DOCUMENT RESUME

ED 158 143 CE 017 793

TITLE	Aluminum, Iron and Steel, and Foundry Industries. Reprinted from the Occupational Outlook Handbook, 1978-79 Edition.
INSTITUTION	Bureau of Labor Statistics (DOL), Washington, D.C.
REPORT NO	Bull-1955-39
PUB DATE	78
NOTE	24p.; Photographs in this document will not reproduce well; For related documents see CE 017 756-797
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 ($0.50 per reprint; $8.00 for set of 42)
EDRS PRICE	MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS	*Employment Opportunities; *Employment Projections; *Employment Qualifications; Employment Trends; *Foundries; Information Sources; Job Skills; Job Training; *Metal Industry; *Occupational Information; Occupational Mobility; Promotion (Occupational); Salaries; Wages; Work Environment
IDENTIFIERS	*Aluminum Industry

ABSTRACT

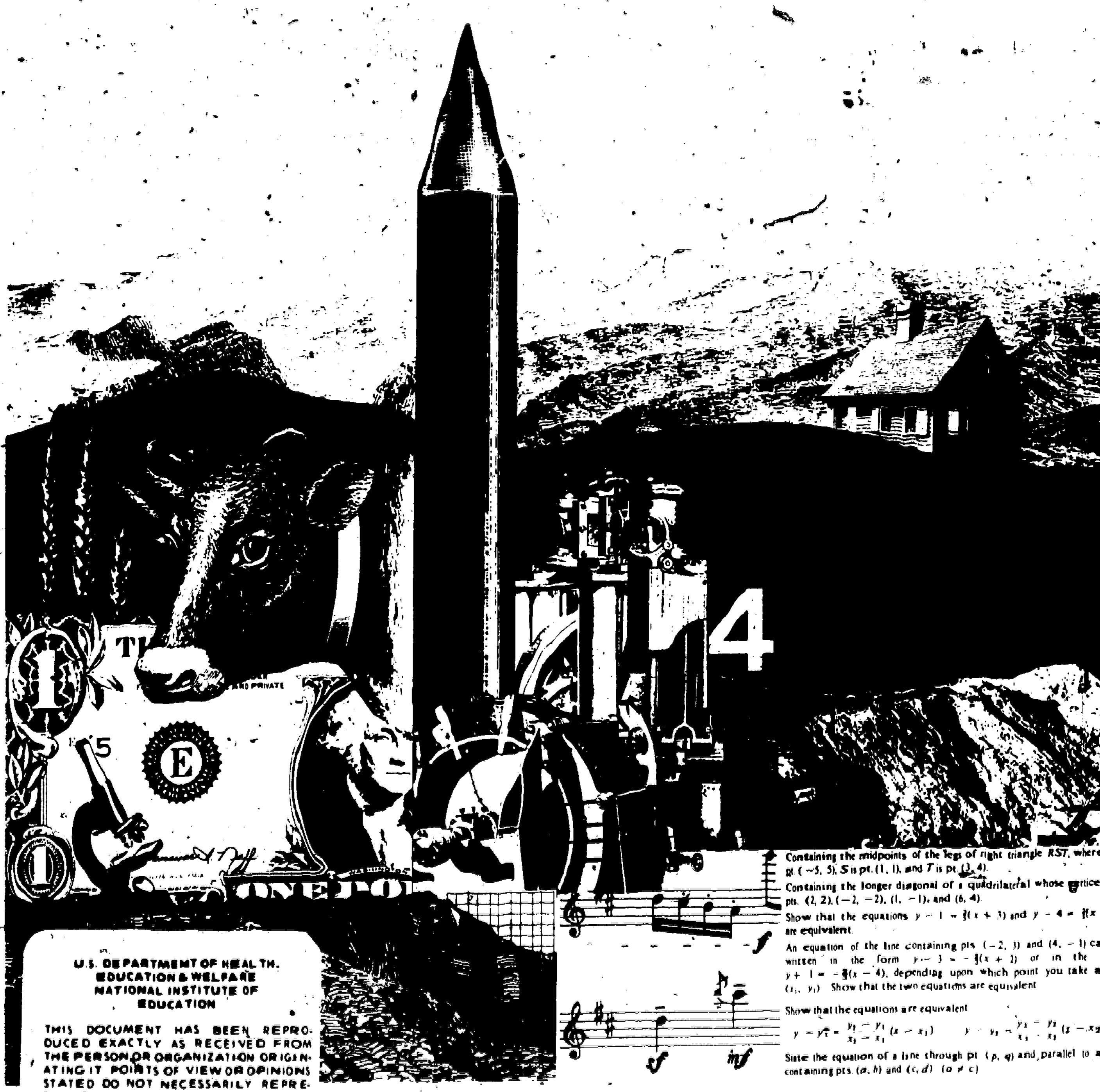
Focusing on occupations in the various metal industries, this document is one in a series of forty-one reprints from the Occupational Outlook Handbook providing current information and employment projections for individual occupations and industries through 1985. The specific occupations covered in this document include occupations in the aluminum industry, occupations in foundries (patternmakers, molders, coremakers), and occupations in the iron and steel 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)

Aluminum, Iron and Steel, and Foundry Industries

Reprinted from the
Occupational Outlook Handbook,
1978-79 Edition.

U.S. Department of Labor
Bureau of Labor Statistics
1978

Bulletin 1955-39



OCCUPATIONS IN THE ALUMINUM INDUSTRY

Aluminum was once considered a specialty metal having limited applications. Today it is produced in quantities second only to iron and steel. It is used in products that range from household appliances and cooking utensils to automobiles, aircraft, and missiles. In recent years, many new uses for aluminum have been developed, including house siding, food and beverage containers, and electrical cables. In 1976, the industry produced about 12.9 billion pounds of primary aluminum, or about twice the output of only 10 years earlier.

This statement describes occupations in plants that produce ingots (bars) of primary aluminum. It also describes occupations in plants that shape the ingots into sheets, wire, and other forms by rolling, stretching, or forcing the aluminum through an opening. Occupations concerned with casting, forging, stamping, machining, and fabricating aluminum are discussed separately in the *Handbook* statements dealing with forge shop, foundry, and metalworking occupations.

More than 93,000 persons worked in the aluminum industry in 1976. Approximately one-third helped make primary aluminum; the remainder helped convert large pieces into sheets, cables, and other industrial products.

Since the huge machinery necessary for making aluminum is very expensive, the production of primary aluminum is concentrated in a relatively small number of plants. These plants generally are located near abundant sources of alumina and electricity. Many are in Arkansas, Louisiana, Texas, Alabama, and Tennessee, where bauxite ore is mined locally or imported from the Caribbean area, and electricity is obtained from the Tennessee Valley Authority or generated from local deposits of natural gas or oil. About two-fifths of the employees who make aluminum work in these States. Another one-fifth work in the State of Washington, where plants obtain electricity from the Bonneville Power Authority and serve customers on the West Coast. A significant number of employees also work in plants located in Ohio, Indiana, and New York.

Plants that shape aluminum into sheets, wire, and other products are more dispersed geographically. Over one-half of the employment in these plants is in California, Pennsylvania, Tennessee, Illinois, Alabama, New York, and Ohio. The remainder is widely scattered throughout a large number of States.

Occupations in the Industry

Employment in the aluminum industry falls into several categories. The largest group of workers—about three-fourths—are the production workers directly involved in operating or maintaining the industry's production equipment. The remaining one-fourth are in professional, technical, administrative, clerical, and supervisory positions.

Production Occupations. To illustrate the production occupations found in the industry, a description of the major steps in making and shaping aluminum follows.

