in 86 volumes. The OTS has prepared a list of volume titles and prices of this set (*26*). An English translation of the FIAT Review is being published by the O. W. Liebiger Research Laboratories, but only a few volumes have been issued to date (*27*).

Government-Sponsored Reports. A list of the government document series analyzed by the OTS has been issued (*43*). The PB report series includes some British and other foreign Allied government-sponsored reports in addition to the U. S. documents; unclassified and declassified U. S. government-sponsored research reports form the bulk of the material abstracted in the *Bibliography of Technical Reports* to an increasing extent since Volume 12 (1949). Scientific and technical reports on wartime and postwar research sponsored by government agencies are currently disseminated by the OTS at the rate of about a thousand a month.

In addition to listings in the BTR, Atomic Energy Commission reports are also entered in *Nuclear Science Abstracts* (*30*). This journal issues cumulative subject indexes. Reports issued by the Office of Scientific Research and Development (OSRD) have been cataloged by the Navy Research Section of the Library of Congress. An explanation of the contents and organization of the catalogs is available (*31*). NDRC reports are included in the catalogs. A bibliography and index of the numbered series of OSRD reports has been published (*32*).

Numerical and Correlative Indexes

An important bibliographical aid in using the PB collection is the correlation index which relates various other document series designations to PB numbers. Since all reports in the PB collection must be ordered by PB number, the Technical Oil Mission reel number, the FIAT report number, or other series number must be correlated with the PB number before a report can be obtained from OTS.

The Special Libraries Association published a very useful numerical index to volumes 1 through 10 of the *Bibliography of Scientific and Industrial Reports* (*36*). The main body of the publication is a numerical list of PB report numbers referring to the volume and page of the *Bibliography* on which the abstract of the report appears. A numerical list of German and Japanese patents issued as PB's, referring to the volume and page of the *Bibliography,* is also included. Indexes correlating the following report types with the corresponding PB number are included: BIOS Final Reports; CIOS Evaluation Reports: CIOS Roman Numeral Series; FD Reports; FIAT Final Reports; MDDC and AECD Reports; and OSRD Reports. The publication also contains a list of other published subject and correlation indexes to PB reports. The Special Libraries Association is planning to publish a comprehensive correlative index for report series and PB reports (*35*).

The Office of Technical Services compiles and issues numerical indexes of PB reports (*38*) referring to the volume and page number of the *Bibliography* where the abstract occurs. This index was initiated with Volume 11, January 1949. The index is issued after the completion of each volume of the *Bibliography.*

The subject indexes prepared by the Technical Information Service (*2*) also contain a numerical list of PB reports indexed and a correlation of PB with other series identification numbers for the 2 volumes published. In 1952 Technical Information Service initiated a monthly numerical index of the PB's in each issue of the *Bibliography of Technical Reports,* starting with Volume 19 (*37*). The series and sources of reports are also listed and are correlated to PB numbers. Semiannual and annual indexes of these reports are planned.

The "FIAT Microfilm Reel Index" (*34*) correlates reel number to PB number and vice versa. "FIAT reports: A Bibliography and Index of Reports on German Industry" (*6*), a numerical title list of FIAT reports, includes a correlation with PB-FIAT report number.

The contents of certain TOM reels are correlated with FIAT Reel and PB number in one of the TOM reel indexes (*14*).

German patent numbers are correlated with the volume and page reference of the *Bibliography of Scientific and Industrial Reports* where an abstract and the corresponding PB number may be found, in lists in the subject indexes for Volumes 3 to 5 of the *Bibliography* (*4*). The SLA numerical index to the *Bibliography* (*36*) also contains a list of German and Japanese patent numbers referring to the volume and page of the *Bibliography* abstract.

"American and British Atomic Energy Reports: A List of Reports on Atomic Energy Released by the Office of Technical Services" (*33*) contains correlations from MDDC to PB numbers and vice versa, a list of MDDC reports and a list of BDDA reports with the corresponding PB numbers. The supplement lists MDDC and BDDA reports, giving corresponding PB numbers.

Extensive correlation card indexes are maintained in the OTS offices, and mail and phone inquiries will be answered from these files.

Trade Names

A "Glossary of Some German Names for Chemical Products" was prepared for CIOS (*39*). This indicates composition or systematic chemical nomenclature. Some entries refer to CIOS and other series reports where the chemical product named is mentioned. Trade name glossaries included in the "Master Index of Reports on Chemical Industry in Germany" are also available separately (*40*). The numerical index to reels 1–119 of the Technical Oil Mission (*14*) contains a lubricating oil glossary. The I. G. Farbenindustrie index cards (*17*) include trade name literature. Review reports such as are cited (*24, 25, 28, 29*) and similar survey reports are sources of information on trade names.

Translations

Much of the PB report collection has been translated by government agencies like Central Air Documents Office; by trade associations, like the American Institute of Petroleum; by commercial translators, like Charles Meyers; and by literature chemists in industrial firms. The OTS received copies or notices of almost all of these translations from every source except the last group, and it is considering attempting also to include these. Because of budgetary problems, however, the OTS has not found it possible to list translations or similar older material in the *Bibliography*. A complete card index correlating translations and original documents is maintained at the OTS Washington office and may be consulted there; telephone or mail inquiries are answered. In addition, a list of translated German documents was compiled by O. W. Holloway (*41*) and is available from the OTS. "The German Chemical Industry" (*42*) contains a list of translations of PB reports available from various commercial agencies. The "Indexes to Technical Oil Mission Microfilm Reels" (*14*) contain lists of translations from TOM reels.

The catalogs of translations issued by commercial translating services usually do not identify the reports by PB number. The best method to check on the existence of a translation is to send a request for quotation on that report to the OTS. The quotation sent will include a note of any known translations, or other material related to the PB report in question.

Other Searching Aids

"The German Chemical Industry" (*42*) includes a brief discussion of the handling of reports on the German chemical industry in the U. S., Great Britain, and Canada; a list of BIOS, CIOS, and FIAT depository libraries; a list of translations of PB reports; a tabulation of references in the published journal literature relating to PB reports, including abstracts of PB reports; a short list of abbreviations and their meanings; indexes to reports cited, by PB, BIOS, and FIAT number; and an author and subject index of reports cited. The subject index may be used for searches as a supplementary aid to other indexes.

"Technical Exploitation of the German Chemical Industry" by B. H. Wilcoxon (*44*) is a guide for U. S. investigators in chemicals and related fields. This report contains an illuminating discussion of the organization of investigating teams, a useful list of indexes, and lists of reports available as of 1946. It includes a list of CIOS reports, as far as XXXII, relating to chemicals, and a list of abbreviations used for I. G. Farbenindustrie "Commission" names.

Another publication, "Government Document Series Analyzed by the Office of Technical Services" (*43*), gives alphabetical abbreviations and symbols used in identifying report series included in the PB collection with their meaning.

Evaluating Types of Reports

The final phase in consideration of a search of the PB collection concerns the extraction of information from the reports themselves, once a list of the pertinent reports has been assembled by an index search. There is a tremendous amount of duplication of information from one PB report to another. The extent of repetitive material to be consulted can sometimes be reduced by a consideration of the types of reports included in the collection and their purposes.

The so-called preliminary reports, written by Allied investigating teams, are usually interrogations of scientists or inspections of sites; in most cases, these can be ignored. Final reports written by Allied teams of investigators may be either a general survey of an industry, useful for orientation, or a detailed description of a manufacturing process, which probably repeats data in the original German reports. The Allied investigators' reports are helpful as background, particularly as they often comment on how the German practice differs from U. S. or British art in a given field, and establish its importance, but they are only secondary sources.

The meat of the information is in the original German records. These, like all industrial company files, include many summary, management, and progress reports, which are again secondary sources, and can be skimmed quickly. The detailed data are in the laboratory reports and operating records; it is from these that all the other reports are derived. A cursory literature search may depend on the secondary sources just described for a review or abstract approach. A thorough literature survey should as far as possible, identify the pertinent original laboratory and operating records.

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The French Chemical Literature and Its Use

ERNEST F. SPITZER

Chas. Pfizer & Co., Inc., Brooklyn 6, N. Y.

The major sources of French chemical literature are discussed. Some French-English dictionaries are listed; compendia and reference works are discussed. An industrial directory and publications listing dissertations and theses and recent books are available. Sources of abstracts are three journals; these and other French chemical journals are evaluated.

In common with chemical information published in many other countries, material of interest printed in French chemical books, journals, and patents has, in the past, been difficult of access, primarily because of the lack of organization and centralized documentation on one hand, and as a result of haphazard indexing on the other. This applies especially to the publications printed during the nineteenth century and the early part of the twentieth century.

Yet, whatever its indexing problems, the French chemical literature has by no means been dormant; it may well be characterized by its long period of continuous growth and its steady rate of progress up to 1940, and it now appears to be in the midst of an active period of postwar resurgence, marked by the publication of many excellent books and journals. Quite recently, Boig and Howerton, in the course of their studies of the history and development of chemical periodicals in the fields of organic and analytical chemistry (*7, 8*) listed the ten leading journals throughout the world and included two French journals of long standing—the *Comptes rendus hebdomadaires des séances de l'académie des sciences* and the *Bulletin de la société chimique de France* (*14, 20*).

Laboratory and literature chemists using English as their primary language today find themselves in a singularly fortunate position. Theirs is the best documented of the natural sciences. The bulk of the world's chemical literature, with the possible exception of the Russian literature, is at their fingertips through two major abstract journals published in the English language. The wartime slump in scientific publication has been superseded by a new flood of books and periodicals made available by improved methods of coverage and new abstract journals such as the *Bulletin analytique* (*10*).

Thus, an approach to the French chemical literature by an English-speaking chemist involves the scaling of a threefold psychological hurdle—the high percentage of French original material already covered in the Anglo-U. S. abstract journals, the occasional lack of accessibility to the primary sources, and, finally, the language barrier.

There are indications that French chemical literature is becoming more familiar to English-speaking users, and, in this connection, the growing interest in world-wide scientific documentation has been a contributing factor of major importance. A list of documentation centers and documentation services in France was published in 1951 under the auspices of the UNESCO and under the direction of the Library Service of France. It is called "Répertoire des Bibliothèques de France" (*48*) and is the third of three volumes dealing with French library resources; the two preceding volumes covered the libraries of Paris and of the Departments. This compilation is well indexed and includes services offered as well as descriptions of the general nature of the library holdings.

The English-speaking chemist has many aids to assist him in reading chemical French. Assuming a reasonably good background of college French or, better still, the benefit of a period of actual conversational practice, he can refer to a number of fine technical and chemical French-English and English-French dictionaries.

But chemical French, like chemical German, has its own peculiarities and its traps for the unwary. The capital letter M, for instance, used before an author's last name, is not likely to be his first initial, but rather an abbreviation for Monsieur. This custom of preceding a person's name with Mister has had its effects on the documentation of early French literature in some English-language indexes where most, if not all, French authors seemed to have first names starting with the letter M.

Some other points to be guarded against in reading and translating chemical French are these. In French the hydroxyl group is not usually expressed as "hydroxy," but rather as "oxy." "Oxy" is also sometimes used to designate the ketonic group. "Hydrate" in French is used to indicate hydroxide as well as hydrate. The French equivalent for ester is "éther."

The meaning of the French word "billion" should always be checked from the context. It may, and usually does, conform to American usage. If, however, the term "milliard"—i.e., one thousand million, has been used to denote billion (U. S. usage), the French "billion" becomes the equivalent of the U. S. "trillion."

Transliteration from Russian into French differs from German and English practice. Thus, the German transliteration of a Russian author may appear as Tschitschibabin whereas the French equivalent will be Chichibabin.

Because of the wealth of the French language in idioms, figures of speech and proverbial expressions, a book of idioms (*39*) in addition to the dictionary is not amiss as part of one's reading and translating equipment.

Dictionaries

A considerable number of general and special dictionaries are available which are suitable for use in reading chemical, technical, and medical French. A few of the better known ones are listed (*19, 23–25, 33, 34, 38–40, 46, 56*).

Compendiums and Reference Works

Like other countries, France has its classics in the field of chemical compendiums and reference works. Mostly, they are part of the chemical literature of the nineteenth and early twentieth century, and today their value and significance are mainly historical. The first three titles discussed belong to this group.

The "Dictionnaire de Chimie Pure et Appliquée" is a set of fourteen books, made up of three original volumes in five books and two supplements in nine books (*58*). The "Encyclopédie Chimique" is a compendium of ninety-four volumes containing historical and biographical data and reporting advances in various branches of chemistry (*28*). "Traité de Chimie Minérale" (*43*), a set of five volumes, has been superseded by the second edition under the authorship of Pascal. The second edition (*45*) comprises twelve volumes, is of an encyclopedic nature, and is generally considered a fairly recent basic set in the French literature of inorganic chemistry. "Traité de Chimie Organique" comprises twenty volumes, of which nineteen, in twenty-three books, are available at present. Written in monograph style, this large and complete compendium may be considered the organic counterpart of Pascal's treatise on inorganic chemistry (*31*). "Traité de Chimie Industrielle" is a three-volume reference work on industrial chemistry, with special emphasis on mineral acids, industrial water treatment, fuels and the petroleum industry, and metallurgy; other industrial topics are also covered (*6*).

Annual Tables

The "Tables Annuelles de Constantes et Données Numériques de Chimie, de Physique, de Biologie, et de Technologie" (*53*), which have been printed with both French and English text, were originally published under the auspices of the International Council of Scientific Unions and of the International Union of Chemistry. They were started in 1910 with the intention of bringing together all the numerical data published in chemistry, physics, biology and technology in a given year. These annual summaries however, gradually fell behind schedule, and publication stopped somewhere around 1945, with data for 1939. These tables are frequently used as a supplement to the "International Critical Tables" for the years after 1924. It should be noted however, that no critical selection was made in assembling the numerical data and constants.

Dissertations and Theses

The Ministry of Education in Paris has been publishing an annual volume called "Catalogue des Thèses et Escrits Académiques," arranged by academic subjects and universities, then by authors. The volume for 1949 appeared in 1952 (*42*). However, the best place to look for recent French theses in the field of chemistry is the volume on chemistry of the "French Bibliographical Digest," which includes doctoral theses and dissertations in chemical subjects published between 1940 and 1948 (*29*); later years will be covered in a supplement.

Industrial Directory

"L'Annuaire Industriel" is a French industrial directory of 87,000 firms, goods, and services in three volumes (*4*).

Recent French Scientific Books

The chemistry volume of the "French Bibliographical Digest" (*29*) mentioned in connection with French dissertations in chemistry, is a valuable source of information and a bibliographic guide to recent French chemical books. It is one of a series of bibliographical digests published by the Cultural Division of the French Embassy in New York City and describes scientific works published in France between 1940 and 1948. A supplementary series of digests is now in preparation and will list books published during 1949 to 1951. There are eight of these digests: No. 1, Biology (part I); No. 2, Biology (part II), Zoology, Botany; No. 3, Geography; No. 4, Geology, Paleontology; No. 5, Psychology; No. 6, Mathematics, Astronony; No. 7, Physics; and No. 8, Chemistry.

Digest No. 8 includes a number of books published in French by Belgian and Swiss scientists. Each book or set listed carries full bibliographical information, including publisher, year of publication, format, and number of pages, and a review selected from one of the following journals: *Nature (London)*, *Bulletin analytique du C.N.R.S.*, *Revue générale des sciences*, and *Bulletin critique du Livre Français*. The bibliography includes sections on general, organic, inorganic, analytical, physical, and industrial chemistry. It lists thirty representative French periodicals in the field of chemistry and general science, with name of publisher and frequency of publication. A directory of French and Swiss publishers is also supplied.

The most recently published volume in the field of chemical bibliography is Gaudenzi's "Guida Bibliografica Internazionale per il Chimico"; it lists about 3200 books and 1100 periodicals on chemistry in English, French, German, and Italian (*30*).

French Chemical Journals

For historical searches in the French chemical journal literature, reference should be made to Dyson's list of obsolete journals (*26*). This list covers obscure titles and short runs published during the nineteenth century, with special attention to the problem of multiple publication, anonymity, briefness of publication period, and changes of title.

Annales de chimie. The years of inception and earliest growth of the French chemical journal literature and the present period are linked by *Annales de Chimie* (*1*) which is the oldest chemical journal still being published. Established in 1789 by Lavoisier, Berthollet, and several others, it appeared under the title of *Annales de chimie et de physique* until 1914 when it was divided into separate journals, the *Annales de chimie* and *Annales de physique*. The *Annales de chimie* is known for its complete and detailed papers which, in some instances, may have been published previously in the *Comptes rendus* (*20*) in very brief form.

Comptes rendus hebdomadaires des seances de l'academie des sciences. French chemists sometimes seem to prefer publication of their original work in the *Comptes rendus* (*20*) which, although a general scientific journal, is not a chemical periodical in the strict sense of the term. It does, however, assure prompt publication, and publication in its pages carries a very high prestige rating. Its policy of limiting all papers to about two printed pages has, no doubt, had its effects in furthering the discipline of concise writing.

Comptes rendus has appeared continuously since 1835. It is published in two volumes per year and contains many important chemical papers, usually in the form of first announcements, with detailed publication at a later date and in other journals.

Bulletin de la societe chimique de France (*14*). This is the official journal of the French Chemical Society and is devoted to the field of pure chemistry. It has been published since 1858 and has gone through a number of variations in publication procedure. The *Bulletin* used to appear in alternate volumes of papers and abstracts with the Memoirs in odd-numbered volumes and the Documentation in even-numbered ones. Abstracts were started in 1863 and, for some years prior to 1930, abstracts of foreign papers were printed separately; then all abstracts were combined in one volume. No abstracts of patents are included. Memoirs and Documentation sections were merged in 1946, and the Documentation section was discontinued in 1949. The Documentation part of this journal, up to 1949, is an important source of French abstracts in pure chemistry; after this date, the *Bulletin analytique* should be consulted.

Chimie et industrie. *Chimie et industrie* (*18*) is, without doubt, the best and most important French journal publication on industrial chemistry, and merits general and frequent use in reference and research work. Started in 1918 and published monthly by the Société de Chimie Industrielle, it now appears in two volumes per year. Each issue at present is made up of three main sections: Technology, containing complete papers on all phases of industrial chemistry, Documentation, which is a very complete abstract section, and a section on Economics. In addition, there may be other brief sections headed Sociology, Teaching, Organization, and Miscellaneous News.

The Documentation section compares very favorably with the German, British, and American abstract journals with regard to the quality of its abstracts on applied chemistry since 1919, and for abstracts of French patents. It is also well worth consulting for abstracts of patents from European countries in general. Unfortunately, no numerical patent indexes are supplied.

Bulletin analytique. The *Bulletin analytique* (*10*) is published by the Documentation Center of the Centre National de la recherche scientifique (C.N.R.S.) in Paris. It is a general scientific abstract journal appearing in three parts. Part 1 covers mathematics, physics, chemistry and related aspects; part 2 deals with the biological sciences, agriculture and the food industries: and part 3 is headed philosophy. Parts 1 and 2 come out monthly, part 3, three times a year. The abstracts are fairly brief summaries prepared from scientific and technical original papers selected from the world scientific literature. *Bulletin analytique* started in 1940 with parts 1 and 2 containing about 10,000 abstracts per year for each part. In 1950 it averaged more than 100,000 yearly abstracts and covered more than 4000 scientific periodicals. The C.N.R.S. Documentation Center also furnishes photostats and microfilms of articles abstracted in the *Bulletin*.

The five aforementioned journals will, in all likelihood, be the ones most frequently consulted by the literature chemist. Some of the many other more specialized French chemical periodicals have been listed in the bibliography.

Sources of Abstracts

As regards the total number of scientific abstracts produced per year, France is now in third place after the U. S. and Britain (*55*). But, whereas U. S. and British abstracts in the chemical literature can be approached through single major sources, the *Chemical Abstracts* (*16*) and the *British Abstracts* (*9*), checking of French abstract literature in chemistry requires a triple approach—the *Bulletin analytique* for general science and chemistry, the Documentation Section of the *Bulletin de la société chimique de France* for pure chemistry abstracts, and the Documentation Section of *Chimie et industrie* for abstracts in applied chemistry and for patents. Because of overlapping and in view of the difficulties of classifying borderline subjects in pure or applied chemistry, both chemical journals should ordinarily be consulted, at least prior to 1949.

In addition to these major and general publications, quite a number of French journals carry good documentation sections. The *Bulletin de l'institut Pasteur* (*12*), a monthly abstract journal in the field of bacteriology, medicine, biology, physiology, biological chemistry, and microbiology, publishes about 4400 abstracts and book reviews per year, and there are two journals in the perfumery field, *La Parfumerie moderne* (*44*) and *l'Industrie de la Parfumerie* (*35*), both having good abstract sections. Mellon's "List of Sources of Chemical Abstracts" (*41*) covers various branches of chemistry, including sources of French abstracts on applied chemistry prior to 1919.

No discussion of the French journal literature would be complete without a reference to some of the important journals published outside of France, either entirely in French or containing individual papers in the French language. To this group belong the *Bulletin des sociétés chimiques Belges* (*15*), formerly called *Bulletin de la société chimique de Belgique*, the *Helvetica Chimica Acta* of Switzerland (*32*), and the *Recueil des travaux Chimiques des Pays-Bas* (*47*) of the Netherlands. These are primarily chemical journals; a broader scientific approach is met in journals such as the *Comptes rendus des travaux du laboratoire Carlsberg* (*22*) of Denmark, and the *Arkiv för Kemi*, of Sweden (*5*).

French Patents

French patents as a source of information for chemical literature research have undoubtedly been the source of many a headache, if one can judge from the exasperated comments of Worischek (*57*) and Fleischer (*27*); nor can any encouragement be offered at this time. French patents list no claims, but provide resumes which summarize their contents. Their only function is to establish a priority date for use in French courts in case of litigation. There is no formal examining procedure, and duplication of patents is not uncommon. Pharmaceutical compositions or medicines cannot be patented under French law, but the processes for manufacturing them are patentable. French patents do not extend to French Morocco, Tunis, Syria, or Lebanon which have separate patent systems. They do, however, extend to the other French colonies.

From the U. S. point of view, French patents are of interest especially because of the priority established by their dates.

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The Japanese Chemical Literature

LEO J. STEVENS

Smith, Kline & French Laboratories, Philadelphia, Pa.

in collaboration with

SHIN-ICHIRO FUJISE

Tôhoku University, Sendai, Japan

The *Journal of the Japanese Chemical Society* was first published in 1880, and other scientific journals appeared in Japan soon thereafter. Today the literature is extensive and holds much chemical knowledge, particularly in the special fields of natural products and alkaloids. The use of original Japanese literature by American chemists is handicapped by the linguistic barrier, although a few publications include abstracts or complete papers in a language other than Japanese, and by unavailability. *Chemical Abstracts* lists or abstracts published Japanese chemical work, and when the number of articles abstracted is taken as a criterion of the significance of the Japanese literature, it ranks eighth (in 1949), trailing the United States, England, Russia, France, Germany, Switzerland, and India, and preceding Italy.

