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ABSTRACT

Focusing on occupations in energy-producing industries, this document is one in a series of forty-one reprints from the Occupational Outlook Handbook providing current information and employment projections for individual occupations and industries through 1985. The specific occupations covered in this document include coal mining, occupations in the electric power industry, powerplant occupations, transmission and distribution occupations, customer service occupations, occupations in the nuclear energy field, occupations in petroleum and natural gas production and gas processing, and occupations in the petroleum refining industry. The following information is presented for each occupation or occupational area: a code number referenced to the Dictionary of Occupational Titles; a description of the nature of the work; places of employment; training, other qualifications, and advancement; employment outlook; earnings and working conditions; and sources of additional information. In addition to the forty-one reprints covering individual occupations or occupational areas (CE 017 757-797), a companion document (CE 017 756) presents employment projections for the total labor market and discusses the relationship between job prospects and education. (BM)

Energy-Producing Industries

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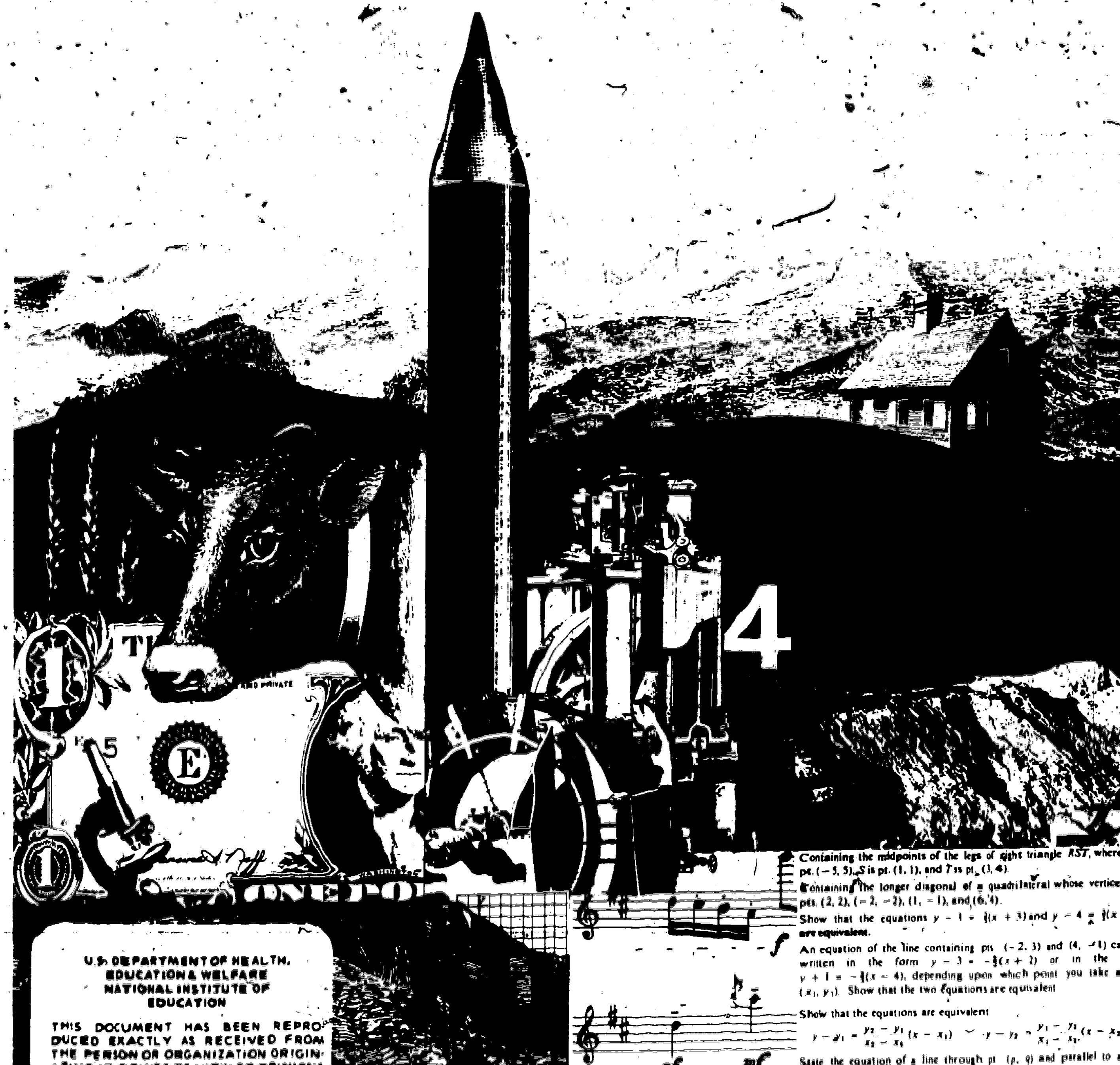


COAL MINING

Nature of the Industry

Coal has played a vital role in the development of this Nation. Originally used only as a source of heat, coal grew rapidly as a source of power with the coming of the steam engine. By the beginning of the 20th century, coal had become vital, not only for heating homes and powering locomotives, but also as a source of energy for producing electric power and a necessary ingredient for making steel. Although coal has been largely replaced by other fuels for heating and transportation, it is used in products ranging from lipstick to chemicals, and most importantly as a source of electric power.

Coal usually is divided into two classes, bituminous and anthracite. Bituminous, or "soft" coal, is the most widely used and the most plentiful, and accounts for most coal production. Production of anthracite, or "hard" coal, on the other hand, is steadily declining due to dwindling reserves and difficulty of recovery. Other forms of coal, such as lignite and peat, are used in only limited amounts.

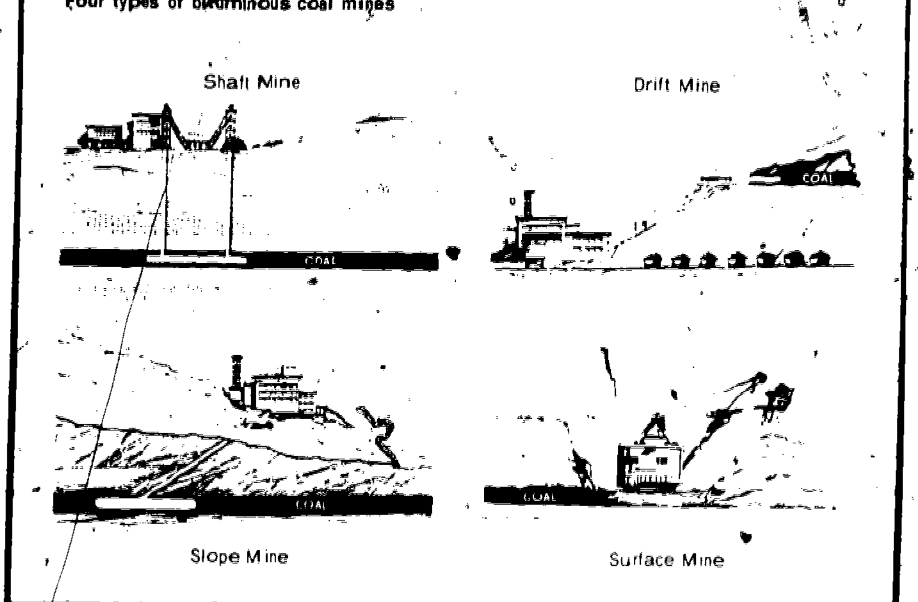
Most of the Nation's coal is mined in the Appalachian area that extends from Pennsylvania through Eastern Ohio, West Virginia, Virginia, Kentucky, Tennessee, and Alabama. Large amounts of coal also are mined in Indiana, Illinois, and in the Rocky Mountain States.

Types of Mines

Coal is either mined underground or extracted from the earth's surface. Underground mines employ most of the workers in the industry but produce less than half of all bituminous coal. Surface mining, a more productive type than underground mining, employs fewer miners to produce more coal.

The type of mine a company decides to open depends on the geological formation and the depth and location of the coal seam. Underground mines are used to reach coal that lies deep below the surface. A series of entries must be constructed so that air, miners, and equipment can reach the seam and coal can be carried out. Depending on the depth of the coal seam, the entry may be vertical (shaft mine), horizontal (drift mine), or at an angle (slope mine). (See chart.) Shaft mines are used to reach coal lying far below the surface. Drift and slope mines are usually not as far underground as shaft mines.

Four types of bituminous coal mines



After the coal seam has been reached, nearly all underground mines are constructed the same way. Miners make a network of interconnecting tunnels so that the mine resembles a maze with passageways going off in predetermined directions, sometimes extending over many miles. As coal is removed, the tunnels become longer and longer. Throughout this process, a significant amount of coal (pillars) is left between the tunnels to support the roof. When miners reach the end of the company's property, they start working back toward the entrance, mining most of the remaining coal as they retreat. This is called retreat mining.

If the coal seam is not too far below ground, surface mining is practiced. Two types of surface mines are strip and auger. At strip mines, huge machines remove the earth and expose the coal. Auger mining is used to remove coal from extremely steep hillsides. A large auger (drill) bores into the hill and pulls the coal out.

Occupations in the Industry

In 1976 about 210,000 people worked in the bituminous coal and lignite mining industry. An additional 4,000 people were employed by companies producing anthracite coal. About 85 percent of all persons in these industries were production workers who mined and processed coal.

Mining jobs range from apprentice miners who usually act as helpers in several occupations to highly skilled and experienced miners who operate equipment worth several hundred thousand dollars. Jobs available in a mine vary by type and method of mining.

Mining Occupations. Two basic methods of mining underground coal, conventional and continuous, account for 95 percent of total underground production. A third method, longwall, makes up most of the remaining production and is increasing in importance. The hand loading method is rarely used.

Conventional mining is the oldest method and requires the most workers and procedures. This type of mining, however, is rapidly being phased out. In conventional mining, the *cutting machine operator* (D.O.T. 930.883) uses a huge electric chain saw, with a cutter ranging in length from 6 to 15 feet, to cut a strip, or kerf, underneath the coal seam to control the direction of the coal as it falls after it has been blasted. Next the *drilling machine operator* (D.O.T. 930.782) drills holes into the coal where the *shot firer* (D.O.T. 931.281) places explosives. This work can be dangerous and must be timed very carefully. The shot firer, for example, must allow enough time for miners to leave the area before the blast.

After the blast, the *loading machine operator* (D.O.T. 932.883) scoops up and dumps the coal into small rubber-tired cars, which are run by the *shuttle car operator* (D.O.T. 932.883). Depending on the type of haulage system used, these cars take the coal to a conveyor belt, for shipment to the main entry or to the surface, or onto mine cars that are transported on tracks to the surface.

The continuous mining method eliminates the drilling and blasting operations of conventional mining. The *continuous-mining machine operator* (D.O.T. 930.883) sits or lies in a cab and operates levers to cut or rip out the coal and load it directly onto a conveyor or shuttle cars.

Longwall mining is basically an extension of continuous mining. In this method, the *longwall machine operator* runs a huge machine with drums which shear and automatically load coal onto a conveyor. At the same time hydraulic jacks reinforce the roof. As the coal is cut and the face progresses, the jacks are hydraulically winched forward and the roof is allowed to cave behind.

Many other workers are required to run a safe and efficient underground mine. Before miners are allowed underground, the *fire boss* or preshift examiner (D.O.T. 939.387) inspects the work area for loose roof, dangerous gases, and adequate ventilation. If safety standards are not met, the fire boss will not allow the miners to enter. The *rock-dust machine operator* (D.O.T. 939.887) sprays limestone on the mine walls and ground to hold down dust since coal dust is extremely explosive and interferes with breathing.

The *roof bolter* (D.O.T. 930.883) operates a machine to install roof support bolts. This operation is extremely important because of the ever-present threat of roof cave-ins, the biggest cause of mine injuries. The *stopping builder* (D.O.T. 869.884) constructs doors, walls, or partitions in the passageways to force air through the tunnels to working areas. The supervisor, called a *face boss* (D.O.T. 939.138), is in charge of all operations at the work site where coal is actually mined.

Teamwork is very important in all types of underground mining. Miners are dependent upon each other when accidents occur for first aid and, if necessary, assistance in leaving the mine. A simple slip around a continuous mining machine, for example, could result in severed limbs.

Most surface miners operate the large machines that either remove the earth above the coal or dig and load the coal. The number of workers required to operate a surface mine depends on the types of machines used and the amount of overburden above the coal seam. The more overburden present, the greater the number of workers usually required.

In many strip mines, the overburden is first drilled and blasted. Then the *overburden stripping operator* or *dragline operator* (D.O.T. 859.883) scoops the earth away to expose the coal. Sometimes, a dragline is so huge and complicated to run that a team of persons is required to operate the levers.

Once the overburden is removed, the *coal loading machine operator* (D.O.T. 932.883) rips coal from the seam and loads the coal into trucks to be driven to the preparation plant. In auger mines, the *rotary auger operator* (D.O.T. 930.782) runs the machine that pulls the coal from sides of hills. *Tractor operators* (D.O.T. 929.883) drive bulldozers to move materials or pull out imbedded boulders or other objects. Helpers assist in operating these machines.