Making Aluminum. Aluminum is obtained from alumina by using electricity to create chemical changes that separate pure aluminum from other materials. Alumina—a fine, white powder processed from bauxite ore—is placed in large containers called "pots" that are filled with a special liquid. Suspended in the liquid are poles (anodes); electric cables are attached to the pots and poles. When the process is in operation, electricity flows from the poles, through the liquid containing the alumina, to the walls and floors of the pots. As the electricity passes through the liquid, it heats and chemically changes the alumina to pure, liquid aluminum. Because the aluminum is heavier, it settles to the bottom of the pot; waste materials go to the top of the liquid. Periodically, pure aluminum is removed from the bottom of the pot.

Pot tenders (D.O.T. 512.885) see that the pots operate continuously. Each is responsible for a number of pots. As a result of the chemical changes, the alumina in each pot is slowly used up. Instruments monitor the level of alumina and signal the tender when to add alumina from the overhead storage compartment.

Every 24 to 72 hours, molten aluminum is drawn from the bottom of the pots into huge brick-lined, steel containers or "crucibles." The *tapper* (D.O.T. 514.884) and *tapper helper* (D.O.T. 514.887) signal the *hot-metal crane operator* (D.O.T. 921.883 place the overhead crane near the pot. Using automatic equipment, they break a hole in the crust of waste materials that forms on the top of the liquid. One end of a curved, cast iron tube is inserted into the pot; the other end is placed into a crucible and the molten metal is drawn from the pot into the crucible.

After aluminum has been taken from several pots and the crucible is full, *charge gang weighers* (D.O.T. 502.887) weigh and sample the molten metal for laboratory analysis. Weighers also select chemicals that the analysis indicates should be blended with the molten aluminum. Then, workers operating overhead cranes pour the molten metal from the crucible into a remelting furnace. A *remelt operator* (D.O.T. 512.885) adds portions of aluminum scrap, other molten metal, or chemicals that will produce metal with the desired properties. Finally, hand skimmers remove waste products that have been forced to the surface of the molten metal.

The metal is then transferred to the second or holding compartment of the furnace until a sufficient supply is obtained for pouring. The *d.c. casting operator* (D.O.T. 514.782) has charge of the pouring station where the molten metal is cast into ingots—large blocks of metal. The operator controls the cooling conditions of the casting unit by keeping the molds full of metal and spraying water against the molds to produce ingots of uniform size and quality.

After a pot has been operating for a number of months, the heat and chemical reactions make holes in the pot's lining so that the liquid metal contacts the steel container. When this happens, the pot is shut down and the liquid drained so that *pot liners* (D.O.T. 519.884) can make repairs. Depending on the condition of the pots liners may patch holes in the lining or may completely remove and replace the lining.

Shaping aluminum. The large ingots must be reduced in size before the aluminum is useful to customers. Depending on the final product desired, several methods may be used to shape the ingot. Aluminum products such as plate, sheet, and strip are produced by rolling.

The first step in rolling is to remove surface impurities from the ingot. The *scalper operator* (D.O.T. 605.782) manipulates levers of a scalper machine and cuts thin layers of the rough metal from the ingots so that the surfaces are smooth. Then, the ingots are heated to proper working temperatures for rolling. Workers operating overhead cranes lower the ingots into furnaces, or "soaking pits," where they are kept sealed for 12 to 18 hours. *Soaking pit operators* (D.O.T. 613.782) manage the furnace and control the temperature and heating time.

After being heated, the huge ingots are positioned on the "breakdown" or hot rolling mill where they are converted into elongated slabs. *Rolling mill operators* (D.O.T. 613.782) manipulate the ingots back and forth between powerful rollers until they are reduced in thickness to about 3 inches. The slabs then move down the line on the rollers to additional hot mills that work them down to a thickness of about one-eighth of an inch. At the end of the hotline, a *coiler operator* (D.O.T. 613.885) tends a coiler that automatically winds the metal onto reels.

The coiled aluminum cools at room temperature before being cold-rolled still thinner. Cold-rolling produces a better surface finish and increases the metal's strength and hardness. Since continuous cold-rolling could make the metal too brittle, an *annealer* (D.O.T. 504.782) occasionally heats (anneals) the metal.

To relieve internal stress created during the rolling process or surface contours the metal may be stretched. *Stretcher-level-operators* (D.O.T. 619.782) and *stretcher-level-operator helpers* (D.O.T. 619.886) position the finished plate or sheet in clamps, determine the stretch required to remove surface contours, and operate the machine that pulls the metal from end to end to stretch it.

Sometimes ingots are melted and cast in molds to produce "billets." Besides being smaller and easier to handle than ingots, billets can be molded into shapes which make it easier to produce the final product.

In the rod and bar factory, billets are heated to make them softer and then are rolled through progressively smaller openings, until the desired size is obtained. To produce wire, hot-rolling continues until the rod is about three-eighths of an inch in diameter. Then, *wire draw operators* (D.O.T. 614.782) operate machines that pull the cold wire through a series of holes (dies) that gradually reduce its size. The machines also automatically coil the wire on revolving reels.

Structural products such as I-beams and angles may be hot-rolled or extruded. Hot-rolled products are made by passing a square billet with rounded corners between grooved rolls that gradually reduce the thickness and change the shape of the metal.

Extruding of metal often is compared with squeezing toothpaste from a tube. Extruded aluminum shapes are produced by placing hot billets (bars) inside a cylinder in a powerful press. A hydraulic ram that usually has a force of several million pounds pushes the metal through, a hole (die) at the other end of the cylinder. The metal takes the shape of the die and then may be cut into desired lengths. By using dies of varying design, almost any shape of aluminium product may be formed. *Extrusion press operators* (D.O.T. 614.782) regulate the rate at which the metal is forced through the press.

Of increasing importance in shaping aluminum is the continuous casting process. This process uses a tall, curved mold that is wider at the top than at the bottom. The mold has an opening at the bottom that is the shape of the final product—for example, it is square if billets are being made. As space becomes available, molten aluminum is added to the top of the mold and moves down through the mold while being cooled by water sprays. When the now solid aluminum comes out of the mold, it moves onto a conveyor belt where it is cut to the desired lengths.

During both the production and the shaping process, workers and machines inspect the metal to assure quality. *Radiographers* (D.O.T. 199.381) operate various types of X-ray equipment to inspect the metal. Computers monitor operations and

Aluminum ingot is removed from vertical casting unit.

automatically adjust metal temperature and mill speed.

Other production workers in the aluminum industry keep machines and equipment operating properly. Some move materials, supplies, and finished products throughout the plants; still others are in service occupations such as guard and custodian.

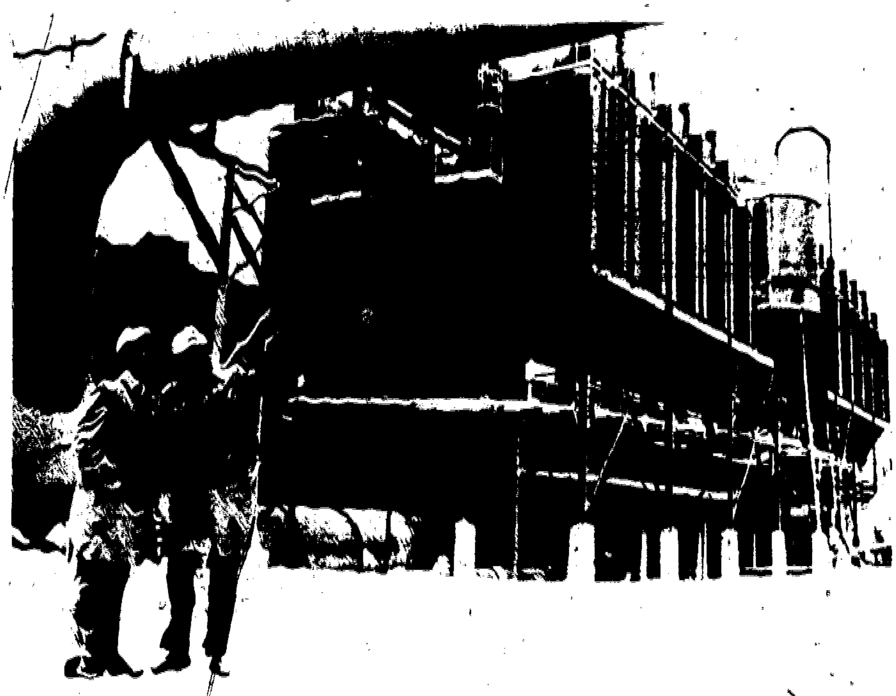
Since electricity is vital to making aluminum, the industry needs many electricians to install and repair electrical fixtures, apparatus, and control equipment. Other employees, such as millwrights and maintenance machinists, make and repair mechanical parts for plant machinery. Stationary engineers operate and maintain the powerplants, turbines, steam engines, and motors used in aluminum plants.

