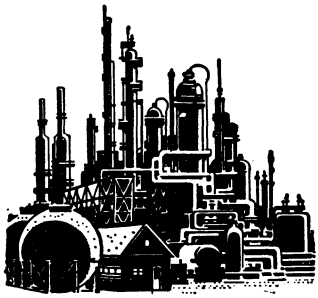

chapter 5

Industries That Employ Engineers

IN THE discussion which follows we shall present a very brief outline of the opportunities that are available for engineers in a number of industries. Any attempt to offer detailed information about any or all of these would call for a volume much beyond the aim of this booklet. It is the author's hope that these outlines will serve as guides and suggestions to the reader who is seeking a picture of the scope of engineering. The reader can fill in the details if he will read descriptive books and pamphlets that are written for that purpose. Some of this interesting and informative material may be obtained from the companies who employ young engineers. Recently those companies have been preparing pamphlets and brochures which describe the work and opportunities that engineers may find with them. In most instances they would welcome inquiries from young men who are seeking information.

It should be pointed out, too, that the list of companies or industries chosen for inclusion in this book is by no means complete. Nor is the arrangement or grouping based upon a strict system. For example, radio and telephone might have been combined under the general heading communications. The author believes that the fields included are important. Furthermore, they are grouped so that they will be recognized readily by the reader.

AUTOMOBILE INDUSTRY

This is an alert, aggressive, dynamic, sales-minded, and highly competitive industry. It has had a phenomenal growth which has affected many segments of our economy. Actually it is an industry

of many parts, each of which is large. There are engine-manufacturing plants, body plants, frame plants, generator plants, axle plants, radiator plants, and many others. All of these are brought together in an assembly line operation that is one of the remarkable developments of the American automobile manufacturers. Several other manufacturers have copied this technique.

The work is specialized. In fact, several of the automobile companies carry on their own educational programs at both the college and the trade school level. Most college men who enter the automobile industry do so by way of one of these training programs. One company has an advanced program which they designate as a graduate engineering course.

The industry has use for all kinds of engineers because the manufacturing companies have very diversified activities on a very large scale. Probably the need would be greatest for mechanical, metallurgical, industrial, and electrical engineers, with a lesser need for chemical, ceramic, and civil engineers. From the functional standpoint the industry uses design, development, research, production, plant, construction, sales engineers, and others.

AVIATION

The aviation industry offers opportunities to aeronautical, mechanical, electrical, civil, chemical, and other engineers in the design and manufacture of the airplane and its accessories, in the construction, operation, and maintenance of airports and landing fields, in the operation and testing of airplanes, in research and teaching, and in governmental employment.

In manufacture there is the design of the plane structure, which is a problem in stress analysis and the selection of parts. Much of this work is routine drafting, but there are opportunities to rise above the drafting board.

The design, production, and testing of the engines offer a field for all types of ability from the routine draftsman to the most creative genius. Much of the work must be experimental, so there are many places, both training and permanent, in this field.

World War II gave tremendous impetus to research and development. The federal government is spending billions of dollars on plants, equipment, and men, for wind tunnels, supersonic research, rockets, and others. The need is for engineers and physicists with keen research and development ability.

The construction and operation of airports require the services of engineers who have had experience in such work. Of course, there are many staff jobs involving schedule and tariff-making,

accounting and auditing, and others, which may be handled by non-engineers. Many of the airline companies are placing their retired pilots in some of these executive and operating positions.

Perhaps a technical education will become an important qualification for pilots because of the increasing number of intricate mechanical features of the airplane, which the pilot must understand. It is probable that the trend will be toward increasing emphasis on educational qualifications. When a college degree becomes an important prerequisite, a man with an engineering degree would have that as a "plus" qualification.

CHEMICAL INDUSTRY

This is a very large, much diversified, and rapidly growing industry. It could be classified into subgroups such as heavy chemicals, light chemicals, and organic chemicals. Probably the most satisfactory way for us will be to make the classification according to important groups of products.

Generally this is the field for chemical engineers, with some demand for mechanical engineers, and less for civil or electrical engineers. They find work, usually, in the following functional departments: Engineering, Development, Research, and Manufacturing.