Other workers, not directly involved in the mining processes, work in and around coal mines. For example, skilled repairers, called *fitters* (D.O.T. 801.281), fix all types of mining machinery, and electricians check and install electrical wiring. Carpenters construct and maintain benches, bins, and stoppings. Many mechanics and electricians assemble, maintain, and repair the machines used in mines. While these workers generally need the same skills as their counterparts in other industries, they require additional training to work under the unusual conditions in the mines. Mechanics, for example, may have to repair machines while on their knees with only their headlamp to illuminate the working area. Truckdrivers haul coal to railroad sidings or preparation plants and supplies to the mine.

Preparation Plant Occupations. Rocks and other impurities must be removed before coal is crushed, sized, or blended to meet the buyer's wishes. These processes take place at the preparation plant.

Many preparation plants are located next to the mine. The plant's size and number of employees vary by the amount of coal processed and degree of mechanization. Some plants have all controls centrally located and require few workers to oversee all washing, separating, and crushing operations. Among these workers is the *preparation plant central control operator* (D.O.T. 549.138) who oversees all operations. Plants that are not as mechanized, however, need workers at each step, such as the *wash box attendant* (D.O.T. 541.782) and *separation tender* (D.O.T. 934.885). Wash box attendants operate equipment that sizes and separates impurities from coal. The separation tender operates a device that further cleans coal with currents of water. Most jobs in the preparation plant are very repetitive.

Administrative, Professional, Clerical, and Technical Occupations. A wide range of administrative, professional, technical and clerical personnel work in the coal industry. At the top of the administrative group are executives who make all policy decisions. A staff of specialists, such as accountants, attorneys, and market researchers, supply legal, technical, and market information for decisionmaking. Clerical and secretarial workers assist the administrative staff.

A variety of engineering and scientific personnel work in the coal industry. *Mining engineers* (D.O.T. 010.081 and .187) examine coal seams for depth and purity, determine the type of mine to be built, and supervise the construction and maintenance of mines. *Mechanical engineers* (D.O.T. 007.081, .151, .168, and .187) oversee the installation of equipment, such as centralized heat and water systems, while *safety engineers* (D.O.T. 010.081) are in charge of all health and safety programs.

The scientific staff conducts research on means to make coal a cleaner, more efficient, and more easily transportable energy source. For instance, many physicists, chemists, and geologists are studying feasible alternatives for converting coal into a gas or liquid.

Other technical personnel are required to assist scientists and engineers. For example, *surveyors* (D.O.T. 018.188) help map out the mining areas. Engineering and science technicians may assist in research efforts.

Training, Other Qualifications, and Advancement

Most miners start out as helpers to experienced workers and learn skills on the job. Formal training, however, is becoming more important due to the growing use of technologically advanced machinery and mining methods. As a result, most companies supplement on-the-job training with formal programs and actively seek recent graduates of high school vocational programs in mining, or junior college or technical school programs in mine technology.

Mine technology programs are available in a few colleges throughout the country, mostly in coal mining areas. The programs lead either to a certificate in mine technology after 1 year, or an associate degree after 2 years. Courses cover areas such as mine ventilation, roof bolting, and machinery repairs. Prospective students do not need a high school education but must pass an entrance examination in basic math and English.

The type of formal training administered by coal companies varies. For example, some companies have training mines where skills are taught; others give classroom instruction for a few weeks before allowing workers into a mine. All miners working at mines covered by the United Mine Workers of America contract, however, must receive both preservice and annual retraining sessions from their employers. These programs include subjects such as machine operation, first aid, and health and safety regulations. The U.S. Mining Enforcement and Safety Administration also conducts classes on health, safety, and mining methods, and mine machinery manufacturers offer courses in machine operation and maintenance.

As miners gain more experience, they can move to higher paying jobs. When a vacancy occurs, an announcement is posted and all workers qualified may bid for the job. A mining machine operator's helper, for example, may become an operator. The position is filled on the basis of seniority and ability. A small number of miners advance to supervisory positions and, in some cases, to administrative jobs in the office.

Miners must be at least 18 years old and in good physical condition. A high school diploma is not required. All miners should be able to work in close areas and have quick reflexes in emergencies.

Requirements for scientific and engineering, administrative, and clerical jobs are similar to those in other industries. College graduates are preferred for jobs in advertising, personnel, accounting, and sales. For clerical and secretarial jobs, employers usually hire high school graduates who have training in stenography and typing.

Employment Outlook

Coal is expected to play an increasingly important role as a basic energy source. Rising demand for electric power coupled with greater emphasis on developing domestic energy supplies should result in accelerated coal production. The extent of growth in production, however, is uncertain. Oil, natural gas, and nuclear energy also are used to generate electricity, and the demand for coal will be determined, to some extent, by the price and availability of these fuels. Growth in production also depends on how quickly economical methods of coal gasification and liquification are developed. Environmental standards relating to strip mining and the use of high sulfur content coal, which causes air pollution, may also affect coal output. More coal, however, will be needed to make steel, chemicals, and other products.

Employment is expected to increase but the amount of growth will depend on the level of production, on the types of mines opened, and the mining methods and machinery used. In addition to openings due to growth, several thousand openings will occur each year as experienced miners retire, die, or transfer to other fields of work.

Earnings and Working Conditions

In 1976, union wage rates for miners ranged from $48.62 to $58.92 a day; workers in underground mines generally earned slightly more than those in surface mines or preparation plants. In comparison, production workers in manufacturing averaged $41.52 a day.

Because underground miners spend time traveling from the mine entrance to their working areas, they have a slightly longer day than surface miners. Those in surface occupations work a 7 1/4-hour shift (36-1/2-hour week), while underground miners work an 8-hour day (40-hour week).

Union miners receive 10 holidays and 14 days of paid vacation each year. As their length of service increases, they gain extra vacation days up to a total of 29. Union workers also receive benefits from a welfare and retirement fund, and workers suffering from pneumoconiosis (black lung) receive Federal aid.

Miners have unusual and harsh working conditions. Underground mines are damp, dark, noisy, and cold. At times, several inches of water may be on tunnel floors. Although mines have electric lights, many areas are illuminated only by the lights on the miners' caps. Workers in mines with very low roofs have to work on their hands and knees, backs, or stomachs in cramped areas.

Though safety conditions have improved considerably, miners must constantly be on guard for hazards. There also is the risk of developing pneumoconiosis from coal dust and silicosis from the rock dust generated by the drilling in the mines. Surface mines and preparation plants are usually less hazardous than underground mines.

Sources of Additional Information

For details about job opportunities in mining, contact individual coal companies. General information on mining occupations is available from:

United Mine Workers of America, 900 15th St. NW., Washington, D.C. 20005.

National Coal Association, 1130 17th St. NW., Washington, D.C. 20036.

Mining Enforcement and Safety Administration, Department of Interior, Washington, D.C. 20240.

OCCUPATIONS IN THE ELECTRIC POWER INDUSTRY

Electricity has become so much a part of our daily lives that most people take it for granted. But just imagine not being able to ride the elevator to your apartment and instead having to walk up all those flights of stairs. Or think about having no lights, television set, or radio in your home. Today, it would be difficult to get used to living without electricity.

Bringing electricity into our homes and places of work and recreation is not as simple as just turning on a switch. There are thousands of employees working in the electric power industry to make all this possible.

Nature and Location of the Industry

The delivery of electricity to users at the instant they need it is the unique feature of the electric power systems. Electricity cannot be stored efficiently but must be used as it is produced. Because a customer can begin or increase the use of electric power at any time by merely flicking a switch, an electric utility system must have sufficient capacity to meet peak consumer needs at any time.

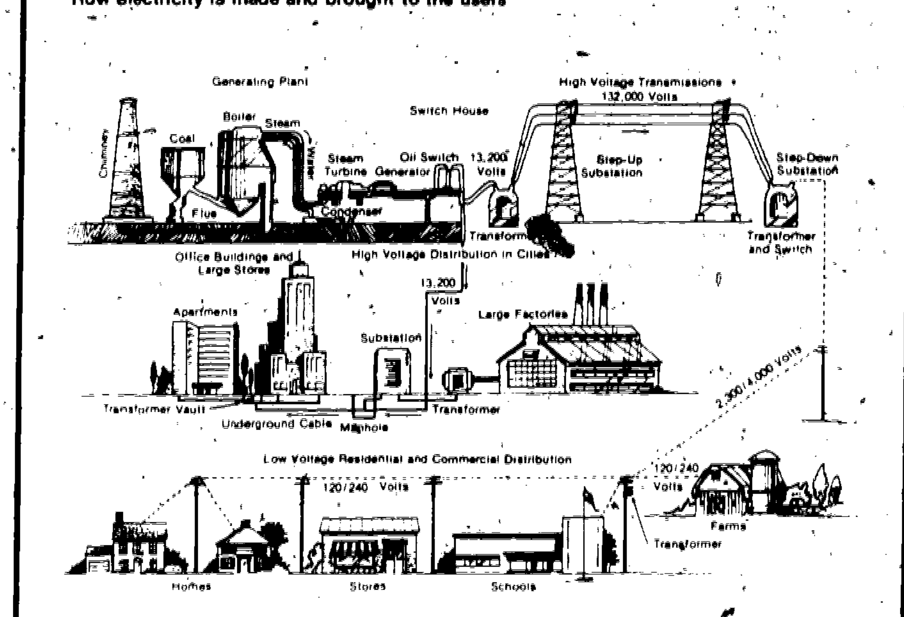
An electric utility system includes powerplants that generate electric power, substations that increase or decrease the voltage of the power, and vast networks of transmission and distribution lines. Electric utilities range from large systems serving broad regional areas to small power companies serving individual communities. Most electric utilities are investor-owned (private) or owned by cooperatives; others are owned by cities, counties, and public utility districts, as well as by the Federal Government. While some utilities generate, transmit, and distribute only electricity, others distribute both electricity and gas. This chapter is concerned with employment relating only to the production and distribution of electric power.

Producing and distributing large quantities of electrical energy involves many processes and activities. The accompanying chart shows how electric energy is generated, and how it travels from the generating station to the users.

The first step in providing electrical energy occurs in a generating station or plant, where huge generators convert mechanical energy into electricity. Electricity is produced primarily in steam-powered generating plants that use coal, gas, oil, or nuclear energy for fuel. In addition, a considerable amount of electricity is produced in hydroelectric generating stations that use water power to operate the turbines. Still other generators, primarily for use in standby service or to provide electricity for special purposes, are powered by diesel engines or gas turbines.

After electricity is generated, it passes through a "switchyard," where the voltage is increased so that the electricity may travel long distances without excessive loss of power. Next the electricity passes onto transmission lines that carry it from the generating plant to substations,

How electricity is made and brought to the users



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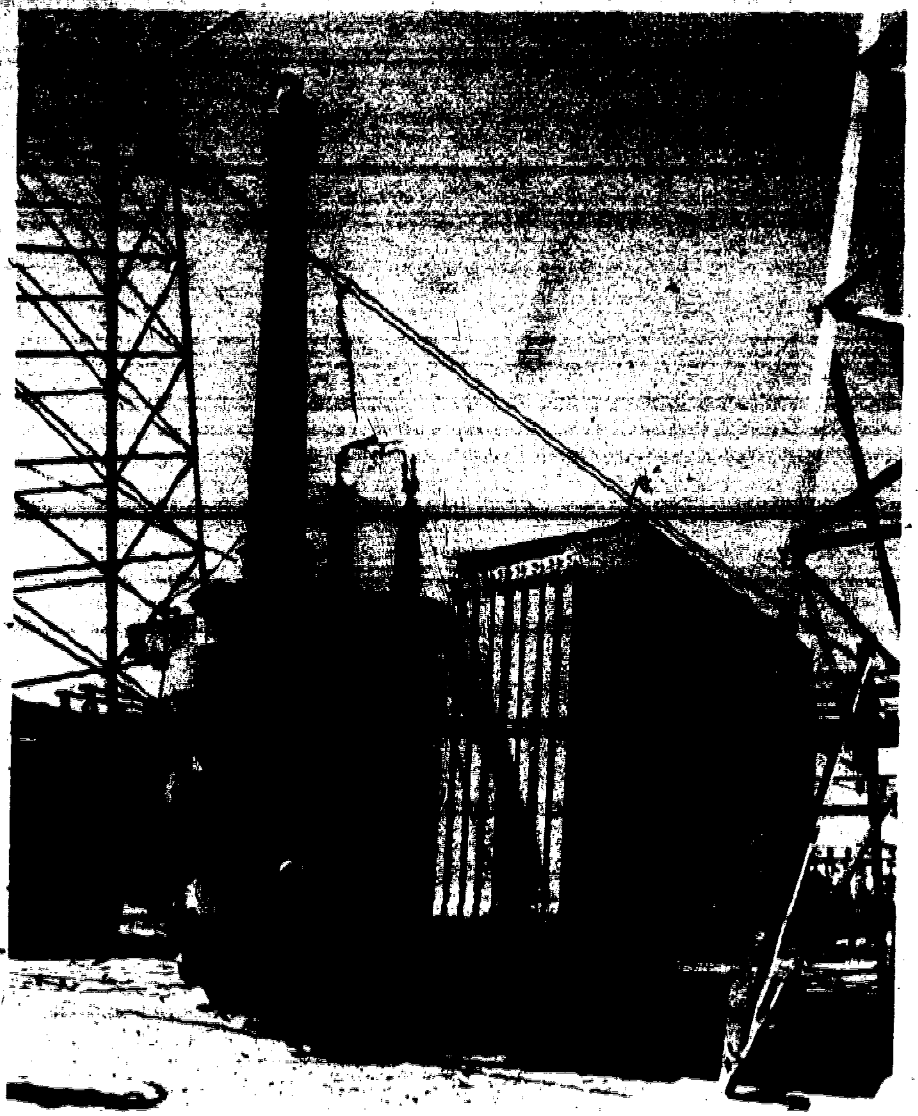


Jobs in the electric power industry are found throughout the country.

where the voltage is decreased and passed on to the distribution networks serving individual customers. Transmission lines tie together the generating stations of a single system and also the power facilities of several systems. In this way, power can be interchanged among several utility systems to meet varying demands.