The Portuguese and Dutch share the honor of being the first to introduce certain aspects of western science to Japan—for example, medicine in the sixteenth century (*7*). Yoan Udagawa first translated a chemical text imported from Holland, the author of which was a Britisher named Henry (*12*). In 1823, Philip Franz von Siebold, a German physician in Dutch employ, arrived in Nagasaki to initiate lectures on clinical medicine (*7*). However, science in the occidental tradition did not develop until the Emperor Mutsuhito (better known as Meiji) was restored to power as the actual ruler of Japan (Meiji Restoration, 1868)—a historical event which brought about the abolition of many of the outward vestiges of Japanese feudalism, with the repudiation of the preceding policy of isolation and the introduction of occidental knowledge. Then followed the founding of Tokyo Imperial University in 1877. Its early faculty included R. W. Atkinson and S. Divers of Great Britain as professors of chemistry.

The Tokyo Chemical Society was formed in 1878. Within two years a periodical was inaugurated, later to become known as the *Journal of the Chemical Society of Japan.* In 1921, the Tokyo Chemical Society was reorganized into the Chemical Society of Japan. This learned group has cooperated with the International Atomic Weight Committee since 1899 (*12*).

With the modernization of Japan, science and scientific literature made rapid progress; a considerable number of distinguished Japanese chemists emerged, among them Nagai, the discoverer of ephedrine (1887). However, the war years 1941–45 proved detrimental to scientific progress in Japan and, with the end of hostilities, economic conditions during the occupation often interfered with academic or industrial research. Nonetheless, considerable scientific activity, particularly in chemistry, is revealed by the growth of professional societies—the Chemical Society of Japan now has more than 12,000 members—the increase in the number of periodicals published, and many other related developments.

Publications of Scientific Institutions and Professional Societies

Nihon Gakushin is the Japan Academy, formerly known as the Imperial Academy of Japan, inaugurated in 1887. It is now an honorary organization affording membership to those who have made outstanding contributions to science. The Japan Academy is comprised of two sections: Cultural Sciences and Natural Sciences (*11*). The *Proceedings of the Japan Academy* are published in English by the Japan Academy in Tokyo.

Nippon Kagakukai, the Chemical Society of Japan, assumed its present name in 1921. As a professional society it publishes several important periodicals. *Nippon Kagaku Zasshi,* which began publication in 1880, is the Pure Chemistry Section of the *Journal of the Chemical Society of Japan;* it appears monthly in Japanese. *Kōgyō Kagaku Zasshi,* the Industrial Chemistry Section, is a monthly printed in Japanese. The *Journal of the Chemical Society of Japan* was subdivided into the two sections mentioned in March 1948 (*4*). The *Bulletin of the Chemical Society of Japan* is likewise published by the society. A bimonthly, the *Bulletin* appeared first in 1927, and it prints articles in English, German, and French. Another organ of the Chemical Society of Japan is *Kagaku To Kōgyō, Chemistry and Chemical Industry,* printed monthly in Japanese.

The Society of Organic Synthetic Chemistry sponsors *Yūki Gōsei Kagaku Kyôkai Shi,* the *Journal of Organic Synthetic Chemistry.* The Journal is a monthly, printed in Japanese with English titles (*4, 12*).

Nippon Butsuri Kagaku Kenkyu Kai, the Physicochemical Society of Japan, was founded in 1925 in connection with the Faculty of Science, Kyoto University, and has at the present more than 700 members (*11*). The *Review of Physical Chemistry of Japan* is printed by Marzen & Co., Ltd. Tokyo (*4*). *Nippon Nōgeikagaku Kaishi,* the *Journal of the Agricultural Chemical Society of Japan,* is printed monthly in Japanese with English summaries (*4, 12*). *Kagaku No Ryôiki,* the *Journal of Japanese Chemistry,* is published monthly in Japanese by the Nankôdô Publishing Co. It was introduced in 1922 (*12, 23*). *Acta Phytochimica* is published by the same firm for the Societas Phytochimica. It appears irregularly and is printed in English, French, or German (*4, 12*).

Kagaku Kikai, Chemical Engineering, is the organ of the Society of Chemical Engineers, appearing bimonthly in Japanese with English abstracts (*12*). *Tokyo Kogyo Shikenjo Hokoku, Report of the Government Chemical Industrial Research Institute, Tokyo,* is published twice a year in Japanese. *Science Reports of the Research Institutes, The Tôhoku University* (Series A, Physics, Chemistry, and Metallurgy) had its inception in 1948 as a bimonthly. It is printed in English.

Nihon Seika Gakkai, the Japanese Biochemical Society, is associated with the Department of Biochemistry, Medical School, Tokyo University. The society publishes *Seikagaku, Biochemistry* (*4, 12*). Nippon Butsuri Gakkai, the Society of Japanese Physicists, dates its origin to 1877. With a roster of over 2000 members, it publishes *Nippon Butsuri Gakkai shi,* the *Journal of the Society of Physicists* (*11*).

The Pharmaceutical Society of Japan is one of the most important professional societies. Since 1880 it has published *Yakugaku Zasshi* the *Journal of the Pharmaceutical Society,* and since 1953, the *Pharmaceutical Bulletin,* a quarterly in English, German, or French. Nihon Yakuri Gakkai, the Pharmacological Society of Japan, was instituted in 1881, a few years following the introduction of pharmacology to Japan in 1876 (*12*). This society has headquarters at the Department of Pharmacology, Medical School, Tokyo University. It publishes *Nippon Yakurigaku Zasshi,* the *Journal of the Japanese Pharmacological Society,* and *Yakurigaku, Pharmacology,* both appearing monthly in Japanese (*24*). The *Folia Pharmacologica Japonica* is published irregularly by the Japanese Pharmacological Association at Kyoto University, usually appearing in Japanese with a *Brevaria*, containing abstracts in English or German of the articles printed wholly in Japanese (*4*). Nihon Seiri Gakkai, the Japanese Physiological Society, publishes *Nihon Seirigaku Zasshi*, the *Journal of the Japanese Physiological Society*, in Japanese with short English summaries (*4*). Nihon Saikingakkai, the Congress of Japanese Bacteriological Societies, one of the larger professional societies with 2500 members, publishes the *Japanese Journal of Bacteriology*. *Kampo To Kanyaku, Chinese Medicine and Drugs*, is published by the Japanese Society of Chinese Medicine, appears irregularly, and is printed in Japanese (*24*).

Abstracts of Japanese Chemical and Related Literature

The importance of abstracting Japanese scientific articles, otherwise wholly or partially inaccessible because of the linguistic barrier, was recognized early by the German *Chemisches Zentralblatt*, the American *Chemical Abstracts*, the *Journal of the Chemical Society* (*London*) (abstracts 1871–1925), and the *British Chemical Abstracts*. Since its first appearance in 1907, *Chemical Abstracts* has given increasing attention to Japanese chemical literature. This is described by the editor, E. J. Crane, in two articles (*8*, *9*) from which the following statistics are taken.

Abstracts of Japanese articles published in *Chemical Abstracts* were 0.3% of the total in 1909, and 9.1% in 1951 (first half of the year); however, the Japanese chemical literature was not covered completely before 1918. In comparison, American articles were 20.1% in 1909 and 36.6% in 1951; German articles made up a large part of the total in 1909 (45.0%), while they represented only 7.9% in 1951 (*9*).

For a number of years World War II prevented the growth of the coverage of Japanese chemical literature. After the war, Crane re-established connections with Japanese literature (*5*) and by 1948 *Chemical Abstracts* had again received abstracts of approximately 5000 articles that had appeared in Japan since 1941 (*6*).

Boig and Howerton made a statistical analysis of articles abstracted from chemical periodicals in the field of organic chemistry (1877–1949). They show that 88 Japanese articles were abstracted by *Chemical Abstracts* in 1949, to account for the sixth place—English, German, Russian, French, and Italian organic articles leading in that order (*1*). Similar statistics for analytical periodicals (1877–1950) reveal 48 Japanese articles abstracted by *Chemical Abstracts* in 1950, again placing the Japanese language sixth after English, Russian, French, German, and Spanish (*2*).

The need for abstracting facilities was recognized by a group of Japanese chemists around Riko Majima, formerly professor of chemistry at Tôhoku University, now a member of the Japan Academy. He began, in cooperation with Junjiro Kushibiki and others, to classify, abstract, and index Japanese chemical literature. In 1926 Nihon Kagaku Kenkiukai, the Japanese Chemical Abstracting Society, was founded. Seven volumes were published from 1927 to 1938, covering Japanese chemical literature from 1877 to 1926; more than 23,000 abstracts and a great number of patents (21,662) were published. Monthly issues appeared from January 1927 to July 1945, when the editorial office and the library were destroyed in air raids. Following World War II, financial conditions made publication very difficult and in that period only incomplete abstracts were published. Financial subsidies by the Japanese Ministry of Education and many chemical firms permitted the resumption of monthly abstracts from 1951 on, and an annual index appeared. At present, the abstracting service is functioning normally. In 1951, 3503 abstracts and 1252 patents were published; in 1952, 4255 abstracts and 1697 patents; and up to July 1953, 2535 abstracts and 1443 patents were published. In 1952, 736 publications were abstracted; of these were 113 written in English, French, or German. This would indicate that *Nihon Kagaku Soran, Japanese Chemical Abstracts*, is progressing satisfactorily (*12*).

Since 1941, *Seitetu Gizyutu Soran, Metallurgical Abstracts*, has been published monthly in Japanese by the Engineering Department of the Yawata Iron and Steel Co. Some chemical articles are abstracted (*16*). *Nippon Kôgyô Sôran, Japanese Engineering*

Abstracts, are published by the Kôsyunkaku Publishing Co. and edited by Nippon Kôgakukai, the Engineering Society of Japan. Printed in Japanese, they have appeared since 1949 (*17*). Gakuzyutu Bunken Hukyukai is an abstracting service which brings abstracts of scientific and technical literature in the form of printed cards. Interrupted during the war, it was resumed in 1950; the abstracts are in Japanese (*17*). The oldest Japanese abstract journal is *Igaku Tyuo Zasshi*, the *Central Review of Medicine*, with an abstract service inaugurated in 1903 by Siro Amako. The *Review* appears bimonthly, covers more than 270 medical, pharmacological, and related journals, and is printed in Japanese (*17*).

No treatises of chemistry of the type of Beilstein or Grignard exist in the Japanese language (*25*).

Medical Publications

The present favorable development of clinical research in Japan is reflected by the great number of clinical journals and papers printed. Practically all specialized fields of medicine are represented in Japan by learned societies and pertinent publications. Several are of interest to chemists concerned with problems of medicinal or pharmaceutical chemistry.

Acta Scholae Medicinalis Universitatis in Kioto prints in English or German papers originating from the Medical and Pharmaceutical Departments of Kyoto University. The journal is distributed without charge to suitable institutions or scientists. The *Tôhoku Journal of Experimental Medicine* incorporating *Arbeiten aus dem anatomischen Institut der Kaiserlich-Japanischen Universität zu Sendai*, and *Mitteilungen über allgemeine Pathologie und pathologische Anatomie*, is printed in English, French, and German and is one of the oldest in Japan. Publication began in 1877; United States representative is the Chas. E. Tuttle Co., Rutland, Vermont. Papers on experimental medicine, pathology, and other related subjects are very frequent. The *Japanese Journal of Experimental Medicine* has been published semiannually since 1930 by the Institute of Infectious Disease, Tokyo University. Articles appear in English. *Nippon Saikingaku Zasshi, Japanese Journal of Bacteriology*, is printed monthly, in Japanese. The *Japanese Medical Journal*, published by the National Institute of Health of Japan, appears in English, bimonthly; it is concerned with medical progress and public health. The *Japanese Journal of Medical Science and Biology*, also published by the National Institute of Health, has appeared quarterly since 1947. It is printed in English, featuring papers on immunology, biology, and virology.

The *Keio Journal of Medicine* is published quarterly by Keio University and dates from 1952; all articles are in English. The *Yokohama Medical Bulletin*, founded by I. Takaki, is a bimonthly publication of Yokohama University, in English. *Kyoto Furitsu Ikadaigaku Zasshi, Journal of the Kyoto Prefecture College of Medicine*, is distributed monthly in Japanese with English or German summaries; occasionally articles are printed in English or German with Japanese summaries.

The Pharmacopoeia Japonica, written in Japanese with titles in Latin and English, makes reference to the United States and British Pharmacopoeias, the National Formulary and New and Nonofficial Remedies; there is an edition in English.

Dictionaries and Patents

Although there are Japanese and Japanese-English dictionaries, only a few specialize in chemical or related terminology. "Rikagaku Jiten, Dictionary of Physics and Chemistry," is a Japanese-English (and French and German) dictionary (*16,25,27*). "Rikagaku Jiten Zohokaitei Han, Dictionary of Physics and Chemistry, revised and enlarged by Ishihara and coworkers, has an American edition (*15, 21*). A specialized "Medical Dictionary" is published (*18,25*).

Chemical terminology may be found in ordinary dictionaries—for example, in Satow and Ishibashi's "English-Japanese Dictionary of the Spoken Language, American Edition." This book is somewhat out of date (*22*). The Japanese equivalents of the English words are written in romanized form (*26*). Fujita's "Kenkyusha's English-Japanese Dictionary, Commercial and Technical Terms," contains some chemical terms and a list of English abbreviations with Japanese equivalents (*13*).

A Webster-type dictionary published in the United States is "Kenkyusha's New English-Japanese Dictionary on Bilingual Principles" (*19, 26*). Representative of other purely Japanese dictionaries is one by Daniels, "Dictionary of Japanese (Sōsho) Writing Forms" (*10, 16*). There is also the "Dai-Jiten, Great Dictionary," in 26 volumes, which is the Japanese equivalent of a dictionary of the unabridged Webster or Oxford type (*14, 26*). Otsuki's "Dai-Genkai" consists of four volumes and index (*20, 26*). This dictionary includes the etymology of words, a rare practice among Japanese lexicographers.

Little can be said about Japanese patents as a source of information for the chemist searching the literature; however, Japanese patents are being abstracted by *Chemical Abstracts*. Information about them may also be had from *Tokyo Koho*, the official patent report appearing irregularly in Japanese, published by Hatsumei Kyokai, The Patent Office, Tokyo (*3*).

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The Italian Chemical Literature

LEO J. STEVENS

Smith, Kline & French Laboratories, Philadelphia, Pa.

The Italian chemical literature, though an important source of information, has found only a limited interest among American chemists. This is in part explainable by the linguistic barriers, and by the fact that it has suffered from a lack of centralized documentation and indexing in Italy. Italian chemical literature seems sure to become of increasing importance to the American chemist.

The Italian chemical literature deserves more attention than it receives from American chemists. It is true, of course, that in scope, in importance, and in volume it is led by the liberature written in English, German, Russian, and French. It is also true that it is not as accessible as it might be (although a considerable part of it may be found abstracted in *Chemical Abstracts*) and that it has, until recent years, suffered from a certain lack of centralized documentation and indexing in Italy. When one adds to these handicaps the fact that a reading knowledge of Italian is not nearly so widespread among American chemists as a reading knowledge of German and French, one can readily understand why the Italian chemical literature gets scant attention. Yet it deserves more, for its history is long, its present is impressive, and its future seems bound to become increasingly important to the American chemist.

Universities and Societies

The scientific literature of any country has always depended to a great extent on the progress of scientific education and on the effectiveness and prestige of its central research organizations and professional societies.

Italy, from medieval times, has had several outstanding universities. Today, more than 20 state universities teach chemistry, pharmacy, and the biological sciences. The University of Rome, Italy's largest (40,000 students) and perhaps most important university, was founded in 1303. The large (15,000 students) and distinguished University of Bologna was founded in 1088. Milan (1853) and Turin (1906) are the homes of two technical universities where chemistry is taught (*8*).

The central research organization of Italy is the Consiglio Nazionale delle Ricerche (or CNR) in Rome. Founded in 1923, this important source of scientific documentation publishes a comprehensive and well-organized index, the *Indice di periodici scientifici e tecnici*, and a periodical, *La ricerca scientifica*. The Società Chimica Italiana, founded in Rome in 1919, the representative Italian chemical society, also has made important contributions to scientific literature, presently publishing the *Gazzetta chimica italiana* and the *Annali di chimica*. The Società Italiana per il Progresso delle Scienze, organized in 1839 in Rome, publishes *Scienza e tecnica*. In Naples the Società Italiana di Biologia Sperimentale is associated with an important biological and pharmacological periodical, the *Bollettino della Società Italiana di Biologia Sperimentale;* however, the latter is actually published by the Consiglio Nazionale delle Ricerche.

Finally, there is the Istituto Superiore di Sanità in Rome, one of the most active and important research groups in Italy. Headed by Marotta, it maintains laboratories for organic, therapeutic, and biological chemistry, microbiology, parasitology, and other sciences. Scientists of international reputation, such as D. Bovet and many others, are on its staff. Since 1937 the institute has published the *Rendiconti istituto superiore di sanità*.

History of Journals

The birth of the modern Italian literature of chemistry is usually thought to have occurred in 1871, the year when the *Gazzetta chimica italiana* was first published. Actually, the origin is of a much earlier date. In 1846 Francesco Selmi (1817–81), an inorganic chemist, pharmacist, and toxicologist at the University of Bologna, published the *Annuario chimico italiano*, presumably the first modern chemical publication in Italian. In his preface to the *Annuario*, Selmi told of some of the difficulties that accompanied such an undertaking (*22, 25*). He also defined the purpose of the publication: "It is the aim of the *Annuario* to assemble the scattered papers of the Italian chemists and to demonstrate the actual condition of the science within the peninsula."

Other Italian chemical or related journals appeared prior to the *Gazzetta*. In the *Atti della reale accademia nazionale dei Lincei* (founded by Federico Cesi in 1603) chemical papers were published by 1847, in one of its first series (*4*). The *Giornale di farmacia, di chimica e di scienze affini* was published from 1851 until 1936; and the *Bollettino chimico farmaceutico*, first published in Milan in 1861, is still published today. In historical perspective, then, the Italian chemical literature is older than the American, the *American Chemist* having been first published in 1870 and the *Journal of the American Chemical Society* in 1876.

Although the *Gazzetta chimica italiana* is not the oldest Italian chemical journal, it is by far the most important. Following the complete political unification of Italy, there was a growing realization that Italian chemists needed a new chemical journal comparable to the leading chemical journals of Germany and other European countries. Stanislao Cannizzaro (1826–1910) was asked to be its editor. His activities as organic chemist and as teacher at several Italian universities, especially at Palermo and Rome, had made him at that time the only chemist in Italy with an international reputation. But Cannizzaro had little faith in the future of the proposed journal and therefore was reluctant to accept its editorship. Another chemist did accept, however. He was Emanuele Paternò (1847–1935), also a teacher at Palermo and Rome. His main fields of interest were physical and inorganic chemistry. Paterno devoted much of his life to the *Gazzetta*. Until 1881 he published abstracts of foreign papers in it. Then he started, and continued for six years, a separate abstract journal, the *Appendice alla gazzetta chimica italiana*. At present abstracts are once more published in the *Gazzetta*. Another change occurred in 1914, when papers on applied chemistry were excluded from the *Gazzetta* and included in a new journal, the *Annali di chimica*. The *Gazzetta* now covers the whole field of pure chemistry, with organic chemistry predominating. In Boig and Howerton's statistical articles on the history and development of periodicals devoted to analytical and organic chemistry (*2*), *Gazzetta* ranked side by side with the well known *Annalen der Chemie* and *Monatshefte für Chemie*.

In 1951 *Chemical Abstracts* listed about 300 Italian journals of chemistry and the related sciences. The following are a few of the more important ones:

Annali di chimica. An organ of the Italian Chemical Society, primarily concerned with organic chemistry, this journal was known as the *Annali di chimica applicata* before 1950.

Archivio italiano di scienze farmacologiche. An important pharmacological journal.

Archivio di fisiologia. A very good journal (50 years of publication), edited in Florence, covering the fields of pure physiology and biology.

Bollettino della società italiana di biologia sperimentale. Important in biology, physiology, and pharmacology and published under this name since 1927.

La chimica e l'industria (Milan). A journal corresponding to the British publication

Chemistry and Industry and the French *Chimie et Industrie*, it has appeared since 1919 and is edited by the Associazione Italiana di Chimica.

Rassegna chimica dell'industria e dei professionisti chimici. Before 1950 this journal was known as *Rassegna chimica.* Most of its published papers concern industrial and applied chemistry.

La ricerca scientifica. Published by the Consiglio Nazionale delle Ricerche, Rome, this journal covers miscellaneous fields of science.

Scientia (Milan). Rivista internazionale di sintesi scientifica. A journal covering science in general, with articles in English, French, German, Italian, and Spanish.

Il farmaco, edizione scientifica and *Il farmaco, edizione pratica,* known as *Il farmaco scienza e tecnica* before January 1953. Although this last journal is only 7 years old, it has gained considerable importance owing to the inclusion of high-quality papers (mostly medicinal chemistry, drug action, etc.). In fact, a good part of the recent research carried out in the laboratories of the leading pharmaceutical manufacturers in Italy finds publication in *Il farmaco.* The journal is published by the School of Pharmacy of the University of Pavia and is promoted by Carlo Erba, Dr. Recordati, Farmitalia, Lepetit, Maggioni and Co., and Laboratorio Zambeletti. *Il farmaco* carries its own set of abstracts.

The great number of Italian medical journals, some very important, cannot be discussed in this paper. Many of them are abstracted in *Chemical Abstracts.*

Reference Books

As for dictionaries of the Italian language, the "Vocabolario della Lingua Italiana," compiled by Nicola Zingarelli (*31*) may be recommended. An important Italian-English dictionary (they are few and not always satisfactory) is that of Lysle-Gualtieri, the "Nuovo Dizionario Moderno delle Lingue Italiana e Inglese" (*17*). Unfortunately, there are no Italian-English chemical dictionaries, as Singer has pointed out (*27*), although one would be most useful.

Therefore, the chemist searching the Italian chemical literature has to seek other tools. For example, while there is no Italian-English chemical dictionary, several exist for Italian-German. Of these, the one of Bulle and Rigutini, "Dizionario Italiano-Tedesco e Tedesco-Italiano"(*3*), and that of Giua and Giua-Lollini, "Dizionario Tedesco Italiano di Chimica e Scienze Affini" (*13*), and Rossi's "Dizionario Tecnico Tedesco-Italiano e Italiano-Tedesco con Particolare Riguardo alla Chimica e Merceologia" (*24*) are very helpful. Also, Dorrer's "Dizionario Tascabile delle Lingue Tedesca e Italiana per l'Industria Chimica" (*6*) should be mentioned.

A somewhat unique Italian dictionary should not be overlooked. This is Testi's "Dizionario di Chimica Antiquaria e di Alchimia" (*28*), listing terms used in medieval alchemy.

Finally, two small dictionaries are worth mentioning: Denti's "Dizionario Tecnico Italiano-Inglese, Inglese-Italiano" (*5*) and Marolli's "Dizionario Tecnico, Inglese-Italiano, Italiano-Inglese" (*19*). These are more technical than chemical dictionaries.