Engineering in many chemical companies includes the following: Design, which means the design of new plants and plant additions, changes in layouts, and equipment; Construction, where estimates are prepared, contracts made, field work supervised; Industrial Engineering, where the main objective is to lower cost of production and improve quality of products.

In the **Development Department,** patents and processes are evaluated from a commercial point of view, and trends in certain lines of manufacture are analyzed.

The importance of **Research** to the chemical industry is well known. Millions of dollars are spent annually in a search for new products and for new uses for old products. Some engineers enter research.

In the **Manufacturing Department** most of the engineering graduates will be engaged in production work, that is, in the actual processes of turning out the company's product. Mechanical engineers will find opportunities here in design, power, maintenance, and construction.

As mentioned previously, entire industries have been built around individual products in the chemical field. Some of these include: ammonia, where fertilizers, antifreeze, high alcohols, some resins, etc., are made; explosives, including glycerine, nitroglycerin, and gunpowder; fabrics and finishes, which include artificial leather

and lacquered fabrics, enamels, solvents, etc.; pigments that are used in paint, lacquer, linoleum, rubber, inks, paper, soap, textiles, etc.; plastics, where many shapes and sizes are molded from sheets, rods, and tubes; rayon, from which yarn, film, caps, and bottle closures are made; chemicals, inorganic and organic, such as insecticides, dyestuffs, and ethyl alcohol.

CONSTRUCTION INDUSTRY

The construction industry is second in size to agriculture. We include in the industry, although not directly involved in actual construction projects, the mines, mills, and factories that produce the materials such as cement, glass, sand and gravel, and brick, and the heating and plumbing systems, elevators, electrical and power systems, and other equipment and apparatus. Men who work in it include those who conceive and design, those who build with their own hands, and those who own the business. These men build thousands of structures ranging from farm buildings to water and sewage works, highways, skyscrapers that cover a city block, long bridges, and high dams. There will be continuing and increasing need for such men because there is more and more demand for projects that produce power, flood control and irrigation, also national and regional highway systems and toll roads, city planning projects, airports, industrial plants, and homes.

All of this will mean an increaesd demand for engineers in the construction industry. A civil engineer would begin work on these jobs as a timekeeper, instrumentman, or assistant estimator, or he might, if granted permission by the labor union officials, serve as a common or semiskilled laborer to learn construction operations firsthand. As he gained experience, the civil engineer would advance, in the office, to estimator or office engineer; in the field, to construction superintendent. Mechanical and electrical engineers would be responsible for the proper use and maintenance of equipment and the applications of power, on the job.

ELECTRICAL MANUFACTURING

This large industry employs approximately one-fourth of the engineering graduates of our colleges each year. It includes, in its broadest phases, some of the industries which we are listing separately in this discussion. Some of the principal divisions are appliances, automotive electrical equipment, radio and television, electrical controls, computers, business machines, transmission supplies, wire and cable, and generation equipment. Except for appliances (toasters, washing machines, sweepers) the products of this industry are for use by other industries. Therefore, there must be close

cooperation in the planning, design, and manufacture of the equipment. These and other problems require many engineers. As a result, engineers make up a large percentage of the total number of employees of the industry.

Probably the largest number of these will be electrical engineers, although mechanical engineers will be a close second, followed by industrial and chemical, with a few ceramic engineers. The design of electrical equipment has both electrical and mechanical engineering problems. These involve stress, heat flow, vibration, friction, dynamics, and many others. Furthermore, the need for close cooperation between the manufacturer and the user of a piece of equipment makes it necessary that there be engineers, called application engineers, skilled in this field. Also, there is a demand for many sales engineers. Research, too, in many phases of the industry has kept it in the forefront both in people's thinking and in the up-to-dateness of its products.

ELECTRICAL UTILITY

The electric utility companies have always employed large numbers of engineers. In the main, these have been civil, electrical, industrial, and mechanical engineers. The work includes engineering, construction, testing, operating, sales, and service, which are necessary in the production, transmission, and distribution of electrical energy.

Engineering involves drafting and design in connection with the planning of equipment and line additions and improvements.

Construction includes surveying, line construction, and equipment installation.

Testing refers to line, equipment, and material testing. Electricity is an essential and useful form of energy when properly handled, but all possible safeguards must be provided to prevent accidents. Testing helps to provide those safeguards.