In 1976, 544,000 people worked in the electric power industry. Most of them, 461,000, worked in investor-owned utilities and cooperatives and 80,400 worked in Federal and municipal government utilities. A few large manufacturing establishments, which produce electric power for their own use, also employ electric power workers.

Since electricity reaches almost every locality, jobs in this industry are found throughout the country. Although hydroelectric power projects have created jobs in relatively isolated areas, most utility jobs still are found in heavily populated urban areas.

Electric Utility Occupations. Many different types of workers are required in the electric power industry. About 40 percent of the industry's employees work in occupations related to the generation, transmission, and distribution of electricity, and in customer service occupations. (These occupations are discussed in detail later in this chapter.) The industry also employs large numbers of workers in engineering, scientific, administrative, sales, clerical, and maintenance occupations. A brief discussion on these occupations is given below. Further information can be found in statements covering individual occupations elsewhere in the *Handbook*.

Engineering and Scientific Occupations. Engineers plan generating plant construction and additions, interconnections of complex power systems, and installations of new transmission and distribution systems and equipment. They supervise construction, develop improved operating methods, and test the efficiency of the many types of electrical equipment. In planning modern power systems, engineers help select plantsites, types of fuel, and types of plants. Engineers also help industrial and commercial customers make the best use of electric power. For example, they may demonstrate how to modernize a chemical manufacturing plant or how to remodel a store or hotel, suggesting changes that would use electricity more effectively.

Administrative and Clerical Occupations. Because of the enormous amount of recordkeeping required, electric utilities employ many administrative and clerical personnel. Large numbers of stenographers, typists, bookkeepers, office machine operators, file clerks, accounting and auditing clerks, and cashiers are employed. These workers keep records of the services rendered by the company, make up bills for customers, and prepare a variety of statements and statistical reports. An increasing amount of this work in the larger offices now is being performed by computers. This generally results in more clerical work being done either by fewer or by the same number of employees. The use of this equipment also creates a need for programmers and computer operators. Administrative employees include accountants, personnel officers, purchasing agents, and lawyers.

Maintenance Occupations. A considerable number of workers test, maintain, and repair equipment. The duties of these skilled craft workers are similar to those of maintenance workers in other industries. It may be necessary to replace a switch or transformer, for example, or a weak section in a boiler may have to be repaired. Among the more important skilled workers are electricians, instrument repairers, industrial machinery repairers, machinists, pipefitters, welders, and boilermakers.

Employment Outlook

Employment in the electric power industry is expected to increase about as fast as the average for all industries through the mid-1980's. The greater use of electric power in industrial processes, growth of commercial centers such as shopping malls, and population growth all will contribute to an increased demand for electricity. However, due to the growing use of automatic controls, employment will not increase as fast as electric power production.

Trends in growth will differ from one occupation to another in the industry. The need for scientific, engineering, and technical employees is expected to increase sharply as construction of power generating plants increases and as research into developing more efficient energy usage to combat shortages and higher prices of fossil fuels becomes necessary. Much of this increase in employment will be in the development and construction of new nuclear power facilities.

In many other occupations in this industry, only slight increases in employment are expected. Larger, more efficient powerplants will limit growth of employment of powerplant employees. The increased use of electronic data processing equipment for billing and recordkeeping will restrict growth in some clerical jobs. In occupations that will experience little or no growth, most job openings will result from the need to replace workers who die, retire, or leave the electric power industry for other reasons.

People hired by electric power companies are likely to have relatively secure jobs. Even during downturns in the economy, these companies seldom lay off employees.

Earnings and Working Conditions

Earnings in the electric utility industry are relatively high. In 1976, nonsupervisory employees in private electric power companies averaged $6.60 an hour. By comparison, the average for all nonsupervisory workers in private industry, except farming was $4.87 an hour.

Because supplying electricity is a 24-hour, 7-day-a-week activity, some employees work evenings, nights, and weekends, usually on rotating shifts. Most union contracts with electric utilities provide a higher rate of pay for evening and nightwork than the basic day rate.

Overtime work often is required, especially during emergencies such as floods, hurricanes, or storms. During an "emergency callout," which is a short-notice request to report for work during nonscheduled hours, the worker generally is guaranteed a minimum of 3 or 4 hours' pay at 1 1/2 times the basic hourly rate. Travel time to and from the job is counted as worktime.

In addition to these provisions that affect pay, electric utilities provide other employee benefits. Generally, annual vacations are granted to workers according to length of service. A typical contract or employee benefit program provides for a 1-week vacation for 6 months to 1 year of service, 2 weeks for 1 to 10 years, and 3 weeks for 10 to 20 years. Some contracts and programs provide for 4 weeks after 18 years, 5 weeks after 25 years, and 6 weeks after 30 years. The number of paid holidays ranges from 6 to 12 a year. Nearly all companies have benefit plans for their employees. A typical program provides life, hospitalization, and surgical insurance and paid sick leave. Retirement pension plans supplement Federal social security payments and generally are paid for in full or in part by the employer.

Because of the dangers of electrocution and other hazards, electric utilities and unions have made intensive efforts to enforce safe working practices. This has resulted in an injury rate lower than in most manufacturing industries. However, some occupations, especially those on line-crews, are more subject to accidents than others.

Many nonsupervisory electric utility workers in production, transmission, and distribution departments are union members. The bargaining representative for most of these workers is either the International Brotherhood of Electrical Workers or the Utility Workers Union of America. Independent unions represent some utility workers.

Sources of Additional Information

Information about jobs in the electric power industry is available from local electric utility companies, from industry trade associations, or from the local offices of unions that represent electric utility workers. Additional information also may be obtained from:

Edison Electric Institute, 90 Park Ave., New York, N.Y. 10016.

International Brotherhood of Electrical Workers, 1125 15th St. NW., Washington, D.C. 20005.

Utility Workers' Union of America, 815 16th St. NW., Washington, D.C. 20006.

POWERPLANT OCCUPATIONS

Nature of the Work

Powerplants employ many different types of workers to produce electricity. All equipment in the plants must be kept in good running order; thus the machinery must be regularly cleaned and serviced, and all operations carefully checked and controlled. Maintenance personnel, including electrical, instrument, and mechanical repairers, inspect and repair this equipment. For example, an instrument repairer may notice that a gauge connected to a turbine does not register properly. The repairer may disassemble the gauge, locate the specific problem, and replace a part if necessary.

Other powerplant workers include helpers and cleaners, and the custodial staff, including janitors and guards. In steam generating plants using coal for fuel, coal handlers also are employed. In hydroelectric plants, gate tenders open and close the headgates that control the flow of water to turbines. Supervision of powerplant operations is handled by chief engineers called operations supervisors, and by their assistants, watch engineers (also called shift supervisors).

Operators are the key workers in a powerplant. They include four basic classes of workers—switchboard, boiler, turbine, and auxiliary equipment operators. Their job is to observe and regulate the various kinds of powerplant equipment, keep records of all operations to make certain that equipment functions efficiently, and to detect any trouble that may arise. In this way, operators ensure that power production will not be interrupted.

Switchboard operators (D.O.T 952.782) control the amount of electric power flowing from generators to outgoing powerlines by watching instrument panels and by operating switchboards. Switches control the movement of electric current through the generating station circuits and onto the transmission lines. Instruments mounted on panelboards show the power demand on the station at any instant, the powerload on each line leaving the station, the amount of current being produced by each generator, and the voltage.

The operators use switches to distribute the power demands among the generators, to combine the current from two or more generators, and to regulate the flow of the electricity onto various powerlines according to the changing needs of consumers. When power requirements change, they order generators started or stopped and, at the proper time, connect them to the power circuits in the station or disconnect them. In doing this, they follow telephone orders from the load dispatcher who directs the flow of current throughout the system.

Switchboard operators and their assistants also check their instruments frequently to see that electricity is moving through and out of the powerplant properly, and that correct voltage is being maintained. Among their other duties, they keep records of all switching operations and of load conditions on generators, lines, and transformers. They obtain this information by making regular meter readings.

Boiler operators (D.O.T. 950.782)—employed only in steam-powered generating plants—are responsible for maintaining the proper steam pressure needed to turn the turbines. They note and regulate the fuel, air, and water supply used in the boilers using control valves, meters, and other instruments which are mounted on panel boards. The size of the generating unit determines the number of boilers used; thus a boiler operator may be responsible for operating one or several boilers.

Turbine operators (D.O.T. 952.138) control the turbines that drive the generators. In small plants, they also may operate auxiliary equipment or a switchboard. Since modern steam turbines and generators operate at extremely high speeds, pressures, and temperatures, the operator must give close attention to the pressure gauges, thermometers, and other instruments showing the operations of the turbo-generator unit. Turbine operators record the information shown by these instruments and check the oil pressure at bearings, the speed of the turbines, and the circulation and amount of cooling water in the condensers that change the steam back into water. They also are responsible for starting and shutting down the turbines and generators, as directed by the switchboard operator in the control room. Other workers, such as helpers and junior operators, assist the turbine operators.

Auxiliary equipment operators (D.O.T. 952.782) check and record the readings of instruments that indicate the operating condition of pumps, fans, blowers, condensers, evaporators, water conditioners, compressors, and coal pulverizers. Precise operation of this machinery is directly related to the proper functioning of boilers and turbines. For example, after steam goes through the turbines, it enters the condensers. Here the steam becomes water. This operation of the condensers provides some of the force that drives the turbines. Since auxiliary equipment may occasionally break down, these operators must be able to detect trouble quickly, and sometimes make minor repairs. In small plants which do not employ auxiliary equipment operators, these duties are performed by turbine operators.

In most powerplants constructed in recent years—including nuclear—the operation of boilers, turbines, auxiliary equipment, and the switching required for balancing generator output has been centralized in a single control room. From here, central *control room operators* (D.O.T.

Operators check and record the readings of instruments.

950.782) or powerplant operators regulate all the generating equipment, which in older plants requires specialists such as boiler and turbine operators. Control room operators have several assistants who patrol the plant and check the equipment. When equipment is not operating properly, operators report problems to the plant superintendent or a watch engineer.

Watch engineers or shift supervisors (D.O.T. 950.131) oversee the workers in the powerplant who operate and maintain the boilers, turbines, generators, transformers, switchboards, and other machinery and equipment. Watch engineers are supervised by a chief engineer or a plant superintendent who is in charge of the entire plant. In small plants, the watch engineer also may be the general plant supervisor.

Generally, a nuclear-powered plant requires about the same kind and number of employees as a steam-generating plant powered by coal. However, nuclear plants employ a few additional employees such as health and safety specialists.

Training, Other Qualifications, and Advancement

New powerplant workers generally begin at the bottom of the ladder—usually on cleanup jobs. Such work gives beginners an opportunity to become familiar with the equipment and the operations of a powerplant. They advance to the more responsible job of helper as openings occur. Formal apprenticeships in these jobs are uncommon. Applicants generally are required to have a high school or vocational school education.

It takes from 1 to 3 years to become qualified as an auxiliary equipment operator and from 4 to 8 years to become a boiler operator, turbine operator, or switchboard operator. A person learning to be an auxiliary equipment operator progresses from helper to junior operator to operator. A boiler operator generally spends from 2 to 6 months as a laborer before being promoted to the job of helper. Depending on openings and the worker's aptitude, the helper may advance to junior boiler operator and eventually to boiler operator, or transfer to the maintenance department and work up to boiler repairer. Turbine operators advance from the ranks of auxiliary equipment operators.

Where a utility system has a number of generating plants of different size, operators usually first get experience in the smaller stations and then are promoted to jobs in the larger stations as vacancies occur. Thus, how rapidly a worker advances also may depend on the availability of openings. If these are few, it may take longer to obtain a particular job than just to learn it.

In many States and large cities, employees who operate equipment in powerplants must be licensed by local or State agencies. While licensing requirements often vary from place to place, the National Institute for the Uniform Licensing of Power Engineers (NIULPE) is attempting to standardize these requirements.

