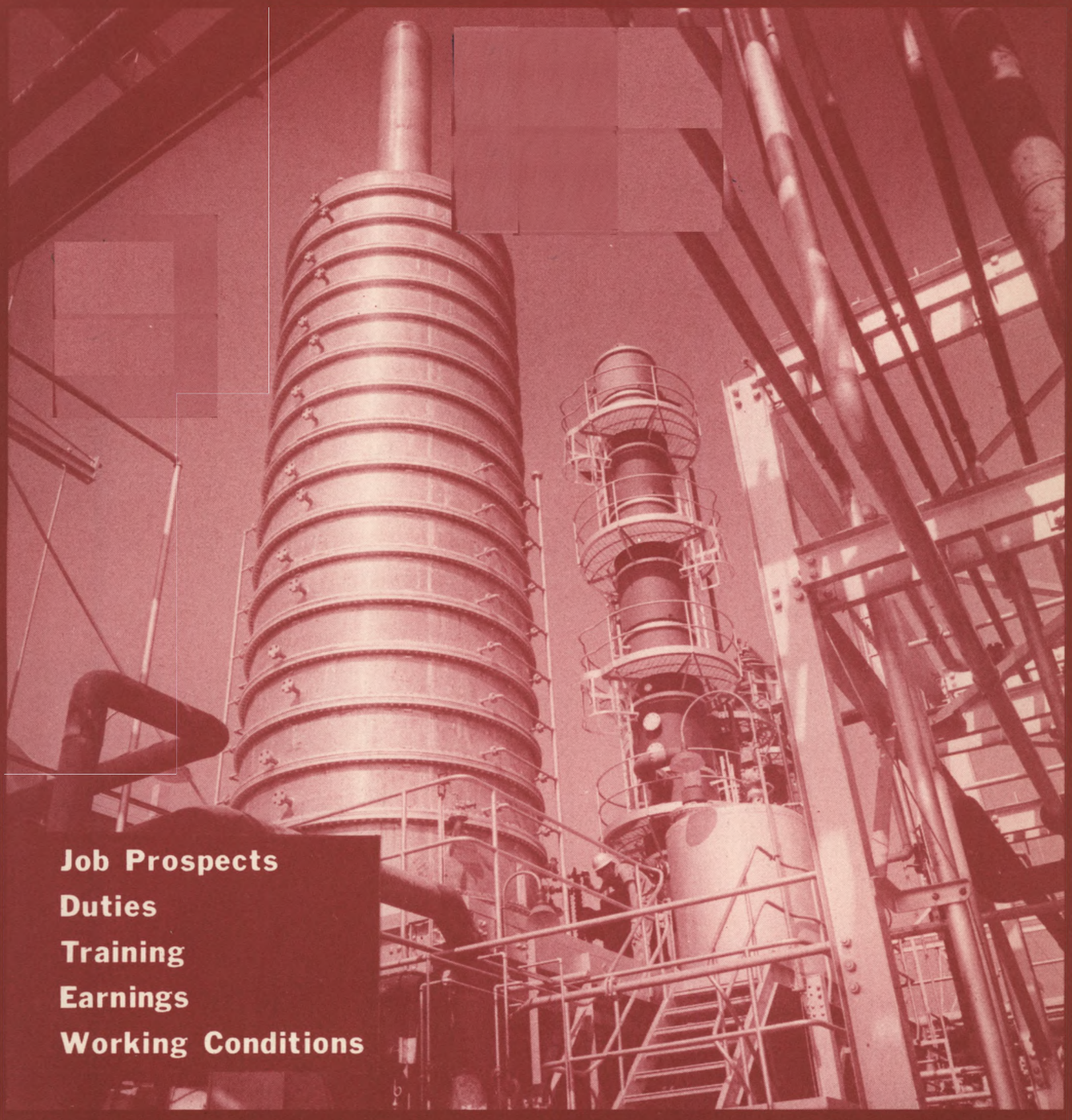
EMPLOYMENT OUTLOOK IN THE

INDUSTRIAL CHEMICAL INDUSTRY



Job Prospects
Duties
Training
Earnings
Working Conditions

UNITED STATES DEPARTMENT OF LABOR
James P. Mitchell, Secretary

BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

In cooperation with VETERANS ADMINISTRATION

OCCUPATIONAL OUTLOOK SERIES

BULLETIN No. 1151

EMPLOYMENT OUTLOOK IN THE INDUSTRIAL CHEMICAL INDUSTRY

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LETTER OF TRANSMITTAL

United States Department of Labor,
Bureau of Labor Statistics,
Washington, D. C., September 1, 1953.

The Secretary of Labor:

I have the honor to transmit herewith a report on the employment outlook in the industrial chemical industry. This is one of a series of Occupational Outlook studies for use in vocational counseling of veterans, young people in schools, and others interested in choosing a field of work.

The study was conducted in the Bureau's Division of Manpower and Employment Statistics. The present report was prepared by Sol Swerdloff and Evelyn R. Kay. It is a revision and enlargement of a pamphlet prepared in the Bureau of Labor Statistics, but financed and published in 1952 by the Veterans Administration for use in vocational rehabilitation and educational activities. The original Veterans Administration pamphlet was prepared by Raymond Larson and William Shickler. The Bureau wishes to acknowledge the generous assistance received in connection with this study from the Manufacturing Chemists Association and from officials of labor unions, other government agencies, and various chemical manufacturing firms.

Ewan Clague, Commissioner.

Hon. James P. Mitchell,
Secretary of Labor.

EMPLOYMENT OUTLOOK IN THE INDUSTRIAL CHEMICAL INDUSTRY

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Photographs are through the courtesy of the Monsanto Chemical Company, St. Louis, Missouri; the Libbey, Owens, and Ford Glass Company, Toledo, Ohio; the Davison Chemical Corporation, Cincinnati, Ohio; and the Manufacturing Chemists Association, Inc., Washington, D. C.

EMPLOYMENT OUTLOOK

IN THE INDUSTRIAL CHEMICAL INDUSTRY

During the last 25 years, the industrial chemical industry has become one of the Nation's major industries. The public is generally unaware of the millions of tons of industrial chemicals produced yearly because most of these chemicals never reach the consumer in the form in which they leave the factory. This industry, however, is one of the Nation's largest material suppliers; its products are used as raw materials or as processing agents by almost every manufacturing industry. It also has an important defense role since the manufacture of armaments and munitions requires many types of industrial chemicals. The more than 1,000 industrial chemical plants are widely dispersed throughout the country. They make thousands of chemicals ranging from sulfuric acid and chlorine to rayon and synthetic rubber.

The long-range employment outlook for the industry is favorable, the steady expansion of employment in the past quarter-century is expected to continue. At the beginning of 1953, the industry employed more than 350,000 wage and salary workers. It provides many job opportunities for men and women in a wide range of occupations. Training requirements vary from college degrees for chemists and engineers to a few days of on-the-job training for some of the less-skilled plant workers. About 15 percent of the industry's work force are women. Earnings compare favorably with other manufacturing industries, and working conditions are relatively good.

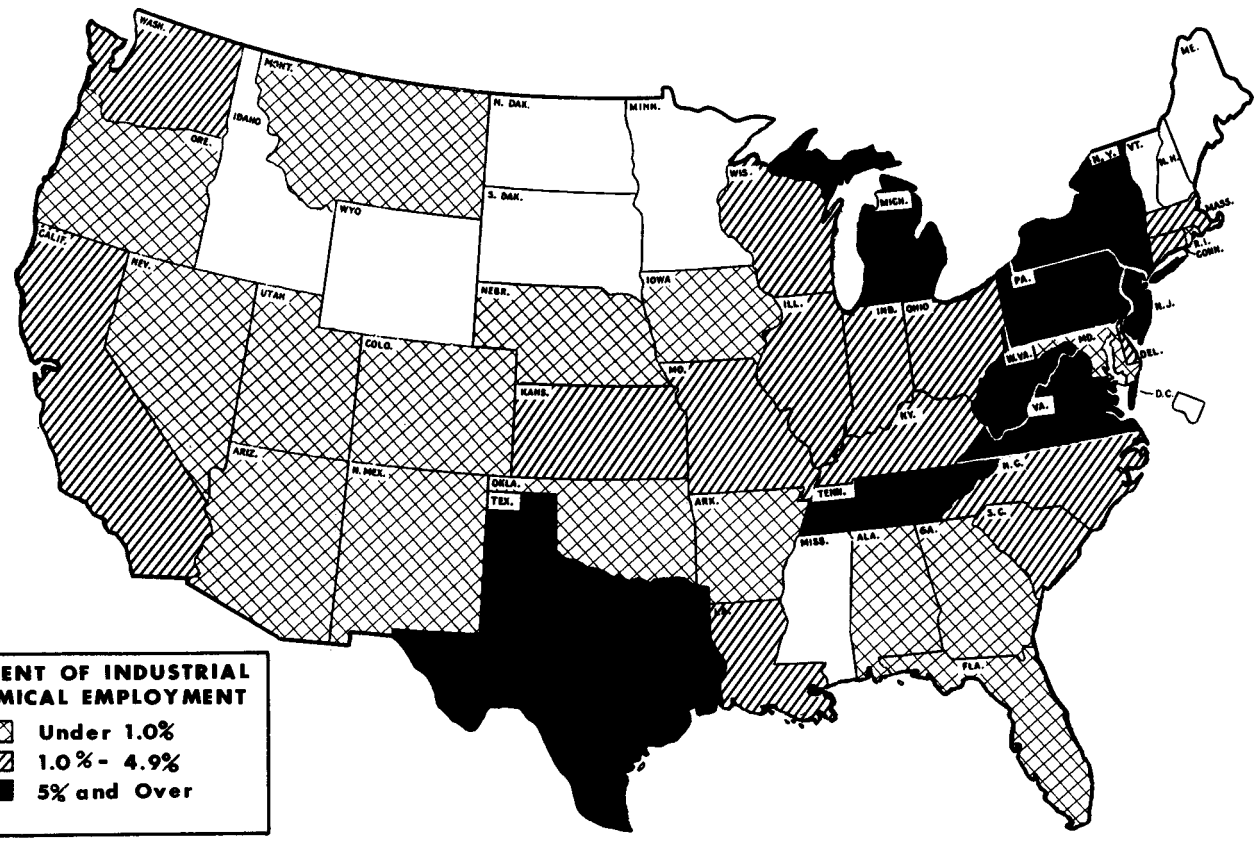
This report outlines the trends of employment and production in the industry and discusses the employment outlook. It presents the duties and training requirements for some of the important occupations and it provides information regarding earnings and working conditions.