Other important groups are the diemakers who assemble and repair dies used in aluminum metalworking operations; the bricklayers who build and reline furnaces, soaking pits, and similar installations; and the welders who join metal parts together with gas or electric welding equipment. In addition, plumbers and pipefitters lay out, install, and maintain piping and piping systems for steam, water, and other materials used in aluminum manufacturing.

Professional, Technical, Administrative, Clerical, and Sales Occupations. About one employee in ten is a professional or technical worker; about the same proportion are clerks. The few remaining workers are in administrative and sales positions.

Aluminum companies employ a variety of professional specialists. Quality control chemists analyze the aluminum and the raw materials used in its production. Process metallurgists determine the most efficient methods of producing aluminum from raw materials. Physical metallurgists test aluminum and aluminum alloys to determine their physical characteristics and also develop new alloys and new uses for aluminum.

Chemical engineers and mechanical engineers design and supervise the construction and operation of production facilities. Mechanical engineers may design new rolling mills or improve existing mills and related equipment. Electrical engineers plan and oversee the installation, operation, and maintenance of the electric generators and distribution systems used in the manufacture of aluminum. Industrial engineers conduct work measurement studies and develop management control systems to aid in financial planning and cost analysis.



Engineers examine air pollution abatement equipment installed in an aluminum plant.

Engineering technicians, laboratory technicians, and chemical analysts assist engineers and chemists in research and development work. Drafters prepare the working drawings that are required to make or repair production machinery.

A wide range of other profesional and administrative workers is needed in the manufacture of aluminum. Top executives manage the companies and determine policy. Middle managers and superintendents direct individual departments, offices, and production operations. The industry also employs other adminstrative personnel, as well as accountants, lawyers, statisticians, economists, and mathematicians. Clerical workers, including bookkeepers, secretaries, stenographers, clerk typists, and keypunch and computer operators keep company records and do other routine office work.

Training, Other Qualifications, and Advancement

Most production workers are hired as unskilled laborers. They generally begin their careers in a labor pool and substitute for absent workers until they become eligible for a permanent positon in a shop or department.

Production workers, such as pot tenders or liners, receive their training on the job. Under the guidance of experienced workers, these employees begin by doing simple tasks and progress to operations requiring progressively greater skill as they acquire experience. As they gain additional skills and seniority, they usually move to more responsible and better paying jobs within their department.

Craft workers usually are trained on the job. A number of companies, particularly the larger ones, have craft apprenticeship programs that include classroom or home study courses, as well as on-the-job training. Generally, candidates for these programs are chosen from promising young workers already employed by the company. The length of the apprenticeship varies according to the craft, although most require 3 to 4 years. Examples of crafts that can be learned through apprenticeship are: Electrician, welder, brickmason, carpenter, machinist, maintenance mechanic, pipefitter, and general maintenance mechanic.

Applicants and current employees who demonstrate an aptitude for technical work have opportunities to qualify as technicians, laboratory assistants, and other semiprofessional workers. However, some college background in engineering and science, or graduation from a technical institute or community college, is required for many technical jobs.

Most professional jobs require at least a bachelor's degree. Graduate degrees in science or engineering are preferred for research and development work. Administrative and managerial positions usually are filled by workers who have an engineering or science background and have been promoted to these jobs. Some new graduates who have degrees in business administration or liberal arts may fill entry level administrative jobs. Sales positions often are filled by persons with engineering or related technical backgrounds.

Employment Outlook

Employment in the aluminum industry is expected to grow about as fast as the average for all industries through the mid-1980's. In addition to openings created by growth of the industry, many job opportunities will arise from the need to replace workers who retire, die, or leave the industry for other reasons. The number of job opportunities may vary from year to year, however, because the demand for aluminum fluctuates with the ups and downs in the economy.

Over the long run, the demand for aluminum is expected to grow as population increases and aluminum is substituted for other materials. Industries that represent major markets for aluminum are growing industries with potential for new product development. For example, aluminum studs are replacing wood studs in the construction of large buildings and for residential construction and remodeling. With the growing emphasis on fuel economy, car and truck manufacturers are expected to use more aluminum in the future to reduce the weight of vehicles.

Employment, however, will grow more slowly than the demand for aluminum. Furthermore, the aluminum industry supports a strong research and development program and an aggressive marketing program which should continue to develop new alloys, processes, and products. As a result, the number of engineers, scientists, and technical personnel is expected to increase as a proportion of total employment. Technological developments, such as continuous casting and computer-controlled rolling operations, will limit employment growth among some production occupations.

Earnings and Working Conditions

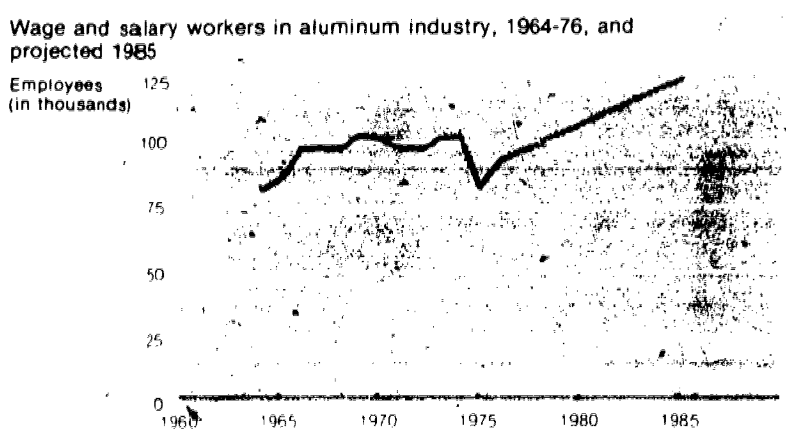
Hourly earnings of plantworkers in the aluminum industry are higher than the average for manufacturing industries. In 1976, production workers in plants which make aluminum averaged $7.29 an hour; and those in aluminum rolling and drawing plants averaged $6.27. In comparison, production workers in manufacturing industries as a whole averaged $5.19 an hour.

Skilled operators and skilled maintenance and craft workers hold the highest paying plant jobs. Hourly rates in 1976 for selected occupations in a number of plants covered by one major union-management contract are shown below.

Occupation	*Hourly wage rate*
Making Aluminum:	
Anode rebuilder	$7.09
Pot liner	6.57
Pot tender	6.74
Head tapper	7.00
Charge weigher	6.30
Shaping Aluminum:	
Scalper operator	6.74
Soaking pit operator	6.48
Hot mill operator, junior	7.35
Continuous mill operator	7.61
Annealer	6.30
Stretcher and flattener operator	6.39
Inspector	6.57
Extrusion press operator	7.00
Maintenance:	
Boiler operator	6.57
Brick mason	7.44
Welder	7.35
Pipefitter	7.35
Millwright (maintenance mechanic)	7.35
Electrician	7.61
Machinist	7.61

Aluminum workers receive many fringe benefits, such as paid vacations and holidays, retirement benefits, life and health insurance, shift differentials, supplemental jury-duty pay, and supplemental unemployment benefits. Most workers receive paid vacations ranging from 1 to 4

Although long-term employment growth is expected in the aluminum industry, the number of job openings each year will fluctuate with economic conditions



Source: Bureau of Labor Statistics

weeks, depending on length of service. In addition, there are extended vacation plans that provide a 10-week vacation with 13 week's pay every 5 years.