Some powerplant workers employed in atomic-powered electric plants must have special training to work with nuclear fuel, in addition to the knowledge and skills required for conventional steam-generated electric power. All control room operators, assistant control room operators, and some operators of high pressure auxiliary equipment in nuclear powerplants must be licensed by the Nuclear Regulatory Commission.

New workers in the switchboard operators section begin as helpers, advance to junior operators, and then to switchboard operators. Some utility companies promote substation operators to switchboard operating jobs. The duties of both classes of operators have much in common. Switchboard operators can advance to work in the load dispatcher's office.

Watch engineers are selected from among experienced powerplant operators. At least 5 to 10 years of experience as a first-class operator usually are required to qualify for a watch engineer's job.

Employment Outlook

Employment of powerplant operators is expected to increase more slowly than the average for all occupations through the mid-1980's, even though the production of electrical energy will increase at a rapid rate. Although some new jobs will become available, most job openings will occur because of the need to replace workers who retire, die, or leave the industry for other work. People hired by electric power companies are likely to have relatively secure jobs. Even during downturns in the economy these companies seldom lay off employees.

Because of the increased demand for electric power, it will be necessary to build and operate many new generating stations. The use of larger and more efficient equipment, however, will result in a great increase in capacity and production without a corresponding increase in the number of powerplant operators. For example, it takes only one turbine operator to control a turbo-generator regardless of the generator's size. Also, automatic equipment makes it possible to control several boilers from a central control room.

Earnings and Working Conditions

The earnings of powerplant workers vary by occupation and locality. The following tabulation shows estimated average hourly earnings for selected powerplant occupations in privately owned utilities in 1976.

	Average hourly earnings
Auxiliary equipment operator	$5.66
Boiler operator	7.44
Control room operator	8.26
Switchboard operator:	
Switchboard operator, Class A	7.56
Switchboard operator, Class B	7.03
Turbine operator	7.26
Watch engineer	8.67

A powerplant is typically well-lighted and ventilated, clean, and orderly, but there is some noise from the equipment.

Switchboard operators in the control room often sit at the panel boards, but boiler and turbine operators are almost constantly on their feet. The work of powerplant operators generally is not physically strenuous, particularly in the new powerplants. Since generating stations operate 24 hours a day, 7 days a week, some powerplant employees must work nights and weekends, usually on rotating shifts.

Sources of Additional Information

For information concerning licensing of powerplant employees, contact State and local occupational licensing agencies in your area or write to:

National Institute for Uniform Licensing of Power Engineers, 176 W. Adam St., Suite 1914, Chicago, Ill. 60603.

TRANSMISSION AND DISTRIBUTION OCCUPATIONS

Nature of the Work

One-fourth of the workers in the electric power industry are in transmission and distribution jobs. This phase of the utility system links the electric power produced in generating plants to individual customers according to their needs. The principal workers in these jobs are those who control the flow of electricity—load dispatchers and substation operators—and employees who construct and maintain powerlines—line installers and repairers, cable splicers, troubles ground helpers, and laborers.

Load dispatchers (D.O.T. 950.168), also called system operators or power dispatchers, control the flow of electricity throughout the area served by the utility. They operate the plant equipment used to generate electricity and direct its flow. The load dispatcher's source of information for the entire transmission system is the pilot board. This board, which dominates the load dispatcher's room, is a complete map of the utility's transmission system. It enables the dispatcher to determine, at a glance, the existing conditions at any point in the system. Often lights are connected to the pilot board, which show the positions of switches that control generating equipment and transmission circuits, as well as high-voltage connections with substations and large industrial customers. The board also may have meters and several recording instruments that make a graphic record of operations for future analysis and study.

Because it takes some time to change the level of electricity being produced, the load dispatcher must anticipate power demands so that the system will be prepared to meet them. Power demands on utility systems may change from hour to hour. A sudden afternoon rainstorm, for example, may cause a million lights to be switched on in a matter of minutes. Dispatchers telephone instructions to the switchboard operators at the generating plants and the substations, telling them when to start or stop additional boilers and generators so that power production will be in balance with power needs.

Dispatchers also direct the handling of any emergency situation, such as transformer or transmission line failure, and route current around the affected area. They also may be in charge of interconnecting their utility system with other systems and directing transfers of current between systems as the need arises.

Substation operators (D.O.T. 952.782) generally are responsible for the operation of the step-up or step-down substations. A step-up substation usually is located adjacent to the powerplant to raise the voltage of the electricity so it can travel long distances. A step-down substation, at the other end of the transmission lines, reduces power voltage before it is sent out to the customer. Under orders from the load dispatcher, these operators use a switchboard to direct the flow of current out of the station. Ammeters, voltmeters, and other types of instruments register the amount of electric power flowing through each line. The flow of electricity from the incoming to the outgoing lines is controlled by circuit breakers. The substation operators, using switchboard levers that control the circuit breakers, connect or break the flow of current. In some substations, where alternating current is changed to direct current to meet the needs of special users, the operator controls converters which perform the change.

In addition to switching duties, substation operators check the operating condition of all equipment to make sure that it is working properly. They supervise the activities of the other substation employees on the same shift. In smaller substations, the operator may be the only employee.

Some utilities employ a mobile operator who drives from one automatic station to another, inspecting powerlines, operating controls, and assisting customers' electricians in large commerical or governmental installations.

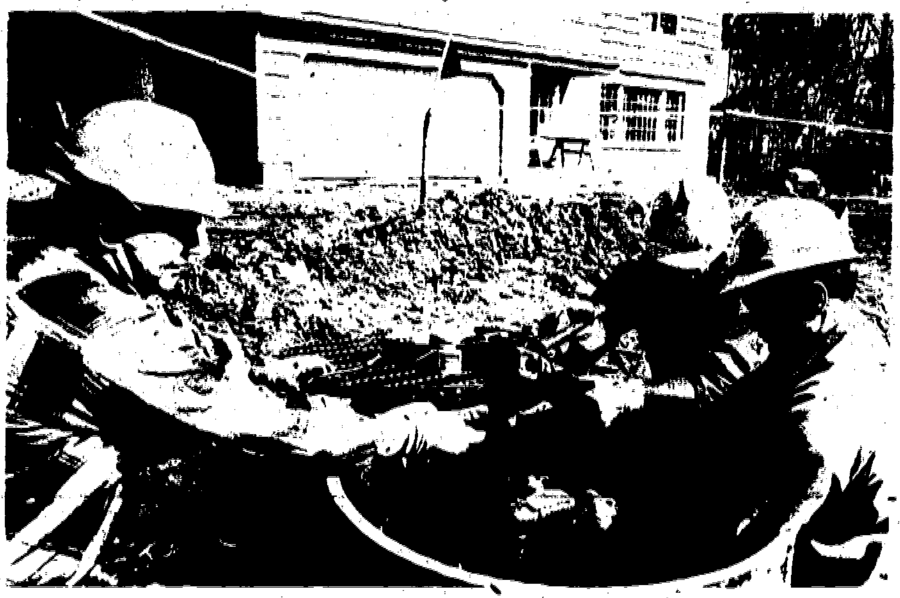
Line installers and repairers (D.O.T. 821.381) make up the largest single occupation in the industry. They construct and maintain the network of powerlines that carries electricity from generating plants to consumers.

Installers bolt crossarms to transmission poles and then bolt or clamp insulators in place on the crossarms. Next, they raise wires and cables and attach them to the insulators. Other equipment, such as lightning arrestors, transformers, and switches, also must be attached to the poles. Any routine maintenance and replacements necessary are performed by line installers and repairers.

When wires, cables, or poles break, it means an emergency call for a linecrew. Line repairers splice or replace broken wires and cables and replace broken insulators or other damaged equipment. Most installers and repairers now work from "bucket" trucks with pneumatic lifts that take them to the top of the pole at the touch of a lever.

In some power companies, linecrew employees specialize in particular types of work. Those in one crew may work on new construction only, and others may do only repair work.

Trouble shooters (D.O.T. 821.281) are experienced line installers and repairers who are assigned to special crews that handle emergency calls. They move from one job to another, as ordered by a central service office that receives reports of line trouble.



Line installers constructing underground electric power lines.

Often troubleshooters receive their orders by direct radio communications with the central service office.

To do this job well, these workers must have a thorough knowledge of the company's transmission and distribution network. Upon reaching the location of the break, they first find and report the source of trouble, and then attempt to restore service by making the necessary repairs. For example, depending on the nature and extent of the problem, troubleshooters may have to install new fuses or cut down live wires. They must be familiar with all the circuits and switching points so that they can safely disconnect live circuits when lines break down.

Ground helpers (D.O.T. 821.887) assist in constructing, repairing, and maintaining the transmission and distribution lines. For example, they dig pole holes, and then help the line installers and repairers to raise the poles while positioning them into the holes.

Cable splicers (D.O.T. 829.381) supervise the installation of insulated cables on utility poles and towers, as well as those buried underground and those carried in underground conduits. When cables are installed, these workers direct the laying of the conduit and the pulling of the cable through it. The cables are joined at connecting points in the transmission and distribution systems. At each connection—or break in the system—insulation is wrapped around the wiring and the cable is sealed with lead sheathing. Most of the physical work in placing new cables or replacing old ones is done by laborers.

Cable splicers spend most of their time repairing and maintaining cables and changing the layout of the cable systems. They must know the arrangement of the wiring systems, where the circuits are connected, and where they lead to and come from. When making repairs, they must make sure that the continuity of each line is maintained from the substation to the customer's premises. Cable splicers also periodically check insulation on cables to make sure it is in good condition.

Training, Other Qualifications, and Advancement

Load dispatchers are selected from experienced switchboard operators and from operators of large substations. Usually, 7 to 10 years of experience as a senior switchboard or substation operator are required for promotion to load dispatcher. To qualify for this job, an applicant must have thorough knowledge of the entire utility system. Substation operators generally begin as assistant or junior operators. Advancement to the job of operator in a large substation requires from 3 to 7 years of on-the-job training.

About 4 years of on-the-job training are needed to qualify as a skilled line installer and repairer. New workers usually begin training as ground helpers, and assist the line installers and repairers. For example, they may help set poles in place or pass tools and equipment. Some companies have formal apprenticeship programs for line employees. Apprenticeship programs combine on-the-job training with classroom instruction in blueprint reading, elementary electrical theory, electrical codes, and methods of transmitting electrical energy. After about 6 months, apprentices begin to do simple linework under close supervision, and progress to more difficult work as they gain experience. A line installer and repairer may advance to troubleshooter after several years of experience.

Candidates for linework should be strong and in good physical condition because climbing poles and lifting lines and equipment is strenuous. They also must have steady nerves and good balance to work at the top of the poles and to avoid the hazards of live wires and falls.

Most cable splicers get their training on the job, usually taking about 4 years to become fully qualified. Workers begin as helpers and then are promoted to assistant or junior splicers. In these jobs, they are assigned more difficult tasks as their knowledge of the work increases.

Employment Outlook

Several thousand job opportunities are expected to be available in transmission and distribution occupations through the mid-1980's. Most of these opportunities will occur because of the need to replace experienced workers who retire, die, or transfer to other fields of work. Workers hired by electric power companies are likely to have relatively secure jobs. Even during downturns in the economy, these companies seldom lay off employees.

Some increase in the employment of transmission and distribution workers is expected, although employment trends will differ among the various occupations in this category. In spite of the need to construct and maintain a rapidly growing number of transmission and distribution lines, the number of line installers and repairers and troubleshooters is expected to increase only slightly because of the use of more mechanized equipment. A limited increase in the number of cable splicers is expected because of the growing use of underground lines in suburban areas. The need for regular substation operators, however, will be reduced substantially, since the introduction of improved and more automatic equipment makes it possible to operate more substations by remote control.

Earnings and Working Conditions

Wages for transmission and distribution workers vary by occupation and geographic location. The following tabulation shows estimated average hourly earnings for major transmission and distribution occupations in privately owned utilities in 1976.

	Hourly earnings
G[illegible]	$[illegible]
Line installer	[illegible]97
Load dispatcher	8.18
Substation operator	7.14
Troubleshooter	9.15

Load dispatchers [illegible] operators generally [illegible] pleasant surroundings. Line installers and repairers, troubleshooters, and ground helpers work outdoors, and in emergencies, may work in all kinds of weather. Cable splicers do most of their work beneath city streets, often in cramped quarters. Safety standards developed over the years by utility companies with the cooperation of labor unions have greatly reduced the hazards of these jobs. Workers stringing high voltage lines, for example, protect themselves by wearing rubber gloves. Also, barricades and specific warning signs usually are posted where workers lay conduits or run wires underground.

CUSTOMER SERVICE OCCUPATIONS

Nature of the Work

Workers in customer service occupations include people who read, install, test, and repair meters so that the utility company can accurately charge customers for their consumption of electric power. Also included are workers who represent the utility company in rural areas, and appliance repairers, who work in company-operated shops, fixing customers' electrical equipment.