Indexes, Encyclopedias

The foremost Italian scientific index is the *Indice di periodici scientifici e tecnici* of the Consiglio Nazionale delle Ricerche. It has appeared since 1948 under the editorship of G. Borghi and is divided into eleven independent parts, of which chemistry is Part IV and medicine-biology-psychology is Part V. This comprehensive index lists and annotates the Italian and foreign literature. Very recently, the "Guida Bibliografica Internazionale per il Chimico. Libri e Riviste" by Nerio Gaudenzi (*11*) appeared. This is a very complete index of international chemical literature, dictionaries, encyclopedias, texts, handbooks, etc. The use of the index is explained in four languages (Italian, French, English, and German); however, the index itself is written in Italian.

Among others, three Italian encyclopedias of chemistry should be mentioned: first, the "Dizionario di Chimica Generale e Industriale, Chimica Agraria, Biologica, Bromatologica, Farmaceutica, Geologica, Mineralogica, Tecnologica, Tossicologica" by Giua and

Giua-Lollini (*12*). There are three volumes, alphabetically arranged. Second, the comprehensive encyclopedic dictionary of Villavecchia, "Dizionario di Merceologia e di Chimica Applicata" (*29*). It covers applied chemistry and *merceologia*, or the study of natural sciences. Third, Longhini's "Piccola Enciclopedia chimica per domande e risposte" (*16*). Its format is made up in the form of questions and answers.

Another useful reference is the Italian pharmacopoeia (*14*), "Farmacopea Ufficiale." Very important is Fumi's "Repertorio Terapeutico Elenco Generale delle Specialità Medicinali" (*9*). Its text consists of two parts. One, corresponding to the American "Red Book" of drugs, is a compilation of all drugs, medicinal specialities, etc., that have been marketed in Italy, with their retail prices, sales forms, etc. The other part contains data on the chemical composition, therapeutic indications, and manufacturers of the drugs listed.

There is no specific text that can be used as reference for Italian chemical patents. Moreover, because certain changes are being considered, the Italian patent law, based on the process-patent conception, is at present in a state of transition. Generally, Italian patents do not assume the importance of United States, British, or German patents.

Abstracts, Textbooks, and Treatises

There are no centralized Italian chemical abstracts of the nature of *Chemical Abstracts* or *Chemische Zentralblatt.* However, several chemical periodicals have their own abstracting services, of which those appearing in the *Gazzetta, Bollettino chimico farmaceutico,* and *Il farmaco* are most important.

Of the many chemical, pharmacological, and other texts, treatises, and handbooks written in Italian, only a few can be discussed. The little text of Vouch, "Costanti Fisico-Chimiche di Oltre 1300 Composti Organici" (*30*) is a useful compilation of organic compounds, listing physical constants such as melting points, and boiling points. Marini-Bettolo's "Reazioni Organiche" (*18*) deals with organic-synthetic reactions and preparations. Its author is an organic chemist associated with Bovet at the Istituto Superiore di Sanità. The well-known text of Karrer, "Lehrbuch der organischen Chemie," has been translated into Italian, and is as widely used in Italy as it is elsewhere (*15*). Gabba and Molinari's "Manuale del chimico" (*10*) is comparable to English handbooks such as the "Handbook of Chemistry and Physics." Barbieri's "Enciclopedia-Ricettario" (*1*) contains 10,000 formulas and procedures. Four very good Italian textbooks of pharmacology are Meneghetti's "Lezioni di Farmacologia" (*20*), Mascherpa's "Trattato di Farmacologia e Farmacognosia" (*26*), Simon's "Trattato di Farmacologia" (7), and Erspamer's "Lezioni di Farmacologia." Of biochemistry texts, that of Rondoni, "Elementi di Biochimica" (*23*), is widely used.

Language Difficulties

Italian has its peculiarities, problems, and pitfalls, but unfortunately there is little opportunity for the English-speaking chemist to become aware of them. It is a rare curriculum that includes a course in scientific Italian. Although the scope of this paper does not permit a discussion of translation problems, a mention of a few of the peculiarities may prove instructive.

Often one will find in an Italian scientific text the letters AA., usually preceded by an article—e.g., *gli* AA. This abbreviation means *gli autori*, or the authors.

Some general rules will facilitate the reading of chemical Italian, as there are similarities in spelling of chemical names and nomenclature used. For example, a chemical compound spelled in English with a *y* is written in Italian with the letter *i*. The *z* in English often corresponds to a double *z* in Italian; also the letter *t* of the English version corresponds to a *z* in Italian. Thus, pyrrone is *pirone* and polymerization is *polimerizzazione*. Names of elements, such as palladium, are similarly written in Italian, as *palladio*.

Chemical words starting with an *h* in English are written without it in Italian—e.g., hydrogenation is *idrogenazione*.

Alcohol is *alcool* or *alcole;* ether is *etere* and so forth.

The melting point (abbreviated m. p.) finds its Italian counterpart in *punto di fusione* (abbreviated *p. f.*); decomposition in melting is usually abbreviated as *con dec.* The boiling point (b. p.) is *punto d'ebollizione* (*p. e.*).

A water bath is referred to in Italian as *bagnomaria* (corresponding to the French word *bainmarie*).

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Foreign Alphabetization Practices

ERNST VAN HAAGEN
126 East 31st St., New York 16, N. Y.

"A" may become the last letter of the alphabet, and a variety of other disconcerting transpositions may be encountered, in passing from the author index of *Chemical Abstracts,* for instance, to that of a foreign-language publication. This can be a cause of failure to locate the foreign reference sought. For the principal languages affected that, like English, employ the Roman alphabet—Czech, Danish, Dutch, German, Icelandic, Norwegian, Polish, Rumanian, Spanish, Swedish—some alphabetization practices that tend to mislead the English-speaking reader are explained.

The international literature of chemistry is becoming increasingly available in the form of English abstracts. At the same time, the searcher is being urged to go directly to original sources, making use of foreign bibliographies and indexes, as well as foreign-language dictionaries. Transliteration between Roman and other alphabets complicates this process. Analogous difficulties may arise even within the Roman alphabet, because for alphabetization purposes it is differently treated by the various languages that use it. In an extreme case, these differences may demote a simple surname from a position under A in English to the very end of a foreign alphabetization, without change in spelling.

For example, in column 4771 of Volume 37 of *Chemical Abstracts,* we find Gunnar Alvik, the author of an article entitled "A New Theory of Salt Accumulation in Plants." Alvik writes in German in a Norwegian periodical, the *Papers of the Norwegian Academy of Sciences* at Oslo. In the Decennial Index of *Chemical Abstracts,* however, he appears as "Ålvik, G.," between "Alviella" and "Alving." His initial A now has a small circle over it, as in Ångström. The preface to the Decennial Index tells us to trust the index rather than the original abstract in such cases, because efforts are made to verify authors' names before indexing. This is very helpful, because while in the United States this Å is merely an A with a circle over it, in Norway it represents a distinct alphabetic individual. In Norwegian, this letter is placed at the end of the alphabet, so that in the index to the Norwegian periodical "Ålvik" will follow "Zenobia."

Ålvik may have written other works in German, or even in English for our special benefit; but so far as Norwegian indexes are concerned, these works will thus be concealed from us by the spelling reform of 1917. In that year, the Norwegian government dropped AA as a letter of the alphabet and substituted Å (alphabetized at the end). Since the last war, Danish has followed Norwegian in this substitution, except for certain proper names. Unlike Norwegian, however, Danish has left the new letter at the beginning of the alphabet, in the place occupied by former AA.

Table of Foreign Alphabetizations

Table I is intended to help the user anticipate possibilities of this kind in the case of eleven European languages. Some major languages—for instance, French and Italian—

Table I. Foreign Alphabetization Practices

Index	
aa	Former Danish & Norwegian aa before A
a	Danish å before A
	German ä as A or as AE
	Icelandic á after A
	Norwegian å at end of alphabet
	Polish ą after A
	Swedish å after Z, ä after Å
ae	Dan., Icel. & Norw. æ after Z
	German ae (ä) as AE or as A
c	Czech č after C
	Polish ć after C
ch	Czech ch after H
	Spanish ch after C
e	Icelandic é after E
	Polish ę after E
i	Dutch ij as such or (formerly) after I
	Icelandic í after I
	Romanian î after I
j	Sometimes as I
l	Polish ł after L
	Spanish ll after L
mc-	English M'-, Mc-, or Mac- as such, as MAC or before M
n	Polish ń after N
	Spanish ñ after N

1 Czech	2 Danish	3 Dutch	4 English	5 German	6 Icelandic	7 Norwegian	8 Polish	9 Rumanian	10 Spanish	11 Swedish	(Composite)	Summary: List of Characters as Alphabetized in Respective Languages
	Å										'A	Danish Åå (formerly Aa aa)
A	A	A	A	A	A	A	A	A	A	A	A	Incl. Ger. Ää; Rum. Ââ, Ăă
					Á		Ą				A'	Icelandic Á á; Polish Ą ą
B	B	B	B	B	B	B	B	B	B	B	B	
C	C	C	C	C	C	C	C	C	C	C	C	
Č							Ć		Ch		C'	Czech Č č; Pol. Ć ć; Span. Ch ch
D	D	D	D	D	D	D	D	D	D	D	D	Incl. Czech Ď ď
					Đ						D'	Icelandic Đ ð
E	E	E	E	E	E	E	E	E	E	E	E	
					É		Ę				E'	Icelandic É é; Polish Ę ę
F	F	F	F	F	F	F	F	F	F	F	F	
G	G	G	G	G	G	G	G	G	G	G	G	
H	H	H	H	H	H	H	H	H	H	H	H	
Ch											H'	Czech Ch ch
I	I	I	I	I	I	I	I	I	I	I	I	
		IJ			Í			Î			I'	Dutch IJ ij (formerly Ÿ ÿ); Icel. Í í; Rum. Î î
J	J	J	J	J	J	J	J	J	J	J	J	
K	K	K	K	K	K	K	K	K	K	K	K	
L	L	L	L	L	L	L	L	L	L	L	L	
							Ł		Ll		L'	Polish Ł ł; Spanish Ll ll
			Mc								'M	English Mc
M	M	M	M	M	M	M	M	M	M	M	M	
N	N	N	N	N	N	N	N	N	N	N	N	Incl. Czech Ň ň
							Ń		Ñ		N'	Polish Ń ń; Spanish Ñ ñ
O	O	O	O	O	O	O	O	O	O	O	O	Incl. German Ö ö
					Ó		Ó				O'	Icelandic Ó ó; Polish Ó ó
P	P	P	P	P	P	P	P	P	P	P	P	
Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	
R	R	R	R	R	R	R	R	R	R	R	R	Incl. Czech Ř ř
									RR		R'	Spanish RR rr (formerly so placed)
S	S	S	S	S	S	S	S	S	S	S	S	
Š				Sch			Ś	Ş			S'	Czech Š š; German Sch sch; Polish Ś ś; Rumanian Ş ş

o	Dan. & Norw. Ø after Æ (see *ae*)	T	T	T	T	T	T	T	T	T	T	T	T	Incl. Cz. Ť ť
	German ö as O or as OE									Ţ			T′	Rumanian Ţ ţ
	Icelandic ö after Æ (see *ae*)	U	U	U	U	U	U	U	U	U	U	U	U	Incl. German Ü ü
	Icel. & Pol. ó after O						Ú						U′	Icelandic Ú ú
	Swedish ö after Ä (see *a*)	V	V	V	V	V	V	V	V	V	V	V	V	
		W	W	W	W	W	W	W	W	W	W	W	W	
oe	German oe (ö) as OE or as O	X	X	X	X	X	X	X	X	X	X	X	X	
		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
rr	Spanish rr as such or (formerly)						Ý						Y′	Icelandic Ý ý
	after R	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z	
	Czech š after S	Ž							Ź				Z′	Czech Ž ž; Polish Ź ź
	Polish ś after S								Ż				Z″	Polish Ż ż
	Rumanian ş after S						Þ						Þ	Icelandic Þ þ
												Å	Å	Swedish Å å
sch	German sch sometimes after S		Æ				Æ	Æ				Ä	Æ	Dän., Icel. & Norw. Æ æ; Swed. Ä ä
ss	(formerly also sz) German ß as S or as SS		ß				Ö	Ø				Ö	Œ	Dan. & Norw. Øø; Icel. & Swed. Ö ö
								Å					AA	Norw. Å å (formerly Aa aa)
t	Rumanian ţ after T													
th	Icelandic ð after D, þ after Z													
u	German ü as U or as UE Icelandic ú after U													
ue	German ue (or ü) as UE or U													
v	Sometimes as U													
w	Sometimes as V or VV													
y	Former Dutch ÿ (ij) after I Icelandic ý after Y													
z	Czech ž after Z Polish ź after Z, ż after Ź													

Remark. Not all of the practices indicated are universal with respect to the languages concerned; an attempt has been made to cover the commoner current alphabetizations.

have been omitted from the list because their diacritical markings do not tend to affect alphabetization.

Table I contains three presentations of substantially the same data, to permit consultation in as many different ways.

Columns 1 to 11 are the typical alphabetizations of the eleven languages, with gaps left where necessary to keep corresponding Roman letters in line. It would not be accurate to call these the alphabets of the languages. For example, although the letter W is officially foreign to six of the alphabets, it has been included in all of the alphabetizations because of its occurrence in proper names. Again, many languages give alphabetic status to certain combinations without assigning them special positions. Columns 1 to 11 may be consulted as an advance guide to practices in any given language.

The summary at the right of the table is arranged in an artificial international alphabetical order representing a composite of columns 1 to 11. This alphabetization comprises 49 positions—namely, the familiar 26 plus an additional 23 interspersed here and there. Of the latter, 18 immediately precede or follow the letters from which they are derived, and have been given generic names by means of a system of primes. For example, C′ means a letter derived from C by addition of diacritical marks or auxiliary letters, and alphabetized immediately after C; ′A means a letter derived from A and immediately preceding it; and Z″ means a letter derived from Z and immediately following Z′. The remaining 5 positions are those relegated to the end of the alphabet, and have each been named in a historically appropriate but otherwise arbitrary manner. This alphabetization of 49 positions is not recommended for actual indexing purposes. It not only retains all the complexities and difficulties of its component systems, but compounds them by allowing an identical character such as Ä, for example, to occur in any of several different places. However, it is unfortunately true that some indexes attempt to alphabetize on this principle; in at least one, German ä's were alphabetized under A, Scandinavian ä's or æ's after Z, and Icelandic ð's in position D′. Thus the summary affords a guide to existing indexes of this kind, as well as a convenient approach for memorizing the contents of the table if desired, since each of the 49 entries is followed by a recapitulation of any special features in the corresponding row of columns 1 to 11.

Alphabetical Dislocations

The index at the left of the table is in English alphabetical order. Under each spelling as it might conceivably appear in *Chemical Abstracts* are its possible foreign alphabetical forms and positions. The index may be used to predict the possible alphabetic dislocations of a name of known spelling, but possibly incomplete diacritical marking.

In those many cases where the modified letter immediately precedes or follows the primitive Roman letter from which it is derived, usually no very serious dislocation with respect to English alphabetical order will result. However, Czech Ch is in position H′, where it stands as a derivative of H rather than C. Those who speak English set a trap for foreign searchers by their treatment of the prefix Mac- in its various forms, which is often alphabetized in position ′M, and in other curious ways.

In the case of the four North Germanic languages, demotion of letters to the end of the alphabet creates a more serious problem. The primitives affected are the vowels A and O, whose mutates, or umlauted forms (in the German sense), occupy positions 47 and 48. In Swedish, Å precedes them in position 46. In Norwegian, Å follows in position 49 and last. The ligature Æ æ was a letter of the English alphabet until some time after the Norman Conquest, but before alphabetization (at least beyond the first letter of a word) had been invented. At that time English also employed the two Icelandic letters listed in the index under th. Their English names are "edh" (Đ ð) and "thorn" (Þ þ). Thorn survives as the letter Y in such formations as "Ye Olde Tea Shoppe"; the modern pronunciation of the Y as such instead of as th is spurious. Both of the Icelandic letters would appear in *Chemical Abstracts* as th. Icelandic writers tend to publish in Norwegian periodicals, often in the English or German language, and to be there indexed in the Icelandic style.

Reasons for Alphabetical Complexities

In conclusion, it may be helpful to suggest how these complexities have come about in the course of the seemingly simple process of adoption of the Latin alphabet by most European vernaculars. Consider the familiar example of umlaut, or mutation. We are acquainted with the umlaut in German, as double-dotted A, O, and U. We also have such survivals of the umlaut in English as man, men; goose, geese; mouse, mice; old, elder. Scandinavian umlauted A and O are variously represented, as described above. Scandinavian umlauted U is written as Y, by right of descent from Greek upsilon.

In its primitive form, and as preserved in Icelandic, the umlaut is less capricious. There, when a syllable, usually an inflectional ending, contained a sound in the nature of y in yes, there was an irresistible temptation to give the vowel of the preceding syllable a correspondingly palatal tone. The palatal inflectional ending was later lost in most Germanic languages, but the modification of the preceding syllable was preserved. The resulting sounds were unprovided for in the Latin alphabet, which at first represented them as AE, OE, UE. The modern umlauted characters are all descended from the adscript or superscript auxiliary E, just as the mark placed over certain N's in Spanish is originally a second or doubling N. Only a few generations ago, books printed in German script had a tiny German e over the umlauted letter, instead of two dots; in parts of Pennsylvania, Martin Luther's translation of the Bible is printed in this fashion to the present day.

No method of alphabetizing such constructs can be ideal; it is not surprising that sovereign nations and learned societies have made diverse choices. *Chemical Abstracts* alphabetizes umlauts as, or as if, with written auxiliary E, in order to bring possible variants of the same author's name into the same place; most indigenous German alphabetizations ignore the umlaut mark, because it usually does not affect the root meaning of a German word; the Scandinavian languages, in which the modern umlaut is less clearly grammatical in function, deal with it as we have seen.

Similar alphabetization problems are to be met with in Croatian, Finnish, Hungarian, Slovenian, Turkish, and other languages which the table does not attempt to cover. Nearly all cases can be anticipated by carefully scanning foreign indexes before use, with special attention to the end of the alphabet and to the end of the listing for each letter.

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Abbreviations in the German, French, And Italian Literature

HENRY FISCHBACH

The Language Service, New York, N. Y.

The mania for abbreviations has become world-wide, especially in such languages as Russian and German. Abbreviations come in all lengths, sizes, and degrees of unrecognizability and are constantly being changed. The origin and differentiating characteristics of abbreviations in German, French, and Italian chemical literature are briefly discussed here, and the underlying principles of their formation are explained, with typical examples and practical suggestions for a general approach to foreign abbreviations.

Abbreviations, as distinct from symbols, appeared in man's written record at a comparatively late date. Even so, the earliest abbreviations known to us go back to pre-Roman times, although the Romans were the first to use abbreviations on a fairly large scale. In the days of the great calligraphic transcriptions, centuries before the advent of printing, when written works had to be copied laboriously by hand, extensive use of abbreviations became a necessity as overworked scribes constantly sought short cuts for long and often-used words.

Today, when the desire to compress long scientific terms into briefer spans of space and time is just as strong, although for somewhat different reasons, the mania for abbreviations has become a world-wide disease. It is especially chronic in such languages as Russian and German, where the practice may be condoned as being logically needed by reason of excessively long words and cumbersome endings.

An abbreviation is defined as an arbitrary shortening of a word by cutting off letters from the end. A contraction serves the same purpose, but is understood strictly to be the shortening of a word by cutting out letters from the middle, the omission sometimes being indicated by an apostrophe. Many English and foreign writers hold that a contraction in which the last letter of the word appears should not be followed by a period, though an abbreviation should. The National Bureau of Standards, however, recommends that the period be omitted after all abbreviations of units unless the abbreviation forms an English word, and that the same abbreviation be used for both singular and plural. In German, French, and Italian, there is a trend to omit the period not only after abbreviations of units, but also after other abbreviations. Usage continues to differ widely, however.

German, French, and Italian abbreviations come in all lengths, sizes, and degrees of unrecognizability, and are constantly undergoing change so as to defy standardization and codification. Foreign scientific writers use either what they believe to be "standard" abbreviations or, frequently, go to the trouble of coining new ones, presumably to endear themselves to their space-conscious editors and publishers. The victim is, of course, the reader, especially if the language in question is not his native tongue. To make matters worse, abbreviations are perennially in a state of flux, from which they periodically emerge when the public clamor for standardization becomes too great. The cycle starts by abbreviations tending toward increasingly shorter forms as the demand for space saving becomes more pressing. Then, when they have been compressed into one or two letters and have finally become undistinguishable from other, identical-looking, abbreviations representing entirely different and even antonymous words, they are once more lengthened to restore a semblance of intelligability. Like some chemical reactions, this process is reversible at will.

Many foreign abbreviations are really a form of shorthand which frequently only the author can decipher. They are not necessarily coined on the basis of any uniform system, and that is where the main difficulty lies. This paper does not solve the difficulties encountered in connection with abbreviations used in the German, French, and Italian chemical literature, nor does it cover foreign abbreviations of journal citations or symbols. It is intended solely to afford an insight into whatever method there is in the madness, and to draw attention to some of the features to watch for as possible clues. Tables I and II list many of these abbreviations.

Table I. Abbreviations in the German, French, and Italian Literature

Major Types of Abbreviations

First Letter of Word or Words

1.	F.	Fliesspunkt or Fusionspunkt, melting point
2.	H.	Härte, hardness
3.	M.	Masse, mass
4.	W.	Wasser, water
5.	ll.	leichtlöslich, readily soluble
6.	wl.	wenig löslich, difficultly soluble
7.	swl.	sehr wenig löslich, very difficultly soluble
8.	h.s.l.	heiss sehr löslich, very soluble hot
9.	h.w.l.	heiss wenig löslich, not very soluble hot
10.	k.s.l.	kalt sehr löslich, very soluble cold
11.	k.w.l.	kalt wenig löslich, not very soluble cold
12.	D.R.P.	deutsches Reichspatent, German state patent
13.	I.P.S.	indizierte Pferdestärke, indicated horsepower
14.	a.	asymétrique, asymmetrical
15.	C.A.	coefficient d'abaissement, coefficient of freezing point lowering
16.	c.-à-d.	c'est-à-dire, that is to say, i.e.
17.	c.g.s.	centimètre-gramme-seconde, centimeter-gram-second
18.	f.e.m.	force électromotrice, electromotive force
19.	F.O.	flamme oxydante, oxidizing flame
20.	F.R.	flamme réductrice, reducing flame
21.	p.c.c.	pour copie conforme, for true copy
22.	p.s.	poids spécifique, specific gravity
23.	p. de f.	point de fusion, melting point
24.	SGDG	Sans Garantie du Gouvernement, without government guarantee
25.	A.B.I.	Associazione bibliotecari italiani, Association of Italian Librarians
26.	A.F.	alta frequenza, high frequency
27.	d.	destro, right
28.	N.d.R.	notizia del redattore, editor's note
29.	n.n.	niente di notevole, nothing worthy of note
30.	p.a.	peso atomico, atomic weight
31.	p.f.	punto di fusione, melting point
32.	V.M.	valore medio, average or mean value

Two, Three, or More Letters of Word or Words

33.	Abk.	Abkürzung, abbreviation
34.	blf.	blätterförmig, in flakes or leaflets
35.	Bllg.	biologische Lösung, biological solution
36.	frbl.	farblos, colorless
37.	Frdl.	*Friedländers Fortschritte der Teerfarbenfabrikation*
38.	Gef. P.	Gefrierpunkt, freezing point
39.	Kwst.	Kilowattstunde, kilowatt-hour
40.	wlösl.	wasserlöslich, soluble in water
41.	amp.	ampère, ampere
42.	atm.	atmosphère, atmosphere

Table I (continued)

43.	cent. cube	centimètre cube, cubic centimeter
44.	cuill.	cuillerée, spoonful
45.	dem.	demain, tomorrow
46.	dil.	dilué, dilute or diluted
47.	éq.	équivalent, equivalent
48.	fasc.	fascicule, part (of a publication)
49.	ind.	industrie, industry
50.	mol.	molécule, molecule
51.	mn.	minute, minute
52.	qqf.	quelquefois, sometimes
53.	solv.	dissolvez, dissolve
54.	vap.	vapeur, vapor (or sometimes, steam)
55.	ac.	acido, acid
56.	Batt.	batteriologia, bacteriology
57.	calc.	calcolato, calculated
58.	cmq.	centimetro quadrato, square centimeter
59.	conc.	concentrato, concentrated
60.	crist	cristallizzato, crystallized or crystalline
61.	ecc.	eccetera, et cetera
62.	dill.	dilluito, dilute or diluted
63.	Md.	medio or media, medium, media or average
64.	p. eb.	punto di ebollizione, boiling point
65.	Pr. Max.	pressione maxima, maximum pressure
66.	R. Ind.	reazione indiretta, indirect reaction
67.	rip.	ripetizione or ripetuto, repetition or repeated
68.	sp.	sperimentale, experimental
69.	teor.	del teorico, of theoretical
70.	trov.	trovato, found
71.	v. per es.	vedi per esempio, see e.g.