Making aluminum requires high temperatures and some potrooms may be hot, dusty, and smoky. However, working conditions in plants have been improved as a result of control programs and other projects. Because making aluminum is a continuous process, some production employees have to work nights and weekends.

The shaping sector of the industry generally offers more favorable working conditions, although workers in certain jobs are subjected to heat and loud noises.

The industry stresses safe working conditions and conducts safety education programs. Plants where aluminum is made have had a lower rate of injuries than the average for all metal industries, while the rate for aluminum rolling and drawing mills has been about the same as the average. However, the average number of workdays lost for each injury in the aluminum industry has been greater than the average for all metal industries.

Most process and maintenance workers in the aluminum industry belong to labor unions. In addition, labor organizations represent some office and technical personnel. The unions having the greatest number of members in the industry are United Steelworkers of America; Aluminum Workers International Union; and International Union, United Automobile, Aerospace and Agricultural Implement Workers of America.

Sources of Additional Information

Information on aluminum production and uses, as well as careers in the industry, many be obtained from:

The Aluminum Association, 750 Third Ave., New York, N.Y. 10017.

OCCUPATIONS IN FOUNDRIES

Metal castings produced by foundry workers are essential parts of thousands of products ranging from missiles to cooking utensils. The strength of metal that has been cast makes it suitable for many household and industrial items, and the development of improved alloys, or combinations of metals, has widened the range of products made by casting.

In 1976, about 300,000 people worked in the foundry industry producing bath tubs, tubing, plumbing fixtures, and thousands of other products. Thousands of other workers were employed in the foundry departments of other industries that make castings to use in their final product, such as crank shafts and engine blocks for automobiles and compressors for refrigerators.

Casting is a method of forming metal into intricate shapes. To cast metal, a mold is created that has a cavity exactly shaped like the object to be produced. Molten metal, usually iron, is poured into the mold where it cools and solidifies.

Nature and Location of the Foundry Industry

Nearly three-fourths of the foundry industry's employees work in iron and steel foundries. The remainder work in plants that cast nonferrous metals, such as aluminum, bronze, and zinc. Foundries usually specialize in a limited number of metals, because different methods and equipment are needed to melt and cast different alloys.

There are six principal methods of casting, each named for the type of mold used. In the most common method, green-sand molding, a special sand is packed around a pattern in a boxlike container called a flask. The pattern is withdrawn and molten metal is poured into the mold cavity to form the desired shape. Because sand molds can be used only once, a second method, called permanent molding, was developed which employs a metal mold that can be used many times. Permanent molding is used chiefly for casting nonferrous metals.

Precision investment casting, a third method (often called the lost wax process), uses ceramic molds. A wax or plastic pattern is coated with clay; after the coating hardens, the wax or plastic is melted and drained so that a mold cavity is left. Unlike the first two methods, castings produced from these molds are precise and require little finishing.

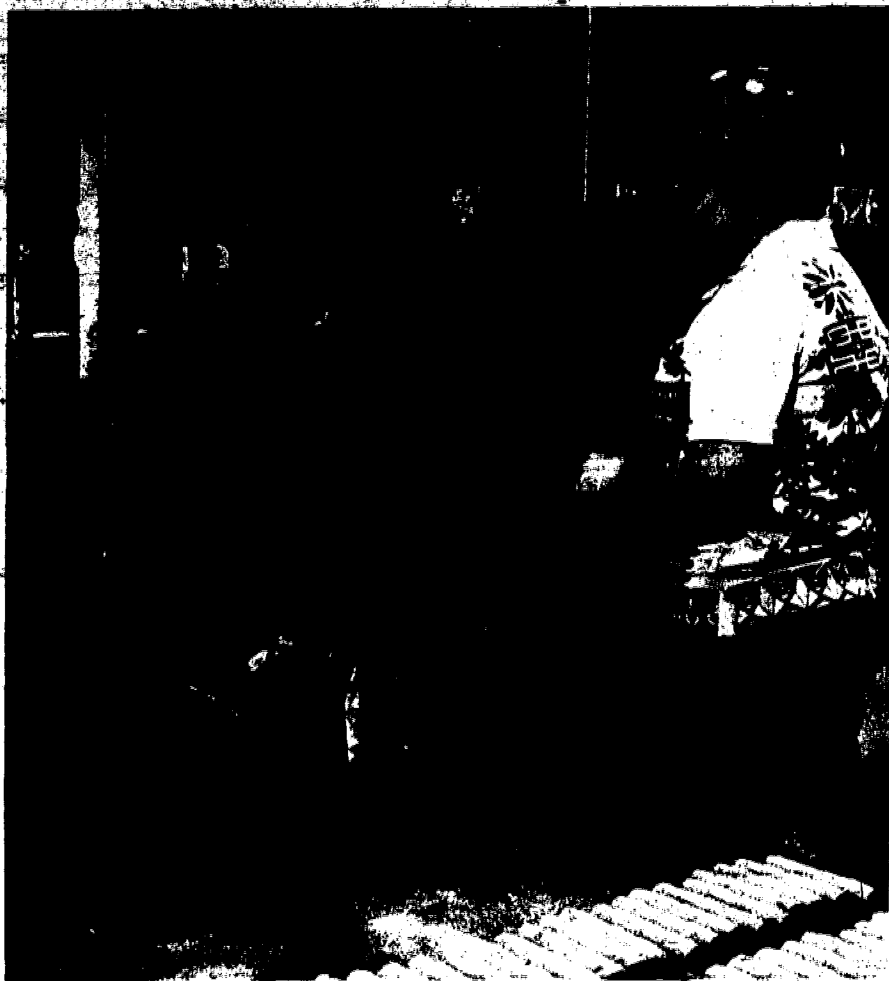
Shell molding, a fourth process, is becoming increasingly important because castings produced from these molds not only are precise but also have a smooth surface that requires almost no finishing. In this method, a heated metal pattern is covered with a mixture of sand and resin. The sand forms a thin shell mold that, once hardened, is peeled from the pattern.

Diecasting, a fifth process, is done mostly by machines. Dies are impressions that are carved by machines into metal blocks or plates. Molten metal is forced under high pressure into dies from which the castings are later automatically ejected or removed by hand.

A sixth method, centrifugal casting, is used to make pipe and other products that have cylindrical cavities. In this process, molten metal is poured into a mold that is spinning at a very high speed. The spinning motion forces the metal against the walls of the mold where it then hardens.

Most foundries are small. More than 90 percent employ fewer than 250 workers, although several of the largest employ more than 5,000 workers.

Small foundries generally produce a variety of castings in small quantities. They employ hand and machine molders and coremakers (the key foundry occupations) and a substantial number of unskilled laborers. Large foundries often are highly mechanized and produce great quantities of identical castings. These shops employ relatively few unskilled laborers because cranes, conveyors, and other types of equipment replace manual labor in the moving of materials, molds, and castings. Since



Supervisor inspects cores.

much of the casting in large shops is mechanized, they also employ proportionately fewer skilled molders and coremakers than small shops. However, many skilled maintenance workers, such as millwrights and electricians, are employed to service and repair the large amount of machinery.

Though foundries are located in many areas, jobs are concentrated in States that have considerable metalworking activity, such as in Michigan, Ohio, Pennsylvania, Illinois, Indiana, and Wisconsin.