Electric meter repairers (D.O.T. 729.281) are the most skilled workers in this group. Their main duties are to maintain and repair meters, although they also may install and test meters. Some of these workers specialize in repairing simpler types of meters, such as those in homes. Others can handle all kinds of meters, including the more complicated ones used in industrial plants where large quantities of electric power are consumed. Often, some of the large systems require specialists, such as *meter installers* (D.O.T. 821.381) who put in and take out meters, and *meter testers* (D.O.T. 729.281).

Meter readers (D.O.T. 239.588) go to customers' premises to check the meters that register the amount of electric energy used. They record the amount used during the current billing period and watch for, and report, any tampering with meters.

District representatives usually serve as company agents in outlying districts that are too small to justify more specialized workers and in localities where the utility company does not have an office. They collect overdue bills; make minor repairs; and read, connect, and disconnect meters. They receive service complaints and reports of line trouble from customers, and send them to a central office.

Appliance repairers are discussed in a separate chapter elsewhere in the *Handbook*.

Meter readers go to customers' homes to record electricity used.

Training, Other Qualifications, and Advancement

Meter repairers begin their jobs as helpers in the meter testing and repair departments. Persons entering this field should have a basic knowledge of electricity. About 4 years of on-the-job training are required to become thoroughly familiar with all types of repairs. Some companies have formal apprenticeship programs in which the trainee progresses according to a specific plan.

Inexperienced workers can qualify as meter readers after a few weeks of training. Beginners accompany the experienced meter reader on the rounds until they have learned the job.

The duties of district representatives also are learned on the job. An important qualification for this occupation is the ability to deal tactfully with the public in handling service complaints and collecting overdue bills.

Employment Outlook

Employment in customer [illegible] occupations is expected to show little change through the mid-1980's. The need for meter readers will be limited because of the trend toward less frequent readings. Moreover, automatic meter reading may become more common, and new meters will require less maintenance. However, some job openings for meter repairers and meter readers will occur each year because of the need to replace workers who retire, die, or transfer to other fields of work. People hired by electric power companies are likely to have relatively secure jobs. Even during downturns in the economy, these companies seldom lay off employees.

Earnings and Working Conditions

The earnings of customer service workers vary according to the type of job they have and the section of the country in which they work. The following tabulation shows estimated average hourly earnings for major customer service jobs in privately owned utilities in 1976.

OCCUPATIONS IN THE NUCLEAR ENERGY FIELD

Nuclear energy is a source of heat and radiation that can be used for peaceful as well as military purposes. Although peaceful applications have been expanding rapidly in recent years, they are still in the early stages of development. Continuing research and development programs will be needed during the next several decades to find newer, safer, and more efficient ways of utilizing this energy.

In 1976, about 300,000 people worked in nuclear energy activities. Most were employed in the design and engineering of nuclear facilities and in the development and manufacture of nuclear weapons and nuclear reactors and their components. Many persons also were involved in research and development of nuclear energy. Most nuclear energy workers are scientists, engineers, technicians, and craftworkers.

Applications [illegible]

One significant [illegible] ergy is the production of electricity by nuclear reactors. Steam produced by reactors now generates electricity for many communities. These reactors have become competitive with systems that use fossil fuels (such as coal and oil). In early 1977 there were 65 nuclear reactors in commercial operation. About 170 plants were either in the planning stage or were being constructed. Dual-purpose nuclear power desalting plants which would at the same time provide a new source of fresh water and electric power, are being studied.

Nuclear reactors also power submarines and surface vessels. By eliminating refueling, nuclear propulsion extends the range and mobility of our naval forces.

Although existing reactors already generate huge quantities of power from a small amount of uranium, more efficient reactors may be in operation by the mid 1980's. Further in the future, controlled fusion reactors may provide an even more efficient method of producing electricity.

Another significant application of nuclear energy is in the use of radioisotopes. Radioisotopes emit radiation that special instruments such as thickness gauges can detect and are valuable research tools in environmental studies, agriculture, medicine, and industry.

[illegible] Produced

[illegible] most common method [illegible] is the fission process. It involves splitting uranium or plutonium nuclei by neutron bombardment. When neutrons emitted from this fission process bombard other nuclei, further fission takes place and, under proper conditions, results in a "chain" reaction. This reaction releases energy that is converted into power. This energy can be controlled for commercial use.

Controlled fission is the essential feature of a nuclear reactor. The reactor is like a furnace, and needs fuel to operate. The principal source material for reactor fuel is uranium 235. Uranium in its natural state contains less than 1 percent of readily fissionable material, U-235. Although natural uranium sometimes is used as reactor fuel, a more concentrated and enriched fuel can be produced by increasing the proportion of U-235 isotopes through a process called gaseous diffusion. The rate of fission and energy produced in a nuclear reactor usually is controlled by inserting special neutron-absorbing rods into the fuel chamber or "core."

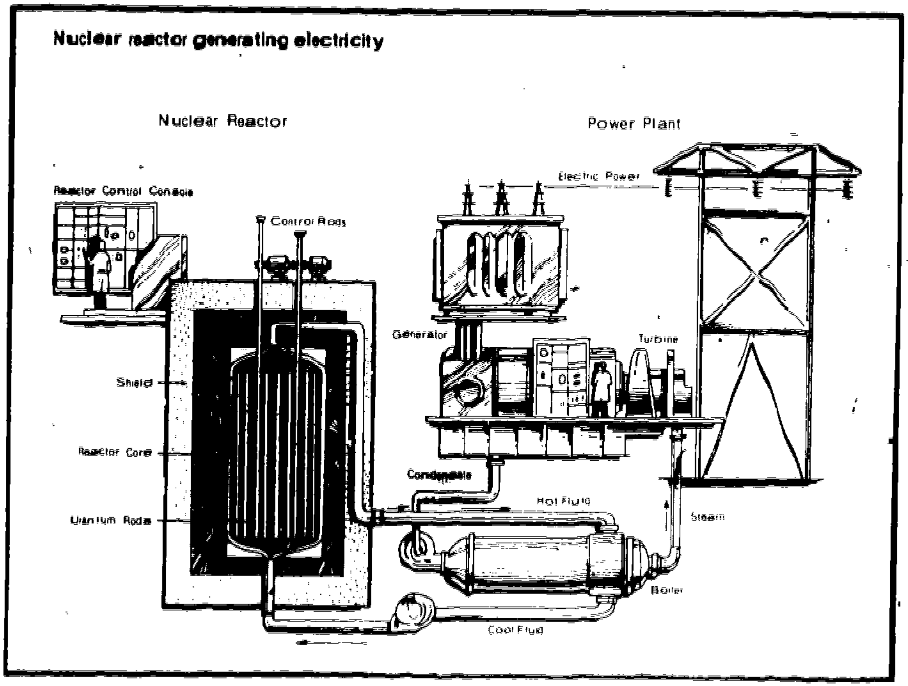
When nuclear energy is used commercially for power, the heat generated must be converted to electricity by conventional power equipment. The major difference between nuclear and conventional thermal electric power stations is that the steam to drive turbines comes from a nuclear reactor rather than from conventional power sources. (See accompanying chart.)

Because of the potential hazards of nuclear radiation, special radiation-resistant materials are used in reactors, and extensive safety measures are taken to protect personnel.

Nature of the Nuclear Energy Field

[illegible] al activities are required for the production and use of nuclear energy. These processes include the exploration, mining, milling and refining of uranium bearing ores; the production of nuclear fuels; the manufacture of nuclear reactors, reactor components, and nuclear instruments; the production of special materials for use in reactors; the design, engineering, and construction of nuclear facilities; the operation and maintenance of nuclear reactors; the disposal of radioisotopes; the production of nuclear weapons; and research and development work.

These activities take place in various types of facilities. Some work, such as mining and milling, manufacturing heat transfer equipment, and constructing facilities, differs little from similar work in other fields.



Nuclear reactor generating electricity

Other activities, however, such as producing fuels needed to run reactors, are unique to the nuclear energy field.

The Federal Government supports about half of the basic nuclear energy activities, although private support has been increasing. The U S Energy Research and Development Administration (ERDA) directs the Federal Government's nuclear energy research program, and the Nuclear Regulatory Commission (NRC) controls the use of nuclear materials by private organizations. The operation of ERDA owned facilities, including laboratories, uranium processing plants, nuclear reactors and weapons manufacturing plants, is contracted to private corporations. Most of these operations involve research into the expansion of medical and industrial applications of nuclear energy and the advancement of reactor technologies for generating electricity. Production of nuclear materials for civilian needs is also done in some of these facilities.

Privately owned facilities do all types of nuclear energy work except for the development and production of military weapons and certain nuclear fuel-processing operations. Some research is carried out independently by colleges and universities and by nonprofit organizations.

Occupations in the Nuclear Energy Field

Engineers, scientists, technicians, and craftworkers account for a higher proportion of total employment in this field than in most others, mainly because much of the work is still in the research and development phase. Office personnel in administrative and clerical jobs represent another large group. Most of the remainder are semiskilled and unskilled workers involved in production operations, plant protection, and services.

Although many engineers working in the nuclear energy field are trained in nuclear technology, engineers trained in other branches also are employed. Mechanical engineers are the largest single group, but many electrical and electronic, chemical, civil, and metallurgical engineers also work in this field. Many of these engineers do research and development work, others design nuclear reactors, nuclear instruments, and other equipment.

Research laboratories and other organizations that do nuclear energy work employ scientists in basic and applied nuclear research. Most are physicists and chemists, but mathematicians, biological scientists, and metallurgists also do nuclear energy research.

Large numbers of engineering and science technicians, drafters, and radiation monitors assist the engineers and scientists in conducting research and in designing and testing equipment.

Many highly skilled workers build equipment for experimental and pilot work and maintain the complex equipment and machinery. Many maintenance mechanics and all-round machinists work in most nuclear energy activities, as do electricians, plumbers, pipefitters, and other craftworkers and chemical-process operators.

Activities in the Nuclear Energy Field

The following sections briefly describe some major nuclear energy activities and their workers.

Uranium Exploration and Mining. The 9,500 people employed in uranium exploration and mining in 1976 had jobs similar to those in mining of other metallic ores. They mainly work in the Colorado Plateau area of the Far West, in the States of New Mexico, Wyoming, Utah, Colorado, and Arizona. A relatively small number of mines account for the bulk of production and employment. Most workers in uranium mines are in production jobs. Among them are miners and drillers in underground mines and truckdrivers, bulldozer operators, and machine loaders at open pit mines. Scientists and engineers—mining engineers, geologists—also work in uranium exploration and mining.

Uranium Ore Milling. In uranium mills, metallurgical and chemical processes are used to extract uranium from mined ore. Uranium mills, located primarily in the Colorado Plateau, employed about 1,700 workers in 1976.

These mills employ skilled machinery repairers, millwrights, pipefitters, carpenters, electricians, and chemical-process operators. A small proportion of those working in milling operations are scientists and engineers.

Uranium Refining and Enriching. Milled uranium is chemically processed to remove impurities and is then converted to metal or intermediate chemical products for reactor fuel preparation. Conventional chemical and metallurgical processes are used, but they must meet more exacting standards than in most other industries. The output of refining plants may be further processed to obtain enriched uranium.

Activity in this segment of the nuclear energy field is centered in Ohio, Tennessee, Kentucky, and Illinois. In 1976 uranium refining and enriching plants employed about 11,800 workers.

Maintenance craftworkers, particularly in the highly automated uranium enriching plants, constitute a large proportion of skilled workers in this area. Many chemical-process operators also are employed. More than one-third of the engineers and scientists are chemical engineers and chemists.

Reactor Manufacturing. About 27,800 people were employed in the design and manufacture of nuclear reactors and reactor parts in 1976. Reactor manufacturers do extensive development work on reactors and auxiliary equipment and generally build most of the intricate components, such as fuel elements, control rods, and reactor cores.

Over one-third of the employees in firms that design and manufacture reactors are scientists, engineers, and technicians. Engineers alone represent nearly one-quarter of the employment. Most are mechanical engineers and engineers who specialize in reactor technology. Assisting these engineers and scientists are many drafters and engineering technicians. Reactor manufacturers employ skilled workers, mostly all-round machinists, in experimental, production, and maintenance work. Nuclear reactor operators also are employed to operate experimental and test reactors.

Reactor Operation and Maintenance. About 13,000 workers operated and maintained nuclear reactors in 1976. Nuclear power stations employ reactor operators, mechanical, electrical and electronic engineers, instrument and electronic technicians, and radiation monitors. Machinery and instrument repairers, electricians, and pipefitters maintain and repair the reactors.

Research and Development Facilities. A number of research and development laboratories are operated for ERDA by universities and industrial concerns. These facilities are major centers for basic and applied nuclear research in engineering, in physical and life sciences, and in the development of nuclear reactors and other nuclear equipment. More than half of the 30,000 employed in ERDA research and development facilities are engineers, scientists, and supporting technicians, including radiation monitors.

Although most nuclear energy research is done in ERDA research and development facilities, about 2,600 persons conducted research in privately owned laboratories of educational institutions, other nonprofit institutions, and industrial concerns in 1976. Nearly 3 out of 4 were in scientific, engineering, and technical jobs.