Contractions

72.	Eg.	Eisessig, glacial acetic acid
73.	fbls.	farblos, colorless (cf. 36)
74.	lfd.	laufend; current, consecutive
75.	Lfg.	Lieferung; delivery, issue
76.	KHz	Kilohertz, kilocycle(s) per sec.
77.	MHz	Megahertz, megacycle(s) per sec.
78.	Pkt.	Punkt; point, period
79.	Sg.	Streckung; stretching, spread
80.	Tfl.	Tafel, table
81.	T(h)l.	T(h)eil, part
82.	asse	assurance, insurance
83.	bce	balance, balance
84.	blle	bouteille, bottle
85.	bté	breveté, patented
86.	fque	fabrique, plant or factory
87.	gal	général, general
88.	gtte	goutte, drop
89.	jer	janvier, January
90.	jet	juillet, July
91.	pain	prochain, next
92.	pd	pied, foot
93.	ppté	précipité, precipitated
94.	Xbre	décembre, December

Several Abbreviations for the Same Word or Words

95.	A., A.G., A.-G., At.-Gew.	Atomgewicht, atomic weight
96.	ang., angew.	angewandt, applied
97.	c., ca., cca.	circa, approximately
98.	F., Fp., F.P.	Fusionspunkt, Fliesspunkt; melting point (cf. 104)
99.	G.T., Gew. T.	Gewichtsteil, part by weight
100.	L., Lsg., Lös., Lösg.	Lösung, solution
101.	o.dgl., o.drgl., od. dgl.	oder dergleichen, or the like
102.	Pf., P.K., PS, P.S., Pst.	Pferdekraft, Pferdestärke; horsepower
103.	s.G., sp. Gew.	spezifisches Gewicht, specific weight
104.	Sm., Sch. P.	Schmelzpunkt, melting point (cf. 98)
105.	u.f., u. ff., uff.	und folgende, et seq. or ff.
106.	U/Min., U.p.M., Upm.	Umdrehungen or Umlaufungen in der Minute, revolutions per minute (cf. variety of abbreviations in English: rpm, RPM, r.p.m., R.P.M.)
107.	b.p., BP, B.P.	basse pression, low pressure
108.	ch., ch. v., ch. vap.	cheval vapeur, horsepower
109.	P.A., p. at.	poids atomique, atomic weight
110.	P.E., p. d'éb.	point d'ébullition, boiling point
111.	P.M., p. mol.	poids moléculaire, molecular weight
112.	t.: m., t.p.m.	tours par minute, revolutions per minute
113.	Dr., Dt., Dott.	Dottore, Doctor

Table I *(continued)*

Same Abbreviations Having Several Meanings

SINGLE LETTERS

114.	A.	Alkohol, alcohol; *Annalen der Chemie;* Atomgewicht, atomic weight; Arbeit, work, task, job, paper, article, investigation
115.	B.	*Berichte der deutschen chemischen Gesellschaft;* Band, volume; Blatt, leaf
116.	f.	fest, solid; fein, fine; für, for; folgende, following
117.	h.	hochschmelzend, high-melting; heiss, hot; hoch, high or great; heilig, holy
118.	H.	Härte, hardness; Höhe, altitude or height
119.	k.	konstant, constant; kalt, cold
120.	s.	siehe, see; symmetrisch, symmetrical; schwer, difficult or heavy; sehr, very; Sekunde, second (Sekunde is abbreviated as s to differentiate it from the abbreviation for Stunde, hour, which is S)
121.	Z.	Zähigkeit, toughness; Zeitschrift, periodical or journal; Zahl, number; Zeile, line; Zeit, time; Zoll, inch
122.	c.	centimètre, centimeter; petite calorie, small calorie; capacité, capacity; contre, versus; courant, current
123.	f. or F.	force, force; Fahrenheit; fréquence, frequency; franc; foyer, focal length
124.	l. or long.	longueur, length; longitude, longitude
125.	p. or P.	page, page; poids, weight; puissance, power; pression, pressure
126.	t.	tonne(s), ton(s); tour(s), revolution(s); température, temperature

SEVERAL LETTERS

127.	A.G.	Atomgewicht, atomic weight; Aktiengesellschaft, joint-stock company; Amtsgericht, local court
128.	Best.	Bestimmung, determination; Bestellung, order; Bestand, amount, stock
129.	bez.	beziehungsweise, respectively; bezüglich, with regard to; bezogen, referred or relative to; bezahlt, paid
130.	erw.	erwärmt, warmed or heated; erwähnt, mentioned
131.	ff.	feinfein, very fine; feuerfest, fireproof or refractory; und folgende, et seq. or ff.
132.	fl.	flüssig, liquid; flüchtig, volatile
133.	gbr.	gebräuchlich, usual(ly); gebraucht, used; gebrannt, burned.
134.	gem.	gemein or gemeinsam, common or mutual(ly); gemischt, mixed; gemahlen, ground or milled
135.	ges.	gesättigt, saturated; gesetzlich, by law or legal; gesamt, total
136.	i.D.	in Dampf, in steam; in Dampfform, in vapor form; im Durchschnitt, on the average; im Dunkeln, in the dark
137.	M.G.	Molekulargewicht, molecular weight; Massenwirkungsgesetz, law of mass action
138.	Verf.	Verfasser, author; Verfahren, process or method
139.	Zus.	Zusammensetzung, composition; Zusatz, addition

CONTRADICTORY MEANINGS

140.	verm.	vermehrt, enlarged or increased; vermindert, diminished or reduced
141.	p.	pouce, inch; pied, foot

Plural Formation

142.	D.D.	Dichten, densities (cf. DD., Dampfdichte, vapor density)
143.	FF., Ff.	Fusionspunkte, melting points
144.	SS.	Säuren, acids
145.	AA.	autori, authors
146.	GG	giorni, days
147.	Fll.	Flüssigkeiten, liquids
148.	Legg.	Legierungen, alloys
149.	Lsgg.	Lösungen, solutions
150.	Ndd.	Niederschläge, precipitates
151.	Rkk.	Reaktionen, reactions
152.	Vbb.	Verbindungen, compounds
153.	Vff.	Verfasser, authors
154.	Dtt.	Dottori, Doctors
155.	Bde.	Bände, volumes
156.	Tle.	Teile, parts
157.	Gln.	Gleichungen, equations
158.	frs	francs, francs
159.	Mrs	Messieurs, Messrs.
160.	pts	parts, parts
161.	chx	chevaux (vapeur), horsepower

Table I *(continued)*

Capitalization in German Abbreviations

162.	dest.	destilliert, distilled
	Dest.	Destillation, distillation
163.	fl.	flüssig, liquid (adj.)
	Fl.	Flüssigkeit, liquid (noun)
164.	lösl.	löslich, soluble
	Lösl.	Löslichkeit, solubility
165.	abh.	abhängig, dependent
	Abh.	Abhandlung; treatise, paper, or transaction of a society
166.	ber.	berechnet, calculated
	Ber.	Berichte, reports (specif., *Berichte der deutschen chemischen Gesellschaft*)
167.	entw.	entweder, either
	Entw.	Entwickelung, evolution or development
168.	kl.	kaum löslich, scarcely soluble
	Kl.	Klasse, class
169.	m.E.	meines Erachtens, in my opinion
	M.E.	Mache-Einheit, Mache unit; Mäuse-Einheit, mouse unit
170.	mBV-Verfahren	modifiziertes Bauer-Vogel Verfahren, modified Bauer-Vogel process
	MBV-Verfahren	Mayer-Bauer-Vogel Verfahren, Mayer-Bauer-Vogel process
171.	s.S.	siehe Seite, see page
	S.S.	Schwefelwasserstoffsäure, hydrosulfuric acid
172.	v.T.	von Tausend, per mille
	V.T.	Volumenteil, part by volume
173.	a.G.	auf Gegenseitigkeit, mutual
174.	ä.W.	äussere Weite, outside diameter
175.	F.f.	Fortsetzung folgt, to be continued (cf. 143)
176.	m.A.n.	meiner Ansicht nach, in my opinion
177.	u.d.M.	unter dem Mikroskop, under the microscope
178.	G.T.	Gewichtsteil, part by weight
179.	N.D.	Niederdruck, low pressure
180.	RV	Reduktionsvermögen, reducing power
181.	Nd.	Niederschlag, precipitate
182.	Sd.	Siedepunkt, boiling point
183.	Nk.	Normalkerze, standard candle (also abbreviated NK)
184.	Kp.	Kochpunkt, boiling point
185.	Ntf.	Naturforscher, scientific investigator
186.	RGT-Regel	Reaktionsgeschwindigkeit-Temperatur Regel, reaction-velocity-temperature rule

Unusual Abbreviations

187.	Achema	Ausstellung für chemisches Apparatenwesen, Exhibition for Chemical Apparatus and Equipment
188.	Atü or atü	Atmosphärenüberdruck, metric atmospheres (kg./sq. cm.) excess pressure
189.	Dechema	Deutsche Gesellschaft für chemisches Apparatenwesen, German Association for Chemical Apparatus and Equipment
190.	A.K.-Satz	Aktivitätskoeffizientsatz, activity coefficient rate
191.	Labor	Laboratorium, laboratory
192.	Jato	Jahrestonnen, tons per year
193.	Moto	Monatstonnen, tons per month
194.	Tato	Tagestonnen, tons per day
195.	F. Z_J	Farbezahl gegen Jod, iodine number
196.	M/1	soluzione molare, molar solution
197.	M/2	soluzione mezzo molare, half-molar solution
198.	msec.	millesimo di secondo, thousandth of a second
199.	O/A	olio nell'acqua, oil in water
200.	Torr., Tor. or tor.	Torricelli—i.e. pressure of 1 mm. mercury, 1/760 atmos.
201.	Tln.	Genitive or dative plural of Teil, part. (One of the rare instances of an abbreviation that is declined.)
202.	Ann.	Annali
203.	Boll.	Bolletino
204.	Chim.	Chimica
205.	Gaz.	Gazetta
206.	Gior.	Giornale
207.	Rass.	Rassegna
208.	R.C.	Rendiconti
209.	Riv.	Rivista
210.	Sper.	Sperimentale

Table II. Abbreviations Used in *Chemisches Zentralblatt, Beilstein, Bulletin de la Societé Chimique de France,* and *Bulletin Analytique*

Listed in Chemisches Zentralblatt

A.	Alkohol, alcohol (only for ethyl alcohol)
Abb.	Abbildung, illustration
absol.	absolut, absolute
Ae.	Äther, ether (only for ethyl ether)
akt.	aktiv, active
alkoh.	alkoholisch, alcoholic
allg.	allgemein, general or common
App.	Apparat, apparatus; Apparatur, equipment
asymm.	unsymmetrisch, unsymmetrical
at.	Atmosphäre, atmosphere
At.-Gew.	Atomgewicht, atomic weight
ausg.	ausgegeben, yielded or produced
AZ.	Acetylzahl, acetyl number
bes.	besonders, especially; insbesondere, particularly
Best.	Bestimmung, determination
Bibl.	Bibliographie, bibliography
bin.	binär, binary
biol.	biologisch, biological
Bldg.	Bildung, formation or structure
bzgl.	bezüglich, with reference to
Bzl.	Benzol, benzene (sometimes benzol)
Bzn.	Benzin, gasoline
bzw.	beziehungsweise, respectively
ca.	zirka, approximately
Chlf.	Chloroform, chloroform
d.	der, die, das, the
D.	Dichte, density (specific gravity)
dad. gek.	dadurch gekennzeichnet, characterized by
Darst.	Darstellung; preparation, production, description
DK.	Dielektrizitätskonstante, dielectric constant
Deriv.	Derivat, derivative
Dest.	Destillation, distillation
dest.	destilliert, distilled; destillieren, to distill
E.	Erstarrungspunkt; freezing point, solidification point
Eig.	Eigenschaft, property
Einfl.	Einfluss, influence or effect
Einw.	Einwirkung, action or effect
EMK.	Elektromotorische Kraft, electromotive force
Entw.	Entwickelung, development or generating (of gases)
EZ.	Esterzahl, ester number
F.	Fliesspunkt, melting point
Fl.	Flüssigkeit, liquid or fluid
fl.	flüssig, liquid or fluid (adj.)
Geh.	Gehalt, content or capacity
gek.	gekennzeichnet, characterized
gesätt.	gesättigt, saturated
Ggw.	Gegenwart, presence
Herst.	Herstellung, preparation or production
inakt.	inaktiv, inactive
tern.	ternär, ternary
tert.	tertiär, tertiary
u.	und, and
JZ.	Jodzahl, iodine number
Koeff.	Koeffizient, coefficient
Koll.	Kolloid, colloid
koll.	kolloid(al), colloidal
Konst.	Konstitution, constitution
Konz.	Konzentration, concentration
konz.	konzentriert, concentrated
korr.	korrigiert, corrected
Kp.	Kochpunkt, melting point
krist.	kristallisiert, crystallized
KW-stoff	Kohlenwasserstoff, hydrocarbon
Labor.	Laboratorium, laboratory
lösl.	löslich, soluble
Lösungsm.	Lösungsmittel, solvent
Lsg.	Lösung, solution
M.	Masse, mass
Meth.	Methode, method
Min.	Minute, minute
Mitt.	Mitteilung; communication, report
mkr.	mikroskopisch, microscopic(al)
Mol.	Molekül, molecule
mol.	molar, molar; molekular, molecular
Mol.-Gew.	Molekulargewicht, molecular weight
Mol.-Refr.	Molekularrefraktion, molecular refraction
n.	normal, normal
nachst.	nachstehend, following or below
Nachw.	Nachweis detection, proof, information, index
Nd.	Niederschlag, precipitate
opt.-akt.	optisch-aktiv, optically active
PAe.	Petroläther, petroleum ether
pharmakol.	pharmakologisch, pharmacological
physiol.	physiologisch, physiological
Präp.	Präparat, preparation
prim.	primär, primary
Prior.	Unionspriorität, convention agreement, priority
Prod.	Produkt, product
rac.	racemisch, racemic
Red.	Reduktion, reduction
red.	reduziert, reduced
Ref.	Referat, abstract, review, report
Rk.	Reaktion, reaction
s.	siehe, see
schm.	schmelzen, melt; schmilzt, melts
sd.	sieden, boil; siedet, boils
Sek.	Sekunde, second
sek.	sekundär, secondary
Spektr.	Spektrum, -ren, spectrum(s)
std.	stündig, for an hour
Std.	Stunde, -en, hour(s)
symm.	symmetrisch, symmetric(al)
Synth.	Synthese, -en, synthesis, -es
Syst.	System, -e, system(s)
SZ.	Säurezahl, acid number
Temp.	Temperatur, temperature
Wrkg.	Wirkung, action, effect, reaction, result
wss.	wässerig, aqueous

Table II (continued)

u. a.	und andere, and others; unter anderem, among others
u.dgl.	und dergleichen, and the like
ungesätt.	ungesättigt, unsaturated
unlösl.	unlöslich, insoluble
Unters.	Untersuchung, examination, investigation, research
usw.	und so weiter, and so forth, etc.
UV	Ultraviolet, ultraviolet
v.	von, vom, from, by, of the
Verb.	Verbindung, compound or bond
verd.	verdünnt, dilute(d)
Verf.	Verfahren, process or procedure
Verh.	Verhalten, behavior or quality
Vers.	Versuch, experiment or test
verschied.	verschiedene, various or different
Vf.	Verfasser, author or writer
Vgl.	Vergleich, comparison
vgl.	vergleiche, compare, cf.
Vol.	Volumen, volume
Vork.	Vorkommen; presence, existence, deposit
Vorr.	Vorrichtung; device, apparatus, appliance
vorst.	vorstehend, aforesaid or preceding
VZ.	Verseifungszahl, saponification number or value
W.	Wasser, water
z.B.	zum Beispiel, for example
Zers.	Zersetzung, decomposition
zers.	zersetzen, -setzt, decompose(d)
Zus.	Zusammensetzung, composition, synthesis, combination

Patent Abbreviations

A.P.	American patent
Aust. P.	Australian patent
Belg. P.	Belgian patent
Can. P.	Canadian patent
Dän. P.	Danish patent
D. B. P.	German patent (Munich)
D. R. P.	German state patent
E. P.	English patent
F. P.	French patent
Finn. P.	Finnish patent
Holl. P.	Netherlands patent
Ind. P.	Indian patent
It. P.	Italian patent
Jug. P.	Yugoslav patent
N. P.	Norwegian patent
Oe. P.	Austrian patent
Poln. P.	Polish patent
Russ. P.	Russian patent
Schwed. P.	Swedish patent
Schz. P.	Swiss patent
Tschech. P.	Czech patent
Ung. P.	Hungarian patent

Listed in Beilstein's Handbuch der Organischen Chemie[a]

absol.	absolut, absolute
ac.	alicyclisch, alicyclic
äther.	ätherisch, ethereal
AGFA	Aktien-Gesellschaft für Anilinfabrikation
akt.	aktiv, active
alkal.	alkalisch, alkaline
alkoh.	alkoholisch, alcoholic
ang.	angular, angular
Anm.	Anmerkung, note or remark
ar.	aromatisch, aromatic
asymm.	asymmetrisch, asymmetric(al)
At.-Gew.	Atomgewicht, atomic weight
B.	Bildung, formation or structure
Bac.	Bacillus, bacillus
Bact.	Bacterium, bacterium
BASF	Badische Anilin- und Sodafabrik
ber.	berechnet, calculated
bzw.	beziehungsweise, respectively
ca.	circa, approximately
D	Dichte, density
Darst.	Darstellung, preparation, description, production
Dielektr.-Konst.	Dielektrizitätskonstante, dielectric constant
Diss.	Dissertation, dissertation, thesis
E	Erstarrungspunkt, freezing point or solidification point
Einw.	Einwirkung, action or effect
EMK	Elektromotorische Kraft, electromotive force
Ergw.	Ergänzungswerk, supplement
F	Fliesspunkt, melting point
Hptw.	Hauptwerk, main work
inakt.	inaktiv, inactive
konz.	konzentriert, concentrated
Mitarb.	Mitarbeiter, coworker, collaborator, contributor
Mol.-Gew.	Molekulargewicht, molecular wt.
Mol.-Refr.	Molekularrefraktion, molecular refraction
ms-	meso-, meso-
n.	normal, normal
opt.-akt.	optisch-aktiv, optically active
prim.	primär, primary
Priv.-Mitt.	Privatmitteilung, personal communication
racem.	racemisch, racemic
R.I.-Bzfg.	Ring Index-Bezifferung, ring index numeration
RV	Reduktionsvermögen, reducing power
S.	Seite, page
s.	siehe, see
s.a.	siehe auch, see also
s.o.	siehe oben, see above (vide supra)
s.u.	siehe unten, see below (vide infra)
sek.	sekundär, secondary
spezif.	spezifisch, specific
Spl.	Supplement, supplement
Stde(n).	Stunde, -en, hour(s)
stdg.	stündig, for an hour, for x hours
symm.	symmetrisch, symmetric(al)
Syst. Nr.	System-Nummer, system number
Tab.	Tabelle, table, chart, etc.
Temp.	Temperatur, temperature
tert.	tertiär, tertiary
Tl., Tle., Tln.	Teil, -e, -en, part(s)
V.	Vorkommen, presence, existence, deposit

Table II (*continued*)

korr.	korrigiert, corrected
Kp	Kochpunkt, boiling point
lin.	linear, linear
m.	molar, molar
Min.	Minute, minute
verd.	verdünnt, dilute(d)
vgl. a.	vergleich auch, compare also
vic.	vicinal, vicinal
Vol.	Volumen, volume
wässr.	wässrig, aqueous
Zers.	Zersetzung, decomposition

Listed in Bulletin de la Société Chimique de France[b]

ac.	acide, acid
aig.	aiguilles, needles
alc.	alcool, alcohol
ald.	aldéhyde, aldehyde
anh.	anhydride, anhydride
asym.	asymétrique, asymmetric(al)
B.-M.	bain-marie, water bath
comb.	combinaison, combination, compound, etc.
comb. mol.	combinaison moléculaire, molecular combination
conc.	concentré, concentrated
condens.	condensation, condensation
corresp.	correspondant, corresponding
crist.	cristaux, crystals
cristall.	cristallisation, crystallization
D	densité, density
dér.	dérivé, derived or derivative
dist.	distillation, distillation
déc.	décomposition, decomposition
1,2 Aq.	eau de cristallisation, water of crystallization
ébull.	ébullition, boiling
F. 200° (déc.)	fusible à 200° avec décomposition, melts at 200° with decomposition
gr.	gramme, gram
insol. H_2O etc.	insoluble dans l'eau, etc., insoluble in water, etc.
m.	mètre, meter
mm.	millimètre, millimeter
mol.	molécule, molecule moléculaire, molecular
p.	parties, parts
Eb_{100}	point d'ébullition sous 100 mm., boiling point at 100 mm.
F. (corr.)	point de fusion corrigé, melting point (corrected)
0/0	pour cent, per cent
0/00	pour mille, per mil
p. rot.	pouvoir rotatoire, rotatory power
ppté	précipité, precipitated
pptation	précipitation, precipitation
prép.	préparer, prepare préparation, preparation
proport.	proportionnel, proportional
propr.	propriété, property
R.M.	réfraction moléculaire, molecular refraction
R^t	rendement, yield
sol.	soluble, soluble
sol. aq.	solution aqueuse, aqueous solution
sol. alcool.	solution alcoolique, alcoholic solution
sym.	symétrique, symmetric(al)
T.	température, temperature
transf.	transformation, conversion, transformation, rearrangement

Listed in Bulletin Analytique of the Centre de Documentation du Centre National de la Recherche Scientifique

atm.	atmosphère, atmosphere
BF	basse fréquence, low frequency
BT	basse tension, low pressure or low tension
c	concentration, concentration
c.a.	courant alternatif, alternating current
c.c.	courant continu, direct current
cal.	calorie-gramme, gram calorie
ch	cheval-vapeur, horsepower
coeff.	coefficient, coefficient
c/s	cycle par seconde, cycle per sec.
cte	constante, constant
d	densité, density
db	décibel, decibel
diff. de pot.	différence de potentiel, potential difference
dpl.	dépliant, folder
E	Est, East
f.c.é.m.	force contre-électromotrice, back electromotive force
f.é.m.	force électromotrice, electromotive force
g	gramme, gram
groupt	groupement, group or connection
IR	infrarouge, infrared
j	jour, day
k	kilo, kilogram
l	litre, liter
M	masse moléculaire, molecular mass
max.	maximum, maximum
MF	moyenne fréquence, medium frequency
min.	minimum, minimum
mol.	molécule, molecule
moy.	moyen, mean, average, medium
mn	minute, minute
N	Nord, North
p.	pression, pressure
PE	point d'ébullition, boiling point
PF	point de fusion, melting point
p.p.m.	partie par million, part per million
QR	quotient respiratoire, respiratory quotient
rdt	rendement, yield
S	Sud, south
s	seconde, second
sol.	solution, solution

Table II (continued)

h	heure, hour	sup.	supérieur, higher, upper, more
HF	haute fréquence, high frequency	t°	température, temperature
HP	horsepower	UI	unité internationale, international unit
HT	haute tension, high pressure or high tension	UV	ultraviolet, ultraviolet
inf.	inférieur, inferior, lower, less	v	vitesse, velocity

[a] Every volume of Beilstein lists publications cited in volume.
[b] First page of every volume lists abbreviations and exact titles of publications abstracted.