THE INDUSTRIAL CHEMICAL INDUSTRY

Industrial chemicals are produced primarily for use by other industries in further manufacturing. Industrial chemicals are distinguished from other chemical products, such as pharmaceuticals and fertilizers, which go directly to the consumer without additional processing. The industrial chemical industry[1] is composed of plants primarily engaged in manufacturing basic industrial inorganic and organic chemicals. Industrial inorganic

[1] The definition of the industry used in this report covers industrial groups 281 (Industrial Inorganic Chemicals) and 282 (Industrial Organic Chemicals) of the Standard Industrial Classification Manual, Bureau of the Budget, November 1945.

Chart 1. More Than Three-Fifths of the Workers Making Industrial Chemicals Are Employed in Eight States, 1953



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chemicals are those produced from inorganic matter such as salt, sulfur, mineral ores, limestone, air, and water. Basic chemicals in this segment of the industry include acids, salts, and alkalies. Industrial organic chemicals are derived from once-living matter, such as agricultural and forest products, coal, and petroleum. Included in this group are synthetic fibers, synthetic rubber, plastics, dyes, explosives, and coal-tar products, such as cresols and benzene.

Location of industrial chemical plants

There are more than 1,000 industrial chemical plants scattered throughout the country with almost every State having at least one plant. There are a number of factors affecting the location of these plants. To minimize transportation costs, establishments making inorganic chemicals are usually located near the source of raw materials. For example, plants producing salts and alkalies are located near great underground deposits of salts (such as are found in Louisiana) which are pumped to the surface as brine and then converted. Other types of chemical plants are located near the users of their products. Because of the large amount of space required for plants and the problem of disposal of waste products and gases, many plants are located in rural areas or on the outskirts of industrial centers.

Nearly one-half of the work force in the industrial chemical industry is concentrated in the Middle Atlantic and the South Atlantic States (chart 1). The other large concentration of employment is in the East North Central and the East South Central States. Tennessee, Virginia, New York, New Jersey, and West Virginia employ the greatest numbers of industrial chemical workers. These States account for almost half of the industry's total employment. Other States with a large number of industrial chemical workers are Texas, Michigan, Pennsylvania, and Delaware.

Although the number of industrial chemical workers has increased in every region since 1939, there has been a gradual geographic shift in employment in the industry. The Middle Atlantic and the South Atlantic States, the two regions employing the greatest number of workers, had a smaller proportion of the industry's employment in 1953 than in 1939 (table 1). The greatest proportionate increase during this period occurred in the West South Central, Mountain, and Pacific Coast regions.

Table 1.

LOCATION OF CHEMICAL JOBS IS RAPIDLY CHANGING

Estimated Employment in Industrial Chemical Industry by Region, 1939 and February 1953

Region	February 1953		Average 1939	
	All employees	Percent	All employees	Percent
Total	350,300	100.0	158,100	100.0
New England	9,700	2.8	4,400	2.8
Middle Atlantic	73,200	20.9	56,200	35.5
East North Central	60,300	17.2	25,000	15.8
West North Central	10,300	2.9	2,900	1.8
South Atlantic	88,800	25.4	44,300	28.0
East South Central	48,000	13.7	16,200	10.3
West South Central	33,700	9.6	3,000	1.9
Mountain	3,500	1.0	800	.5
Pacific Coast	22,800	6.5	5,300	3.4

Employment is concentrated in large plants

The industrial chemical industry consists of some 1,000 plants ranging in size from those employing only a few workers to those with more than 12,000 employees. The majority of the plants are small; but employment is concentrated in the larger establishments, particularly in those plants producing organic chemicals. The 1947 Census of Manufactures shows that about 46 percent of the workers in plants making organic chemicals were employed in 23 establishments each having 2,500 or more workers[2] (table 2). In contrast, 351 of the 563 organic chemical plants in 1947 had less than 100 workers each and employed only about 5 percent of the total number of workers. Employment in the inorganic chemical segment of the industry is not concentrated in large plants to the same extent as in the organic segment. The 15 largest inorganic chemical establishments, each having 1,000 or more workers, employed about 38 percent of all the workers in that segment.

[2] By way of comparison, less than one-fifth of all manufacturing employees in the United States worked in establishments with 2,500 or more employees.

Table 2.

DISTRIBUTION OF EMPLOYMENT
IN THE INDUSTRIAL CHEMICAL INDUSTRY,
BY SIZE OF ESTABLISHMENT, 1947

Manufacturing establishments with average employment of:	Organic chemicals		Inorganic chemicals	
	Number of establishments	Percentage of total employment	Number of establishments	Percentage of total employment
All plants.....	563	100	412	100
1 - 99 employees.....	351	5	296	12
100 - 249 employees....	73	6	58	14
250 - 499 employees....	56	9	25	14
500 - 999 employees....	30	10	18	22
1000 - 2499 employees..	30	24	(15	(38
2500 or over employees.	23	46	(	(

Source: 1947 Census of Manufactures

MAJOR PRODUCTS AND THEIR USES

The industrial chemical industry produces thousands of products. A few of these, such as synthetic fibers, synthetic rubber, and plastic materials, have been extensively publicized. However, a large number of every-day products are made from the many lesser known industrial chemicals. These industrial chemical products do not go to the public directly because they must be further processed by other manufacturing industries. Industrial chemicals, either in the form of raw materials or as processing agents, enter directly or indirectly into virtually every branch of industry. They are important ingredients in the manufacture of steel, glass, paper, plastics, textiles, and thousands of other products in every-day use. They are also essential materials in the manufacture of armaments and munitions.

Among the principal inorganic chemicals are sulfuric, nitric, hydrochloric, and phosphoric acids; soda ash; caustic soda; chlorine; and ammonia. Some of the organic compounds are also well known; for example, synthetic fibers, such as rayon, nylon, orlon, and dacron; synthetic rubber; and plastic materials. Less well known are many other important organic chemicals, such as industrial explosives, the wide variety of dyes and color pigments, industrial alcohol, formaldehyde, benzene, and glycerin. A short discussion

of the major chemicals and where they are used should provide a better understanding of the importance of the industrial chemical industry and the widespread use of its products.

Inorganic chemicals are used throughout industry

Sulfuric acid is by far the most widely used of all industrial inorganic chemicals. The fertilizer industry, which uses sulfuric acid in the manufacture of superphosphates, normally consumes about 35 percent of the total production of this acid. The petroleum refining industry uses about 10 percent of total output and about 20 percent of sulfuric acid production is consumed in the making of other chemicals. Sulfuric acid is so widely used that it is sometimes regarded as a rough barometer of industrial activity.

Among the acids, nitric acid is second only to sulfuric acid in value and diversity of uses. Formerly produced by the action of sulfuric acid on Chilean nitrates, it is now made principally from synthetic ammonia. Important uses are in the manufacture of military and industrial explosives, fertilizers, plastics, paints, and solvents.

Hydrochloric acid has numerous special uses, although its production tonnage is only one-twentieth that of sulfuric acid. It is used in pickling steel for tin plating; making chlorine compounds; activating oil wells; and manufacturing dyes, plastics, and other chemicals.

Phosphoric acid ranks second to sulfuric acid in volume production. It is essential for rustproofing steel and in the manufacture of high grade fertilizer phosphates, cleansing agents, phosphates for the food industry, synthetic detergents, and ammoniated dentifrices.

Of the alkalies, soda ash is the most important in terms of total volume of production. It is also the cheapest to manufacture. It is used primarily in the manufacture of glass (40 percent), chemicals and drugs (30 percent), and soap and cleanser products (10 percent). The remaining 20 percent is used in the nonferrous metals industries, paper and pulp manufacture, textile manufacture, and in water softening and petroleum refining. In some common forms sold on the retail market, soda ash is called sal soda or washing soda.

Second alkali in terms of volume, caustic soda is stronger and more expensive than soda ash. It is consumed chiefly in the manufacture of rayon (20 percent), chemicals (16 percent), soap (13 percent), petroleum refining (12 percent), and in numerous other process industries (39 percent).

Many other inorganic chemicals are utilized by manufacturing industries. Sodium sulfate, for example, is used in the manufacture of Kraft paper, window glass, and medicines, and in textile dyeing and nickel smelting. Sodium silicate, made by fusing sand and soda ash, is used for impregnating wood, fixing dyes, rendering cement and brick non-porous, and as a detergent and adhesive. Calcium carbide is important mainly because, when combined with water, it forms acetylene, which in turn is used in manufacturing many organic chemicals.

The most important use of chlorine, another inorganic chemical, is in the manufacture of such products as antifreeze solutions, carbon tetrachloride, synthetic rubber, dry-cleaning fluids, and ethyl gasoline. The paper and pulp industry consumes about 11 percent of the chlorine produced, and sewage and sanitation consumes 4 percent. Chlorine is also used as a bleach in the textile industry and as a raw material in the dye and explosives industries.

Organic chemicals are more commonly known to the public

Synthetic fibers is a major branch of the organic chemical industry. These fibers are used primarily in clothing, fabrics for household use, and in tire cord (Chart 2). In terms of volume of use, synthetic fibers exceeds wool and outranks all other textile fibers except cotton. The rapid growth in the use of rayon, nylon, and other artificial fibers has been one of the most spectacular examples of the ability of new products to compete successfully in an established industrial field. Rayon, first marketed as a substitute for silk, has long far outsold silk; it comprises about a fifth of the total consumption of textile fibers. Rayon and nylon, along with other new fibers constantly being developed, probably will win an increasing share of the textile market.

Synthetic rubber is produced mainly in Government-owned, privately operated plants which were built during World War II because the import of natural rubber supplies was curtailed. The most widely used synthetic rubber product is GR-S which accounts for 85 percent of total synthetic rubber production. It is a general-purpose synthetic made from butadiene and styrene and used principally in the manufacture of automobile tires. GR-I is a special-purpose synthetic rubber used for tire tubes. Neoprene, another type of synthetic rubber, is used extensively for life-saving equipment, solid airplane tires, and hose (Chart 3).

Plastics is another group of organic chemical products which has rapidly developed in recent years. Leading plastic materials, in order of volume produced, are vinyl resins, phenolics, alkyd resins, and polystyrenes. Vinyl resins, of which lime and coal are

Chart 2.

PRODUCTION OF SYNTHETIC FIBERS

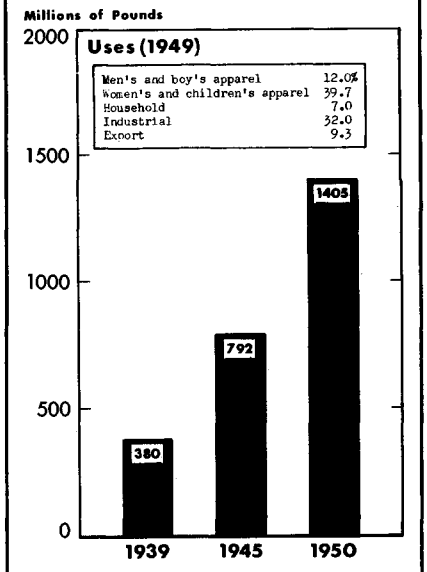


Chart 3.