Production of Nuclear Weapons and Other Defense Materials. Establishments producing nuclear weapons, weapon components, and other defense materials employed about 32,700 persons in 1976. Among the large number of scientists and engineers employed at these facilities are physicists, chemists, and mechanical, electrical, and electronic engineers. Many engineering and physical science technicians, drafters, and radiation monitors assist scientists and engineers.

Construction of Nuclear Facilities. In 1976, about 66,000 persons worked on the construction of nuclear facilities; most were craftworkers. About 18,000 of these were pipe- and steamfitters, 8,100 were electricians, and 11,200 were laborers. Several thousand carpenters, ironworkers, operating engineers, and boilermakers also were required in nuclear construction.

Other Nuclear Energy Activities. About 2,400 workers produced special materials such as beryllium, zirconium, and hafnium for use in reactors in 1976. About 8,500 workers were employed in companies that made reactor control instruments and radiation detection and monitoring devices. Large numbers of engineers and technicians are employed in these industries.

About 6,900 people were involved in the design, construction, or operation of particle accelerators used in nuclear research. Particle accelerators enable scientists to study the structure and properties of elementary particles in the nucleus of an atom.

Other workers process and package radioisotopes, produce radiography units and radiation gauges, and package and dispose of radioactive waste.

Government Employment. In 1976, the Energy Research and Development Administration (ERDA) employed nearly 7,000 workers who were involved in nuclear energy activities. The Nuclear Regulatory Commission (NRC) employed about 2,500 persons. Since ERDA and NRC are primarily administrative and regulatory agencies, nearly 9 out of 10 employees are in administrative, professional, or clerical jobs. Several thousand employees are engaged in nuclear energy work in other Federal agencies and in regulatory activities and radiological health programs of State and local governments.

Unique Nuclear Energy Occupations. Most of the occupations discussed in the preceding sections are similar to those found in other industrial activities, even though they may have job titles unique to the nuclear energy field (such as nuclear engineer, radiation chemist, and nuclear physicist) and require some specialized knowledge of nuclear energy. (A detailed discussion of the duties, training, and employment outlook for most of these occupations appears elsewhere in the *Handbook*.)

The health physics occupations and some other occupations that are unique to the nuclear energy field and require specialized training are discussed briefly in the following sections.

Health physicists (sometimes called radiation or radiological physicists or chemists) detect radiation and apply safety standards to control exposure to it. In 1976, about 650 health physicists were employed in radiation protection work, research, or teaching.

Health physicists are responsible for planning and organizing radiological health programs at nuclear energy facilities. They establish inspection standards and determine procedures for protecting employees and eliminating radiological hazards. Some supervise the inspection of work areas with potential radiation hazards and prepare instructions covering safe work procedures.

Health physicists also plan and supervise training programs dealing with radiation hazards and advise others on methods of dealing with them. In some cases, they work on research projects dealing with the effects of human exposure to radiation and may develop procedures for using radioactive materials.

Radiation monitors (also called health-physics technicians) generally work under the supervision of health physicists. About 1,900 radiation monitors were employed in 1976. They use special instruments to monitor work areas and equipment to detect radioactive contamination. Soil, water, and air samples are taken frequently to determine radiation levels. Monitors also may collect and test radiation detectors worn by workers, such as film badges and pocket detection chambers, to ensure that they are functioning properly. Monitors calculate the amount of time that personnel may safely work in contaminated areas, considering maximum radiation exposure limits and the radiation level. They also give instructions in radiation safety procedures and prescribe special clothing requirements and other safety precautions for workers entering radiation zones.

Nuclear reactor operators perform work in nuclear power stations similar to that of boiler operators in conventional power plants; however, the controls they operate are different. They also help to load and unload nuclear fuels used in reactors. Those who work with research and test reactors check reactor control panels and adjust the controls to maintain specified operating conditions within the reactor. About 2,100 people worked as nuclear reactor operators in 1976.

Accelerator operators set up, maintain, and coordinate the operation of particle accelerators. They adjust machine controls to accelerate electrically charged particles, based on instructions from the scientist in charge of the experiment, and set up target materials that are to be bombarded by the particles.

Radiographers take radiographs to check the condition of metal castings, welds, and other objects by exposing them to a source of radioactivity such as X rays or gamma rays. They select the proper type of radiation source and film and use standard mathematical formulas to determine exposure distance and time. After processing the radioactive film, the radiographer is able to discover cracks and weaknesses in the object radiographed so that it may be repaired.

Hot-cell technicians operate remote-controlled equipment to test radioactive materials that are placed in hot cells—rooms enclosed with radiation shielding materials such as lead and concrete. By controlling "slave manipulators" (mechanical devices that act as a pair of arms and hands) from outside the cell and observing their actions through the cell window, they perform standard chemical and metallurgical operations with radioactive materials. Hot-cell technicians also enter the cell wearing protective clothing to set up experiments or to decontaminate the cell and equipment. This classification is divided into several groups. *Decontamination workers* use radiation detection instruments to locate plant areas and materials that have been exposed to radiation and decontaminate them with special equipment, detergents, and chemicals. They also verify the effectiveness of the process. *Waste treatment operators* operate heat exchange units, pumps, compressors, and other such equipment to decontaminate and dispose of radioactive wastes. *Waste-disposal workers* seal contaminated wastes in concrete containers and transport the containers to be buried underground.

Radioisotope-production operators use remote control manipulators and other equipment to prepare radioisotopes for shipping and to perform chemical analyses to ensure that radioisotopes conform to specifications.

Training and Other Qualifications

Training and education requirements and advancement opportunities for most workers in the nuclear energy field are similar to those doing comparable jobs in other industries. These are discussed elsewhere in the *Handbook* under the specific occupations. However, additional specialized training is required for many workers because the field requires exacting work standards in both its research and production activities, and because it has unique health and safety problems.

Many engineers and scientists in the nuclear energy field have advanced training, particularly those doing research, development, and design work. Some employers require a Ph.D. degree. In some jobs, an advanced degree is not required but it often increases one's advancement opportunities.

The specialized knowledge of nuclear energy essential for most scientific and engineering positions can be obtained at a college or university or through on-the-job experience. Many colleges and universities have expanded their facilities and curriculums to provide training in nuclear energy. Most persons planning to work in the nuclear energy field as scientists and engineers choose to major in a specific nuclear discipline, although a degree in a traditional engineering or science curriculum often is sufficient to begin work in the field. Some colleges and universities award graduate degrees in nuclear engineering or nuclear science. Others offer some graduate courses in these fields, but award degrees only in the traditional engineering or scientific fields.

Health physicists should have at least a bachelor's degree in physics, chemistry, or engineering, and a year or more of graduate work in health physics. A Ph. D. degree often is required for teaching and research.

Skill requirements for craftworkers in the nuclear energy field are higher than in most industries because of the precision required to insure efficient operation and maintenance of complex equipment and machinery. For example, pipefitters may have to fit pipe to tolerances of less than one ten-thousandth of an inch and work with pipe made from rare and costly metals. Welding also must meet higher reliability standards than in most fields. These craftworkers generally obtain the required additional specialized skills through apprenticeship training programs of employers and unions.

High school graduates who have taken science courses can qualify for on-the-job training as radiation workers, accelerator operators, radiographers, hot-cell technicians, decontamination workers, radioisotope production operators, and radioactive waste disposal workers.

Nuclear power reactor operators need a basic understanding of reactor theory and a working knowledge of reactor controls. Most operator trainees are high school graduates. Some receive specialized training either through a technical school or through training programs in the military service. Many trainees are selected from conventional power plant personnel with experience operating boilers, turbines, or electrical machinery. Workers operating nuclear reactor controls must be licensed by the Nuclear Regulatory Commission. To qualify for a license the trainee must pass an operating and written test given by the NRC along with a medical examination. The preparation for NRC licensing generally lasts at least 1 year. Licenses must be renewed every 2 years, however, due to rapid technological change. Consequently, continual training is necessary. Additional preparation beyond the operator's license is needed for a senior operator's license, which authorizes the holder to supervise a nuclear control room.

All employees who work in the vicinity of radiation hazards are given on-the-job training in the nature of radiation and the procedures to follow in case of its accidental release.

Individuals who handle classified data (restricted for reasons of national security) or who work on classified projects in the nuclear energy field must pass a security clearance.

The Energy Research and Development Administration, at its contractor operated facilities, supports on-the-job and specialized training programs to help prepare scientists, engineers, technicians, and other workers for the nuclear energy field.

Additional educational and training opportunities are offered in cooperative programs arranged by ERDA laboratories with colleges and universities. Temporary employment at these laboratories is available to faculty members and students. Many undergraduate and graduate engineering students work at laboratories and other ERDA facilities on a rotation basis, and many graduate students do their thesis work at ERDA laboratories.

Government [illegible] provide employees with training at their own plants or at nearby colleges and universities.

Employment Outlook

Employment in the nuclear [illegible] is likely to grow much faster than the average for all industries through the mid 1980's. However, much public concern exists regarding the safety and environmental effects of the use of nuclear power. Continued controversy in this area could result in a slower rate of industrial growth than initially anticipated.

Expansion of nuclear generating capacity and continued increases in research and development expenditures should account for most of the growth in the field. Besides the job openings created by employment growth, many openings will occur as workers retire, die, or transfer to other occupations or industries.

The number of nuclear power plants is expected to be several times greater in 1985 than it was in 1976. This anticipated growth will require large increases in the number of workers in the design, construction, operation, and maintenance of these plants. In design, many more engineers and drafters will be required. Construction needs will call for large numbers of craftworkers and laborers. Many more nuclear reactor operators and maintenance personnel will be needed to bring these plants into operation and keep them running efficiently.

Expansion will require substantial employment increases in the sectors involved in mining and milling uranium ore, processing reactor fuel, and producing special materials for reactors. Also, because of the concern about the possible health hazards of nuclear radiation, increasing numbers of persons involved in reactor and personnel safety, such as health physicists and radiation monitors, should be needed.

Employment associated with research and development also is expected to increase, though not as fast as in the areas directly affected by nuclear construction. An increasing number of scientists, engineers, and technicians will study methods to improve the efficiency of the nuclear generation of electricity, peaceful uses for nuclear explosives, and the possible bio-medical applications of nuclear science.

Earnings and Working Conditions

[illegible] earnings of [illegible] workers employed by contractors at ERDA laboratories and other installations averaged $6.21 in 1976, compared with $5.19 for those in all manufacturing industries.

Scientists and engineers employed at ERDA installations averaged $2[illegible] 700 a year in 1976. Clerical personnel earned an average of $5.15 an hour, while technicians averaged about $6.55 an hour. (Earnings data for many of the occupations found in the nuclear energy field are included in the statements on these occupations elsewhere in the *Handbook*.)

Working conditions for most workers in the nuclear energy field generally are similar to those in other industries, except for radiation safety precautions. For instance, all uranium mines are equipped with mechanical ventilation systems that reduce the concentration of radioactive radon substance that may cause lung injury if inhaled over a number of years. Efforts to eliminate this hazard are continuing. Manufacturing facilities, power plants, and research laboratories are generally well-lighted and well-ventilated. Only a small proportion of employees in the nuclear energy field actually work in areas where direct radiation dangers exist. Even in these areas, shielding, automatic alarm systems, and other devices and clothing give ample protection to the workers.

Extensive safeguards and operating practices protect the health and safety of workers, and ERDA and its contractors have maintained an excellent safety record. The NRC regulates the possession and use of radioactive materials, and inspects nuclear facilities to insure compliance with health and safety requirements. Constant efforts are being made to provide better safety standards and regulations.

Most hourly paid plant workers belong to unions that represent their particular craft or industry.

Sources of Additional Information

Information about research programs in the nuclear energy field is available from:

U.S. Energy Research and Development Administration, Washington, D.C. 20545.

For information about licensing and safety requirements, contact:

U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

OCCUPATIONS IN PETROLEUM AND NATURAL GAS PRODUCTION AND GAS PROCESSING

[illegible] and Location of the Industry

[illegible] from the decay of plants and animals. Buried beneath the ground for millions of years under tremendous heat and pressure, this organic matter became petroleum, or what is usually called oil. Natural gas is formed by a similar process.

Oil and natural gas [illegible] position of such importance that they now furnish more than three-fourths of our energy needs. Oil and natural gas run our factories and transportation systems, heat our homes and places of work, and are basic raw materials for many products such as plastics, chemicals, medicines, fertilizers, and synthetic fibers. In spite of efforts to decrease our Nation's dependence on petroleum as a source of energy, petroleum and natural gas will continue to supply the major [illegible] needed [illegible] years to come.

Although [illegible] oil and natural gas [illegible] been on the [illegible]. In recent years, most experts feel that there are large amounts of petroleum in this country that have not yet been discovered. Locating and extracting these petroleum reserves will make a significant contribution to the country's energy independence.