Major Forms of Abbreviations

Although a uniform system of abbreviation coinage does not exist in German, French, or Italian, any more than in English, abbreviations in these languages generally embody one of three major forms.

1. The first letter of the word being abbreviated, or, when several words or an expression are abbreviated, the initial letter of each of the words, with or without periods or spaces between them. The letter or letters of the abbreviation may or may not be capital letters, depending on factors discussed in connection with capitalization requirements in German. Examples 1 through 32 (Table I) illustrate this most common form of abbreviation.
2. Two, three, or more letters of the word or words being abbreviated, or in the case of German compound words, the first two or three letters of one or all of the elements in the compound. This type of abbreviation is reflected in examples 33 through 71.
3. The initial and last letter of a word, or the first two or three letters plus the last (more properly called contraction). In French, where the distinction between an abbreviation and a contraction is much more rigorously observed, a period generally denotes an abbreviation and the lack of one a contraction. Contractions are more common in French, especially for titles, than in the other two languages. A number of typical contractions are listed in examples 72 through 94.

There are many words, especially in German, for which several abbreviations are in use. These generally differ only in length. As examples 95 through 113 show, it can be assumed that originally the longer, and consequently less ambiguous, forms were in use and that these were later shortened until only a single letter came to be accepted. But because these single-letter abbreviations could have several meanings and confusion set in, editors reluctantly agreed to revert to the earlier, longer forms. The evidence to support this assumption, although not conclusive, is fairly substantial. In Italian, this form of confusion is rare.

Abbreviations with Several Meanings

Many abbreviations, especially those consisting of only the original letter of the words they represent, have several meanings. When any of the abbreviations listed in examples 114 through 126 are encountered, only the context can provide a clue as to the correct meaning. Single-letter abbreviations are not the only ones that can have several meanings. As examples 127 through 139 indicate, the same is true of abbreviations consisting of several letters, although naturally not so frequently. To confuse matters even more, occasionally an abbreviation can represent two words of not only different but even contradictory meaning, as examples 140 and 141 attest.

The plural form of nouns is abbreviated in one of three ways: by doubling the letter used to abbreviate the noun in its singular form (examples 142 through 146), by doubling the last letter of the abbreviation when the latter consists of several letters (examples 147 through 154), or by adding the last letter of the plural noun to the singular abbreviation. A glance at examples 155 through 161 reveals that, in German, this last type of plural formation is achieved by adding an *e* or an *n*, and in French by adding an *s* or an *x*.

In German, nouns must be capitalized. Fortunately, this practice is also observed in the abbreviations. One can therefore differentiate between two similar abbreviations which differ only in that respect. As examples 162 through 164 show, the abbreviation of an adjective and that of its corresponding noun are frequently the same, except for the initial capital in the abbreviation of the noun. In examples 165 through 171, the fact that one of two otherwise identical abbreviations begins with a capital letter is of considerable help in distinguishing between two or more meanings. In German abbreviations containing both upper and lower case letters (with or without periods or spaces between them), it can be assumed for all practical purposes that the capital letter or letters will invariably refer to nouns, as evidenced by examples 172 through 176. In two-letter abbreviations representing compound words, if both letters are capitals followed by periods, the abbreviation generally represents a compound noun, each of its two letters being the initial letter of each noun (examples 177 through 180). If the second letter is in lower case, both letters were taken from the first element of the compound word and there is no period between them (examples 181 and 182). There are exceptions, as examples 183 and 184 indicate. German compound nouns may also be abbreviated with three letters, in which case either only the initial one (example 185) or all three (example 186) are in upper case.

Table III. Dictionaries

Baudry, Hubert. "D. A. Dictionnaire d'Abréviations Françaises et Etrangères—techniques et usuelles, anciennes et nouvelles," Paris, 1951.

De Vries, Louis. "German-English Technical and Engineering Dictionary," McGraw-Hill Book Co., Inc., New York, 1950. See pp. 893–928.

Kettridge, J. O. "French-English Dictionary of Technical Terms and Phrases," H. W. Wilson Co., New York, 1949. See pp. 539–541.

Mansion, J. E. "Heath's Standard French and English Dictionary," D. C. Heath & Co., New York, 1939. See pp. 907–912 of Part I.

Patterson, Austin M. "A German-English Dictionary for Chemists," 3rd ed., John Wiley & Sons, New York, 1950. Abbreviations included in text.

Patterson, Austin M. "A French-English Dictionary for Chemists," 2nd ed., John Wiley & Sons, New York, 1954. Abbreviations included in text.

Pfohl, Ernst. "Kurzwort-Lexikon (KWL)," Muth'sche Verlagsbuchhandlung, Stuttgart, 1934. Dictionary of German abbreviations from many fields.

Peyser, Alfred. "Pars pro Toto, Breviarium Medicum Internationale," Almquist & Wiksell, Upsala, 1950. Abbreviations used in international medical literature and related sciences.

Webel, A. A. "A German-English Technical and Scientific Dictionary," 2nd ed., E. P. Dutton & Co., New York, 1937. Abbreviations separately listed in back.

Examples 187 through 208 cover a number of unusual or otherwise interesting abbreviations, as well as the abbreviations most commonly found in the names of Italian publications.

Table III gives a list of readily accessible dictionaries which may be worth consulting for the key to obscure foreign abbreviations.

RECEIVED June 2, 1954. Presented before the Division of Chemical Literature, at the 124th Meeting of the AMERICAN CHEMICAL SOCIETY, Chicago, Ill.

Translating German, French, and Italian Chemical Literature

HENRY FISCHBACH

The Language Service, New York, N. Y.

Recognizing English cognates of foreign technical terms greatly facilitates the translation of technical material. Vowel and consonant changes which frequently occur are enumerated. Caution must be exercised in translating words which closely resemble English words, as they may have a different meaning. Examples are cited. Some typical prefixes and suffixes are discussed. Complications which arise from inversions, compound words, the position of the verb, demonstrative pronouns, accents, and variations in form expressing decimal points, percentage, and abbreviations are also discussed.

The object of this paper is to outline briefly some of the major problems facing the translator of foreign chemical texts, and to offer a few practical suggestions for solving them. The intention is not to lay down any ironclad rules which will apply in all cases, but rather to recommend a few simple mental techniques calculated to facilitate the work of the chemist who may be called upon to translate from the foreign literature.

Before embarking upon a discussion of specific translating procedures, a few words about the principles of technical translation in general might serve as an introduction to the subject [borrowed from a valuable paper by Holmstrom (*1*)].

The primary principle of good technical translating is to translate ideas and not words. In translating scientific as distinct from literary material, forms of words are not an end but a means—admittedly an imperfect means—for transmitting the ideas from the mind of the foreign author to that of the English-speaking reader. If the foreign author's expression of these ideas is deficient or otherwise lacking in clarity, it is the duty of the translator to disentangle the author's possible intended meanings and subsume them within an acceptable English rendition.

It has been said before, and it is worth repeating here, that a technical translator must combine three faculties:

1. He must have a fairly extensive knowledge of, and be able to reason in, the subject matter of the translation—in this case, chemistry.
2. He must be able to read the language he is translating well enough so that he can grasp the author's intended meaning, even if poorly expressed.
3. He must himself be able to embody that meaning in lucid and straightforward English.

Because of the principle that ideas rather than words should be translated, style is somewhat of a secondary consideration, except to the extent that it should always be appropriate to the subject matter at hand. Generally speaking, in technical English it is advisable to prefer the concrete word to the abstract, and the active and transitive verb to the passive and intransitive (*4*). A whole book could—and should—be written on the principles and problems of technical translation. A few of these problems have been selected here for comment.

Cognates

Recognition. The ability to recognize English cognates of foreign technical terms greatly facilitates the translation of technical material for anyone who is faced with a foreign text in his own field of specialization. Chemists who write in German, French, and Italian—the only languages which will be considered here—are not only professional colleagues whose minds are likely to work along the same scientific lines as that of American chemists, but they are also to some extent terminological brothers under the skin. This is more or less true of all fields of science, where specialized terminology has been evolved in one country and just as quickly adopted in another. Technical terminology generally keeps pace with scientific discovery, and as the results of individual and original research become known so do the new terms used to describe this research. Of course, by the time they reach us many of these terms have already been anglicized. Familiarity with a few basic principles enabling one to spot cognates automatically, as it were, will obviate the need for much time-consuming word hunting in the many instances where the English cognates can be detected at a glance. The examples given below are not always applicable, and there are a number of linguistic pitfalls to be avoided—cases where apparent cognates can turn out to be "false friends."

Perhaps the most useful aid in recognizing cognates is a knowledge of the vowel and consonant changes which tend to recur frequently. The following enumeration of such changes makes no pretense at completeness, and although the cases illustrated will not be applicable always, they will be helpful in most instances.

The consonants **b**, and **f**, **v**, or **w** are sometimes interchangeable. Thus, the German word *Silber* is cognate to sil**v**er. *Wismuth*, on the other hand, is **b**ismuth. In German, the letter **b** will often reveal an English cognate when changed to **f**, as in *halb* meaning half.

In Italian, the letters **c, ch,** or **cc** will often hide a cognate. Thus, *caolino* is **ka**olin, *eccipiente* is e**x**cipient, and *chinino* is **qu**inine. In German, the letters **ch** will frequently become **qu**, as in *Chinaldin* (**qu**inaldine) and *Chinol* (**qu**inol). In French, **ch** is also sometimes equivalent to **qu**, as in *chinoline* (**qu**inoline).

The letter **k** does not exist in Italian, except in a handful of foreign words—mostly proper names. For example, one of the standard Italian dictionaries (*5*), somewhat like the French "Larousse," contains roughly 120,000 entries, but only about 50 of these appear under the letter **k**. Since **ch** in Italian is generally pronounced **k,** such Italian words as *chilometro* and *chilogramma* are cognate to the English words **k**ilometer and **k**ilogram.

Therefore, when confronted with a word containing the letters **ch**, one should mentally allow for the possibility that there is an English cognate where these letters will have changed to **qu** or **k**. As often as not, however, the English will also be written with **ch**, but then there is no problem because the cognate is overt and not hidden.

The combination **cl** or **cr** in Italian will often stand for **chl** or **chr** in English, as in *cloro* (**chl**orine) and *cromo* (**chr**omium).

Conversely, English words written with a **c** will often be cognate to German words written with a **k**, as in *kolloidal* (colloidal), *Koks* (coke) and *kalorisch* (caloric). German words ending in **cht** are generally cognate to English words ending in **ght**, as in *Licht* (li**ght**) and *Fracht* (frei**ght**).

The thing to remember, therefore, is that the letters **c, ch, qu, k,** and **gh** are to a large extent interchangeable, and when confronted with a word containing any of these consonants one should be mentally prepared for the change.

With regard to the letter **d**, in cognate words it corresponds to German **t** or **th**, as in *Tochter* (**d**aughter) and *Tod* (**d**eath). This latter example shows that, conversely, German **d** is sometimes cognate to English **th**, as also in *Bruder* (bro**th**er).

When faced with a foreign word containing the letter **f**, especially in Italian, the English cognate (if there is one) will immediately come to mind if the **f** is mentally changed to **ph**, as in *fenolo* (phenol), *asfalto* (asphalt), and a less obvious example, because it contains a double consonantal change, *canfora* (camphor). In cognate words, English **f** may also correspond to German **v**, which is understandable if one remembers that in German the letter **v** is pronounced **f**. Here are two examples: *Vater* (father), *vorwärts* (forward).

A single or double **g** in Italian will often give a clue to the English cognate when the **g** or **gg** is changed to **j** or **dj**, as in *getto* (jet) and *aggiustare* (adjust).

Although the letter **h** does exist in Italian, it exists only as an expedient in writing to differentiate between two words which are identical in pronunciation but dissimilar in meaning (as between *anno*, year, and *hanno*, they have), or else as part of a consonantal group such as **ch** or **cch**. In Italian, the letter **h** has no consonantal standing of its own. When it occurs by itself, other than in such cases as just illustrated, it is as part of a foreign word, proper name, or place name. The standard Italian dictionary mentioned earlier lists only about 80 words under the letter **h**. This therefore presents a problem since a large number of Italian words will be recognized as cognates only if an **h** is mentally added. First of all, there are all the words containing such radicals as **hydro** and **hypo**, which in Italian will appear as *idro* and *ipo*. For example, rather than reach for the dictionary, supply an **h** in such words as *alcool* (alcohol), *idrato* (hydrate), *iposulfato* (hyposulfate), *aldeide* (aldehyde), *idrolisi* (hydrolysis).

The last four examples conveniently bring us to the vowel **i**. In Italian, this vowel can probably hide more cognates than any other single letter. Since Italian does not have the letter **y** at all, countless Italian words with **i** are direct cognates to English words written with **y**. The example of *idrolisi* (hydrolysis) is especially revealing because both the first and second **i** change to **y**. The same is true of *idrossile* (hydroxyl). Here are two more examples of this change: *acetile* (acetyl), *amile* (amyl). Therefore, when an Italian word with an **i**, either at the beginning or in the middle of the word, is suspected of being a cognate, the assumption can often be turned to certainty by mentally substituting a **y** or **hy** for the **i**.

The letter **j** in English presents no problem in French to which it is cognate. Nor does it present a problem in Italian for the very good reason that it simply does not exist in that language. In German, however, the **j** is sometimes cognate to our **y** or **i**, as in *Jahr* (year), *Jodid* (iodide) and *Jon* (ion).

The letter **k** was discussed above in connection with **c**, **ch**, and **qu**, and the letter **l** is generally cognate in the foreign. **M** and **n**, however, are sometimes interchangeable when preceding **f** and **ph**. We have seen that the English cognate of the Italian word *canfora* is camphor. The same is true of French where, for example, the word *confort* is cognate to comfort.

The vowel **o**, notably in French and Italian, may be cognate to **u**, as in *fonction* (function) and *pompa* (pump).

In German, **pf** is cognate to English **p**, as in *Hopfen* (hops) and *Tropfen* (drops).

Since the letters **q** and **qu** have already been discussed and since the consonant **r** generally presents no problem, we now come to the letters **s**, **t**, and **z** which do.

In Italian, the double **ss** is almost always cognate to our **x**, as in *complesso* (complex), *ossido* (oxide), and *reflusso* (reflux). When it precedes **p**, the Italian **s** also becomes **x**, as in *espansione* (expansion). In German and French words containing the letter **s**, the **s** generally remains unchanged in the English cognates.

The letter **t** in Italian can also be an annoying but, as we shall see, transparent screen behind which a perfectly good English cognate will lurk, especially when one **t** combines forces with another. Take the word *ottano* (octane), or the words *elettrico* (electric), *effetto* (effect), *contatto* (contact). As is evident, the double **tt** becomes **ct**. Here is one case where it becomes **pt**: *settico* (septic).

Since the letter **h** in Italian is merely an auxiliary and does not have any standing of its own, it is reasonable to expect that English words with **th** will, when we meet them in Italian, have lost the **h** en route. Such Italian words will read like perfect English if the **h** is restored in its familiar place behind the **t**, as in *catodo* (cathode) and *metano* (methane), or, for those who prefer a somewhat more challenging mental exercise, here is an example of another double change: *etile* (ethyl), in which the **t** becomes **th** and the **i** becomes **y**.

The last example of vocalic and consonantal changes in Italian is the Italian name of a chemical compound which requires seven letter changes before it becomes recognizable in English, namely, *esaossicicloesane*. By restoring the two missing **h**'s, changing all the **s**'s to **x** and all the **i**'s to **y**, we finally get **hexaoxycyclohexane**, or, of course, hexahydroxycyclohexane.

In French and German, the letters **t** and **th** are a help rather than a hindrance in recognizing cognates, except that occasionally one will find an extra **h** after the **t** as a form of antiquated spelling in German, as in *Theil* for *Teil* (part).

The letter **z** is the last of the changes selected for illustration. Here, the difficulty is in connection with the **z** in German, which may become **c** or **s** in the English cognate, as in *Kalzium* (calcium) and *Zucker* (sugar).

Those who agree that translating is made easier if one becomes proficient at the game of "cognate-hunting" (or, if you prefer, at the practice of mnemonics) may find Table I of value. This table is far from complete. It is merely a guide and includes only some of the many possible vocalic and consonantal shifts which occur in German, French, and Italian words as compared to their English cognates. By and large, the letters listed will change only occasionally as indicated; where they do not change, the cognate letter is generally the same, and the word therefore presents no problem.

Table I. Table of Cognate Correspondences

German	French	Italian	English
b	..	....	v or f
		c	k or ch
		cc	xc
ch	ch	ch	k or qu
cht	..	....	ght
d	..	....	th
		f	ph
		g	j
		gg	dj
		i	y or hy
j	..	....	y or i
k	..	....	c
	n	n	m
	o	o	u
pf	..	....	p
		s or ss	x
		tt	ct or pt
t	..	....	d
v	..	....	f
w	..	....	b
z	..	....	c or s

Phonetic Versus Etymological Spelling. The reason for all these divergent spellings of cognate words in various languages is that some languages have adopted etymological spelling and others phonetic spelling. K. A. Jensen of Copenhagen dealt with this question in the paper which he delivered at the A.C.S. meeting in New York in 1951 (*1*). He rightfully pointed out that in the last century most philologists were of the opinion that the written language should, as far as possible, be a phonetic rendition of the spoken language. But since languages differ from one another in pronunciation, and since the phonetic value of a given letter is not always the same in different languages, the adoption of phonetic spelling has tended to isolate these languages from each other. An alternative to phonetic spelling, so certain modern philologists contend, is etymological spelling, in accordance with the derivation from a parent language, such as Latin or Greek. Phonetic spelling tends to vary from language to language, whereas etymological spelling will generally be constant. Most of the changes discussed above are due to the fact that cognates are spelled differently in various languages for phonetic reasons. Therefore, a very important asset to anyone who is called upon to translate from the foreign is a knowledge, however rudimentary, of how the words in the particular foreign language are pronounced. I would consequently recommend that those who are interested in translation spend some time familiarizing themselves with the pronunciation of the language from which they are translating.

False Friends

Now a word of caution which should dampen anyone's excessive enthusiasm for cognate-hunting. There are many words, especially in the Romance languages, the spelling of which so closely resembles that of certain English words that one may be tempted to translate them literally. Although similar in form, these words are frequently different in meaning, and the chances are against any passage being correctly translatable by simply substituting the apparent—but false—cognate. This is an important pitfall to avoid, and such "false friends," as professional translators call them, should never be taken at face value.

This problem is particularly acute when translating from French. A considerable number of French words have found a secure place in the English language in almost unchanged form. However, the meaning of some of these words has evolved along different lines, so that a word which crossed the English Channel at the end of the eleventh century, let us say, and had the same meaning on both sides of the water at that time, may have a different meaning today.

The phrase, "*cette **expérience** a été d'**intérêt**,*" contains two false friends. It does not necessarily mean "this experience was of interest," although in some contexts it may. In technical, and especially in chemical texts, it means, "this **experiment** was **useful**" or "this **experiment** was **of value**," or even "this was a **significant experiment**." Another example: "*Cette réaction a **pratiquement** donné du cuivre*" does not indicate that the "reaction practically yielded copper," but rather that it yielded copper "in practice," or more smoothly rendered, "this reaction **actually** yielded copper."

Another French word which should not always be translated literally, especially in technical texts, is the word ***important.*** In addition to its obvious abstract meaning of "important," it also has the concrete meaning of large or **substantial,** as in this example: "*Nous avons obtenu une quantité **imbortante** de l'acide,*" which should correctly be translated as, "we obtained a **substantial** quantity of the acid." Here are two more French words which should be carefully interpreted on the basis of the context: *une **lecture*** is not "a lecture," but a **reading.** ***Sans doute*** may mean "without doubt," but more often it means just the opposite, namely, **probably** or **perhaps.** You can readily see how a translation of the phrase, "*ne me dérangez pas!*" would be somewhat lacking in accuracy were it rendered as "do not derange me!" Translating from French presents many such pitfalls.

An example of a false friend in Italian is the expression, *temperatura **ambiente**,* which should not be translated as "ambient temperature," needless to say, but as "**room** temperature."

You will also encounter a number of false friends in German, although less frequently so. A few examples which may be regularly found in technical texts have been selected. The expression, *Technische **Hochschule,*** does not, all appearances to the contrary, mean "technical high school." It stands for "**institute** of technology" or "polytechnic **institute**." In German, a *Hochschule* is a **university**. Another false friend in German is one which all of us have warmly embraced at one time or another. I am referring to the word ***eventuell.*** Neither in its adjectival nor in its adverbial form does it mean "eventual" or "eventually." In German, this word denotes contingency in the sense of our own noun "eventuality." According to Webster, the corresponding

English adjective and adverb originally had the same meaning, but this meaning is now obsolete. In German, the word *eventuell* can variously mean, "if necessary," "in certain cases," or just "perhaps." Let me illustrate: "*Diese Ergebnisse werden **eventuell** veröffentlicht werden*" does not mean that the "results will eventually be published," but rather that they **may be** published or that they will "perhaps" be published.