Foundry Occupations

Most of the industry's 300,000 employees in 1976 were plant workers. To illustrate more clearly the duties of these workers, a brief description of the jobs involved in the most common casting process—sand molding—follows:

After the casting is designed, a *patternmaker* (D.O.T. 600.280 and 661.281), following the design blueprint, makes a wood or metal pattern in the shape of the casting. Next, a *hand molder* (D.O.T. 518.381) makes sand molds by packing and ramming sand, specially prepared by a *sand mixer* (D.O.T. 579.782), around the pattern. A *molder's helper* (D.O.T. 519.887) may assist in these operations. If large numbers of identical castings are to be made, machines may be used to make the molds at a faster speed than is possible by hand. The operator of this equipment is called a *machine molder* (D.O.T. 518.782).

A *coremaker* (D.O.T. 518.381 and .885) shapes sand into cores (bodies of sand that make hollow spaces in castings). *Core-oven tenders* (D.O.T. 518.885) bake most cores in ovens to harden and strengthen them so that they can be handled without breaking. When a sufficient number of cores are assembled, they are placed in the molds by *core setters* (D.O.T. 518.884) or molders. Now the molds are ready for the molten metal.

A *furnace operator* (D.O.T. 512.782) controls the furnace that melts the metal which a *pourer* (D.O.T. 514.884) lets flow into molds. When the castings have solidified, a *shakeout worker* (D.O.T. 519.887) removes them from the sand and sends them to the cleaning and finishing department.

Dirty and rough surfaces of castings are cleaned and smoothed. A *shotblaster* (D.O.T. 503.887) operates a machine that cleans large castings by blasting them with air mixed with metal shot or grit. Smaller castings may be smoothed by tumbling. In this process, the castings, together with sand or another abrasive material, are placed in a barrel that is rotated at high speed. The person who controls the barrel is called a *tumbler operator* (D.O.T. 599.885). Sandblasters and tumbler operators may also operate a machine that both tumbles and blasts the castings. A *chipper* (D.O.T. 809.884) and a *grinder* (D.O.T. 809.884) use pneumatic chisels, power abrasive wheels, powersaws, and handtools, such as chisels and files, to remove excess metal and to finish the castings.

Castings frequently are heat-treated in furnaces to strengthen the metal; a *heat treater*, or *annealer* (D.O.T. 504.782), operates these furnaces. Before the castings are packed for shipment, a *casting inspector* (D.O.T. 514.687) checks them to make sure they are structurally sound and meet specifications. Often, the inspection involves X-raying the casting to check for separations in the metal.

Many foundry workers are employed in occupations that are common to other industries. For example, maintenance mechanics, machinists, carpenters, and millwrights maintain and repair foundry equipment. Crane and derrick operators and truckdrivers move materials from place to place. Machine tool operators finish castings. Foundries also employ thousands of workers in unskilled jobs, such as guard, janitor, and laborer.

Employees placing cores into molds.

About one-sixth of all foundry workers are employed in professional, technical, administrative, clerical, and sales occupations. Of these personnel, the largest number are clerical workers, such as secretaries, typists, and accounting clerks.

Foundries employ engineers and metallurgists to do research, design machinery and plant layout, develop improved alloys, control the quality of castings, and supervise plant operations and maintenance. In recent years, many of these workers have been hired to sell castings and to assist customers in designing cast parts. Most foundry technicians are concerned with quality control. For example, they may test molding and coremaking sand, make chemical analyses of metal, and operate machines that test the strength and hardness of castings. Administrative workers employed in foundries include office managers, personnel workers, purchasing agents, and plant managers.

Detailed discussions of three principal foundry occupations—patternmakers, coremakers, and molders—appear elsewhere in the *Handbook*.

Training, Other Qualifications, and Advancement

Most workers start in unskilled jobs, such as laborer or helper, and, after receiving on-the-job training from a supervisor or experienced worker, gradually learn more skilled jobs. This is the usual practice in training workers for casting process jobs such as melter, chipper, and grinder.

Some skilled foundry workers—particularly hand molders, hand coremakers, and patternmakers—learn their jobs through formal apprenticeship. Apprentices receive supervised on-the-job training for 2 to 4 years, usually supplemented by classroom instruction. High school graduates are preferred for most apprenticeship programs, but applicants with less education sometimes are hired. For some apprenticeship programs, especially those for patternmaking, a high school education is the minimum requirement. Management prefers workers who have completed an apprenticeship, because they have a greater knowledge of all foundry operations and therefore are better qualified to fill supervisory jobs.

Skilled foundry workers also can learn their trades informally on the job or through a combination of trade school and on-the-job training. In some cases, trade school courses may be credited toward completion of formal apprenticeships. Some foundries and the American Foundry Society Cast Metals Institute conduct training programs to update and upgrade the skills of experienced workers.

Employment Outlook

Over the long run, population growth and higher incomes will create a demand for more automobiles, household appliances, and other consumer products that have cast parts. More castings also will be needed for industrial machinery as factories expand and modernize. Despite the increasing demand for castings, employment in the foundry industry is expected to grow only about as fast as the average for all industries through the mid-1980's. Technological developments will enable foundries to meet the increased demand for castings with only a moderate increase in employment. Continued improvements in production methods will result in greater output per worker. In addition to those job openings that result from employment growth, many other openings will arise due to the need to replace experienced workers who die, retire, or transfer to other fields of work. The number of openings fluctuates greatly from year to year, since demand for castings is very sensitive to ups and downs in the economy.

Grinders finishing castings.

Much of the employment increase in the foundry industry will be in production jobs. However, employment will increase in other occupations, as well. For example, employment of scientists and engineers is expected to increase because of expanding research and development activities. Technicians also will be needed in greater numbers to help improve quality control and production techniques. More maintenance workers will be hired to keep the industry's growing amount of machinery in working order. In contrast, machine molding and coremaking will be substituted for hand processes, and will limit the need for additional hand molders and hand coremakers. Improved molding techniques, such as quick set molding in which the mold hardens quickly and without baking in an oven, also will limit employment of molders. As more machinery for materials handling is introduced, employment of laborers and other unskilled workers may decline.

Earnings and Working Conditions

Production workers in foundries have higher average earnings than those in manufacturing as a whole. In 1976, production workers in iron and steel foundries averaged $6.16 an hour, and those in nonferrous foundries averaged $5.22. By comparison, production workers in all manufacturing industries averaged $5.19 an hour.

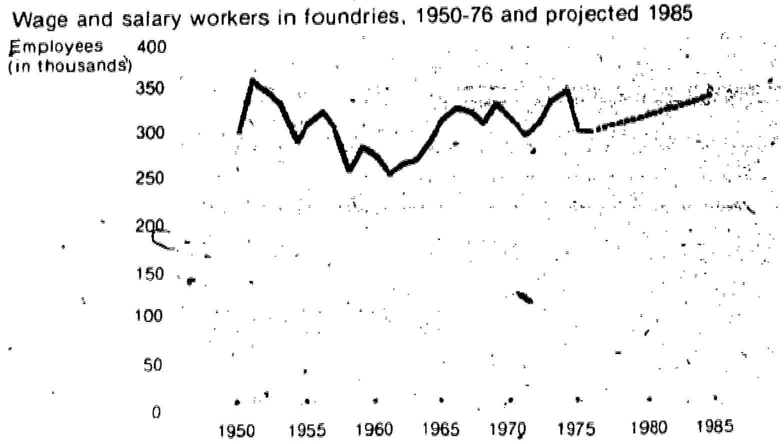
Most foundry industry employees work under union contracts that provide periodic pay increases. In those foundries that operate 24 hours a day, 7 days a week, contracts generally provide for extra pay for shift work and work done on weekends and holidays. Also, most contracts provide paid vacations according to length of service. Typically, an employee receives 1 week of vacation after 1 year of service, 2 weeks after 2 years, and 3 weeks after 10 years. In addition, many employees are covered by paid sick leave plans, group insurance, accident and death benefits, and retirement and disability pensions.