PRODUCTION OF SYNTHETIC RUBBER

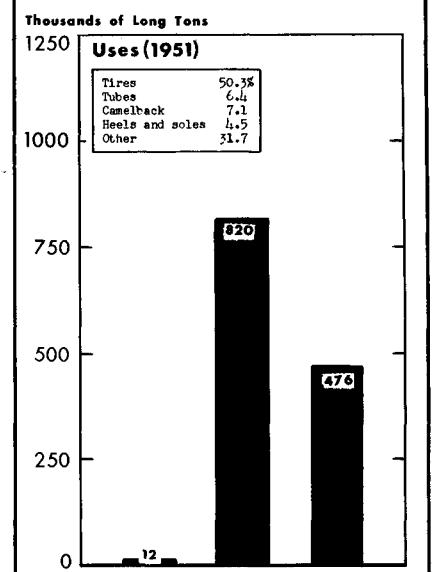


Chart 4.

PRODUCTION OF PLASTICS MATERIALS

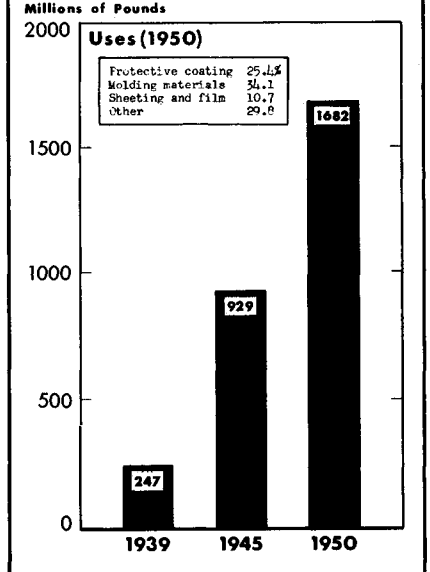
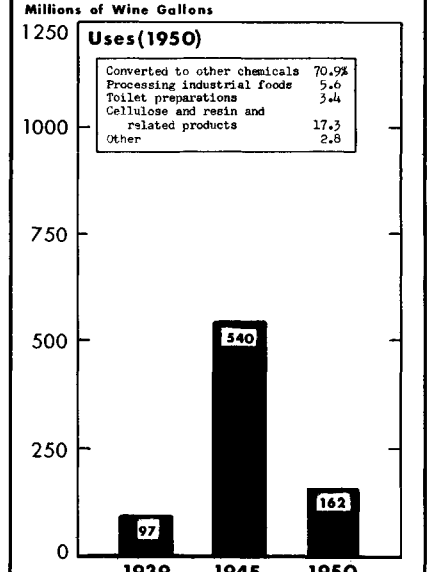


Chart 5.

PRODUCTION OF INDUSTRIAL ALCOHOL



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basic ingredients, are produced in films or sheets for such items as draperies, shower curtains, automotive safety glass, upholstery, wire coating, raincoats, phonograph records, and garden hose (Chart 4). Phenolics plastics, which are made from carbolic acid and formaldehyde, are molded into radio and TV cabinets, table tops, cameras, and telephone parts. The alkyd resins are used in making paints, varnishes, enamels, and especially the hard finishes for automobile bodies and refrigerators. Production of polystyrene, made from styrene, which is also one of the main ingredients of synthetic rubber, has grown more rapidly than any other plastic material in recent years. Its principal advantages are low cost and ability to take colors well. It is used in the manufacture of molded products such as dishware, toys, refrigerator dishes, and novelties.

Industrial alcohol has important and diversified uses (Chart 5). In peacetime, it is used primarily as a solvent and as a raw material in the production of other chemicals. In wartime, or in periods of defense, it has additional important uses in the manufacture of such products as military explosives.

HOW INDUSTRIAL CHEMICALS ARE MADE

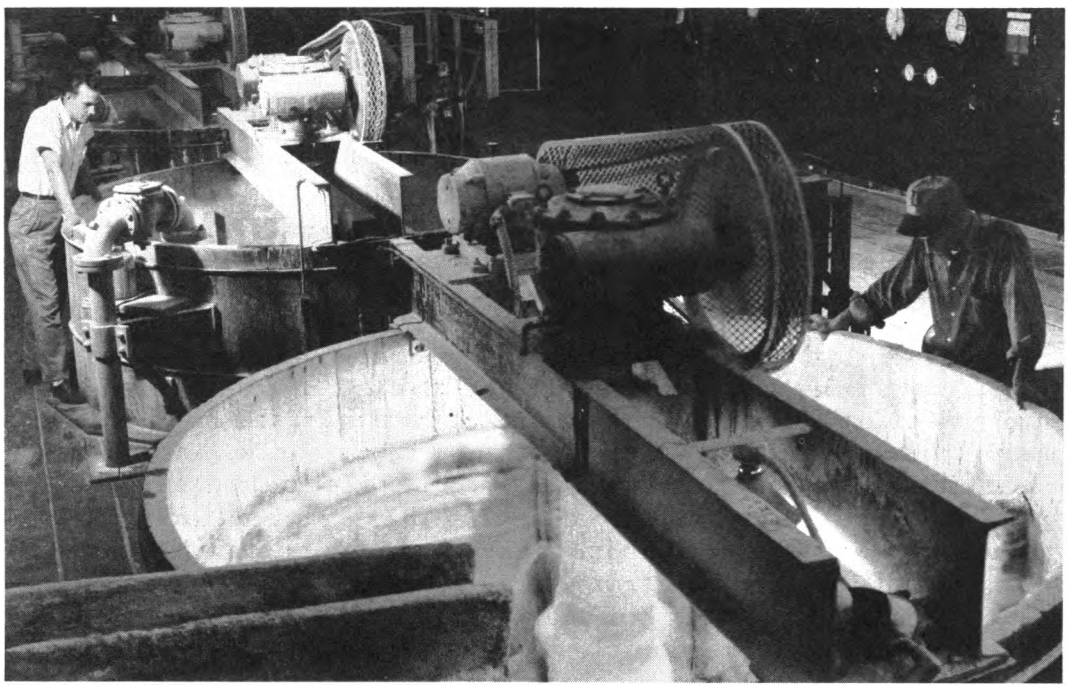
Methods of manufacturing the thousands of industrial chemicals are as varied as the products involved. The chemical manufacturer makes new products that are distinctly different from the raw materials that he starts with; and in the process, he may get one or more by-products. For example, wood is made into methanol (wood alcohol), a product that is different from the raw material; in the process of making methanol, acetic acid is obtained as a by-product. A description of the processes involved in manufacturing any one chemical would not be representative of the industry as a whole since different processes are used to make different chemicals. Certain generalizations, however, can be made concerning basic processes in the industrial chemical industry as a whole.

Among the principal raw materials used in making industrial inorganic chemicals are salt, sulfur, mineral ores, limestone, and water. Coal is the principal raw material used in manufacturing organic chemicals, but petroleum and natural gas are becoming increasingly important. Wood and cotton are basic raw materials in the manufacture of rayon and some kinds of plastics materials. Industrial chemicals are made by changing these raw materials by both chemical and physical processes. Through chemical changes, new compounds are formed from these raw materials by combining various chemicals, by breaking down chemical compounds, or by building them up to more complex forms. The chemical processes used to effect these changes include oxidation, electrolysis, neutralization, cracking, polymerization, and fermentation. Some of the physical processes are grinding, mixing, evaporation, drying, filtration, crystallization, absorption, and distillation. Usually

several possible types of equipment or methods are used to perform each operation. For example, solids may be separated from liquids by filtration, by centrifugal equipment, or by settling. Costs usually determine which method is to be used.

Most chemical plants, especially those making inorganic chemicals such as acids or alkalies, have a vast network of pipes. These pipes are necessary for intraplant transfer of chemicals which are mainly in liquid form during processing. Generally, large volume production methods are used, taking the form of continuous or "automatic process" production, rather than of the assembly line type of operation characteristic of the automobile industry. In the continuous process operation, the raw materials are fed into the pipes and the finished products are withdrawn continuously with minimum handling of materials. This method has generally replaced the "batch method" in which a given quantity of material is carried through an operation and transferred to the next operation. For instance, a batch of solutions may be heated and mixed in a kettle until the right shade of color or size of particle is attained. The kettle is then emptied and a new batch is started. This method is still used in making some dyes. The manufacture of industrial chemicals may be further clarified by describing briefly the processes used in producing some of the major chemicals.

Mixing is one of the basic processes in manufacturing industrial chemicals.



Soda ash, one of the most important inorganic chemicals, is produced mainly by the ammonia-soda process (sometimes called the Solvay process in honor of the Belgian chemist who invented the process). Raw materials for the manufacture of soda ash are plentiful. They consist principally of salt, limestone or oyster shell, coal and other fuel, and a plentiful supply of water.

Salt in the form of brine from salt wells is purified and pumped into a vessel called "the absorber" in which it is saturated with ammonia gas. The solution, ammoniated brine, is then pumped in a continuous stream to the top of carbonating towers where it is reacted with a carbon dioxide gas, forming sodium bicarbonate[3] and ammonium chloride. The suspended sodium bicarbonate is filtered and calcined (roasted in a furnace) to light soda ash. Dense soda ash is produced by adding water to the light ash and recalcining. Soda ash may be stored for future use, usually in concrete silos, or it may be shipped directly to consumers. It may also be converted into caustic soda, refined bicarbonate grades, or other material.

Sulfuric acid is produced by two processes. The older type of chamber acid plant is gradually being replaced by the cheaper method of the contact plant. In the chamber process, sulfur or sulfur compounds, called "pyrites," are burned to sulfur dioxide, which is then combined with oxygen and water to form sulfuric acid. This process is carried out in a series of towers and large lead rooms called chambers. A vapor of burning sulfur, acid, steam, and gaseous compounds of nitrogen oxides introduced to speed the operation is drawn into the large lead chambers of some 200,000 cubic feet capacity. This results in a rain of sulfuric acid of relatively moderate strength falling to the floor. The contact process removes the need for the large chambers by eliminating the need for steam. The reaction between sulfur dioxide and water is hastened by the use of platinum as a catalytic agent to accelerate the chemical reaction. Stronger acids can be made by the contact process.