Operating deals with the production and transmission of the electrical energy. It is produced in generating plants which may be actuated by water or by some form of fuel engine and, soon, by nuclear energy. This is a very important and little publicized phase of the work. Transmission includes studies of tie lines, power flow, high tension terminals and sub-stations, and distribution systems for alternating and direct current.

Sales and **Service** have assumed increasing importance in recent years, as the number of uses for electricity has increased. Utility companies employ sales engineers who are charged with the job of helping the customer to solve his problems electrically.

FOOD TECHNOLOGY AND MANUFACTURING

Engineers are prone to omit this important industry from their list of employment opportunities. In a general way it is well known because of its aggressive and interesting advertising in the press and over the radio.

Probably a career in this field would be made by a chemical, industrial, or mechanical engineer. At the moment we are thinking primarily of the manuafcturing aspects. In this field there are numerous uses for unit operations for the chemical engineer; for the mechanical engineer there are problems of machine development and design; and for the industrial and the mechanical engineer, problems of production and planning and scheduling, efficiency studies, rate making, safety, and other things that go with factory management.

In other than the manufacturing phases of the food technology field, a man with the typical Bachelor of Science degree in engineering would be handicapped. Here there are highly specialized departments built upon chemistry and bacteriology. The engineer who expects to make progress in this area would be obliged to take many courses in those departments before he would be ready for the work.

PETROLEUM INDUSTRY

This industry offers a wide range of opportunity through all of the functional operations to many kinds of engineers, including in this group chemical, civil, electrical, industrial, mechanical, and mining and metallurgical. A brief outline of the work done will suggest these opportunities to the reader.

There is the phase of surveying and prospecting, locating and marking oil desposits, and determining their potentialities. Civil, electrical, and mining and metallurgical engineers and geologists find work here.

Then there are wells to be driven and operated, pipelines to be laid out, built, and operated. Here is work for civil and mechanical engineers.

In the refinery where the oil and fuels are manufactured there are places for many kinds of engineers: ceramic engineers in the design and installation of refractories; chemical and mining and metallurgical engineers in supervising unit operations and cooperation on design problems; civil engineers in structural design and plant construction; electrical engineers for the design and operation of special electrical equipment; and mechanical engineers in equipment design, plant operation, and maintenance.

After the product has been manufactured there are a host of problems in connection with marketing. Many of these are technical and specialized. Men with sales engineering leanings would do this work. Probably they would come from the chemical, industrial, or mechanical engineering groups.

RADIO AND TELEVISION

There is an immense popular appeal to the fields of radio and television, which has induced many young men to take up the study of electrical engineering. A large percentage of them do not have the necessary aptitudes for the course work of that curriculum. However, both the radio and television industries have large opportunities for the right men. These opportunities will be considered in the fields of manufacturing, communications, and broadcasting.

In **Manufacturing,** electrical engineers will find positions in research, development, and design; also as field engineers, where the work will involve installation and testing of equipment, checking of performance, instructing customers, giving technical aid to the sales department.

Mechanical engineers will work in research, development, design, plant engineering, production engineering, and industrial engineering. Plant engineering involves the generation and distribution of heat, light, and power, and the planning of new plants. Industrial engineering involves cost control, making time studies, and motion economy. Production engineering means supervision of manufacturing processes.

In **Communication** and **Broadcasting,** electrical and mechanical engineers will find work in research, design, installation, testing, and operation of all types of equipment. Specific fields include transmission, reception, electroacoustics (conversion of sound to radio wave and vice versa), and television. These various branches are so closely related, in research, design, manufacturing, and operation, that the large broadcasting companies, networks, and manufacturers find it desirable and necessary to engage in all of the activities.

Many of these jobs require skilled operators and technicians, men who have come up through the manually skilled route. As the technical problems increase in complexity there is a growing tendency to replace the artisan-trained men with those who have an engineering college training. It follows that the engineers who go into this type of work will find it advantageous if they have some manual skill.

RAILWAY ENGINEERING

Civil, electrical, and mechanical engineers will predominate here. Civil engineers find work in the field on surveys, construction, and maintenance, and in the office on drafting and design for track and structures.