Working conditions in foundries have improved in recent years. Many foundries have changed plant layouts and installed modern ventilating systems to reduce heat, fumes, dust, and smoke. The injury rate in foundries is higher than the average for manufacturing; foundry workers are subject to burns from hot metal and cuts and bruises from handling metal castings. However, employers and unions are attempting to reduce injuries by promoting safety training.

Foundry workers belong to many unions, including the International Molders' and Allied Workers' Union; the United Steelworkers of America; and the International Union of Elec-

Employment in foundries is very sensitive to year-to-year fluctuations in the business cycle

Wage and salary workers in foundries, 1950-76 and projected 1985



trical, Radio and Machine Workers. Many patternmakers are members of the Pattern Makers' League of North America.

Sources of Additional Information

Further information about work opportunities in foundry occupations may be obtained from local foundries, the local office of the State employment service, the nearest office of the State apprenticeship agency, or the Bureau of Apprenticeship and Training, U.S. Department of Labor. Information also is available from the following organizations:

American Foundrymen's Society, Golf and Wolf Rds., Des Plaines, Ill. 60016.

Foundry Educational Foundation, 1138 Terminal Tower, Cleveland, Ohio 44113.

International Molders' and Allied Workers' Union, 1225 E. McMillan St., Cincinnati, Ohio 45206.

Patternmakers must carefully check each dimension.

PATTERNMAKERS

Nature of the Work

Foundry patternmakers are highly skilled craftworkers who make the patterns used in making molds for metal castings. Most of the workers in the occupation are *metal patternmakers* (D.O.T. 600.280); a smaller number are *wood patternmakers* (D.O.T. 661.281). Some patternmakers work with both metal and wood as well as with plaster and plastics.

Patternmakers work from blueprints prepared by engineers or drafters. They make a precise pattern for the product, carefully checking each dimension with instruments such as micrometers and calipers. Precision is important because any imperfections in the pattern will be reproduced in the castings made from it.

Wood patternmakers select the wood stock, lay out the pattern, and saw each piece of wood to size. They then shape the rough pieces into final form with various woodworking machines, such as lathes and sanders, as well as many small handtools. Finally, they assemble the pattern segments by hand, using glue, screws, and nails.

Metal patternmakers prepare patterns from metal stock or from rough castings made from a wood pattern. To shape and finish the patterns, they use many metalworking machines, including lathes, drill presses, shapers, milling machines, power hacksaws, and grinders. They also use small handtools, such as files and rasps.

Training, Other Qualifications, and Advancement

Apprenticeship is the best means of qualifying as an experienced patternmaker. Because of the high degree of skill and the wide range of knowledge needed for patternmaking, it is difficult to learn the trade on the job, but in some instances skilled machinists have been able to transfer to metal patternmaking with additional on-the-job training or experience. High school courses in mechanical drawing, blueprint reading, and shop mathematics are helpful to persons interested in becoming patternmakers. In addition, vocational and technical school training in patternmaking, metalworking, and machining provide useful preparation for an apprentice, and may be credited toward completion of the apprenticeship.

The usual apprenticeship period for patternmaking is 5 years; however, a few apprenticeships last only 3 or 4 years. Each year at least 144 hours of classroom instruction usually are provided. Apprenticeship programs for wood and metal patternmaking are separate. Employers almost always require apprentices to have a high school education.

Apprentices begin by helping experienced patternmakers in routine duties. They make simple patterns under close supervision; as they progress, the work becomes increasingly complex and the supervision more general. Patternmakers earn higher pay as their skill increases, and some become supervisors.

Patternmaking, although not strenuous, requires considerable standing and moving about. Manual dexterity is especially important because of the precise nature of the work. The ability to visualize objects in three dimensions also is important when reading blueprints.

Employment Outlook

Employment of foundry patternmakers is expected to increase only about as fast as the average for all occupations through the mid-1980's despite the anticipated large increases in foundry production. The increased use of metal patterns will allow production to increase faster than employment. Metal patterns, unlike wooden ones, can be used again and again, thus reducing the number of patterns that have to be made.

In addition to those openings created by employment growth, some job openings will arise because of the need to replace experienced patternmakers who retire, die, or transfer to other occupations. Most of these openings will be for metal patternmakers. The number of openings may fluctuate from year to year since the demand for foundry products is sensitive to changes in the economy.

Because patternmakers learn either basic metalworking or woodworking, they are prepared for jobs in related fields when patternmaking employment is not available. Wood patternmakers can qualify for woodworking jobs such as cabinetmaker, and metal patternmakers can transfer their skills to metalworking jobs such as machinist.

Earnings and Working Conditions

Patternmakers generally have higher earnings than other production workers in manufacturing. In January 1976, average straight-time hourly earnings of wood patternmakers ranged from $6 in gray iron and malleable iron foundries, to $6.25 in nonferrous foundries, according to a wage survey made by the National Foundry Association. In comparison, all production workers in manufacturing industries averaged $5.19 an hour.

Patternmakers work indoors in well-lighted, well-ventilated areas. The rooms in which they work generally are separated from the areas where the casting takes place, so they are not exposed to the heat and noise of the foundry floor.

For sources of additional information, see the introductory section of this chapter.

MOLDERS

Nature of the Work

One of the oldest known methods of making metal products is by metal casting, or the process of pouring molten metal into a previously made mold and allowing the metal to harden in the shape of the mold. There are several different ways of making molds, but sand molding is the most common. In sand molding, molders make the mold by packing and ramming specially prepared sand around a pattern—a model of the object to be duplicated—in a box called a flask. A flask usually is made in two parts that can be separated to remove the pattern without damaging the mold cavity. When molten metal is poured into the cavity, it solidifies and forms the casting. (Other types of molds and molding processes are described in the foundry industry section of the *Handbook*).

Technologically advanced molding machines that pack and ram the sand mechanically are now used to make most molds. Thus, most of the workers in this occupation are machine molders. *Machine molders* (D.O.T. 518.782) operate machines that speed up and simplify the making of large quantities of identical sand molds. Machine molders assemble the flask and pattern on the machine table, fill the flask with prepared sand, and operate the machine with levers and pedals. Many of these workers set up and adjust their own machines.

In a few foundries, hand molders still construct the sand molds, using primarily manual methods. Power tools, such as pneumatic rammers, and handtools, such as trowels and mallets, are used to smooth the sand. Molds for small castings usually are made on the workbench by *bench molders* (D.O.T. 518.381); those for large and bulky castings are made on the foundry floor by *floor molders* (D.O.T. 518.381). An all-round hand molder makes many different types of molds. A less skilled molder specializes in a few simple types.

Training, Other Qualifications, and Advancement

Completion of a 4-year apprenticeship program, or equivalent experience, is needed to become a skilled hand molder. Workers with this training also are preferred for some kinds of machine molding, but in general a shorter training period is required in order to become a qualified machine molder. Some people learn molding skills informally on the job, but this way of learning the trade takes longer and is less reliable than apprenticeship.

An eighth grade education usually is the minimum requirement for apprenticeship. Many employers, however, prefer high school graduates.

Apprentices, under close supervision by skilled molders, begin with simple jobs, such as shoveling sand, and then gradually take on more difficult and responsible work, such as ramming molds, withdrawing pat-

Molders need good vision and manual dexterity.

terns, and setting cores. They also learn to operate the various types of molding machines. As their training progresses, they learn to make complete molds. In addition, the apprentice may work in other foundry departments to develop all-round knowledge of foundry methods and practices. The apprentice usually receives at least 144 hours of classroom instruction each year in subjects such as shop arithmetic, metallurgy, and shop drawing.

Hand molders who do highly re[illegible]petitive work that requires less skill usually learn their jobs during a brief training period. Trainees work with a molder to make a particular kind of mold. After 2 to 6 months, the trained usually is capable of making a similar mold. Most machine molding jobs can be learned in 2 to [illegible] months on the job.