Raw materials are changed into finished organic chemical products for use in industry by a number of different and complicated

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[3] Some of the sodium bicarbonate is purified and sold to other manufacturers to make baking powder, prepared flours, drugs, sponge rubber, for use in treating wool and silk, in tanning, or in gold plating. The ammonia in the ammonium chloride is recovered and reused.

manufacturing processes. Generally, the processes require four major steps: (1) The extraction of tars from coal, oil-gas, or water-gas. This usually takes place as a by-product process in other industries. Coal tar, for instance, is produced chiefly as a by-product of the coke used in the steel industry. Water-gas and oil-gas tars are by-products of the petroleum and natural gas industries. (2) The production of "crudes" from the tars. Benzene, toluene, xylene, and naphthalene are the usual crudes produced from tars and from petroleum and natural gas, small amounts of which are sold as end-products. The greater proportion, however, is used in the third step of the production of organic chemicals. (3) The manufacture of "intermediates" which are more complicated compounds of the tars and crudes. They include alcohol, phenol, nitrobenzene, aniline oil, refined naphthalene, chlorobenzene, and styrene. Some of the intermediates are combined or converted into such functional end-products as explosives, perfumes, dyes, drugs, flavorings, and plastic materials; others may be sold as finished products without further processing. For example, refined naphthalene may be packaged and sold as a moth repellent or as a deodorant. However, most of the intermediates go through the fourth major step. (4) This involves the manufacture of synthetics which transforms intermediates into more complex organic chemicals by a variety of chemical processes. Some of these chemicals which are shipped to other industries for their use include dyes, which are soluble colors used mainly in textile manufacturing; lakes and toners, which are color pigments insoluble in water or oil used in the manufacture of paints and inks; plastics and resin materials in the form of sheets, rods, tubes, and powder, which are used by plastics molders and fabricators; and synthetic fibers used by textile and tire manufacturers.

In contrast to the processes involved in the manufacture of organic chemicals as described above, rayon fiber is manufactured by a completely different method. Rayon fiber is made from cellulose, the solid parts of cell walls of plants. Cellulose usually comes from wood pulp or cotton "linters" which are changed into a sirupy solution by steeping, crumbling, churning, and mixing processes. After filtering and aging, the solution is forced through tiny holes into solid filaments or threads. These are twisted into yarn and wound on spools for use by textile manufacturers who weave the yarn into fabrics.

JOBS IN THE INDUSTRY

Persons interested in a career in the industrial chemical industry with their many different interests and qualifications, will want to know the types of job opportunities offered by the

industry. More than 350,000 men and women who had jobs in industrial chemical plants in early 1953 were employed in a wide range of occupations. Training requirements for workers in these occupations vary from college degrees for chemists and engineers, to a few days of on-the-job training for some of the less skilled plant workers. Women constitute about 15 percent of the industry's work force.

By far the largest proportion of employees in the industrial chemical industry (about 70 percent) are in plant occupations. Technical personnel represent about 17 percent of the industry's labor force. The technical personnel include about 40,000 chemists and chemical engineers and about 15,000 technicians, such as laboratory assistants and draftsmen. Many different types of administrative clerical and related personnel, including purchasing agents, accountants, personnel officials, and salesmen, are also employed in industrial chemical plants. There are also many clerks, stenographers, bookkeepers, typists, and other office workers. The distribution of workers in the industry by major occupational group is shown in chart 6. The duties and training requirements of some of the important occupations are briefly described below. A more complete discussion of many of these occupations may be found in the Occupational Outlook Handbook[4].

Technical Occupations

Because of the highly technical nature of its operations, the industrial chemical industry employs many persons with chemical, engineering, or other scientific backgrounds. A large proportion of these personnel are employed in the industry's research activities to develop new chemical products and new methods of production. In fact, nearly 9 percent of the Nation's research engineers and scientists are employed by industrial chemical firms, according to a recent estimate[5]. This is an impressive proportion since this industry employs only about 2 percent of all manufacturing

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[4] Occupational Outlook Handbook, U. S. Department of Labor, Bureau of Labor Statistics, Bulletin 998, 1951 edition prepared in cooperation with the Veterans Administration. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price $3. The Handbook contains information about other industries in which these workers are employed, the job prospects in those industries, and the training and other qualifications required for workers in these occupations.

[5] Scientific Research and Development in American Industry, A Study of Manpower and Costs, U. S. Department of Labor, Bureau of Labor Statistics, Bulletin 1148, October 1953.

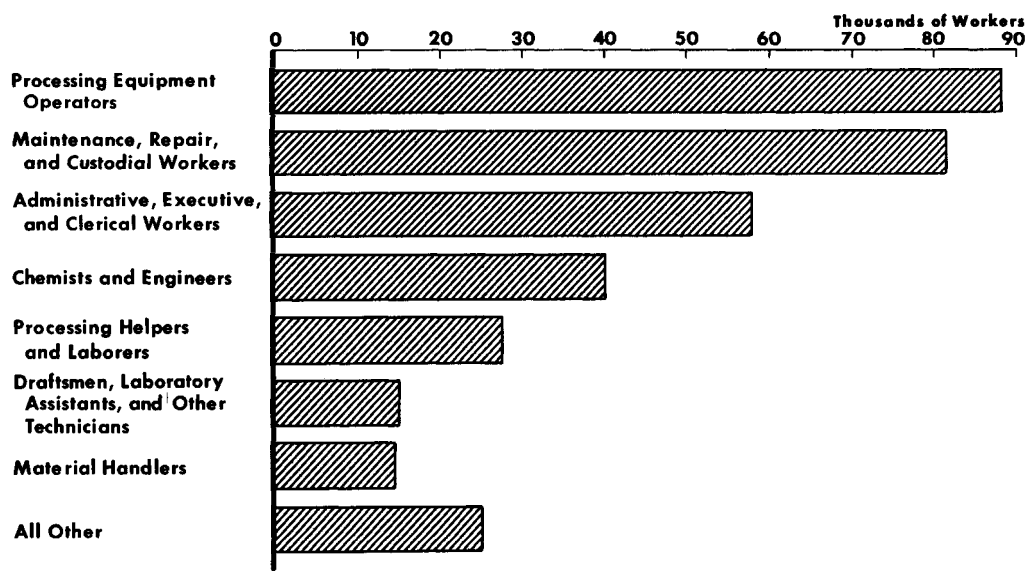
workers. Each year the leading companies allocate large amounts of money and man-hours to research and development work. Since new products are constantly being developed, a company could easily lose its leadership in a particular field if a competitor introduced a superior product.

This industry is one of the principal employers of chemists and chemical engineers. It is noteworthy that a large proportion of the top executives in the chemical industry have a chemical or engineering background. The duties of chemists and chemical engineers in this industry often overlap. Chemists are engaged in a number of different functions. Many work in research laboratories. A large number are employed in the production departments in such work as quality control, supervision of the testing of materials during processing, and the development of laboratory processes. Others work as technical salesmen or technical writers or in administrative positions requiring technical knowledge.

Chemical engineers in these plants are employed in research, design, and operation and perform many management functions. They are concerned with the application of chemical and engineering science to the design, construction, operation, control, and improvement of equipment for the utilization of chemical processes on an

Chart 6. Processing Equipment Workers Make Up Largest Occupational Group in the Industrial Chemical Industry

DISTRIBUTION OF EMPLOYMENT BY OCCUPATIONAL GROUP, 1953



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Many technical workers such as chemists and laboratory technicians are employed in the laboratories maintained by industrial chemical companies.

industrial scale. They convert laboratory processes into large-scale production methods using the most economical manufacturing techniques.

Several other types of engineers are also employed in industrial chemical firms. Mechanical engineers design and lay out plant equipment, and plan and operate the central distributing system for heat, gas, water, or steam. Electrical engineers are concerned with instrumentation and control, and power generation and distribution. They also design and develop all types of electrical and electronic machinery and equipment and operate and maintain these items.

Persons contemplating entering the chemical or engineering field should rate well above the average in mathematics and science courses in high school. A bachelor of science or a bachelor of engineering degree from a recognized college is usually the minimum educational requirement for these fields. An additional consideration is the increasing proportion of technical personnel with graduate college training. Prospective students should also attend a properly accredited school since persons trained at such schools generally have the best employment opportunities.

Many industrial chemical companies recruit chemists, chemical engineers, and other technically trained personnel by sending representatives to colleges and universities each year to interview graduating students. Some companies have formal training programs for young college graduates in which they are rotated through the various plant-operating divisions to provide a broad picture of chemical manufacturing operations before assigning them to a particular department. Other firms immediately assign a newly hired junior chemist or engineer to a specific research, operating, or maintenance unit.

In addition to the large number of professional technical personnel, the industry employs more than 15,000 technical assistants such as draftsmen, laboratory assistants, engineering aides, chemical analysts, and production supervisors. Laboratory technicians assist chemists and engineers in research and development and in production control. They may perform simple routine tests or do highly technical, analytical work, depending on their training and experience. Much of the work of the laboratory technicians consists of conducting routine tests and recording the results--often in the form of simple reports, charts, or graphs for interpretation by the chemists. Laboratory assistants may begin their work in routine jobs and advance to positions of greater responsibility after they have acquired additional experience and demonstrated their ability to work without close supervision.

Draftsmen prepare exact, detailed drawings from sketches or specifications furnished by the various types of engineers. There is a wide range of skill in this occupation. Some draftsmen do rough copying or routine tracing work; others, at higher levels of skill, are often required to make calculations concerning the strength, quality, and cost of materials, and to use engineering handbooks and tables for computations necessary to complete their drawings. Inexperienced draftsmen usually begin their job careers as copyists or tracers. At this level, their work is routine and requires little knowledge or skill. With additional experience and training, workers may advance up the job ladder to more skilled and responsible drafting positions.

Not all persons who work as technicians are specifically trained for their occupations. A person may become a technician by studying at a technical or vocational school--usually a 2-year course. Engineering or chemistry drop-outs; graduates and drop-outs of liberal arts colleges, especially those with chemistry, mathematics, or other scientific training; and other persons who have received post-high school education often become technicians. Workers may also qualify as technicians through experience only. Some industrial chemical firms have programs to train draftsmen and laboratory technicians.

Administrative, clerical, and related occupations

The industrial chemical industry employs a wide variety of administrative, clerical, and other "white collar" personnel, numbering about 60,000 at the beginning of 1953. The role of these workers is important, for they perform the many functions involved in the difficult task of running a business. The administrative field offers opportunities for men and women in many interesting and important jobs. Although the qualifications for and the duties of these positions are similar to those in other industries, a knowledge of chemistry is required sometimes.

Many of the higher level administrative and management positions are filled by technically trained men--many of them chemists or chemical engineers. At the top of the administrative group are the executives who make policy decisions concerning matters of finance, types of products to manufacture, and location of plants. To make such decisions, the executives require the help of a large body of specialized personnel.

The accounting department, which is usually headed by the comptroller, performs important and administrative functions. Here the essential and complicated record-keeping systems are set up and maintained. The services of many accountants, bookkeepers, and clerks are required. Accountants establish and direct the accounting procedures and record-keeping systems. They audit the records kept by bookkeepers and clerks, analyze costs, and prepare tax reports. Bookkeepers keep complete and systematic sets of records of business transactions. They do much of their work on bookkeeping machines, calculators, and adding machines. Clerks keep cost and other daily records, make out payrolls, attend to the mail, and make relatively simple calculations on business machines.