Electrical engineers do the design, operation, and maintenance of the electrical equipment. This includes electrical problems of the motor-driven locomotives, the signal equipment, and others.

Mechanical engineers take care of the design, operation, and maintenance of the motive power.

Opportunities in the railway field are more numerous than one might think. Railway management is showing an increased interest in young engineers. Some day these young men will occupy important executive positions. The way to the top is slow and hard and is beset with much tradition. After all, railroading is a specialty, and no young man should feel that his engineering college degree will admit him to the fraternity without first proving his worth.

Another aspect of this railroad field is the manufacturing of railroad equipment. This includes locomotives, cars, track, terminals, and other equipment. Engineering opportunities would be for mechanical, industrial, and electrical engineers in the various manufacturing companies. The scope of the field is large and the need for new ideas and ingenuity very great.

REFRIGERATION AND AIR CONDITIONING

This is an important and growing field, and students of engineering should know about its engineering opportunities. This is particularly important at a time when there is much talk and advertising to encourage young men to enter the field.

In refrigeration the equipment is classified according to size of the machinery as follows: domestic, commercial, industrial. The household refrigerator in its many forms makes up the domestic field. These boxes, either ice or mechanical, are completely engineered and assembled at the factory. Commercial units, which are larger than the domestic units, are also largely standardized; for this reason, most of their engineering would be done during the manufacturing. Industrial applications are extremely varied. Usually they are specially designed and require considerable engineering on the job, such as determining sizes, making plans, and supervising installation.

Air-conditioning units are made in small or package sizes for home installation. The big field has been in the commercial and

industrial air conditioning of entire buildings. This demands a high type of engineering on the job because no two problems are the same. Opportunities for mechanical and industrial engineers will be found in manufacturing, in sales engineering, and in the design of refrigerating and air-conditioning systems.

The foregoing does not include various types of service and repair work, of which there may be a great deal, which are not considered to be opportunities for engineers.

RUBBER AND PLASTICS

Manufactured products include tires, boots, wearing apparel, belting, hose, insulation, tank lining, numerous molded rubber goods, synthetic rubber, and many others from rubber. Plastics include some of the rubber items, and numerous products that are also made from metals, such as containers, handles, combs, furniture, utensils, bearings, and others.

The technology of rubber and of plastic is built upon the science of chemistry. However, the design and layout of plant and equipment and the carrying out of the manufacturing process are the work of engineers. Because of the special nature of the products and processes, many of the manufacturing companies have found it desirable to give their young engineers a training course of as much as two years' duration.

In the main, chemical and mechanical engineers are employed, with a sprinkling of electrical and industrial engineers. Chemical engineers take charge of the compounding and processing of the products. Mechanical engineers are responsible for mold and machine design and plant operation and maintenance. Electrical engineers design electrical equipment. Industrial engineers see that efficient and profitable operations are maintained.

STEEL INDUSTRY, INCLUDING MANUFACTURING AND FABRICATION

This industry starts with the gathering of the raw materials — ore, coal, and limestone — and passes through successive processes of transformation into useful steel and iron products, including their fabrication into finished structures and machines. It employs a large number of engineers each year. In considering the opportunities, we shall find it helpful to list the work done by each type of engineer.

Architectural engineers find work in the planning and design of buildings and the supervision of their construction.

Ceramic engineers are employed principally in the design, selection, and adaptation of refractory materials to the furnaces. These

are linings which protect the steel frames from intense heat. Another field is that of abrasives, which are used for sharpening, grinding, and polishing. The ceramic engineer's part in applying protective coatings to steel products is growing in importance.

Chemical engineers find their largest field in connection with the design and operation of the apparatus used in the utilization of the by-products, such as coke-oven gases and coal-tar. They, with the mining and metallurgical engineers, also supervise the making of chemical and steel analyses, combustion tests, and others. They work with the ceramic engineer in the application of protective coatings on steel products to prevent rust and corrosion.

Civil engineers are engaged in the layout and construction of the plant, its utilities, equipment, roads, and their maintenance and operation after construction. They also do the planning, designing, and erecting of the buildings, bridges, and the like, that are built from steel shapes.