Physical standards [illegible] jobs are fairly high [illegible] molders stand while working, [illegible] move about a great deal, and frequently must lift heavy objects. They need good vision and a high degree of manual dexterity. Molders may [illegible] vance to a specialized molding job or eventually to a supervisory position.

[illegible]

[illegible] employment of [illegible] increase about as fast as [illegible] average for all occupations [illegible] the mid 1980's. Although the [illegible] demand for metal castings is [illegible] to increase significantly, [illegible] more machine molding such as the sand slinging process, and other labor-saving innovations will al[illegible] large increases in production with only moderate employment growth. In addition to job openings created by employment growth, openings will arise from the need to replace experienced molders who retire, die, or transfer to other occupations. The number of openings, however, may fluctuate greatly from year to year because the demand for foundry products is sensitive to changes in the economy.

Earnings and Working Conditions

[illegible] 1976 [illegible] aged $5.52 an hour, and [illegible] molders averaged $4.98, according to a wage survey made by the National Foundry Association. By comparison, production workers in all manufacturing industries averaged $5.19 an hour. Molders who were paid on an incentive basis generally had higher earnings.

Working conditions vary considerably from one foundry to another. Heat, fumes, and dust have been greatly reduced in many plants by the installation of improved ventilation systems and air-conditioning. However, in many older foundries these still are problems.

Working in a foundry can be hazardous, and the injury rate is higher than the average for all manufacturing industries. Safety programs and safety equipment, such as metal plated shoes, have helped reduce injuries at many foundries. However, molders must be careful to avoid burns from hot metal and to avoid cuts and bruises when handling metal parts and power tools.

For sources of additional information, see the introductory section of this chapter.

[illegible]

[illegible]

[illegible] section [illegible] [illegible] that when the [illegible] [illegible] the desired cavity [illegible] [illegible] this.

[illegible] packed into a block of [illegible] metal in which a space of the desired size and shape has been hollowed out. After the core is [illegible] removed from its box. It is hardened by baking or by another drying method. When hand methods are used, the [illegible] mallets and other hand tools to pack sand into the core box. Small cores are made on the workbench by *bench coremakers* (D.O.T. 518.381) and large ones are made on the foundry floor by *floor coremakers* (D.O.T. 5[illegible].838.)

Machine coremakers (D.O.T. 518.885) operate machines that make sand cores by forcing sand into a core box. Some machine coremakers are required to set up and adjust their machines and do finishing operations on the cores. Others are primarily machine tenders. They are closely supervised and their machines are adjusted for them. (To see how the coremaker's job is a basic step in the casting process, read the description of sand casting given in the statement on foundries elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

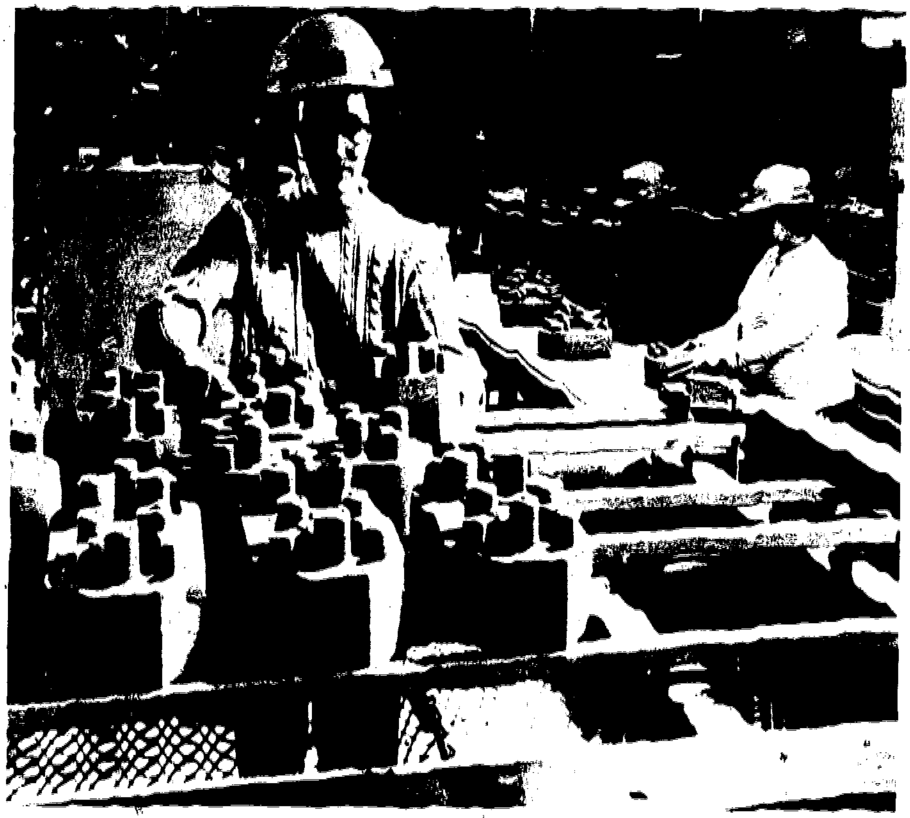
Completion of a 4 year apprenticeship training program or the equivalent experience is needed to become a skilled hand coremaker. Apprenticeships also are sometimes required for the more difficult machine coremaking jobs. Apprenticeships in coremaking and molding often are combined.

Experienced coremakers teach apprentices how to make cores and operate ovens. Classroom instruction covering subjects such as arithmetic and the properties of metals generally supplements on-the-job training. Coremakers earn higher pay as their skill increases, and some may advance to supervisors.

An eighth grade education usually [illegible] the minimum requirement for [illegible] apprentices; however, most employers prefer high school graduates and some employers require apprentices to have graduated from high school. Some types of hand coremaking require a high degree of manual dexterity.

[illegible]

[illegible] employment of coremakers is expected to increase about as fast as the average for all occupations through the mid 1980's, as the growing use of machine coremaking will allow a large increase in production with only moderate employment growth. In addition to those job openings created by employment growth, other open



Coremaker operating machine that produces cores for automobile engine heads.

ings will arise because of the need to replace experienced coremakers who retire, die, or transfer to other occupations. The number of openings may fluctuate greatly from year to year since the demand for foundry products is sensitive to changes in the economy.

Earnings and Working Conditions

In January 1976 average hourly earnings of floor coremakers were $5.30; bench coremakers, $5.2[illegible]; and machine coremakers, $5.31, according to a wage survey made by the National Foundry Association. By comparison, production workers in all manufacturing industries averaged $5.19 an hour. Coremakers who were paid on an incentive basis generally had higher earnings than those who were paid a straight hourly wage.

Working conditions vary considerably from one foundry to another. Heat, fumes, and dust have been greatly reduced in many plants by the installation of improved ventilation systems and air-conditioning. Although the injury rate in foundries is higher than the average for manufacturing, coremaking is one of the least hazardous foundry jobs.

For sources of additional information, see the introductory section of this chapter.

OCCUPATIONS IN THE IRON AND STEEL INDUSTRY

Steel is the backbone of any industrialized economy. Few products in daily use are not made from steel or processed by machines [illegible] steel. For example, steel sheets are made into automobile bodies, appliances, and furniture; steel bars are used to make parts for machinery and to reinforce concrete in building and highway construction; steel plates become parts of ships, bridges, railroad cars, and storage tanks; strip steel is used to make pots and pans, razor blades, and toys.

To satisfy the country's need for steel, the iron and steel industry employed about 540,000 persons in 1976. Employees work in a broad range of jobs that require a wide variety of skills; many of these jobs are found only in iron and steelmaking.

Characteristics of the Industry

The iron and steel industry, as discussed in this chapter, consists of the firms that operate blast furnaces, steel furnaces, and finishing mills. Blast furnaces make iron from iron ore, coke, and limestone. Steel furnaces refine the iron and scrap steel into steel. Primary rolling mills and continuous casting operations shape the steel into semifinished products called blooms, billets, and slabs, which other rolling mills shape into steel sheets, bars, plates, strips, wire, pipe, and various other finished products.