Purchasing agents maintain sources from which raw materials, supplies, equipment, and utility services can be regularly obtained. Specialists in the purchasing department buy different kinds of materials and keep up to date on market conditions and the best sources of supply. They must gage the ability of suppliers to meet their firm's requirements and be good judges of value and quality in order to protect the quality of the finished product.

Chemical companies employ a substantial number of sales personnel. Because of the technical nature of the chemical industry, many of them are persons with chemistry or engineering backgrounds. Such training is necessary in order to give customers technical assistance.

A legal staff advises management on protecting legal rights and on performing obligations under existing laws. Lawyers represent their companies in court or before quasi-judicial governmental agencies. Much of their work involves patent or licensing arrangements. A few doctors and nurses are also employed to care for the health of the industry's workers while on the job.

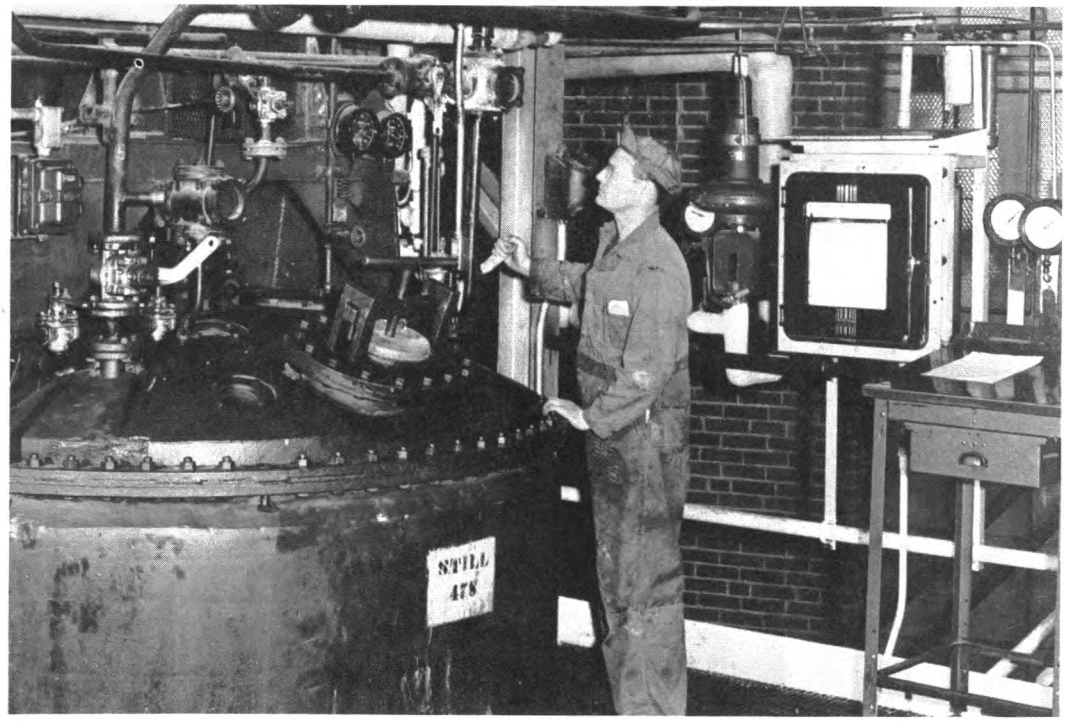
Many industrial chemical companies, especially the larger ones, have industrial relations staffs to formulate, analyze, and recommend labor policies to top management. Trained personnel workers are needed to plan and to assist in the recruiting, training, and rating of employees. They maintain personnel records, classify jobs, engage in employee counseling, and participate in the operation of established health, safety, and retirement systems. These companies employ other administrative workers in such activities as public relations, advertising, and market research.

Thousands of other "white collar" workers are needed to help the specialized workers described above. Included among these are secretaries, stenographers, clerks and typists, and business-machine operators.

Plant occupations

The majority of the employees are in plant occupations; they constitute about 70 percent of the industry's work force. The distribution of these jobs depends on the particular chemical product produced, the process used, and the size and organization of the plant. Chemical plant workers as a whole can generally be divided among three major occupational groups: the process workers who operate the chemical-processing equipment; the maintenance workers who maintain and repair the machinery, pipes, and equipment; and other plant workers, such as stock clerks, material handlers, truck drivers, and others not included in the first two groups.

Process equipment operators and their helpers are the largest occupational group in the industrial chemical industry. Many of the operators are skilled. Chemical operators operate one type of equipment or direct a chemical process utilizing several types of chemical equipment to produce final or intermediate chemical products in accordance with specifications prepared by a chemist. Their duties, however, are relatively similar regardless of the type of equipment. In general, the chemical operator determines the proper proportion of materials according to formulas or specifications. He sets and regulates the controls for temperature, pressure, or flow of materials. In order to check the quality of the operation, the operator uses measuring and testing instruments and keeps records and reports of the operation. He is responsible for the quality and quantity of the product. Usually, he has other chemical operators of lower skill to

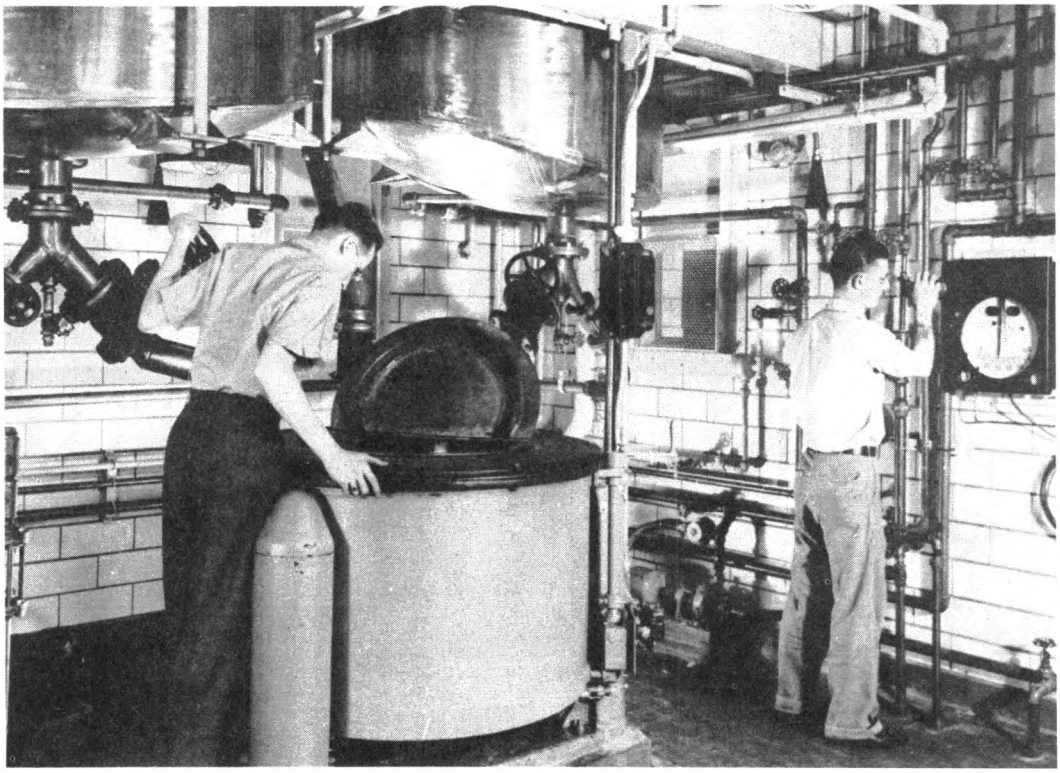


Stillmen are among the most skilled factory workers in the industrial chemical industry.

assist him in addition to various helpers. Since different processes are used to make the many types of chemicals, the kinds of chemical operators vary from plant to plant. For instance, the electric-cell man, an important chemical operator in plants making alkalies and chlorines, may not be found at all in a plant making plastic materials.

Some of the chemical operators are designated according to the type of equipment operated. For example, stillmen operate the distillation equipment that separates volatile mixtures into component parts. Autoclave operators operate high-pressure vessels, called autoclaves, in which the reaction involves chemical changes within highly critical pressure and temperature limits. Evaporator men operate equipment that concentrates chemical solutions by removing part of the water content.

In addition to the chemical equipment operators, there are other process workers who operate the physical process equipment that prepares the raw material for further processing. They tend the various machines which produce physical changes such as the breaking down and refining of chemicals. For example, grinders operate machines which reduce the size of solid particles and screen the resultant powder to meet laboratory specifications. Filterers operate one or more units of filtering equipment used in separating



Autoclave operators tend high pressure vessels in which the reactions involve chemical changes within highly critical pressure and temperature limits.

suspended solids from liquids. Driers operate one or more units of equipment used in separating water or other undesirable volatile liquid components from solids. Volatile components are removed by heating the solids with circulating hot acid or steam and by maintaining a vacuum over the solids. Millers tend one or more units of equipment used to crush, grind, or pulverize materials to specifications. Mixers operate one or more machines in which component parts (liquids or solids) are blended or mixed in controlled amounts.

Most of the skilled chemical operator jobs are filled by promotion from within the plant. New workers are hired as laborers or for some of the other less-skilled plant occupations, such as cylinder filler or drum filler who fill or empty containers for the more skilled workers. The normal progression to jobs of greater skill is first to become a chemical operator's helper. Helpers, after gaining experience, have an opportunity to become highly-skilled chemical operators. Skilled process workers are seldom recruited from other plants. Plant expansion, turnover, and retirement rates are the principal factors determining employment

opportunities for the skilled jobs.

Because industrial chemical manufacturing requires a large amount of complicated equipment relative to workers and because high temperatures and pressures greatly increase the wear on this equipment, the industry employs a high proportion of maintenance workers. In early 1953, they accounted for more than a quarter of all the plant workers. In general, this work is similar to that of maintenance employees in other industries.

Important maintenance occupations in the chemical industry include pipefitters who layout, install, and repair pipes and pipefittings. Carpenters construct and maintain the woodwork and equipment such as doors, partitions, and floors. Maintenance machinists produce replacement parts and new parts for the mechanical equipment in an establishment. Electricians maintain the wiring, motors, switches, and other electrical equipment in good operating condition, and make repairs when equipment breaks down. Lead burners install and repair linings of tanks, lead pipes, and lead fixtures and equipment. Other maintenance workers employed in chemical plants are millwrights and general utility maintenance men.

Although openings in maintenance jobs are sometimes filled by hiring experienced men, they are, generally, filled by men trained in the plant. Most chemical plants conduct apprenticeship programs to meet the needs of their maintenance shops. The apprenticeships usually cover 3 or 4 years and include shop training in the particular job. Usually, classroom instruction in related technical subjects is given either in the plant or in local vocational schools.