The words ***neben*** and ***durch*** are two more examples which should not be taken at face value. Although ***neben*** can mean **next to, it** is often preferable to translate it as **in addition to.** The word ***durch*** may have to be translated as **through** in some contexts, but in others it is more properly rendered as **by** or **by means of.** Thus, ***durch Erhitzen*** is not "through heating," but **by heating.** ***Carbonsäure*** is another case in point. It is properly rendered as **carboxylic acid,** not "carbonic acid," which in German is *Kohlensäure*.

Prefixes and Suffixes

A less elusive subject is that of prefixes and suffixes. I have selected a few typical ones in German, French, and Italian, and shall indicate their English equivalents, which may sometimes be cognate, but just as frequently not.

In German, the prefix ***unter-*** often becomes **hypo-, sub-,** or **infra-,** in addition to the more obvious **under-,** as in the following examples: ***unter**phosphorig* (**hypo**phosphoric), ***Unter**einheit* (**sub**unit), and ***unter**belichten* (**under**expose). The antonymic prefix ***über-*** can become **per-, super-** (or **supra-**), **hyper-,** and **ultra-,** in addition to **over-.** Sometimes, it must be rendered by the word, **excess**: ***Über**oxyd* (**per**oxide), ***über**-basisch* (**super**basic), ***über**elastisch* (**hyper**elastic), ***Über**mikrometer* (**ultra**micrometer), ***über**laufen* (**over**flow or flow **over**), ***Über**hitze* (**excess** heat).

A useful rule to remember is that, generally but by no means always, ***über*** in chemical compounds is **per-** and in verbs **over-.** Conversely, ***unter-*** is **hypo-** in chemical compounds and **under-** in verbs.

The French and Italian prefixes corresponding to those mentioned are fairly easy to identify and need not be discussed. The same is true of the Romance-language suffixes ***-able, -ible,*** and ***-uble*** (in French) and ***-abile, -ibile,*** and ***-ivile*** (in Italian). These correspond to the German suffix ***-bar,*** which, in English, is generally **-able, -ible,** or **-uble.** For example, German *halt**bar*** equals French *st**able*** and Italian *st**abile*** (English: st**able**).

The corresponding nouns—that is, those which in English end in **-ity** (e. **g.**, stabil**ity**)—as a rule have the following endings in the other three languages: German, ***-keit*** (as in, *Beständig**keit***); French, ***-ité*** (as in, *stabil**ité***); and Italian, ***-ità*** (as in, *stabil**ità***.

A chemical suffix which may be difficult to equate is ***-ure*** in French and ***-uro*** in Italian. These suffixes denote a salt and are rendered as **-ide** in English—e.g., *chlor**ure*** or *clor**uro*** is chlor**ide**.

In the introduction to his invaluable "French-English Dictionary for Chemists" (3), Austin M. Patterson mentions some very helpful hints for the translation of organic compounds from French, where the prefix or suffix is the key to the correct translation. They are quoted here, with his kind permission, because as a rule they also apply to Italian.

1. Translate *oxy-* by **hydroxy-** when it designates hydroxyl, as is commonly the case in organic names. When *oxy-* designates the ketonic group (CO) it is preferably translated **oxo-** or **keto-**.
2. Translate names of compounds the chief function of which is alcoholic or phenolic so that the name ends in **-ol**; as, glycerol, resorcinol, mannitol, pinacol (not pinacone).
3. When the French ending *-ol* does not indicate hydroxyl it should be translated **-ole** (as, anisole, indole), or in the case of a few hydrocarbons **-ene** (as *benzol*, benzene; *toluol*, toluene; *styrol*, styrene).

4. The ending *-ine* or *-in* should be translated **-ine** in the case of basic substances and **-in** elsewhere; as, aniline, glycine, palmitin, albumin. Exceptions are *benzine* (meaning benzene) and the names of alcohols and phenols [see (*3*)].

5. The form *amido-* should be so translated only when it denotes combination with an acid group. Usually it is to be translated **amino-**; as, *acide amidoproprionique*, aminoproprionic acid; *amidophénol*, aminophenol. The same holds for imido-, anilido-, etc.

6. In such combining forms as bromo-, cyano-, chloro-, nitro-, etc., when they denote substituting radicals, the connective **o** is to be used invariably; as *chlorobenzène* or *chlorbenzène*, chlorobenzene; *acide chloracétique*, chloroacetic acid. This usage is by no means universal, but those who cannot reconcile themselves to such spellings as "bromoacetic" should at least avoid the German forms bromphenol, acetphenitidine, etc., by using the connective **o** before consonants. (French literature does not contain so many of these objectionable forms as does the German.)

7. The French ending *-ane* should be translated **-ane** if it is the name of a hydrocarbon (or parent heterocyclic compound) which is fully saturated; otherwise, **-an.** Examples: methane, menthane, tolan, furan, pentosan.

8. Names of acids ending in *-carbonique* are translated **-carboxylic,** not -carbonic.

Miscellaneous

Inversions. We now come to the question of inversions, which are characteristic of French and Italian, and which may present somewhat of a problem. Although in German the adjective generally precedes the noun, as is usually the case in English, this is not true of French and Italian where, as a rule, the adjective follows. Here are some examples: *une solution **concentrée*** (a **concentrated** solution), *acide **nitrique*** (**nitric** acid), *nel campo **speciale*** (in the **special** field), *carbonato **sodico*** (**sodium** caronate), etc.

From where the English translator sits, French and Italian invert the words in chemical compounds, occasionally connecting them with the preposition **of**—i. e., *di* in Italian and *de* in French. By reading them in inverted sequence, and forgetting about the preposition, the English equivalent immediately becomes apparent. For example, *bromure **de** calcium* (calcium bromide), *acide **de** tartre* (tartaric acid), *acetato **di** alluminio* (aluminum acetate), *bagno **di** olio* (oil bath), etc. In certain cases, however, the cognate is not as easily detected, even after the inversion has been mentally made. Thus, *acide chlor**hydrique*** (**hydro**chloric acid), *aldeide **formica*** (**form**aldehyde). By locating the **hydro** radical—or, as a colleague once put it, "looking for the hidden water"—in the foreign name of the compound, one will often be able to translate it at a glance.

The fact that the French and Italians call sodium chloride *chlorure de sodium* and *cloruro di sodio* explains why one will occasionally find equations where NaCl appears as ClNa. This is true of so many compounds that some chemical equations in French and Italian often look as if someone just jumbled all the chemical symbols.

Another thing worth remembering is that when an adjective following two or more nouns is in the plural, it applies to all the nouns and, in English, should therefore precede all the nouns, not just the last. For example, "*à une température et une pression élevées*" means "at a **high** temperature and pressure." Likewise, "*acido nitrico, sulfurico e idrofluorico **concentrati***" means "**concentrated** nitric, sulfuric, and hydrofluoric acids."

Such inversions as generally occur in French and Italian may occasionally also occur in German, especially in a composite word designating a chemical compound in which the basic element is at the end. When translated, the elements must be inverted, as in *Kohlen**wasserstoff*** (**hydro**carbon), *Tetrachlor**kohlenstoff*** (**carbon** tetrachloride), *Schwefel**kohlenstoff*** (**carbon** disulfide), *Chlor**wasserstoff*** (**hydrogen** chloride), etc.

Inversions such as the above also extend to dates. When, in a foreign text, you see 6.2.52, what is meant is February 6, 1952, not June 2, 1952.

Compound Words. At this point I cannot escape mentioning a few basic characteristics of German compound nouns and compound verbs. As you know, German—especially scientific German—has many compound nouns. Since their number is practically unlimited and since most are not listed in dictionaries, translators find it helpful to remember the basic words in the compound noun rather than the compound noun itself.

The question of German compound verbs is not quite as simple. Many of them are formed by a simple verb with a prefix, as for example *dampfen* (to steam) and ***verdampfen*** (to evaporate). Some of these compound verbs are separable and some are inseparable—that is, in the case of the latter the prefix is not separated from its basic verb, while in the case of the former it often is. In ordinary sentences containing separable verbs, the prefix appears at the end, as for example in *Der Inhalt siedet* ***über*** (the content is boiling over), *Der Schwefel nimmt an der Reaktion* ***teil*** (the sulfur participates in the reaction), etc. In subordinate clauses, however, verb and prefix reunite at the end of the sentence, as for example in *Der Verfasser berichtet dass der Schwefel an der Reaktion* ***teilnimmt*** (the author reports that the sulfur participates in the reaction).

Here I should like to draw your attention to an important warning. Very often a compound verb in German will have a different meaning than the basic verb in the compound. Before beginning to translate, therefore, one should always look at the end of the sentence or clause to see whether there is a prefix, as the prefix may determine the meaning. For example, in the sentence, *Die Temperatur nahm im Gefäss* ***ab*** (or ***zu***), there is no way of knowing whether the temperature **de**creased or **in**creased if one does not read to the end of the sentence. A somewhat similar phenomenon also exists in English, where compound verbs may have different meanings, depending on where the verbal component is placed with reference to the preposition. Thus, "to **over**sleep" is hardly the same thing as "to sleep **over**" and "to look something **over**" is definitely not the same thing as "to **over**look it."

Position of Verb. A few words about the position of the verb in German sentences might be in order here. The verb does not occur at the end of the sentence quite as persistently as Mark Twain would have us believe. Of course, when it does occur at the end of the sentence, it is often flanked by two or more verbal assistants, especially where the sentence has a number of subordinate clauses. What is generally not realized is that if the sentence begins with the subject, the position of the verb is the same as in English: *Das Gas* ***strömte*** *aus dem R¨hrchen* (the gas flowed out of the tube). If the sentence does not begin with the subject, the verb comes immediately before the subject: *Im Versuch* ***strömte*** *das Gas aus dem Röhrchen* (in the experiment the gas flowed out of the tube). A notable exception to this rule is that in subordinate clauses the verb appears at the end of the sentence: *Der Verfasser sah das Gas aus dem Röhrchen* ***strömen*** (the author saw the gas flow out of the tube).

Demonstrative Pronoun. In all the three languages here discussed, a sentence may often begin with a demonstrative pronoun referring to one or several nouns in the previous sentence. These pronouns (*dieser*, *diese*, or *dieses* in German; *celui-ci*, *celle-ci*, or *ceux-ci* in French; and *questo*, *questa*, or *questi* in Italian), whether in their masculine or feminine form, translate as either **this** or **these,** since the English pronoun does not have the corresponding genders. Therefore, unless it is perfectly clear which principal of the previous sentence is meant in English, it is often preferable to replace the pronoun by the actual noun or nouns to which the foreign pronoun refers.

Accents. Accents in French and Italian, as well as in other languages, often have more than a phonetic function. In German, the umlaut is not an accent but a diacritical mark which changes the vowel over which it appears. Certain words will have different meanings depending on whether they are written with or without accent or umlaut. Here are a few examples.

In German, the verb *fordern* means **to demand** or **to claim**; with the umlaut—i.e., *fördern*—it is an entirely different word meaning either **to promote** or **to convey**.

In French, the noun *cote* means **quota** or **quotation**; with the circumflex accent—i. e., *côte*—it means **slope, coast,** or **rib**; if in addition to the circumflex accent over the *o* there is also an acute accent over the *e*—i. e., *côté*—the word means **side.** The word ***ou*** without an accent is the conjunction **or**, and with an accent—i. e.,—*où.* it is the adverb **where.** In Italian, the letter ***e*** without an accent means **and**; with a grave accent—i. e.—*è*, it is the verbal form of "to be" and means **is.**

The Decimal Point. The decimal point in almost all foreign languages is not a period but a comma. When a German, French, or Italian chemist writes that he added *18,050* grams to a solution in a test tube, he does not mean that "eighteen thousand and fifty" grams were added, but that **18.050** were added; conversely, where we use a comma to set off every thousand group in a figure, the foreign language will generally use a period. Thus, *18.050* grams is not eighteen grams and fifty milligrams, but **18,050** grams. Sometimes, the custom is to use no punctuation at all to set off each thousand group, but merely to leave a space: *18 050.* In some German texts one may find a raised period to indicate the division—i.e., *18·050.*

The Percentage Sign. The percentage sign in the foreign is generally the same as in English—i. e., % or, as acceptable variants, *per* 100, *pour cent, per cento* or even *o/o.* None of these present any particular problem, but what does are such signs as *o/oo* and *o/oo* to indicate **per mill.** In such cases, it is often desirable to convert into **per cent.** For example, *Abbiamo usato soluzioni al 1%o e al 1o/oo* (or *1 o/oo*) *dei sali,* should preferably be rendered as "We have used **1%** and **0.1%** solutions of the salts." Therefore, *1o/oo* should be converted to 0.1% and *1o/ooo* to 0.01%.

Abbreviations. We now come to the problem of foreign abbreviations, and a considerable problem it is, because the abbreviations used are sometimes of the author's own invention (in which case, the best we can hope for is that the context will indicate what they represent), and they may be of a local nature (either limited to a fairly small geographical area, or to a rather restricted field or industry).

When abbreviations consist of several captial letters, one should mentally be prepared to invert the letters, as this may occasionally provide a clue. Thus *DML* —i. e., *dose minima letale*—is MLD (minimum lethal dose); *S.N.C.*—i. e., *système nerveux central*) is C.N.S. (central nervous system); etc. Foreign authors do not appear to adhere to any uniform or standard set of abbreviations for weights and measures. French and Italian texts present the most flagrant evidence of this lack of uniformity. Thus, to indicate cubic centimeters (cc.), we may find such a variety of abbreviations as *cm^3, ccm., cc.m., cm. cube* (or *cm. cubico*), *%m^3*, and occasionally even *cc.* The varieties of abbreviations for milligram (mg.) reflect an even more fertile imagination. At one time or another I have encountered: *mm.g., mm.G., mmg., mmG., mmgr., mmGr., mm/G., G/mm* (which should indicate "grams per millimeter," but not always does), and even *o/oo g.* Where there are several possibilities, the context will have to be relied upon to determine the correct meaning of the abbreviation. An interesting set of abbreviations, found in German, is ***Jato*** for *Jahrestonnen* (tons per year); ***Moto*** for *Monatstonnen* (tons per month); and ***Tato*** for *Tagestonnen* (tons per day).

This completes my brief outline of the problems involved in technical translation. It is very incomplete, even as an outline. But the best I could hope to do was to present some of the highlights, and to offer a few practical suggestions.

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Transfer of Language Training from German (And English) to Swedish

ERNST VAN HAAGEN

126 East 31st St., New York 16, N. Y.

Chemical literacy in German and English can be extended to include Swedish with the aid of a remarkably small amount of additional information; without this, however, very simple Swedish sentences would be unintelligible. An attempt is made to present this information in useful form, so that Swedish chemical literature can be read immediately with tolerable speed and comprehension and without excessive dictionary work. There are only some hundreds of Swedish words not readily intelligible, in context, from the point of view of German and English, and only a few of these are of high frequency. Swedish grammar embodies only two principles foreign to English and German. A specimen passage illustrates practical procedure. Applications to the other Scandinavian and Germanic languages, and to other groups of languages, are suggested. The literature chemist, where his work renders this desirable, can become effectively polyglot for purposes of reading comprehension.

The training that technical people have in their own language and usually in one or more foreign languages can be transferred with great ease to still other foreign languages for searching and reading the literature. English is favorably placed, in that it will serve as one point of reference for either the Romance or the Germanic group of European languages. Add another point of reference—say, German or French—and we can find our bearings throughout the group to which it belongs.

A region that can be navigated very successfully by triangulation on English and German is the literature of Denmark, Norway, and Sweden, which together form a linguistic province of great homogeneity. This area is covered today by a carpet of dialects each differing minutely from its neighbor regardless of national boundaries, and all descended from Old Norse, or substantially Icelandic. In modern times these dialects have produced two great literary languages, Swedish and Danish-Norwegian. They differ, to the foreign eye, chiefly in spelling habits. Since about 1900, standard Danish and standard Norwegian have become slightly differentiated from each other. To read any one of these languages even slightly is to read the other two at least as well. Their vocabulary and grammar offer little that is wholly alien to German and English.

Swedish Literature

The process of transfer of language training is well illustrated by Swedish. Sweden is producing a significant chemical literature, notably in the fields of wood, paper, electrolysis, power, and metallurgy. Swedish patents command widespread interest. Swedish is an important auxiliary language in Finland, which publishes a number of Swedish-language periodicals.

Pronunciation. For purposes of reading comprehension, it is convenient to pronounce the Swedish letters *C*, *V*, and *Z* as in English; *Å* like English *awe;* *Y* like German *ü;* and all other letters substantially as in German.

Stress follows the same principles as in German, falling usually on the first and sometimes on the second syllable, and on the last syllable of words from the French and Latin. Many French words are recognizable only by sound and not by spelling—for example, koaffyr = coiffure; to identify such cases, the final syllable should be stressed and the letters *ch*, *g*, and *j* pronounced as in French.

Spelling. Changes in Swedish spelling have occurred at various times, notably substitution of *v* for *fv* and *f*, and of *t* or *tt* for *dt;* and omission of initial *h* before consonants. There has also been some tendency towards interchanging *ä* and *e*. In reading older literature, or using older dictionaries, words must accordingly be sought in several different alphabetical places.

Specimen Passage. The first part of the following specimen passage has been interlineated with German clues and an English translation. Dashes (-) mark elements best understood directly through English; asterisks (*), initial letters of elements to be found in the special Swedish-English glossary below; and daggers (†), terminations explained in the section on grammar.

Försök till en Chemisk Nomenclatur
Versuch * ein- - -
Essay towards a Chemical Nomenclature

På en tid då hvarje språk dels öfversätter dels
*** einer Zeit da * Sprache teils übersetzt teils**
At a time when each language is in part translating, in part

sjelf bildar nya vetenskaps- och konst-benämning-
selbst bildet neue Wissenschafts- * Kunst- Benennung-
itself forming new scientific and technical terminolo-

ar, enliga med dess eget lynne, torde företaget att
en einlich mit dess eigen Laune * Vor-(nahme)† *
gies, according to its own whim, the project of estab-

åter upställa en Latinsk Chemisk Nomenclatur synas
achter aufstellen ein- - - - * †
lishing anew a Latin Chemical Nomenclature might seem

onyttigt. Emedlertid är det en sanning att veten-
unnützig in-mittler-zeit * das eine * * Wissen-
futile. Nevertheless, it is a fact that the develop-

skapernas odling i allmänhet måste aftaga i mån som
schaften † * in Allgemeinheit mußte ab(nehmen) in * *
ment of the sciences at large was bound to diminish insofar

särskildta Länders vetenskapsidkare skilja sig ifrån
*** Länder † Wissenschafts- * * sich ***
as scientists in different countries have drawn apart from

hvarandra i språkgemenskap. Utom svårigheten att
*** in Sprachgemeinschaft * Schwierigkeit † ***
one another in unity of language. Apart from the difficulty

förstå särskildta tungomål, orsakas deraf en obe-
verstehen * Zunge-Maüle ursacht † - eine Unbe-
of understanding diverse tongues, this causes an indef-

stämdhet i termer, som föder mer eller mindre be-
stimmtheit - * * mehr * minder be-
initeness in terms that gives rise to more or less

tydliga och för vetenskapernas framsteg skadliga
deutliche * für * -Steg schädliche
serious mistakes, detrimental to the progress of the

misstag. Jag önskar vist icke att den tid må återkom-
- * **wünsche gewiß** * * **Zeit mag achterkom-**
sciences. I do not of course wish for a return to the time

ma då de lärda i sina skrifter allenast nyttjade La-
men da die Gelehrten in (ihren) Schriften alleinst benutzten -
when scholars, in their writings, exclusively employed the

tinska språket, hvilket, under det sambandet dem emellan derigenom
welches(währenddem) * - * * *
Latin language, which, while communication among them thereby

lättades, altid betog almänheten begagnandet af deras arbeten och gjor-
leicht-† - * *
de deras kunskaper till ett slags Monopolium för dem. Vetenskaperna

gagna människoslägtet blott i mån som deras resultater blifva almänt
*

fattliga och kunna uttryckas på ett för mängden begripligt sätt; men
* *

äfven de lärde behöfva, oaktat de nyttja sina särskildta språk, i hvarje
unbeachtet *
vetenskap vissa almänt kända benämningar, till hvilka olika språks ve-
gewisse **ungleiche**
tenskaps-termer kunna hänföras, och till sådana allmänna benämningar
*

är intet språk tjenligare än det Latinska: Utan den sådan almän Nomen-
* **dienlicher**
clatur blifva alla termer snart obestämda, osäkra och olika tillämpade
* *

af särskilda författare.

This passage is from an article published in 1812 by Berzelius, the celebrated Swedish chemist responsible for many features of our present nomenclature and notation. The article bears the title "Försök till en Chemisk Nomenclatur," in which *försök* is identifiable with German *Versuch. Till* is the same word as in English, but rather in the sense of "to" or "towards." The other words are obvious, but *Chemisk* and *Nomenclatur* would today be spelled with *k* instead of *ch* and *c*.

Proceeding to the text, we read "På en tid då hvarje språk..." The preposition *på* is conspicuous as a peculiarity of the Scandinavian languages; it may conveniently be read as English *'pon* or *upon.* The word *en* is known from the title as the masculine-feminine indefinite article, German *ein(e)*; the neuter form, by the way, is *ett. Tid* is recognized as German *Zeit* or English *tide.* So far, then, we have "På en tid...," "Upon a time..." The next word, *då*, is to be read as German *da*, in this context logically "when." As in the case of "På," the asterisk under "hvarje" indicates that this word can be found by consulting the special glossary of simple Swedish words not sufficiently similar to German or English equivalents to be readily understandable in context. In the glossary, however, the only entry under *hv-* is "(see *v*-)." Initial *h* before *l* and *v* is obsolete. Looking accordingly under *varje* without the *h*, we find "each." The next word, *språk*, is evidently German *Sprache.* This completes the phrase as "At a time when each language..."

The text continues "...dels öfversätter dels sjelf bildar...," readily suggesting "...teils übersetzt teils selbst bildet...," which is tolerable German for "...partly translates partly itself forms..." The *-r* of *öfversätter* and *bildar* is the characteristic ending of the present singular. Proceeding, *och* is cognate with German *auch* and archaic English *eke*, but more often means "and"; as in this case. Terminal *-r* in nouns, as in *benämningar*, is the commonest sign of the plural. Rereading, "På en tid då hvarje språk dels öfversätter dels sjelf bildar nya vetenskaps och konst-benämningar": "At a time when each language is in part translating, in part itself forming new scientific and technical terminologies..."

"...enliga med dess eget lynne..." *Enliga* suggests *einlich*, which is not good German but in turn contextually suggests its meaning "according to," though perhaps not until the rest of the phrase has been deciphered. *Eget* is to its more recognizable masculine-femine form *egen* as the neuter indefinite article *ett* is to *en. Lynne* might be recognizable as German *Laune,* not a common word in chemical literature; the dictionary (*4*) may have to supplement intuition and the Glossary. We have ". . .according to its own whim, . . ."