Electrical engineers are engaged in the generation, distribution, and application of electric power in the mill. A modern mill depends almost entirely upon electrical power. Its distribution system is very similar to that of a small city. The electrical engineer designs and lays out this system, then builds and operates it.

The industrial engineer has the broad problem of seeing that the plant is run in a businesslike and efficient way. He studies machinery and plant layout and recommends changes; he correlates time and motion studies and wage systems; he makes cost estimates and determines the probable return from new products.

The mechanical engineer's principal work is in the design, construction, and operation of mill machinery and material-handling apparatus. Details include determination of roll size and contour, rolling pressures, speeds, runout tables, conveyor, cranes; also, the design of furnaces and convertors. Many mechanical engineers work into operating positions of responsibility, leading to that of superintendent and works manager. Others are responsible for plant and equipment maintenance.

Mining and metallurgical engineers have the important task of testing and determining the quality of the steel during its manufacture.

TELEPHONE INDUSTRY

Engineering work in this industry will be done largely by electrical, industrial, and mechanical engineers in three broad fields, namely, technical operations, engineering planning, and engineering development and research.

Technical Operations are found mainly in the plant departments of the operating telephone companies and in the manufacturing and installation departments of the maufacturing company.

In the operating companies the engineers will have charge of skilled workmen in three departments. These are: Engineering, where buildings, office equipment, and transmission systems are planned; Plant, where plans are made and carried out for extension of the outside plant, exchange installation, and property maintenance; Traffic, which operates the switchboards that give service to the public.

In manufacturing, the engineers will be in charge of groups of men in a factory where many diverse and highly technical processes are in use.

Engineering Planning involves the construction and maintenance of the telephone plant, the manufacture of apparatus, and the installation of central office equipment. It includes the development of plans and methods by which suitable technical standards may be met in the most satisfactory and economical way.

Engineering Development and Research are usually carried on in laboratories which are arranged for that purpose. Here, engineers make a critical study of the telephone plant and its operating conditions, formulate the requirements to be met, and devise means for accomplishing the desired result. This work is highly technical and involves research in chemistry, magnetism, physics, optics, mathematics, and their numerous applications.

FEDERAL DEPARTMENTS

In the following outline we shall name some of the governmental agencies that employ engineers. Most of these positions are obtained through civil service examinations. The number of engineers in the government service has been growing steadily, and the end is not in sight. This employment offers reasonable security and an opportunity for individual growth.

Bureau of Reclamation employs civil, electrical, and mechanical engineers for surveys, design, and supervision of construction of dams, spillways, and other structures required in the federal land reclamation and power development program.

Bureau of Standards employs all types of engineers with research aptitudes.

Civil Aeronautics Administration employs civil, electrical, and mechanical engineers to supervise construction and operation of airports, airways, and airplanes.

Coast and Geodetic Survey employs civil and electrical engi-

neers for triangulation, leveling, mapping, and hydrographic surveying.

Engineer Department employs civil engineers who work on the improvement of rivers and harbors.

Geological Survey employs civil engineers who make topographic surveys and gauge streams.

Interstate Commerce Commission employs civil, electrical, and mechanical engineers who make necessary studies and assist in regulation of transportation agencies.

Office of Supervising Architect employs architectural, civil, electrical, and mechanical engineers who act as inspectors and supervisors of construction on federal buildings.

Bureau of Public Roads employs civil engineers who cooperate with state highway engineers in the building of federal aid highways, and construct roads in national parks.

Soil Conservation Service employs agricultural and civil engineers for design and construction of soil-saving structures.

Bureau of Mines employs mining and metallurgical engineers on surveys and inspection.

STATE DEPARTMENTS

Highway departments employ civil engineers who plan, design, construct, and maintain state highways.

Sanitary Engineering departments employ civil engineers who supervise the design and construction of sewage and water works, regulate uses of streams, and participate in general sanitation an public health problems.

Building Inspection departments employ architectural, civil, electrical, and mechanical engineers for inspection and supervision of construction of public and other buildings.

COUNTY AND CITY DEPARTMENTS

Civil engineers are employed by counties in connection with the planning, construction, and maintenance of roads and bridges. Large cities employ architectural, civil, electrical, and mechanical engineers to design, construct, and maintain streets, water supply, and sewerage systems, bridges and buildings, power plants, and others.