The other plant workers, not engaged in operating or maintaining equipment, perform a variety of tasks in industrial chemical plants. In early 1953, about 14,500 workers were employed as material handlers. Some workers drive trucks to make deliveries to various parts of the plant; some load materials on to trucks or in and out of containers; and others check stock. The industry also employs guards, janitors, watchmen, and other custodial workers whose jobs are similar to those in other industries.

Jobs for women

At the beginning of 1953, about 50,000 women held jobs in industrial chemical plants. They were employed mainly in office jobs, such as bookkeepers, clerks, stenographers, and office machine operators. In the plants, they usually worked as laboratory assistants, packers, or in custodial jobs. Women comprised less than 10 percent of all employees engaged in producing inorganic

In 1953, about 14,500 workers were employed in various material handling jobs in industrial chemical plants.

chemicals. They were relatively more numerous, however, in some segments of the organic chemical industry. In the manufacturing of synthetic fibers, more than 25 percent of the plant workers were women; in industrial explosives plants, more than 15 percent were women.

EARNINGS AND WORKING CONDITIONS

Earnings

In general, earnings of production workers in the industrial chemical industry are among the highest in the manufacturing industries. In March 1953, data from plants cooperating with the Bureau of Labor Statistics showed that the average hourly earnings for production workers in the inorganic chemical industry was $1.97 and in the organic chemical industry $1.94, exceeding by 22 cents and 19 cents, respectively, the average of $1.75 for all manufacturing industries. In that month production workers in inorganic chemicals earned $80.97 for an average workweek of 41.1 hours, and those in organic chemicals averages $79.15 for 40.8 hours. This compared with average earnings of $71.93 for an average workweek of 41.1 hours for production workers in all manufacturing industries.

That rates of pay vary considerably among the various occupational groups in the industrial chemical industry was demonstrated in a comprehensive survey of wages for various plant occupations in the industrial chemical industry undertaken by the Bureau of Labor Statistics in late 1951.[6] The average straight-time hourly earnings for selected occupations in various sections of the country are shown in table 3. In examining the earnings of the individual occupations, account should be taken of the fact that average straight-time hourly earnings of production workers in industrial chemical plants increased by about 17 cents between November 1951, when the survey was taken and March 1953. In general, it was found that the highest earnings prevailed in the Southwest and the lowest in New England. In the two major regions, the Middle Atlantic and the Great Lakes regions, job averages were approximately the same as the national levels. The survey also showed that occupational wage averages were higher in the larger industrial chemical establishments.

Very little information is available on the earnings for most technical and administrative occupations in this industry. Some data on the income of chemists and chemical engineers are available from a survey conducted in 1951 by the National Scientific Register with the cooperation of the American Chemical Society.[7] This survey showed that the annual income of chemists varied by levels of education. The median annual income for chemists with bachelor degrees was about $5,200; for those with master's degrees, $6,000; and for those with PhD's, $7,900. The median annual income for chemical engineers with bachelor degrees was $5,600. Those with master's degrees and PhD degrees generally had higher earnings.[8] There has been some increase in earnings of chemists and chemical engineers since 1951.

The Bureau of Labor Statistics wage survey of November 1951 and industry sources provide some data regarding the hours of work arrangements in industrial chemical plants. Because of the need for continuous operations, the workweek in the industrial chemical industry, unlike that in many other industries, corresponds to a calendar week of 7 consecutive days, starting on Monday and ending on the following Monday.

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[6] Wage Structure; Industrial Chemicals, October - November 1951, U. S. Department of Labor, Bureau of Labor Statistics. Series 2, No. 87.

[7] Manpower Resources in Chemistry and Chemical Engineering, U. S. Department of Labor, Bureau of Labor Statistics. Bulletin No. 1132, February 1, 1953.

[8] Income data are for chemists and chemical engineers employed in the broad chemical and allied products industry which includes the industrial chemical industry.

Table 3.
Average Straight-Time Hourly Earnings[1] in Selected Occupations in the Industrial Chemical Industry, United States and Selected Regions, October - November 1951

Occupation, grade, and sex	Average Hourly Earnings[1] in --							
	United States[2]	New England	Middle Atlantic	Border States	Great Lakes	South-west	Pacific Coast	South-east
Processing Occupations (Men)								
Absorbermen	$2.03	—	$1.74	$1.69	$1.95	—	—	—
Autoclave operators	1.86	—	1.94	—	1.79	—	—	—
Chemical operators, class A	1.98	$1.62	2.01	2.10	1.82	$2.20	$1.91	$1.62
Chemical operators, class B	1.80	1.48	1.79	1.71	1.71	2.12	1.85	—
Chemical operators' helpers	1.63	1.45	1.63	1.69	1.62	1.75	1.69	—
Compressors	1.73	1.59	1.67	1.80	1.76	1.92	2.00	—
Driers, class A	1.79	1.60	1.74	—	1.85	—	1.80	—
Driers, class B	1.67	—	1.61	1.50	1.78	—	—	—
Electric-cell men	1.89	—	1.99	—	1.83	—	1.91	—
Evaporator men, class A	1.85	—	1.90	1.77	1.79	—	2.00	—
Evaporator men, class B	1.68	—	1.72	—	1.66	—	1.74	—
Filterers, class A	1.80	1.59	1.88	1.67	1.83	—	1.77	—
Filterers, class B	1.64	—	1.62	—	1.69	—	—	—
Kettlemen, class A	1.85	—	1.84	—	1.84	—	—	—
Kettlemen, class B	1.67	—	1.69	—	1.68	—	—	—
Millers, class A	1.70	—	1.64	1.70	1.83	—	—	—
Millers, class B	1.61	—	1.57	—	1.61	—	—	—
Mixers, class A	1.72	1.64	1.66	1.63	1.83	—	1.74	—
Mixers, class B	1.64	—	1.64	—	1.71	—	1.55	—
Pumpmen	1.79	—	1.82	—	1.77	—	1.90	—
Stillmen, class A	1.97	—	1.97	1.87	1.89	—	—	—
Stillmen, class B	1.80	1.64	1.87	—	1.66	—	—	—
Maintenance Occupations								
Carpenters, maintenance	1.99	1.79	2.03	1.92	1.97	2.13	2.02	1.72
Electricians, maintenance	2.02	1.81	2.00	1.97	1.98	2.21	2.05	—
Lead burners	2.22	—	2.34	2.11	2.27	2.09	2.26	—
Machinists, maintenance	2.01	1.84	2.02	1.96	1.98	2.12	2.04	—
Pipefitters, maintenance	2.01	1.80	2.02	2.00	1.92	2.15	2.02	—
Material Handling Occupations								
Carboy fillers	1.60	—	1.70	—	—	—	1.72	—
Cylinder fillers	1.55	1.35	1.54	—	1.66	—	1.64	1.33
Drum fillers	1.68	—	1.64	—	1.51	1.66	1.71	—
Stock clerks	1.68	1.54	1.64	1.68	1.69	1.79	1.69	1.52
Stock handlers and truckers, hand	1.55	1.41	1.54	1.39	1.66	1.58	1.63	—
Truck drivers	1.70	1.56	1.80	1.71	1.76	1.59	1.80	1.41
Truckers, power	1.67	1.60	1.66	1.47	1.72	1.84	1.75	1.34
Custodial Occupations								
Guards	1.68	1.55	1.63	—	1.72	1.81	1.67	1.56
Janitors	1.47	1.36	1.49	1.35	1.56	1.44	1.56	1.21
Watchmen	1.46	1.10	1.39	1.42	1.63	—	1.49	—
Laboratory Assistants								
Laboratory assistants - men	1.77	1.48	1.83	—	1.65	1.87	1.81	1.56
Laboratory assistants - women	1.58	1.48	1.62	1.62	1.39	—	—	—
Office Occupations (Women)								
Bookkeepers, hand	1.53	1.53	—	—	1.59	1.51	—	—
Bookkeeping-machine operators, class A	1.50	—	—	—	1.89	—	1.41	—
Bookkeeping-machine operators, class B	1.28	—	1.27	1.22	1.32	—	1.24	—
Clerks, payroll	1.39	—	1.51	1.27	1.30	1.51	1.42	1.37
Stenographers, general	1.38	1.16	1.41	1.23	1.37	1.48	1.44	1.26
Typists class A	1.32	1.15	1.41	1.08	1.48	1.35	1.37	—
Typists class B	1.18	—	1.23	.98	1.15	1.30	1.22	—

1/ Excludes premium pay for overtime and nightwork.

2/ Includes data for regions not shown separately.

Source: Wage Structure; Industrial Chemicals, October - November 1951, U. S. Department of Labor, Bureau of Labor Statistics, Series 2, No. 87, Table 4.

However, the employees work a scheduled 5-day, 40-hour workweek with their 2 days off falling on various days in the week instead of regularly on Saturday and Sunday. Frequently, time and a half is provided for on the sixth day and for Saturday as such; double time is provided for on the seventh day and for Sunday as such. The working day, as well as the workweek in this industry, is continuous, so that relatively large proportions of workers are employed on the late shifts. About 16 percent were on the second shift and 14 percent on the third. Night shift workers receive extra or "premium" pay. The typical differentials at the beginning of 1953 were 6 cents an hour for the second shift and 12 cents for the third. Most plants regularly shift workers among the 3 shifts so that the disadvantages of working on the second or third shift can be spread more equitably. Some workers, however, prefer night work regularly in order to have a definite and steady work pattern.

Other employee benefits

Most labor-management contracts in the industry provide other employee benefits. A majority of the workers in the industry are covered by group insurance plans which usually include health insurance, hospitalization, and life insurance. State workmen's compensation laws also provide benefits in case of injury on the job. In addition to Federal social security benefits, about 75 percent of the workers in the industrial chemical industry are covered by pension programs paid for either partially or totally by the chemical companies. Some contracts provide for paid sick leave.

According to the 1951 Bureau of Labor Statistics survey, more than 80 percent of the production workers in the major industrial chemical plants received 6 paid holidays a year; about 15 percent received 7 paid holidays. Paid vacation plans are almost universal in the industry. Periods of vacation vary according to the length of service. The usual plan provides 1-week's vacation after the first year of service, 2-weeks' vacation after 2 years of service, and 3-weeks' vacation after 15 years of service. The usual vacation benefits for office workers are 2 weeks after 1 year's service and at least 3 weeks after 15 years.