People with many different skills are needed to explore for oil and gas fields, drill new wells, improve existing wells, and process natural gas. In 1976, about 355,000 workers were employed in these activities. Firms that work on contract for oil companies employed many of these workers, and the major oil companies employed the rest. Occupations in oil refining are discussed in a separate chapter elsewhere in the *Handbook*.

Since oil and gas are difficult to find, exploration and drilling are key activities in the petroleum industry. After scientific studies indicate the possible presence of oil, the company selects a well site and installs a towerlike steel rig to support the drilling equipment. A hole is drilled deep into the earth until oil or gas is found or the company decides to write the effort off as a loss. Although a few large oil companies do their own drilling, most is done by contractors. There are hundreds of firms engaged in the search for and production of oil and natural gas.

When oil or gas is discovered, pipes, valves, tanks, and other equipment are installed to control the flow of these raw materials from the well. There were more than 600,000 wells in this country in 1976, and a large part of the petroleum industry's 250,000 production workers were needed to operate and maintain them.

Oil and gas are transported to refineries by pipeline, ship, railroad, barge, or truck. Many refineries are thousands of miles from oil fields, but gas processing plants usually are near the fields so that water, sulfur compounds, and other impurities can be removed before the liquid gas is piped to customers.

Although drilling for oil and gas is done in 35 States, about nine-tenths of the industry's workers are employed in 10 States. Texas leads in the number of oilfield jobs, followed by Louisiana, Oklahoma, California, Wyoming, Kansas, New Mexico, Colorado, Ohio, and Illinois. Thousands of additional Americans are employed by oil companies overseas, mostly in the Middle East, Africa, Western Europe, South America, and in Indonesia and other Far Eastern countries.

Occupations in the Industry

Workers with a wide range of education and skills are needed to find oil and gas and to drill, operate and maintain wells and process natural gas.

Exploration. Exploring for oil is the first step in petroleum production. Small crews of specialized workers search for geologic formations that are likely to contain oil. Exploration parties study the surface and subsurface of the earth in order to locate places where oil might be concentrated in underground rock formations. They seek clues to the possible existence of oil by examining types of rock formations on and under the earth's surface. Besides detailed ground surveys, aerial exploration and magnetic surveys also are used for a broad picture of the area.

Several methods are used to determine the nature and location of underground rock formations. A technique called seismic prospecting is widely used to map underground rock formations. In this technique, a large shock is set off at the earth's surface. This can be caused by explosives or, more commonly by a "thumper," which is a heavy weight dropped on the ground. The time it takes for the sound waves to reach the rock formations and return to the surface is carefully measured to locate the depth and position of underground features. Subsurface evidence also is collected by boring and bringing up core samples of the rock, clay, and sand that form the layers of the earth. Similar techniques are used to explore offshore areas.

Exploration parties are led by a *petroleum geologist* (D.O.T. 024.081), who analyzes and interprets the information gathered by the party. In addition to the petroleum geologist, exploration parties may include other geology specialists. *Paleontologists* (D.O.T. 024.081) study fossil remains in the earth to locate oil-bearing layers of rock; *mineralogists* (D.O.T. 024.081) study physical and chemical properties of mineral and rock samples; *stratigraphers* (D.O.T. 024.081) determine the rock layers most likely to contain oil and natural gas; *photogeologists* (D.O.T. 024.081) examine and interpret aerial photographs of land surfaces; and *petrologists* (D.O.T. 024.081) investigate the history of the formation of the earth's crust. Often a geologist must have knowledge of some or all of these specialties since not all exploration parties include all these specialists. Exploration parties also include *drafters* (D.O.T. 010.281) and *surveyors* (D.O.T. 018.188), who assist in surveying and mapping operations.

Many geologists also work in district offices of oil companies or exploration firms where they prepare and study geological maps. They also study samples from test drilling to find any clues to oil.

A *geophysicist* (D.O.T. 024.081) usually leads a seismic prospecting crew that may include: *prospecting computers* (D.O.T. 010.288), who perform the calculations and prepare maps from the information recorded by the seismograph, which is an instrument that measures the earth's vibrations, and *observers* (D.O.T. 010.168), who operate and maintain electronic seismic equipment. Other workers whose activities are related to exploration are: *scouts* (D.O.T. 010.288), who investigate the drilling, exploration, and leasing activities of other companies in order to identify promising areas to explore and lease, and *lease buyers* (D.O.T. 191.118) who make the necessary business arrangements with landowners or with owners of mineral rights to obtain the right to use the land.

Drilling. Exploration methods are used to find places where the presence of oil is likely but only drilling can prove the presence of oil. Overall planning and supervision of drilling usually are the responsibilities of the petroleum engineer.

Wells are almost always started in the same way. *Rig builders* (D.O.T. 869.884) and a crew of *rig builder helpers* (D.O.T. 869.887) install a portable drilling rig to support the machinery and equipment that raises and lowers the drilling tools. Rotary drilling is the normal way of drilling a well. A revolving bit bores a hole in the ground by chipping and cutting rock. The bit is attached to a length of revolving pipe. As the bit cuts deeper into the earth, more pipe is added. Drilling pipe is hollow and runs the entire depth of the well. A stream of drilling mud is continuously pumped into the hollow pipe and comes out through holes in the drill bit. This mud is a mixture of clay, chemicals, and water. Its purpose is to cool the drill bit, plaster the walls of the hole to prevent cave-ins, and carry crushed rock to the surface so that drilling is continuous until the bit wears out. When a new bit is needed, all of the pipe must be pulled up out of the hole, a section at a time, a new bit placed on the end of the pipe, and the pipe returned to the hole.

The *tool pusher* or *drilling supervisor* (D.O.T. 930.130) supervises one or more drilling rigs and supplies materials and equipment to rig crews.

A typical rotary drilling crew consists of four or five workers: driller, derrick operator, engine operator, and one or two helpers. Because drilling rigs are operated 24 hours a day, 7 days a week, several crews are needed for each rig.

The *rotary driller* (D.O.T. 930.782) supervises the crew and operates machinery that controls drilling speed and pressure, and records operations. The *rotary rig engine operator* (D.O.T. 950.782) is in charge of engines that provide the power for drilling and hoisting. The *derrick operator* (D.O.T. 930.782), who is second in charge, works on a small platform high on the rig to help run pipe in and out of the well hole, and operates the pumps that circulate mud through the pipe. *Rotary drill helpers* (D.O.T. 930.844), also known as roughnecks, guide the lower end of the pipe to and from the well opening and connect and disconnect pipe joints and drill bits.

Roustabouts (D.O.T. 869.884) are general laborers, though not considered part of a drilling crew, do general oilfield maintenance and construction work, such as cleaning tanks and building roads.

Well Operation and Maintenance. When oil is found, the drill pipe and bit are pulled from the well, and metal pipe known as casing is lowered into the hole and cemented in place. The upper ends of the casing are fastened to a system of valves called a "Christmas tree." Pressure in the well forces crude oil and gas to the surface, through the Christmas tree, and into gas traps and storage tanks. If natural pressure is not great enough to force the oil to the surface, pumps are used.

Petroleum engineers (D.O.T. 010.081) generally plan and supervise well operation and maintenance. To prevent waste, they decide the rate of oil flow and anticipate performance of oil reservoirs by analyzing information such as pressure readings from the well. Engineers are increasingly using computers for analytical work. Some engineers specialize in areas such as overcoming effects of corrosion on well casing, in the selection and design of production equipment and processes, or in the prevention of pollution. Some companies hire engineer aides to make tests, keep records, post maps and otherwise assist engineers.

Pumpers (D.O.T. 914.782) and their helpers operate and maintain motors, pumps, and other surface equipment to force oil from wells. Their chief duty is to regulate the flow of oil according to a schedule set up by the petroleum engineer and production supervisor. Generally, a pumper operates a group of wells. *Switchers* work in fields where oil flows under natural pressure and does not require pumping. Pumpers open and close valves to regulate the oil flow from wells to tanks or into pipelines. *Gaugers* (D.O.T. 914.381) measure and record the flow and take samples to check quality. *Treaters* (D.O.T. 541.782) test the oil for water and sediment and remove these impurities by opening a drain at the tank's base or by using special chemical or electrical equipment. In some fields, pumping, switching, gauging, and treating operations are automatic.

Many skilled [illegible] are employed in maintenance [illegible]. Welders, pipefitters, electricians, and machinists repair and install pumps, gauges, piping, and other equipment.

Natural Gas Processing. M[illegible] processing workers are operators. The *dehydration plant operator* (D.O.T. 541.782) tends an automatically controlled treating unit, which removes water and other impurities from natural gas. The *gas-plant operator* (D.O.T. 953.380) tends compressors that raise the pressure of the gas for transmission in the pipelines. The *gas-compressor operator* (D.O.T. 950.782) assists either of these two employees.

Many workers in the larger natural gas processing plants are employed in maintenance activities. These include instrument repairers, electricians, welders, and laborers.

In numerous smaller natural gas plants, workers combine skills, usually of operator and maintenance worker. Many small plants are so highly automated they are virtually unattended. They are checked at periodic intervals by maintenance workers or operators, or they are checked continuously by instruments that automatically report problems and shut down the plant if an emergency develops.

Other Oilfield Services. Companies that offer services on a contract basis provide another important source of employment. Among these employees are skilled workers such as *cementers* (D.O.T. 930.281) who mix and pump cement into the space between the steel casing and the well walls to prevent cave-ins; *acidizers* (D.O.T. 930.782), who force acid into the bottom of the well to increase the flow of oil; *perforator operators* (D.O.T. 931.782) who use subsurface "guns" to pierce holes in drill pipes or casings to make openings for oil to flow through; *sample-taker operators* (D.O.T. 931.781) who take samples of soil and rock formations from wells to help geologists determine the presence of oil; and *well pullers* (D.O.T. 930.883), who remove pipes, pumps, and other subsurface devices from wells for cleaning, repairing, or salvaging.

Offshore Operations. Most exploration, drilling, and producing activities are on land, but an increasing amount of this work is done offshore, particularly in the Gulf of Mexico off the coasts of Louisiana and Texas. Additional offshore work is being done off the west coast of the United States. Some drilling is expected to take place soon off the east coast. Some wells have been drilled over 100 miles from shore and in water more than 1,000 feet deep. These offshore operations require the same type of drilling crews as are employed on land operations. In addition, offshore operations require radio operators, cooks, ship's officers and sailors, and pilots for work on drilling platforms, crewboats, barges, and helicopters.

(Detailed discussions of professional, technical, mechanical, and other occupations found not only in the petroleum and natural gas production industry, but in other industries as well, are given elsewhere in the *Handbook* in the sections covering individual occupations.)

Training, Other Qualifications, and Advancement

Most workers in nonprofessional jobs with an exploration crew begin as helpers and advance into one of the specialized jobs. Their training may vary from several months to several years. New workers usually are hired in the field by the crew chief or by local company representatives. College students majoring in physical or earth sciences or in engineering may work part time or summers with exploration crews and get full time jobs after graduation.

Members of drilling crews usually begin as roughnecks. The major qualifications needed are mechanical ability and adequate physical strength and stamina. Previous experience is desirable but not necessary. As they acquire experience, they may advance to more skilled jobs. For example, a worker hired as a roughneck may advance to derrick operator and, after several years, become a driller. A driller can advance to the job of tool pusher in charge of one or more drilling rigs.

Companies generally hire people who live near wells for well operation and maintenance jobs. They prefer applicants who have mechanical ability and a knowledge of oilfield processes. Because this type of work is less strenuous than drilling and offers the advantage of a fixed locale, members of drilling crews or exploration parties who prefer not to travel often transfer to well operation and maintenance jobs. New workers may start as roustabouts and advance to jobs as switchers, gaugers, or pumpers. Training usually is acquired on the job; at least 2 years of experience are needed to become an all-round pumper.

For scientists, such as geologists and geophysicists, college training with at least a bachelor's degree is required. The preferred educational qualification for a petroleum engineer is a degree in engineering with specialization in courses on the petroleum industry. However, college graduates having degrees in chemical, mining, civil or mechanical engineering, or in geology, geophysics, or other related sciences often are hired for petroleum engineering jobs. Petroleum engineering aides include people with 2-year technical degrees as well as former roustabouts or pumpers who have been promoted.

Scientists and engineers usually start at junior levels; after several years of experience they can advance to managerial or administrative jobs. Scientists and engineers who have research ability, particularly those with advanced degrees may transfer to research or consulting work.

Information on training, qualifications, and advancement in natural gas processing plants is similar to that for petroleum refining. A statement on petroleum refining can be found elsewhere in the *Handbook*.

Employment Outlook

Employment in petroleum and natural gas production is expected to increase faster than the average for all industries through the mid-1980's. Besides the job openings created by employment growth, many openings will occur as workers retire, die, or leave the industry for other reasons.

Greatly increased prices for crude oil and natural gas and a national policy to move toward energy self-sufficiency are expected to provide the incentives for the industry to expand rapidly. Growth will be concentrated in exploration and drilling, and many more workers will be needed in most occupations associated with these activities. Opportunities should be particularly good in offshore drilling.