Reading on until the easy words outnumber the hard ones, ". . .torde företaget att åter uppställa en Latinsk Chemisk Nomenclatur synas oynttigt." That is the end of the sentence. *Torde* is found in the glossary as "would, should." If we recognize the first part of *företaget* as *fore* and the second part as *take,* and translate *fore-take* literally into German as *Vornehmen,* we get "undertaking" or "project." The dagger under the final *-t* of "*företaget*" calls for reference to the notes on grammar. A seemingly unnecessary syllable involving *n* or *t* at the end of a Scandinavian noun usually represents the definite article. This is one of the two conspicuous peculiarities in the structure of North Germanic languages. *Företaget* therefore means "the project." Just plain "project" would be "*företag*"; "projects," also *företag;* and "the projects," *företagen.*

The next word, *att,* is the preposition *to* with the infinitive, and "att åter uppställa" is a split infinitive. Even today, the Swedes do not object to this. *Åter* reminds one of "after" but here amounts to "again": "to again set up."

The remaining difficulty is *synas,* at the end of the line, where the dagger again refers us to the section on grammar—for the last time. An *-s* at the end of a Scandinavian verb form marks the passive. This is the other major departure of Swedish from German and English grammar, which has no simple passive. *Synas* can thus be read as "to be seen" or "to seem." However, the active verb *syna* does not apply; the passive infinitive *synas* is listed in the glossary as meaning "seem." In this sentence, it goes with *torde:* ". . .torde företaget. . .synas onyttigt," "the project of setting up anew a Latin chemical nomenclature might seem futile." Berzelius' capitalization is capricious, like that of English in 1812; a transitional stage between the usage preserved in German and our own. Present-day Swedish keeps capitals to a minimum.

Archaism versus modernism does not ordinarily present a problem. A certain Scandinavian tendency towards chronic spelling reform has not obscured the close relationship of the languages to English and German, nor has it made them more difficult to read from the present point of view. Variant spellings cause some trouble in the use of dictionaries. Usually one of the obvious ways of respelling a word without substantially changing its apparent sound will lead to success in these cases. Each successful solution is likely to prove the key to other words in the same or different texts. The salient points for Swedish are covered in the remark on spelling. They are typical of the behavior of Norwegian and Danish also.

To continue the reading: "Emedlertid är det en sanning att vetenskapernas odling i allmänhet måste aftaga i mån som särskildta Länders vetenskapsidkare skilja sig ifrån hvarandra i språkgemenskap." *Emedlertid* is today spelled with *ll* instead of *ld,* and appears thus in the Glossary. It suggests *in-mittler-zeit,* which suggests its meaning, "however." *Är* means *is.* *Sanning* is the general Scandinavian word for "truth." *Att* is this time the conjunctive "that." *Vetenskapernas: vetenskap* "science," *vetenskaper* "sciences," *vetenskaperna* "the sciences," *vetenskapernas* "of the sciences." All noun forms, singular or plural, definite or indefinite, make the possessive by adding *-s.* *Odling:* the glossary gives *odla,* "cultivate"; hence "cultivation," "development." *I* is the preposition "in." *Allmänhet* illustrates the fact that the German prefix or infix *-ge-* is generally missing in Scandinavian cognates. In *aftaga,* we must again recognize *taga* as "take" (or find it in the glossary) and translate into German *abnehmen* to arrive at "decrease." The glossary gives *mån* "degree, extent" and *som* "as"; *i mån som* "in so far as." *Särskildt:* glossary, *sär-* "apart," *skil-* "differ"; hence "various." *Länders: land* country, *länder countries, länders* "of countries"; "of various countries." *Vetenskapsidkare:* The question is whether the second member is *sidkare* or *idkare,* since the *-s-* may or may not be part of *vetenskap(s),* as in German compound words. Trying both *sidkare* and *idkare* in the glossary or in the dictionary if that were necessary, we find only *idka* "carry on"; hence "carriers-on of science"—i.e., scientists. *Skilja:* "differ" again. *Ifrån* appears in the glossary as "from"; literally "in-from"; the Scandinavian languages are rich in compound prepositions in which the first element often seems to contribute little to the meaning. *Hvarandra: hvar* (or *var*) "each" as before, making "each other." "Nevertheless, it is a fact that the development of the sciences at large was bound to diminish in so far as scientists in different countries have drawn apart from one another in unity of language." Some liberties have been taken in translation to gloss over the seeming contradiction of "differing in community"; the contradiction vanishes in the Swedish if *skilja sig* is taken more literally as German *scheiden sich* instead of *unterscheiden sich.* Incidentally, *skilja sig* amounts to much the same as the passive form *skiljas*, "are separated"; the *-s* of the passive ending may very conveniently always be read as German *sich* for ease of comprehension.

Merely touching on some of the points of interest in the next sentence: "Utom svårigheten att förstå särskildta tungomål, orsakas deraf en obestämadhet i termer, som föder mer eller mindre betydliga och för vetenskapernas framsteg skadliga misstag. Jag önskar. . ." It is necessary to read words by trial with the stress on different syllables to find the form intelligible to the ear; *för'stå* suggests "first," which makes poor sense, but *för-stå'* suggests *verstehen*, which is right. Incidentally, the letter *å* represented by circled *A* is not found in unstressed syllables. *Orsakas: ursacht sich = wird verursacht* = is caused. *Deraf:* "thereof" = thereby. *Som:* the glossary gives "as; who, which, that"; "as" suffices for reading with the aid of the Cockney idiom "the book as I was reading of." Perhaps most Scandinavian relative clauses are so constructed, with the preposition, if any, duly at the end. *Framsteg: fram* (glossary) "forth"; *fort-steg = Fortschritt. Önskar:* German initial *w-* usually becomes *v-* but vanishes entirely before *o, u* and their umlauts *ö, y.*

Grammar. Endings of Nouns. The ending of a noun in the plural may be *-or, -ar, -er, -n,* or the same as in the singular, with or without vowel change.

The definite article takes the form of a suffix added to the singular or plural of the noun. This suffix is *-en* or *-n* in the masculine-feminine singular, *-et* or *-t* in the neuter singular, and *-na* (rarely *-ne*) in the plural (*-a* if the plural already ends in *n*).

Before an adjective, there may be a detached definite article of the familiar sort. Its forms are *den* in the masculine-feminine singular, *det* in the neuter singular, *de* in the plural.

The possessive of any form of a noun, singular or plural, definite or indefinite, is made by adding *s*. The following is an example of the eight possible forms of a noun:

kemist	chemist
kemister	chemists
kemisten	the chemist
kemisterna	the chemists
kemists	chemist's
kemisters	chemists'
kemistens	the chemist's
kemisternas	the chemists'

Endings of Verbs. The following are the usual endings of verbs, with the conjugation of *kalla* "to call" as an example:

		Active	Passive
Infinitive	-a	kalla	kallas
Present singular	-r	kallar	kallas
Present plural	-a	kalla	kallas
Past singular	-(d)de, -(t)te, —	kallade	kallades
Past plural	-(d)de, -(t)te, -o	kallade	kallades
Present participle	-nde	kallande	
Past part., masc.-fem. sing.	-(d)d, -t, -n	kallad	kallats (been called)
Neuter singular	-(t)t	kallat	
Plural and/or def.	-(d)da, -de, -ta, -na	kallade	
Subjunctive	-e	kalle	kalles

Practically any form of any verb can be made passive by addition of *s*. Before this *s*, the *r* of the present singular drops out; an *e* preceding this *r* may also be dropped. Compound tenses are formed with auxiliary verbs much as in German and in English.

Special Swedish-English Glossary

Simple Swedish words not sufficiently similar to German or English equivalents to be readily understandable in context. In the Swedish alphabet, the letters *Å*, *Ä*, *Ö* follow *Z* in the order named, and are not to be found under *A*, *O*.

A

A.B. (*a*ktie*b*olag)	Inc.
aderton	eighteen
aldrig	never
allvar	seriousness
alst(e)r-	produc-
alv	subsoil
amper	pungent
and-	breath; spirit, mind
andr-	second; other
ang. (*ang*ående)	*re*
ann-	other; second
antingen	whether, either
ark	sheet of paper etc.(cf. G. *Bogen*)
arvode	remuneration
ask	**box**
a.st. (*a*nförda *st*ället)	loc. cit.
att	to, that
av(e)l-	breed, etc.
ax	spike

B

back	slope; ground
bära	(if) only (cf. E. bare)
barn	child (cf. E. bairn)
barr	(pine) needle
bas-	whip; singe; run
be(dj-)	ask
beck	pitch (cf. G. Pech)
belamra	encumber
belåten	contented
berama	arrange
besk	bitter
beskärm-	lament-
bet-	steep, mordant
bil	automobile
bill	(plow)share
bisam	musk
bjugg	barley
björn	bear (G. *Bär*)
black	dark
bl.a. (*bl*and *a*nnat)	i. a.
bland	among
bli	become, be
blid	mild
bliva =	*bli*
blivande	future
bloss-	flare (E. *blush*)
blund	wink
bläck	ink
blöja	bib
blöt	wet
bo	dwell
bod	store
bogsera	tug, tow
boja	bond
bolag	company
bolma	emit smoke
bomolja	bottlenose oil
borde	ought
boricka	donkey
bort	ought; away (cf. G. *fort*)
borta	keep (be) away
boss	chaff
bot	cure, penance
brist	lack
bro	bridge
bror	brother, friend
brosk	cartilage
brunst	oestr-
bryn	verge, brow
bråd	sudden
bräss	thymus
brätte	brim
bulvan	decoy, dummy
by	village; gust
byk	laundry
byta	(ex)change
bål	torso; thallus
bås	compartment
båta	avail (cf. E. boot)
bägge	both
böra	ought (inf.)
börja-	begin

C

cederolja	cedarwood oil
cedroolja	oil of citron

D

damm	dust
dana	to form
den, det, de	the
di-	suckl-
digna	sag
dimma	mist
dis	haze
dit	thither
ditåt	thitherward
djärv	bold
djup	deep
djur	animal (G. *Tier*, E. *deer*)
docka	doll
dog	died (see *dö*)
dok	veil
dold	hidden (see *dölja*)
dom	judgment (cf. *doma*)
domkraft	jack
domna	subside
drack	drank
dricka	drink
drista sig	dare
drott, drottning	king, queen
drucken	drunk
drunkna	drown
dryck	beverage
dryfta	discuss
dryg	swollen

dräpa	kill
drätsel	finance
dröja	lag, take time
-dubbel	-plicate
d.v.s.	(*d*et *v*ill *s*äga) i.e.
dygn	period of 24 hours
dy	mud
dålig	bad
dädan	thence
där-	there-
därest	if
dö, död	die, dead
dölja	conceal
döma	judge (cf. E. *deem*)

E

eder, edert, edra	your
eho	whoever
ehuru	although
ej	not
e.Kr.	(*e*fter *Kr*istus) A.D.
el	electr-
eld	fire
eljes(t)	otherwise, else
eller	or
e.m.	(*e*fter*m*iddagen) p.m.
emedan	because
emellan	between, among
emellertid	however
emot	against
enahanda	= G. *einerlei*
enda(st)	only
endera	either (m. & f.)
enkel	single, simple
enkom	expressly
enskild	private
enstaka	separate
enträgen	urgent
enär	whereas
e.o.	(*e*xtra*o*rdinarie) special
er, ert, era	your
erbjuda	offer
erkänsla	gratitude
ernå	attain
esomoftast	now & then
ett	a, an, one (n. of *en*)
ettdera	either (n.)
evad	whatever
evar	wherever

F

far	father
fartyg	vessel, ship
fast	fast, nearly, though
fasthellre, fastmera	far rather
fastän	although
fattig	poor
f.d. (*f*ör*d*om)	formerly
fem	five
femtio	fifty
femton	fifteen
ficka	pocket
fick, fingo	got (see *få*)
finkelolja	fusel oil, potato oil, amyl alcohol
fjol, fjolår, fjor	yesteryear
fjorton	fourteen
fjäll	mountain; scale
fjärde	fourth
fjäril	butterfly, moth
f.Kr. (*f*ör *Kr*istus)	B.C.
fler	more, several
flesta	most
flicka	girl
flor	gauze; mourning
flott	grease
fläsk	pork
flöts	seam (geol.)
f.m. (*f*ör*m*iddagen)	a.m.
f.n. (*f*ör *n*ärvarande)	pro tem.
f.o.m. (*f*rån *o*ch *m*ed)	from...incl.
fors	waterfall
fradga	froth
fram	forth, forward (= G. *vor*, *hervor*, *her*)
fredag	Friday
frejd	repute
fresta	tempt
fridag	holiday
frk. (fröken)	Miss
från	from
från och med	= *f.o.m.*
frälsa	save
frö	seed
ful	ugly (cf. E. *foul*)
fyra	four
fyrtio	forty
få	few
få	get (modal auxiliary verb; to be interpreted as English *get*, esp. in colloq. senses)
fådd, fången, fått	got
får	sheep
färre	fewer (see *få*)
f.ö. (för övrigt)	furthermore
föda	give birth to
föga	little
för	for, to; too
försvar	defence
förutan	without
förutom	besides, except
förvanska	corrupt
förvåna	surprise

G

gagat	jet (mineral)
gagna	benefit
galler	grating
gam	vulture
gammal	old
gata	street
gen	near
genast	at once
genom	through
gentemot	opposite
gifta	marry
gick, gingo	went (*gå*)
gjord	done, made
glugg	opening
glömma	forget

gnist-	spark; radio
gno	scrub
golv	floor
gran	spruce, fir
grann-	neighbor
granska	examine
gredelin	violet
gren	branch
groda	frog
grumla	turbidity, etc.
grus	gravel
gry	to dawn
gråta	weep (cf. N. Engl. *greet*)
grädda	bake, fry
gränsle	astride
gul	yellow
gunga	swing
gång	time (= G. *mal*)
går(dag)	yesterday
gäng-	(screw)thread
gärning	act, deed
göda	fertilize
gömma	conceal
göra	do, make; business

H

haft	had
haka	chin; hook
hal	slippery
hamn	harbor
han; hans	he, him; his
hane	male
hann	(past of *hinna*)
har	have, has
harm	resentment
hav	sea
heder	honor
hejd	restraint
heller	either
hellre	rather (comp. of *gärna*)
helst	especially (superl. of *gärna*)
henne	her, hers
hinna	reach, accomplish, have time
hit	hither
hitta	find
hjul	wheel
hl-	(see l-)
hon	she
hona	female
honom	him
hop	together
hos	with (= F. *chez*)
hot	threat
hugna	to please
hundra	hundred
hunno, -en, -it	(past of *hinna*)
hur(u)	how
hustru	wife
hv-	(see v-)
hyfsa	tidy up
hygglig	pleasant
hylla	shelf
hädan	hence
hälla	pour
hälsa	health; salute, greet
hämta	fetch
hända	happen
häpen	surprised
här(-)	here(-) (also G. *her*)
härma	imitate
häst	horse
hög(e)r-	right(-hand)
höst	autumn

I

I	you
i	in
ibland	sometimes
icke	not
idel	pure, mere
idissla	ruminate
idka	carry on
idog	industrious
idrott	athletics
ifrån	from
ihop	together
ihåg	to mind
ilska	anger
ima	vapor
inbördes	mutual(ly)
inför	before
ingen	no, none
innan	within, until, before
inte	not
intet	no, none, nothing
is	ice
ister	lard, fat
ist. f. (*ist*ället *f*ör)	instead of

J

jag	I
jaka	affirm
jfr (*j*äm*f*ör)	cf.
jon	ion
jord	earth
jäm(n)-	even, equal, con-
jämka	displace
jämte	together with
järn	iron
jäsa	ferment
jätte	giant
jäv	challenge
jökel	glacier

K

kapp	competition
kar	vat
karm	frame
kav	absolutely
kavla	roll
kika	peek
kimrök	smoke black
kind	cheek
kl. (*kl*ockan)	o'clock
kladd	rough draft
klia	itch
klippa	rock
klot	globe
kläcka	hatch
K.M:t (*K*unglig *M*ajestä*t*)	H.M.; the Govt.
knep	artifice
knop	knot (unit of speed)

kolväte	hydrocarbon
konung	king
kors	cross
korv	sausage
kos	away
kram	wet
krets	circle
kring	around
kropp	body
krossa	crush
kräfta	crayfish, crab
kränga	cant
kugg	cog, tooth
kvar	left (= G. übrig)
kvarn	mill
kvinna	woman
kväll	evening
kväva	suffocate
kväve	nitrogen
käk	jaw
käns(e)l-	touch, sensation, esth-
kön	sex, gender
köra	drive, expedite
körsbär	cherry
kört(e)l-	gland
kött	meat

L

lade	laid
lag	solution
lag	layer; law
lagom	just right
lass	cart, truck
lasur	azure; lazuli
lat	idle
le	laugh, smile
led	way, joint; disgust- (G. leit-, Glied, Leid)
-ledes	-ly
lek	game
lekam	body (cf. G. *Leichnam*)
ler	clay
leta	search
levra sig	coagulate
linda	swaddle
lita	rely
ljum	lukewarm
loj	lax
lugn	calm
lukt	smell
-lunda	-wise
lur	horn, receiver
lut	lye, etc.
lutad	inclined
lyda	obey
låga	flame
lår	box; thigh
lås	lock
låtsa	pretend
lägre, lägst	lower, -est
läka	heal
lämna	leave
lämpa	adapt
läns	dry, empty
lär	is said to
lök	bulb
lördag	Saturday

M

mal	moth
malm	ore
m.a.o. (*m*ed *a*ndra *o*rd)	in other words
mark	ground, soil
mask	worm
mat	food
medan	while
mejeri	dairy
mellan	between
men	but; ill effect
met-	fishing, angling
m.fl. (*m*ed *fl*era)	etc.
mil	(Swedish) mile (10 km.)
minnas	remember
m.m. (*m*ed *m*era)	etc.
mo	sandy soil
mogen	ripe
mol	entirely
moln	cloud
mor	mother
mot	against, towards
mulna	becloud
myra	ant
må	may (auxil. v.); thrive
mål	case; speech; measure; repast; goal
mån	degree, extent; zealous
måndag	Monday
måtte	might (see *må*)
mög(e)l-	mold, fungus
mönja	red lead
mönster	pattern
mör	brittle, tender
mörk	black, dark

N

neka	deny
ni, Ni	you
nio	nine
nittio; nitton	ninety; nineteen
nog(grann)	careful
Norden	Scandinavia
not	net
nå	reach
någon, något	some, any
nå(go)nsin	ever
nål	needle
nämnd	committee
når	when; near
nästan	nearly
nöja-	be content with; satisf-

O

o-	un-
och	and
ock(så)	also
o.d. (*o*ch *d*ylikt)	and the like
odla	cultivate
ok	yoke
olja	oil
om	if
onsdag	Wednesday
ord	word
orka	manage

os	fumes
oss	us
ost	cheese
o.s.v. (*o*ch *s*å *v*idare)	etc

P

padda	toad
palta	rag
panna	forehead
pant	pledge
passare	compasses
peka	indicate
pe(nni)ng(ar)	money
plagg	garment
plants	bar, ingot
prick	dot
pryl	awl
pråm	barge, scow
prång	alley
puttra	simmer
pyts	bucket
på	on
påskynda	accelerate
pösa	puff, rise, swell

Q

See Kv-.

R

rad	row, line, series
rak	straight
raka	shave; rush along
ram	plain (adj.)
ramla	crumble
rappa	to plaster
rata	reject
re(da)n	already
redogör-	report
remsa	strip, ribbon
resår	spring (F. *ressort*)
roa	amuse
ro(de)r	rudder etc.
ruta	square, diamond
råg	rye; heap
råka	meet, hit
räcka	series, sequence
räcke	barrier
rädd	afraid
rämma	split
röja	clear up, disclose
rön	experience
röst	voice

S

sakna	lack
sam-	together; co-
sann	true
sax	scissors, shears
se(da)n	then, since
sen	late
sex	six
sikta	sift
sil	filter
sim-	swim
sina	run dry
sinsemellan	among themselves
sippra	trickle
sist	last(ly)
sitt	his, her, its (n.)
sju	seven
sjunde	seventh
sjuttio; sjutton	seventy; seventeen
sjätte	sixth
s.k. (*s*å*k*allade)	so-called
skada	injury
ska(ll)	shall (will)
ske	happen
skick	condition
skil-	separate, differen-
skingra	disperse
skog	woods
skola	shall
skolat	should (p.p.)
skratt-	laugh
skrymma	occupy space
skugga	shadow
skull	sake
skulle	should (would)
skymma	beshadow
skynda	hurry
skåda	behold
skåp	cabinet
skäl	reason
skär	pink; pure
skölja	rinse
skön	discretion
skör	brittle
sköt-	care
slag	sort, kind
slet, sleto	wore
slit	wear
sliten, slitit	worn
slopa	demolish
slutta	decline
slösa	waste
smet	grease, batter
smitta	infection
smugen, smugit	slipped
smul	smooth; crumb
smyga	slip
smög, smögo	slipped
smör	butter, butyric
snab, snar	swift
sned	oblique
sno	twist
sol	sun
som	as; who, which, that
somna	go to sleep
sonika	simply
sopa	sweep
sot	sickness
sova	sleep
spannmål	grain
spord, sport	asked (see *spörja*)
spricka	crack
sprit	alcohol
späck	lard, blubber
spör-	ask, question
stadga	consistency
stava	to spell
stel	stiff
stinn	distended
stjärt	tail

stoft	dust
stomme	frame
stor	great, large
strupe	throat
sträv	rough
stund	short time, moment
stybb	coal, breeze
stygn	stitch
styr-	control
städ	anvil
stänga	close, shut
stöpa	melt, cast
större, störst	greater, -est (comp. & sup. of *stor*)
sur	sour, acidic
surra	make fast
sval	cool
svalg	throat (cf. E. swallow)
svamp	fungus
svar	answer
svarv	lathe
svavel	sulfur
svavla	sulfide; sulfurate
svimma	swoon
svälja	swallow, gulp
svält	starvation
sy	sew
syfta	aim
syn	vision
syna	inspect
synas	seem
synner-	especial-
syra	acidity, moisture, acid
syre	oxygen
syrlig	subacidic
syrsätta	acidify, oxygenate
syskon	sibling
syss(e)l-	occup-
så(dan)	so, such
såg, sågo	saw
sämre, sämst	worse, -st (comp. & sup. of dålig)
sänder, i	at-a-time
sär-	apart, se-, extra-
sätt	manner, extent
sömn	sleep, sleepiness
söndag	Sunday
söt	sweet
söva	put to sleep

T

ta(ga)	take
tack-	ewe; pig, bar, ingot; thank
tal-	number, speech (E. *tale*, G. *Zahl*)
tall	pine
tand	tooth
tapp-	lose, tap
tarva	require
teg	was silent
ten	rod, pin
tenn	tin
te sig	appear
t.ex. (*t*ill *ex*empel)	e.g.
tiga	be silent
till	to
til och med	= *t.o.m.*
timma	hour
tina	melt
tio, tionde	ten; tenth
tisdag	Tuesday
tjog	score (twenty)
tjugu	twenty
tolft; tolfte; tolv	dozen; twelfth; twelve
tom	empty
t.o.m. (*t*ill *o*ch *m*ed)	to. . . incl.; even
torde	would, should
tordes, torts	dared
torg	market
tork-, torr	dry
torsdag	Thursday
tratt	funnel, hopper
tre, tredje	three; third
trettio	thirty
tretton	thirteen
trolig	likely
trygg	safe
trä	wood
träd	tree
trött	tired
tum	inch
tung	heavy
tusen	thousand
tveka	hesitate
två	two; wash
tvål	soap
tvätt	cleaning
tvär	= G. *quer*
ty	because; *icke för ty*, nevertheless
tynga	weigh
tysk	German
tyst	silent
tyvärr	unfortunately
tåla	endure
tävla	compete
tör	may, might
töras, törs	dare

U

udd	prong
ugn	oven
um-, und-	= G. *ent-*
undan	away
undantag-	except-
under	under; wonder
unna	not to begrudge
ur	out
utan	outside, without
uti	in
utom	outside of, beyond

V

vaja	float, fly
val	four-score
van	expert, familiar
vansklig	hazardous
var	each
vara	be
vara	last, continue
vardag	weekday
varelse	being
varenda	every
vare sig. . .eller	either. . .or

varje	each
varken . . . eller	neither . . . nor
varlig	gentle
varv	turn, revolution
var-	where-
vass	sharp
vatt(en)-	water
vecka	week
ved	wood
vek, vik-	folded
velat	would (p.p.)
vi	we
vid	with
vika	fold
villa	illusion
villo-	false, pseudo-
vilse	astray
vira	twine
virke	timber
vistas	stay
voro	were
våda	danger
våning	storey
vår	our; Spring
våt	wet
vägg	wall
välde	domain
vän	fair; friend
vänst(e)r	left(-hand)
värelse	room
värk	pain
värn	defense
värre, värst	worse, worst
väska	bag
vässa	sharpen
väte	hydrogen
vätska	liquid

W

See V.

wattimme	watt-hour

X Y Z

ylle	wool
ymnig	abundant
ynnest	favor
yppa	reveal
yrka	demand
yrke	skill, craft
ysta	make (into) cheese
yt-	surface
yx-	axe

Å

å-	on, at
åka	go (= G. *fahren*)
ång	steam, vapor
ås	ridge
åska	thunder
åt	towards
-åt	-wards
åtta	eight
åttio	eighty

Ä

äga	own
älska	love
älv	river
ämbet-	office (cf. G. *Amt*)
ämna	intend
ämne	substance
än	even, than
än . . . än	now . . . now
ändock	nevertheless
ändå, ännu	yet
är; äro	am, is; are
ärg	verdigris
ässja	forge
ättik-	vinegar, acetic
även	also
ävla-	effort

Ö

ö	island
ödla	lizard
ö.h. (*ö*ver *h*avet)	above sea level
öka	increase
öl	beer, ale
öm	sensitive
ömsa	change, shed
ömse	both
önska	wish
öppet	openly
öre	öre ($^1/_{100}$ crown)
örlogs-	naval
ösa	dip, pour

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Pitfalls of Transliteration in Indexing and Searching

M. HOSEH

Chemical Abstracts, Library of Congress, Washington, D. C.