Working conditions

The working environment for the industrial chemical worker cannot be described in terms of a typical workplace because of the many types of products and chemical processes used. Working conditions vary with the type of equipment and the size, condition, and age of the plant. In the early stages of the industry's development, working conditions in the chemical plants were unpleasant and hazardous. Disagreeable odors, dust, extremes in temperature,

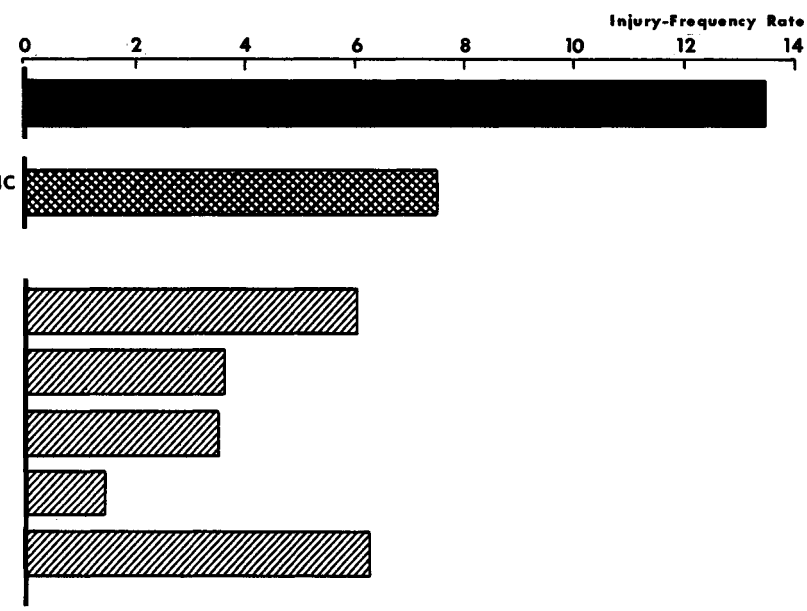
explosions, poisoning from fumes, and chemical burns were common. Chemical companies made intensive efforts to reduce the hazards arising from these conditions by adopting a great many safety measures. For example, ventilating systems minimize odors from fumes and dust from grinding operations. First-aid stations, placard warnings, showers, and eye baths are placed near dangerous work stations; protective clothing, and respirators, also are provided.

As a result of these measures, the industrial injury frequency rate for the industrial chemical industry is about half as high as the average rate for all manufacturing industries. Chart 7 compares the rates for various segments of the industrial chemical industry with the rate for all manufacturing industries combined. In 1952, the average number of disabling injuries was 7.7 for each million man-hours worked in the industrial chemical industry and ranged from 1.4 to 6.3 in industrial organic chemical establishments. This compared with an average of 13.5 for all manufacturing industries.

Labor organizations

Most of the production workers in the industrial chemical industry belong to labor unions. Wage rates, hours of work, vacations, and other matters affecting these employees are, for the most

Chart 7. Injury-Frequency Rate* in the Industrial Chemicals Industries Compared to the Average for Manufacturing Industries, 1952



UNITED STATES DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS

*Disabling Injuries Per Million Man-Hours

part, established by contracts reached through collective bargaining between the unions and the chemical companies. These contracts also contain other provisions, such as those establishing seniority rules and grievance procedures.

The bulk of the workers belong to 1 of the 3 dominant unions in the industry: the International Chemical Workers' Union (AFL); the United Gas, Coke, and Chemical Workers of America (CIO); or District 50, United Mine Workers of America (Ind.). Other unions which organize workers in the industry include the International Association of Machinists (AFL), International Brotherhood of Electrical Workers (AFL), International Brotherhood of Paper Makers of America (AFL), International Union of Operating Engineers (AFL), International Union, United Automobile, Aircraft, and Agricultural Implement Workers of America (CIO), Oil Workers International Union (CIO), Textile Workers Union of America (CIO), United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada (AFL), United Packinghouse Workers of America (CIO), and United Rubber, Cork, Linoleum, and Plastic Workers of America (CIO), and United Textile Workers of America (AFL). In addition, there are many independent (unaffiliated) unions whose collective bargaining activities are usually confined to one establishment.

EMPLOYMENT TRENDS AND OUTLOOK

What is the employment outlook in the industry? This is perhaps the most important question in the minds of young people interested in a career in the industrial chemical industry, for it not only affects their chances for obtaining a job in the industry and holding it over a long period, but also because it influences greatly their promotional opportunities. The employment outlook in the industrial chemical industry is generally favorable. The industry is one of the most rapidly expanding major industries in the United States. The number of workers in the industry has increased from less than 50,000 in 1914 to about 350,000 at the beginning of 1953. The industry developed thousands of new chemical products during this period and improved techniques for producing the older basic chemicals. In the years ahead this pattern of expansion should continue. Technological advances in the manufacture of chemical products now on the market and the development of many new chemical compounds should result in continued growth in employment in the industry.

Industry developed rapidly since World War I

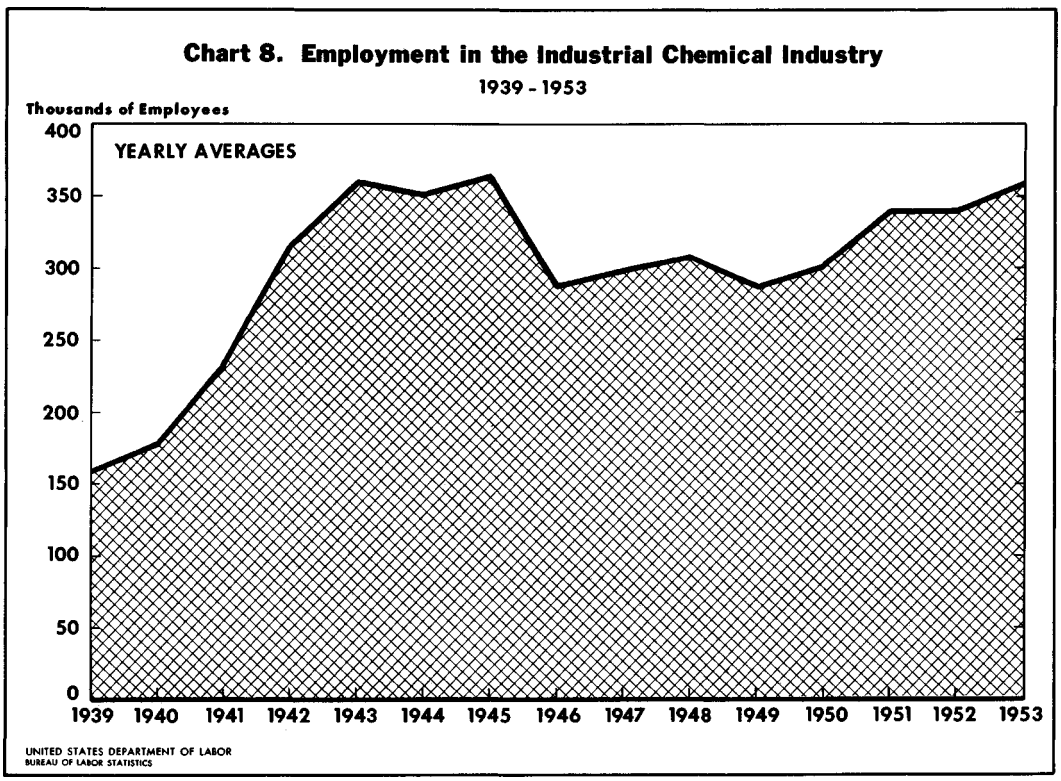
The American chemical industry began over 300 years ago with an alum and saltpeter plant in New England in 1635. During the Revoluntionary War, a number of chemical plants provided the Continental Army with munitions, crude chemicals, and medicines.

A milestone in the industry's development occurred in 1792 when the first sulfuric acid plant in the country was established in Philadelphia. As the Nation expanded and new industries began, the commercial chemical industry grew slowly and steadily. The Civil War stimulated a great expansion of chemical facilities. Toward the end of the 19th century, continuous processing was introduced to replace the old, small-quantity, batch method. Technical "know-how" helped to produce more uniform products, and large-scale production began.

Until the beginning of the first World War, the industrial chemicals industry in the United States was devoted primarily to the production of inorganic or "heavy" chemicals. The organic chemicals segment of the industry was largely limited to dye manufacturers and producers of explosives. The dye plants, however, made less than 10 percent of the dyes and intermediate chemicals needed for American industry. Germany supplied most of the remainder. When these imports ceased at the outbreak of World War I, intensive efforts were made to build an organic chemical industry from the meager facilities available. Employment in industrial chemical plants, more than doubled between 1914 and 1919. By the end of the war, over 90 percent of domestic requirements were being produced in this country. In the interest of national defense, Congress erected tariff barriers after the war to protect the industry from foreign competition. With this protection and the growing demand for chemical products, the industry grew steadily.

Between World Wars I and II great progress was made in developing new products and in improving manufacturing processes. One of the most noteworthy achievements was the development of a method for extracting nitrogen from the air. Particularly large gains were made in synthetic fiber production. The output of rayon increased greatly. In the late 30's nylon was introduced and found a wide market. Plastics made serious inroads into fields previously considered to be exclusively reserved for such materials as wood and metal. Production of many other organic chemicals rose several-fold, and numerous new products were developed.

During World War II the industrial chemical industry expanded rapidly to meet direct military requirements and growing industrial needs. More than 100,000 additional workers were employed during the war in the organic chemical industry to work in the greatly expanded explosives production facilities (Chart 8). Also needed in vast amounts were other industrial chemical products such as synthetic rubber, plastic materials, chlorine, ammonia, and alcohol. Most of the increase in employment in the industrial chemical industry occurred in the early war years. Employment more than doubled between 1940 and 1943 when the number of wage and salary workers



grew to more than 365,000. Employment fluctuated around this level until the war ended.

Employment in the industry dropped sharply at the end of World War II. The number of workers decreased from about 400,000 in June 1945 to about 287,000 in June 1946. Most of the decreases occurred in explosives plants where employment declined by more than 100,000 workers in this 12-month period. By mid-1946, the Nation's manufacturing industries had converted their facilities to the production of peacetime goods and were again using large quantities of chemicals. Employment began to rise in 1947 and continued generally upward for the next few years. The outbreak of hostilities in Korea again stimulated industry expansion. Employment increased from 300,000 in June 1950 to about 362,400 in June 1953.

In mid-1953 employment was still below the peak reached during World War II. However, the industry's output was estimated to be about 50 percent above 1944, the peak wartime year in terms of production of industrial chemicals.[9] (Chart 9).