Earnings and Working Conditions

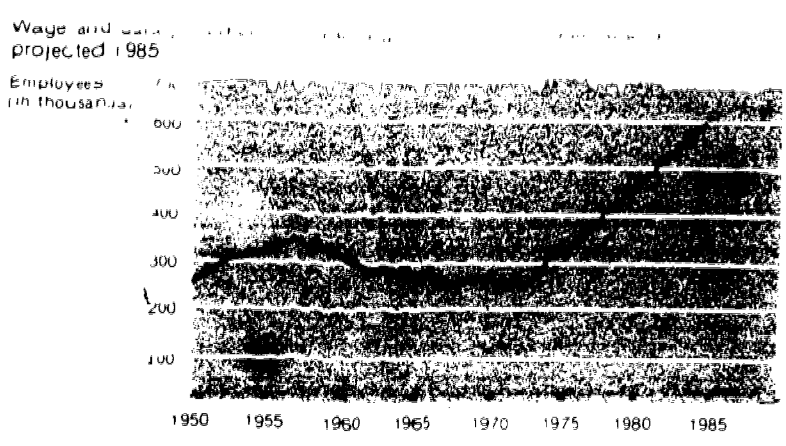
[illegible] nonsupervisory employees [illegible] oil and gas extraction averaged $5.70 an hour. In comparison, the average for all nonsupervisory workers in private industry, except farming, was $4.83 an hour. Earnings usually are higher in offshore operations than in land operations.

Most oilfield jobs involve rugged outdoor work in all kinds of weather. They often are in remote areas in settings as varied as a western desert, the Arctic Circle, or the Gulf of Mexico. Physical strength and stamina are important because the work involves standing most of the time, lifting moderately heavy objects, and climbing and stooping to work with power tools and handtools that often are oily and dirty.

Drilling employees may expect to move from place to place since their work in a particular field may be completed in a few months. Exploration field personnel may be required to move even more frequently. They may be away from home for weeks or months at a time. Well operation and maintenance workers and natural gas processing workers usually remain in the same location for long periods.

On land, drilling crews usually work 7 days, 8 hours a day, and then have a few days off. In offshore operations, they may work 7 days, 12 hours a day, and then have 7 days off. If the well is far from the coast, they live on the drilling rig or on ships anchored nearby. Most workers in well operations and maintenance and natural gas processing work 8 hours a day, 5 days a week.

Very rapid growth in the oil and gas extraction industry will result from expansion of exploration and drilling activities



Sources of Additional Information

Further information about jobs in the petroleum industry may be available from the personnel offices of individual oil companies. For information on scientific and technical jobs, write to:

American Association of Petroleum Geologists, P.O. Box 979, Tulsa, Okla. 74101

Society of Petroleum Engineers of AIME, 6200 N. Central Expressway, Dallas, Tex. 75206

American Geological Institute, 5205 Leesburg Pike, Falls Church, Va. 22041

OCCUPATIONS IN THE PETROLEUM REFINING INDUSTRY

The petroleum refining industry forms the link between crude oil production and the distribution and consumption of petroleum products. Products refined from crude oil supply the fuels and lubricants used for all modes of transportation, for heat in homes, factories, and other structures, and for fuel for the generation of over one-third of our electric power. In addition, basic petroleum compounds are used to manufacture hundreds of everyday products such as synthetic rubber, fertilizers, and plastics.

In 1976 about 160,000 workers who had a wide range of educational backgrounds and skills, were employed in the petroleum refining industry. This industry covers occupations and activities involved in refining oil. Occupations in petroleum and natural gas production and processing are discussed in a separate chapter elsewhere in the *Handbook*.

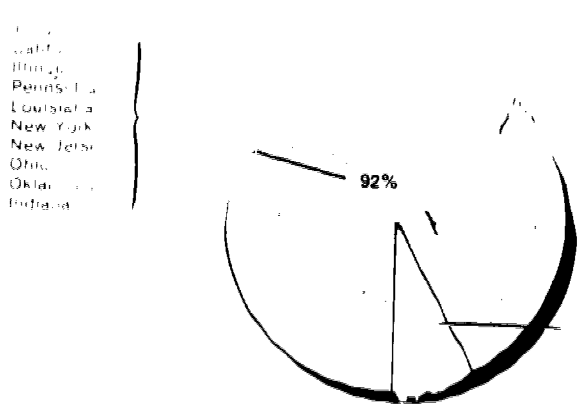
Nature and Location of the Industry

A modern refinery is a [illegible] plant made up of tanks and towers connected by a maze of pipes and valves. From the time crude oil enters the refinery to the shipment of finished products, the production flow is almost continuous. Operators use instruments including computers to measure and regulate the flow, volume, temperature, and pressure of liquids and gases going through the equipment. Manual handling of materials has been virtually eliminated.

Petroleum refining consists of heating crude oil as it flows through a series of pipes in a furnace. The vapors from the heated oil pass into a tower where the various "fractions," or parts, of the oil are condensed. The heaviest parts (for example, heavy fuel oils and asphalt) are drawn off along the bottom of the tower where temperatures are highest, lighter parts (jet fuel and diesel fuel) are drawn off along the middle of the tower, and the lightest (gasoline and gases) are taken off at the top where temperatures are lowest. Since this process does not produce a sufficient quantity of some products, such as gasoline, further processing by more complicated methods combines or modifies products obtained through fractionating to increase the yield of some products. Treating units are used to remove water, sulfur compounds, and other impurities.

About 280 refineries were in operation in 1976. They ranged in size from plants with fewer than ten employees to those with several thousand. Although many States have refineries, about 85 percent of the workers were employed in 10 States: Texas, California, Pennsylvania, Illinois, Louisiana, Oklahoma, Ohio, New York, New Jersey, and Indiana. Refineries usually are located near oilfields, industrial centers, or deepwater ports where tankers can dock.

Over 90 percent of all workers in the petroleum refining industry are employed in ten States



Occupations in the Industry

About 1 out of every 2 workers in a refinery is involved in the operation (as opposed to maintenance) of the plant. A key worker in converting crude oil into usable products is the *refinery operator* (D.O.T. 542.280), or chief operator, who is responsible for one or more processing units. The refinery operator, with help from assistant operators, makes adjustments for changes in temperature, pressure, and oil flow. In modern refineries, operators monitor instruments on panels that show the entire operation of all processing units in the refinery. They also patrol units to check their operating condition.

Other plantworkers may include *still pump operators* (D.O.T. 549.782), also known as pumpers, and their *helpers* (D.O.T. 549.884), who maintain and operate pumps that control all production throughout the refinery, and *treaters* (D.O.T. 549.782), who operate equipment to remove impurities from gasoline, oil, and other products. In automated plants, computers may do the work of pumpers and treaters. Operators monitor the computers to spot potential problem areas, and may make routine checks of the refinery to make sure that valves are operating properly.

Many refineries employ large numbers of maintenance workers to repair, rebuild, replace, and clean equipment. In other plants, some maintenance work is contracted to companies outside the petroleum industry. Many maintenance workers are needed because high heat, pressure, and corrosion quickly wear out the complex refining equipment. Occupations involved in maintenance include skilled boilermakers, electricians, carpenters, instrument

Operator observes refinery controls

[illegible] pipefitters, sheetmetal workers, and welders. There also are helpers and apprentices in these trades. Some skilled workers have a primary skill in one craft and also the ability to handle closely related crafts. For example, a pipefitter also may be a boilermaker and a welder. Maintenance workers who have such combined jobs are sometimes called refinery mechanics.

Plantworkers who do not operate, control, or maintain equipment do many other tasks. Some workers drive delivery trucks; some load and unload materials on trucks, trains, or ships; and others keep stock and tool inventory records. The industry also employs service workers such as guards and janitors.

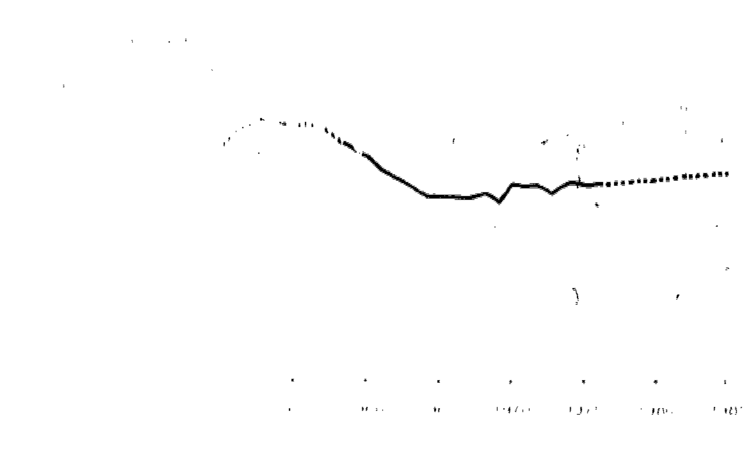
About [illegible] percent [illegible] petroleum refining [illegible] engineers and technicians. Among these are chemists, chemical engineers, mechanical engineers, environmental engineers, laboratory technicians and drafters. Chemists and laboratory technicians control the quality of petroleum products by making tests and analyses to determine chemical and physical properties. [illegible] chemists and chemical engineers develop and improve products and processes. Laboratory technicians assist chemists in research projects or do routine testing and sample taking. Some engineers design chemical processing equipment and plant layout, and others supervise refining processes. Environmental engineers and technicians supervise and improve treatment and disposal of refinery waste waters and gases. Drafters prepare plans and drawings needed in refinery construction and maintenance.

Refining companies employ many administrative, clerical, and other white collar personnel. Administrative workers include managers, accountants, purchasing agents, lawyers, computer programmers, computer analysts, and personnel and training specialists. Typists, secretaries, bookkeepers, keypunch operators, and business machine operators assist administrative workers. (Detailed discussions of professional, technical, mechanical, and other occupations found not only in petroleum refining but also in other industries are presented elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

Employers prefer to hire applicants who are high school graduates. Aptitude testing and interviewing frequently are used in testing applicants for plant jobs. Inexperienced plant workers usually begin as aides in a labor pool; they may move materials, pack cartons, fill barrels, or do

Employment in petroleum refining is expected to show little change through the mid 1980's due to productivity improvements



maintenance work. They may be transferred either to the operating department or the maintenance department when a vacancy occurs.

Workers newly assigned to an operating department learn to operate equipment under the guidance of experienced operators. Formal training courses frequently are given in plant operation.

A supervisor trains inexperienced workers in maintenance skills. Some refineries give classroom instruction related to particular work. After 3 or 4 years, a person may advance from helper to skilled craft worker in one of the maintenance crafts. Some large refineries train workers in several crafts. For example, a qualified instrument repairer may be given electrician or machinist training.

For scientists and engineers, a bachelor's degree in an appropriate field usually is the minimum educational requirement. Advanced degrees are preferred for research work.

For most laboratory assistant jobs, 2 year technical school training is required. Laboratory assistants begin in routine jobs and advance to positions of greater responsibility as they acquire experience and learn to work without close supervision. Inexperienced drafters begin as copyists or tracers and can advance to more skilled drafting jobs.

Administrative positions [illegible] are filled by people who have college degrees in science and engineering, accounting, business, industrial relations, or other specialized fields. For positions as clerks, bookkeepers, secretaries, and typists, most refineries employ persons who have had commercial courses in high school or business school. For occupations associated with computers, educational requirements range from a high school level for keypunch operators to a college degree in the physical science field for analysts.

Employment Outlook

Employment in petroleum refining is expected to show little change through the mid-1980's. Refinery output is expected to increase to meet the Nation's growing demand for petroleum products, but automated, computerized plants, increased refining capacity, and improved refining techniques should make it possible for the industry to increase production without increasing employment significantly. Nevertheless, thousands of job openings will result from the need to replace workers who retire, die, or transfer to other occupations.

Most jobs will be for operators, maintenance workers, administrators, and technicians. More maintenance workers such as electricians, pipefitters, and instrument repairers, will be needed to take care of the increasing amount of automated equipment and complex control instruments.

Earnings and Working Conditions

[illegible] are [illegible] employees in main[illegible] [illegible] $7.76 production workers in petroleum refining averaged $7.72 an hour, compared with an average of $4.83 an hour for production workers in manufacturing industries as a whole.

Because petroleum is refined around the clock, operators may be assigned to any one of the three shifts, or they may be rotated on various shifts. Some operators work weekends and get days off during the week. Employees usually receive additional pay for shift work. Most maintenance workers are on duty during the day.

Most refinery jobs require only moderate physical effort. A few workers, however, have to open and close heavy valves and climb stairs and ladders to considerable heights. Others may work in hot places or may be exposed to unpleasant odors.

Many refinery workers are union members and belong to the Oil, Chemical and Atomic Workers International Union. Some refinery workers are members of AFL-CIO craft unions, or of various independent unions.

Sources of Additional Information

[illegible] information on job opportunities in the petroleum refining industry may be obtained from the personnel offices of individual oil companies. General information on jobs in the industry is available from:

National Petroleum Refiners Association, Suite 802, 1725 DeSales St. NW., Washington, D.C. 20036

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