Translations in systems of transliteration, which may be defined as the rendition of one alphabet in letters of another, hamper the work of the indexer and searcher. Transliteration from the Cyrillic to the Latin alphabet, particularly in connection with publications in the Russian language, may make it almost impossible to locate the name of an author in an index. Special difficulties occur in connection with Russian names that come via French or German—the same name may be written as Shdanow in German, Jdanoff in French, and Zhdanov in English. There are now three main transliteration schemes in the United States: Board on Geographical Names, *Chemical Abstracts,* and Library of Congress and Government Printing Office. Renewed effort should be made to develop a generally acceptable uniform policy.

In a 1941 issue of the *Doklady Akademii Nauk SSSR* appeared a paper by Anton V. Chapek (transliteration) on colloidal gold. The paper was No. 14. In abstracting the paper, the *Chemical Abstracts* reference to paper 13 was wanted, but this name could not be found in the author index. Some time later a paper by Viktor A. Yankovskiĭ No. 7 of a series, was abstracted. Again a search of the author index gave no trace of the preceding papers.

Just about that time, in a number of translations from *Chemisches Zentralblatt* and from *Khimicheskiĭ Referativnyĭ Zhurnal*, the complications began to multiply rapidly. It was hard to believe that *Chemical Abstracts* had missed so many chemical papers. The explanation for not finding these names in the author index must therefore lie elsewhere.

Pondering the original cases, it was reasoned that Chapek is probably a Czech. If so, then his name is spelled Čapek. There it was in the index. Yankovskiĭ assumed to be a Polish name and thus likely to be spelled Jankowski was found with published papers 1 to 6 on a germane topic in a Polish chemical journal. His initials were given as W. J. Further analysis showed that the Russian Viktor would be Wiktor in Polish, but what about the J? It turned out that his middle name was Jędrzej, which during his sojourn in Moscow became Andreĭ! The distance between Čapek and Chapek is 7 pages in the 1951 index and 42 pages in the last Decennial Index. The distance between Jankowski and Yankovskiĭ is 304 pages in 1951 and 1957 pages in the Decennial Index. Although the names Čapek and Jankowski in the related cases are fictitious, the cases themselves are actual. Chemists with such names fled from Czechoslovakia and Poland to the Soviet Union before the invading Germans. They continued their work in the USSR and published in Russian. Their names originally spelled in the Latin alphabet were written in Cyrillic. When their names were written in the Latin alphabet but via another language, the complications arose.

These cases amply illustrate the importance of transliteration and particularly the necessity of a uniform transliteration scheme. Transliteration can be defined as rendition of one alphabet in letters of another. Unless there is a change-over from one alphabet to another, within the same language—e.g., Turkish, which adopted the Latin alphabet around 1920—transliteration applies only to proper nouns.

The different number of letters in different alphabets, the difference in phonetic value of identical letters in two alphabets or even languages, and the absence of phones (speech sounds) in one language common to another, complicate transliteration greatly. This instance is concerned with transliteration of Russian into English.

Table I. Comparative Transliterations

Cyrillic				English					German
Russian		Ukrainian		*CA*	LC	BGN	*Brit. Abstr.*	Bushell	*Chem. Zentr.*
А	а	А	а	a	a	a	a	a	a
Б	б	Б	б	b	b	b	b	b	b
В	в	В	в	v	v	v	v	v	w
Г	г	—	—	g	g	g	g	g	g
—	—	Г	г		h				
—	—	Ґ	ґ[a]		g				
Д	д	Д	д	d	d	d	d	d	d
Е	е	—	—	e	e	ye, e[b]	e	e	je, e[c]
—	—	Е	е	[e][d]	e				
—	—	Є	є	[ye]	îê	—	—	—	—
Ё	ё	—	—	e [ё]	ё	ye, e		ё	
Ж	ж	Ж	ж	zh	zh	zh	zh	zh	sh
З	з	З	з	z	z	z	z	z	s
И	и	—	—	i	i	i	i	i	i
—	—	И	и	[y]	y				
—	—	І	і	[i]	i				
—	—	Ї	ї	[yi]	ï				
Й	й	Й	й	ĭ	ĭ	y	y (y, i)	ĭ	j
К	к	К	к	k	k	k	k	k	k
Л	л	Л	л	l	l	l	l	l	l
М	м	М	м	m	m	m	m	m	m
Н	н	Н	н	n	n	n	n	n	n
О	о	О	о	o	o	o	o	o	o
П	п	П	п	p	p	p	p	p	p
Р	р	Р	р	r	r	r	r	r	r
С	с	С	с	s	s	s	s	s	ss, s[e]
Т	т	Т	т	t	t	t	t	t	t
У	у	У	у	u	u	u	u	u	u
Ф	ф	Ф	ф	f	f	f	f	f	f
Х	х	Х	х	kh	kh	kh	kh	kh	ch
Ц	ц	Ц	ц	ts	ts	ts	ts	cz	z, tz[f]
Ч	ч	Ч	ч	ch	ch	ch	ch	ch	tsch
Ш	ш	Ш	ш	sh	sh	sh	sh	sh	sch
Щ	щ	Щ	щ	shch	shch	shch	shch	shch	schtsch
Ъ	ъ	—	—	″	″	″	—	ʼ	
Ы	ы	—	—	y	y	y	y	ȳ	y
Ь	ь	Ь	ь	ʼ	ʼ	ʼ	—	ʼ	
Э	э	—	—	é[g]	e	e	e	é	e
Ю	ю	Ю	ю	yu	îû	yu	yu	yu	ju
Я	я	Я	я	ya	îâ	ya	ya	ya	ja

[a] This letter, sounded as *g* in good, was dropped from the Ukrainian alphabet in 1945.

[b] Initially, after vowels and after Ъ and Ь ye; elsewhere e.

[c] At the beginning of a syllable je, otherwise e.

[d] *CA* does not provide for transliteration of Ukrainian, nor does *Brit. Abstr.*, Bushell, or *Chem. Zentr.* The letters in brackets are suggestions for transliterating the letters.

[e] Between 2 consonants or at the beginning before a consonant s, otherwise ss.

[f] After a vowel tz, otherwise z.

[g] Acute accent is a suggestion for rendering Э.

CA. *Chemical Abstracts*.

LC. Library of Congress.

BGN. Board on Geographic Names.

Russian and English Alphabets

Russian uses 32 (formerly 36) letters, while English consists of 26. Twelve of the Russian letters look alike in both alphabets: а, в, е, к, м, н, о, р, с, т, and х. Of these, three sound alike at all times: к, м, and т and four sound alike sometimes: a, e, o, c—e.g., *a* as in father; *e* as in pep, although actually e in Russian is palatal and its sound resembles the short e (ĕ) in society and propriety; *o* in more; and *c* in acid. Five sound differently at all times: в, н, р, у, and х, they are respectively, v, n, r, o͝o (as in foot), and German ch.

Once a transliteration system is adopted, the rendition of originally Russian names into English and the location of these names in an English index is simple. However, names originally written in a Latin alphabet, then transposed into Russian and transliterated from the latter, are apt to become separated from their original forms. The following names are taken from a *Chemical Abstracts* author index.

			CA Index Pages	
			1951	Decennial
Dąbrowski	Домбровский	Dombrovskiĭ	17	107
Czarnecki	Чарнецкий	Charnetskiĭ	22	134
Hladky	Хладкий	Khladkiĭ	40	270
Cleja	Цлея	Tsleya	405	2644

Difficulties are also encountered with Russian names which come via French or German. Thus, Ефремов is transliterated in German as Jefremow, Суворов as Ssuworow, and Цыба as Zyba; in English, as Efremov, Suvorov, and Tsyba. The name Жуков is transliterated in German as Shukow, in French as Joucov, and in English as Zhukov. Жданов becomes Shdanow in German, Jdanoff in French, and Zhdanov in English. Ющенко and Ярославский are transliterated in German as Juschtschenko and Jarosslawskij and in English as Yushchenko and Yaroslavskiĭ.

The distance between J and E, Ss and Su, T and Z, J and Z, and J and Y in an author index such as *Chemical Abstracts* is appreciable, and unless one knows that Jdanoff is Zhdanov, a search for this author is greatly impeded.

These differences in spelling must be kept in mind when looking, for example, for Журавлев in *Chemical Abstracts*, *Bulletin analytique*, or *Chemisches Zentralblatt*. They must be remembered too when a paper is indexed, for instance, by Чернов taken from a French (Tchernoff), German (Tschernow), Italian (Cernov), Czech (Černov), or Polish (Czernow) source. Now what happens when Jouin, Williams, and Hückel settle in Russia and start publishing there? We are confronted with papers by Жуэн, Вильямс, and Гюкель; their names as residents of Russia are transliterated as Zhuen, Vil'yams, and Gyukel. These names resemble their original forms only phonetically and will naturally become separated from them in a name index.

Equally troublesome is the spelling of names of Russians who move to the United States, Britain, France, or Germany. Федор Васcильевич Юрьев is likely to become Theodore Basil Urieff, Yuryev, or Yoorieff (English), Theodore Basile Yourieff (French), or Theodor Basil Jurieff (German). Bearing in mind that a man may spell his name as he pleases, the number of possibilities is almost unlimited, and therefore the location of a name in an author index unpredictable.

Scores of names could be quoted from the three mentioned abstract journals as well as from others, names hopelessly lost to the searcher unless he is aware of the intricacies of transliteration in half a dozen languages.

Transliteration Schemes

Of the three abstract journals *British Abstracts* (BA), *Bulletin analytique*, and *Chemisches Zentralblatt* (Chem. Zentr.) a statement concerning the transliteration scheme followed is found only in *Chemisches Zentralblatt*. The transliteration scheme followed by *Chemical Abstracts* is given in "Directions for Abstractors and Section Editors of *Chemical Abstracts*."

The scheme followed by *Chemisches Zentralblatt* (column 8 of Table I) is outlined by *Chemisches Zentralblatt* in General-Register 9, Part 1, page V (1941). The two signs ъ and ь are apparently disregarded, and the semivowel й is rendered by j. "Non-Russian" names are spelled in the "correct" German way. Venus-Danilowa, Müller and not Mjuler, Vogel and not Fogel, Williams and not Wiljams, Friedmann and not Fridman. But, Filossofow, Filonenko, and Filonow are used; apparently, the prefix Philo is not "righted."

As the transliteration scheme for *British Abstracts* was not known, Table I, column 6, was compiled on the basis of an examination of Section A, parts 1 to 3, and the author index of *British Abstracts* for 1949. It appears to resemble closely the transliteration scheme followed by *Chemical Abstracts* except for the semivowel й, in which case no consistency is apparent. Thus, Yavorsky, Vozdvizhensky, and Yatsimirsky, are used but Braunstein, Burstein (here the Russian ш ordinarily rendered by sh is disregarded in favor of a "right" German spelling), Neiman; Mikhailov, Khmelnitzkii, Grum-Grzhimailo, and Kitaigorodsky. The last mentioned name, Китайгородский, is particularly interesting because in the same word the semivowel й is transliterated by i and by y.

The transliteration followed by the *Bulletin analytique*, published by the Centre Nationale de la Recherche Scientifique, seems to be a mixture of German and English systems with unknown elements thrown in; nor is there consistency apparent. Thus, in Volume 9, Part 2 (1948) there are in the index Wojtkevic, A. A., and Vojtkevich, A. A., then Voitkevich, A. A. (item 105, 152), Voitkewitsch, A. A. (117, 614), Vojtkevic, A. A. (131, 633), and Vojtkevjch, A. A. (131, 658); six variations for the spelling of one man's name is a lot. There are also Yuganova, O. N. (108, 886), and Yakovlev, N., but Jushkina, S. I. (108, 180), Jakimov, V. P. (126, 868), Jakhontov, V. D., and Rjabchikov, D. I. Thus, ю is transliterated by Yu and Ju, and я by Ya and Ja. Then again there are Tzalkin, V. J. (9/2, 131, 463), Cvetaeva, E. M. (9/2, 115, 648), Chesmintsev, M. A. (9/1, 17, 207), Kuznecov, A. M. (9/1, 35, 072), and Kuznetzov, A. M. (9/1, 35, 361). Here, ц is transliterated by tz, ts, and c, apart from the fact that the name Kuznetsov (our transliteration) has two variations.

Attempts at Standardization

The English are not the only ones harassed by transliteration troubles. It is obvious that the French, Italian, Scandinavian, and indeed all other languages have their full measure of difficulties. This perplexity being international, it would seem that a common solution may be sought, at least by languages using the Latin alphabet. Indeed, an attempt was made. Committee TC46 of the International Standards Organization (ISO) is studying this problem. Is there a chance of arriving at a generally acceptable solution? It is very doubtful.

A phone represented by a letter in language A can be rendered in language B by one or more letters of language B representing the identical phone, or, if the phone is alien to language B, by a combination of letters which does not ordinarily occur in B.

Take the letter Ж, a sound almost alien to the English language. This is not entirely true: A similar phone occurs in vision, measure, and azure. However, in such instances it is a voiced s or z palatalized by i, y, or u. The English transliterate this letter by zh, a combination not otherwise found in English. Can the French agree to this rendition of this letter? Hardly, the French have a native phone for this letter: j; why then should they use two letters for the same sound, particularly if the combination zh is alien to them? Should the German language accept j or zh for this Cyrillic letter? The answer is neither. J is indigenous to German and is sounded as ye in yes, while the combination zh, although alien to German, has one letter, z, which is sounded as ts, thus remote from Ж. The German language therefore uses sh. This combination is unacceptable to the French and also to the English, because to the latter it is indigenous and is sounded quite differently.

The letter Щ is sounded in a manner alien to English, French, or German. The English represent it by shch. The French transliterate this letter by chtch; shch is not acceptable to the German. Sh is used in German for ж and ch is a heavily aspirated h—e.g., *ich*—closely resembling the gh (ch) in Scottish licht. Nor is chtch suitable for German. Therefore, the Germans adopted schtsch—seven letters for one. Could English use the German rendition? Hardly; sch in English is usually sounded as sk—e.g., school and scheme.

One familiar with the Scandinavian languages, Italian, Spanish, etc., could easily extend this discussion to cover contingencies of transliteration into these languages. Similar reasoning is applicable to other Cyrillic letters. However, these two examples suffice to illustrate the impossibility of an interlingual agreement on a transliteration scheme.

What then about English? Certainly within one language there should be one accepted transliteration scheme for a given alphabet. However, this is not the case. Not only does the United States usage differ from the British but it is far from consistent in itself. At the present there are three main transliteration schemes: (1) Board on Geographical Names, (2) *Chemical Abstracts* and (3) Library of Congress and Government Printing Office. The three differ in transliteration of the following letters:

	Letter	BGN	*CA*	LC
1	е	ye, e	e	e
2	й	y	ĭ	ĭ
3	ю	yu	yu	i͡u
4	я	ya	ya	i͡a
5	ы	y	y	y

Of these, the *Chemical Abstracts* system appears preferable for these reasons: The Board on Geographical Names allows a choice depending on the position of the Russian letter in transliterating letter 1. This is done to reproduce the phone of this letter more accurately, but it also opens the door to ambiguity. The use of y for 2 letters is particularly unfortunate, as 2 is readily confused with 5.

The Library of Congress differs from *Chemical Abstracts* only with respect to 3 and 4. The drawback of the Library of Congress system is that it requires a diacritical mark and, should the Cyrillic letter be upper cased, both English letters are written in caps. To the searcher this difference in transliterating ю and я means that having a reference from *Chemical Abstracts* for Yakovlev, Yudin, or Yur'ev, he may not find them in Library of Congress catalogues, as the distance between i͡a and ya is measured not in pages but in yards.

Beside these three carefully evolved schemes there are others, but they seem to lack consistency and rationalization. Subcommittee Z-39 of the American Standards Association (ASA) was set up for the purpose of effecting an agreement on transliteration of Cyrillic alphabets. This body had a much more complicated problem than the one which chemists have to face. The subcommittee had to adjust and mesh the transliteration of the alphabets used in Russian, Belorussian, Ukrainian, Bulgarian, and Serbian. All these languages use the Cyrillic alphabet, but there are sufficient variations in phonemas and modifications of single letters to complicate the task greatly. Chemists are concerned predominantly with Russian. Furthermore, because they are dealing only with current material, their interest centers on the revised Russian alphabet consisting of 32 letters. The subcommittee had to provide for four additional letters to take care of material published before the revision. During its last meeting this subcommittee agreed that it cannot agree and resolved to disband. There is no body at present attempting to bring about uniform transliteration in this country.

Other Slavic Languages

There are other Slavic languages using the modern Russian alphabet with slight variations. Of these languages, the most important from the point of view of the volume of scientific literature is Ukrainian. This alphabet differs from the Russian in the following:

It has additional letters.

	Transliterated	Sounded
ґ	g	g in good (dropped in 1945)
є	ye	ye in yes
і	i	i in milk
ї	yi	yi in yippee

From it letters are missing.

ё
ъ
ы
э

It has similar letters sounded differently.

г	h	h in hood
и	y	y in thirty
е	e	e in ever

For correct and intelligent transliteration, distinguishing between Russian and Ukrainian is a prerequisite. Careless handling of a foreign, however unfamiliar, language is as bad as sloppy use of one's own tongue.

Mistaken transliteration of Ukrainian is apt to cause difficulties in searching. Scientific journals of the Ukrainian SSR are published in both Ukrainian and Russian. Some journals publish articles in both languages. The name Дымов for example, may appear in a Russian language publication; it will appear as Димов in a journal in Ukrainian. Unless a distinction is made between the two languages, the same name will be transliterated once as Dymov and next time as Dimov. The distance between the two spellings is 12 pages in the 1951 index and 86 in the Decennial Index.

Belorussian differs slightly from the Russian and there too transliteration errors may cause grief to the searcher. One consolation to the indexer and searcher is that as yet the volume of scientific matter in this language is relatively small.

Neither *Chemical Abstracts* nor the other abstract journals mentioned provide for the transliteration of Ukrainian and Belorussian. The other languages using the Cyrillic alphabet, Bulgarian and Serbian, need not be considered at the present.

Recommendations

A plea, or rather two, should be offered in conclusion. The first is for renewed effort toward a uniform transliteration scheme from the Cyrillic alphabet into English, at least acceptable to the major bodies in this country. The American Chemical Society through its Division of Chemical Literature has the knowledge of the subject, the prestige, and the energy to undertake it. H. S. Bushell of the Royal Society has in his latest recommendation a transliteration scheme differing from the one used by *Chemical Abstracts* in one letter only—namely, Ц—which *Chemical Abstracts* renders by ts and Bushell by cz. It is hoped that Mr. Bushell will agree with *Chemical Abstracts* in this detail.

The second plea is on behalf of two Russian letters which were somehow slighted. These letters are Ё sounded like yo and Э sounded like a in bad, both of which are transliterated by e as the Cyrillic letter E. These letters are distinct and should be recognized as such. These two letters should continue to be represented by e and distinguished from each other and from the Cyrillic E by writing Ë for Ё and Ê for Э. This is also recommended in the Bushell scheme.

Russian Practice in Transliteration

No discussion on transliteration of a foreign alphabet is complete without mentioning how this other alphabet is treating the Latin alphabet. In the Russian language foreign words and particularly proper nouns are spelled phonetically. A name is spelled so that phonetically it will reproduce the name as closely as possible the way it sounds in the bearer's tongue. Thus, Cholmondeley is spelled Чамли (transliterated Chamli) and O'Shaughnessy is Ошонеси (transliterated Oshonesi). The abstractor and indexer of Russian material is likely to come across names which in transliteration would appear as Nyuton, Geresgof, Vedzh, Vil'fli, and Vitston. The abstractor and indexer, if they know what they are doing, will recognize the names of Newton, Hereshoff (furnace), Wedge (furnace), Wilfley (table), and Wheatstone (bridge).

Russian language journals are careful in making references to works in the Latin alphabet. Authors' names and titles of journals originally appearing in the Latin alphabet are reproduced as such. Formerly this practice was followed both in the text of the Russian article and in the list of references at the end of it. Lately, however, the Latin spelling in the text has been abandoned but in the list of references and bibliographies it is retained.

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