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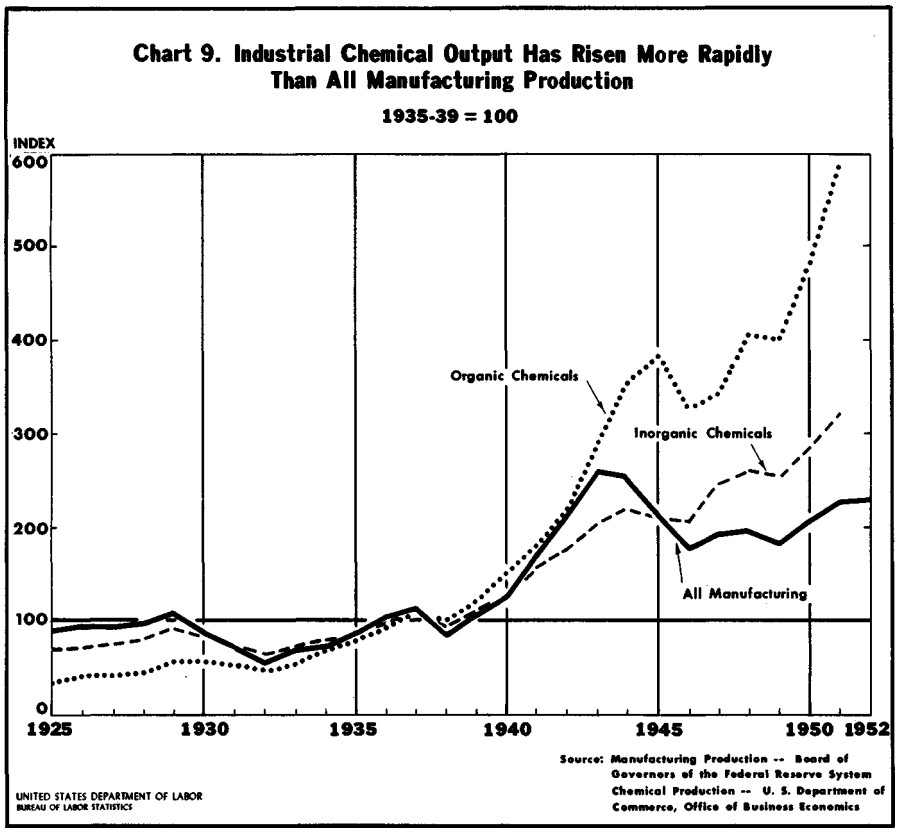
[9] Department of Commerce, "Markets After the Defense Expansion," 1952, adapted from data of the Stanford Research Institute.



This large increase in total output was a result of two factors: (1) a shift from production of military items such as explosives, which require more workers per ton of output, to production of civilian items which are produced in great volume and require fewer workers per ton, and (2) improvements in labor productivity made possible by construction of new plants and installation of more efficient equipment.

Employment outlook favorable

The employment outlook in the industrial chemical industry is favorable for the next few years and over the long run. The industry is presently expanding its capacity. Much of the expansion in facilities has been assisted by the Government's program of rapid tax amortization. At the beginning of 1953, the director of the chemical division of the National Production Authority announced expansion goals for 57 chemicals. Eleven of the goals call for a 1955 production capacity more than double that available in 1951. Defense needs have thus been added to the growing civilian demand for the industry's products. The military preparedness program has increased demand for chemical products such as explosives, industrial alcohol, plastic materials, and synthetic fibers.

The long-range outlook is for continued expansion of the industry. Although it has made amazing progress in the past, the industry has vast potential for further development through the application of laboratory chemistry to industrial production. An official of one of the large chemical companies recently predicted that the industrial chemical industry would increase production five-fold between 1950 and 1975. This dynamic industry has far outstripped most other major industrial groups in rate of growth and in the development of new products. Some of these products have created completely new markets. Others, like plastics and synthetic fibers, have competed successfully in markets previously dominated by wood, natural textile fibers, and metals and are expected to continue to make inroads in these markets. Favorable, also, is the plentiful supply of the raw materials used in chemicals manufacturing.

Employment, however, is not likely to increase in the same proportion as production. The industry is noted for its ability to greatly increase its output with a less than proportionate rise in the number of its employees. For example, production of rayon and other synthetic fibers in 1950 was 3-1/2 times the 1939 output, whereas employment in 1950 was only about 20 percent above the 1939 level. Despite the expected technological progress, the expansion of industry output will be sufficiently great to create a significant increase in the industry's employment requirements.

Employment opportunities will also result from the need to fill vacancies created by death, retirement, or transfer of workers to jobs in other fields. Even without further expansion in the industry, deaths or retirements alone would provide between 5 and 8 thousand openings for new workers each year.

The expected expansion of the industrial chemical industry will bring a rise in employment in all the important occupational groups in the industry. However, the number of workers in some occupations will grow more rapidly than in others. For example, employment opportunities within some of the individual plant occupations will be affected by differences in the rate of expansion in the various branches of the industry. In general, the organic chemical plants are likely to expand more than the inorganic chemical plants. During defense mobilization periods, the greatest proportionate increases occur in plants making explosives, plastic materials, industrial alcohol, synthetic fibers, and synthetic rubber. Technological changes may also affect the employment opportunities in particular occupations. For instance, shifting from the older chamber process to the contact method in manufacturing sulfuric acid decreases the need for lead burners.

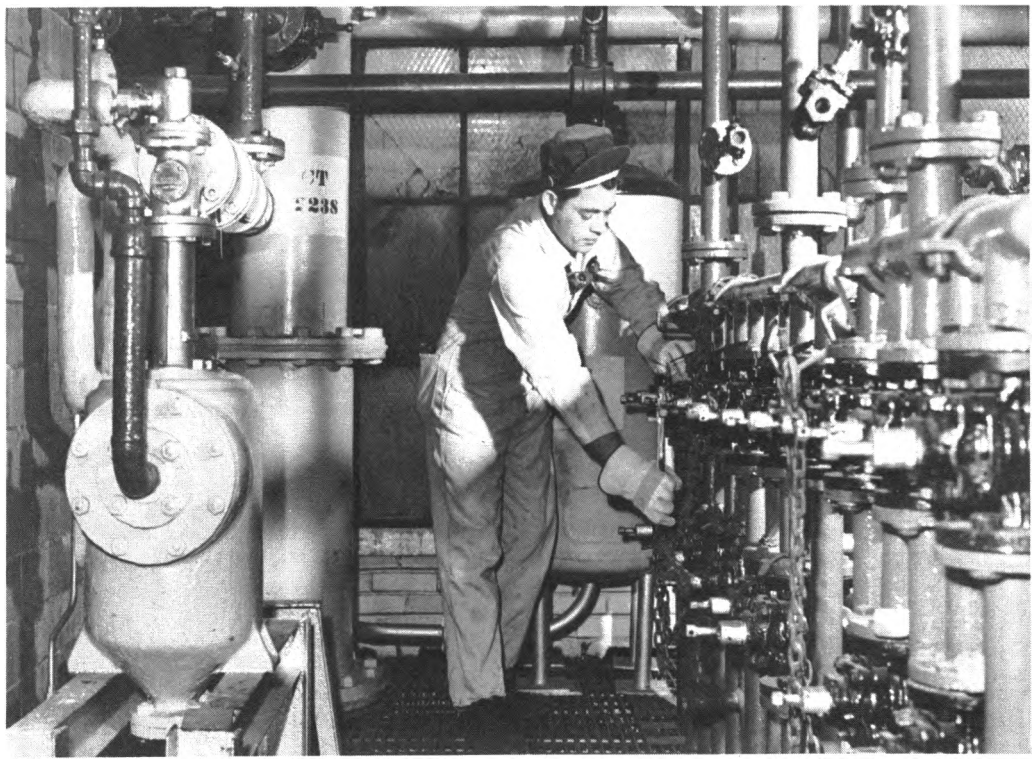
Skilled chemical operators set and regulate the controls for temperature, pressure, and flow of materials.

The processing equipment operators will continue to be the largest occupational group in the industry although the employment in this group may not gain as much as employment of maintenance and repair workers. There has been a continuing development of greater mechanization in chemical plants and, as the trend toward greater automaticity of operation continues, the plants should be able to produce increasing amounts of chemical products with a much less than proportionate increase in the needs for the operators of the various types of processing equipment. At the same time, this increased dependence on mechanical and processing equipment will boost the industry's requirements for workers in maintenance and repair occupations, such as pipe fitters, electricians, and maintenance mechanics. The overall group of plant occupations, which includes the processing and maintenance workers as well as helpers, laborers, and material handlers, will provide the largest number of job openings because the total number of replacement openings will be greater in this field. These replacement needs as well as the expected expanded employment will create many job opportunities for inexperienced persons in the processing occupations. These new workers will be hired in beginning jobs, such as laborers and helpers, with the opportunity to advance to semi-skilled and skilled positions as processing operators. Learning through experience on the job enables the worker to qualify for higher-rated jobs. There will be opportunities for new workers who enter the industry to become skilled maintenance workers by undergoing a formal

apprenticeship program in chemical plants. In addition, some of the skilled maintenance jobs will go to experienced workers from outside the industry.

Because a large proportion of the technical personnel in this industry are employed in the research and development activities, the employment opportunities for professional and technical workers depend to a considerable extent upon the future levels of activities in these fields. The broad group of chemical and allied industries which includes industrial chemicals, has one of the most extensive programs of industrial research in the Nation, ranking third among all industries in the number of research engineers and scientists employed.[10] Because of the vital role of research activities in developing and expanding markets for industrial chemicals, the industry is likely to continue to provide a large number of employment opportunities for chemists, chemical engineers, laboratory technicians, and related staff.

Many skilled maintenance workers are needed in industrial chemical plants because of the large and growing amounts of chemical equipment needed and because high temperatures and pressures greatly increase the wear on this equipment.



[10] See footnote 5, page 13.

OCCUPATIONAL OUTLOOK PUBLICATIONS OF THE BUREAU OF LABOR STATISTICS

Studies of employment trends and opportunities in the various occupations and professions are made available by the Occupational Outlook Service of the Bureau of Labor Statistics.

These reports are for use in the vocational guidance of veterans, in assisting defense planners, in counseling young people in schools, and in guiding others considering the choice of an occupation. Schools concerned with vocational training and employers and trade-unions interested in on-the-job training have also found the reports helpful in planning programs in line with prospective employment opportunities.

Two types of reports are issued, in addition to the Occupational Outlook Handbook: Occupational outlook bulletins describing the long-run outlook for employment in each occupation and giving information on earnings, working conditions, and the training required; and Special reports issued from time to time on such subjects as the general employment outlook, trends in the various States, and occupational mobility.

These reports are issued as bulletins of the Bureau of Labor Statistics. Most of them may be purchased from the Superintendent of Documents, Washington 25, D. C., at the prices listed with a 25-percent discount on 100 copies or more. Those reports which are listed as free may be obtained directly from the United States Department of Labor, Bureau of Labor Statistics, Washington 25, D. C., as long as the supply lasts.

OCCUPATIONAL OUTLOOK HANDBOOK

Employment Information on Major Occupations for Use in Guidance. Bulletin 998 (1951 Revised Edition). $3. Illus.

Includes brief reports on more than 400 occupations of interest in vocational guidance including professions; skilled trades; clerical, sales, and service occupations; and the major types of farming. Each report describes the employment trends and outlook, the training qualifications required, earnings, and working conditions. Introductory sections summarize the major trends in population and employment and in the broad industrial and occupational groups, as background for an understanding of the individual occupations.

The Handbook is designed for use in counseling, in classes or units on occupations, in the training of counselors, and as a general reference. Its 600 pages are illustrated with 103 photographs and 85 charts.

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