The types of operations performed in the more than 900 steel plants in the United States vary throughout the industry. Fully integrated steel plants, which are so large they may cover several square miles, contain blast furnaces, steel furnaces, and rolling mills. These plants perform all the operations necessary to convert processed iron ore into finished steel products. Other plants only perform finishing operations such as making steel wire and pipe from billets.

The number of people employed in the plants of the iron and steel industry also varies greatly. Individual plants typically employ a large number of workers because the production of iron and steel products is a monumental task. It requires the handling and use of thousands of tons of raw materials, and involves enormous facilities and equipment such as blast furnaces that may be 12 stories high and rolling mills that may be several city blocks long. About 65 percent of the industry's employees work in plants that have more than

2,500 employees; fully integrated plants may have more than 10,000. Many plants, however, have fewer than 100 employees.

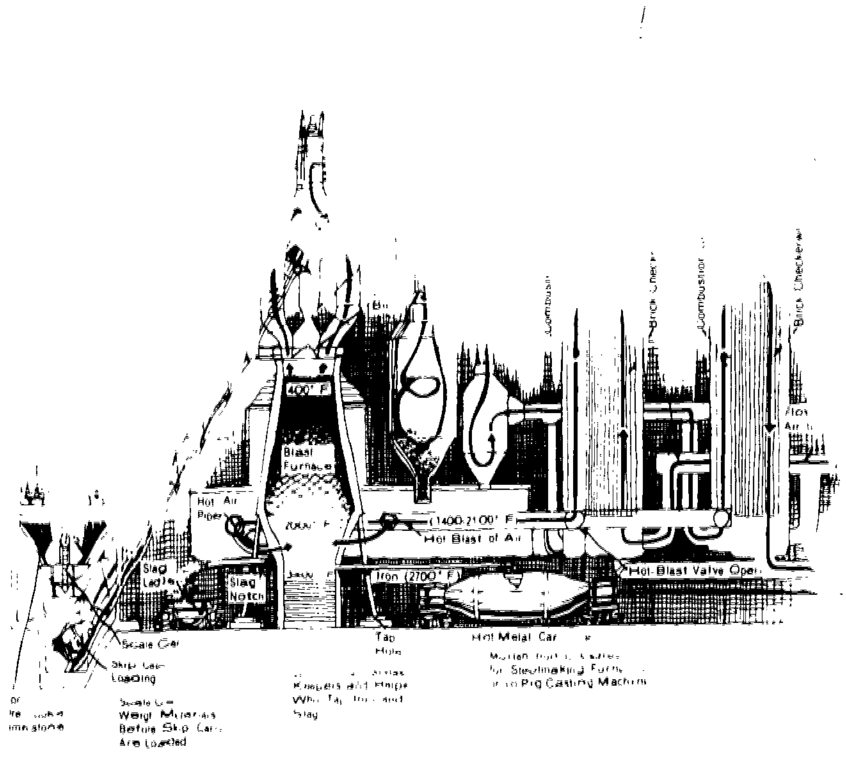
Iron and steel plants are located mainly in the northeastern part of the United States near the abundant iron deposits of the Great Lakes area and the nearby coal deposits. About 7 out of 10 of the industry's workers are employed in five States—Pennsylvania, Ohio, Indiana, Illinois, and New York. Nearly 3 out of 10 are employed in Pennsylvania alone. The largest steel-producing plants are located in Indiana Harbor and Gary, Ind.; Sparrows Point, Md. (near Baltimore); Chicago, and Pittsburgh.

Occupations in the Industry

Workers in the iron and steel industry hold more than 2,000 different types of jobs. About 80 percent of all workers are directly engaged in moving raw materials and steel products about the plants, making iron and steel products, and maintaining the vast amount of machinery used in the industry. In addition, other workers are needed to do clerical, sales, professional, technical, administrative, and supervisory work.

Processing Occupations. The majority of the workers in the industry are employed in the many processing operations involved in converting iron ore into steel and then into semifinished and finished steel products. Because of the extensive use of automated control equipment in making steel from iron ore, most processing jobs are found in the rolling mills where the steel is shaped into semifinished and finished products. Following are brief descriptions of the major iron and steelmaking and finishing operations and some of the occupations connected with them.

Blast furnaces. The blast furnace, a large steel cylinder lined with heat-resistant (refractory) brick, is used to separate the iron from other elements in the iron ore. A mixture of ore, coke, and limestone (called a "charge") is fed into the top of the furnace. As this material works its way down through the furnace, hot air blown into the bottom from giant stoves causes the coke to burn at a high temperature. At this high temperature a chemical reaction takes place between the coke and the iron ore, freeing the iron from other elements in the ore.



The iron, which now is a liquid, trickles down through the burning coke and collects in a pool 4 to 5 feet deep at the bottom of the furnace. As the liquid iron passes through the coke, the intense heat causes another chemical reaction between the limestone, the burned-out coke, and any other materials to form a waste product called "slag". The slag also trickles down through the coke and floats on top of the heavier iron. In a typical furnace liquid iron is removed from the furnace every 3 or 4 hours; slag may be removed more frequently.

A blast furnace operates continuously, 24 hours a day, 7 days a week, unless it is shut down for repairs or for other reasons. A single furnace may produce up to 10,000 tons of iron in a 24-hour period.

The raw materials used in blast furnaces are transferred from storage areas on railroad cars. Moving on elevated tracks to the furnace, the cars are positioned over an open grate. The raw materials are dumped through the grate and into a large funnel-shaped bin called a hopper. *Scale car operators* (D.O.T. 921.883) drive other railroad cars on tracks in tunnels underneath the hoppers. Positioning their car under one of these bins, they fill it with raw material, weigh the loaded car, and then dump the material into skip cars where the ore, limestone, or coke is automatically carried up a steep ramp to the top of the blast furnace and dumped. Scale car operators must keep records of what they put in the furnace. In blast furnace operations without automatic controls, a *skip car operator* (D.O.T. 921.883) uses electric and pneumatic controls to operate the cars.

Stove tenders (D.O.T. 512.782) operate the gas-fired stoves that heat air for the blast furnace. They observe controls that show the temperature of the air inside the stove. When air reaches the correct temperature, the tender opens valves on the stove that allow the heated air to pass to the furnaces. Stove tenders also keep the stove flues clean of carbon and dirt.

Blowers (D.O.T. 519.132) oversee the operation of one or more blast furnaces and are responsible for the quantity and quality of the iron produced. They coordinate the addition of raw materials by stockhouse workers with the operation of the furnace and supervise *keepers* (D.O.T. 502.884) and their *helpers* (D.O.T. 502.887) in removing (tapping) the liquid iron and slag from the furnace. If the iron is not forming correctly in the furnace, blowers may have the stove tenders change the temperature and flow of air into the furnace.

When the blower has determined that the iron is ready to be removed, the keeper and a helper use power drills, air hoses, or small explosive charges to remove the clay that is plugging a taphole above the liquid iron, allowing the slag to flow down a sand-lined channel into huge containers called ladles, which have been positioned under the channel by crane operators. Helpers open gates to divert the slag into other ladles when the first one is filled. After removing the slag, the keeper removes the clay from a lower taphole that allows the iron to flow down another channel into special railroad tank cars called "hot metal cars."

After the slag and iron have been removed, the keeper uses a "mud gun" to shoot clay into the tapholes. The keeper and helpers use tongs to remove solidified iron and slag from the channels and shovels to line the channels with special heat-resistant sand.

Some of the iron taken from the blast furnace is made into finished products such as automobile engine blocks and plumbing pipes. Most of it, however, is used to make steel. Because steel is stronger than iron and can be hammered and bent without breaking, it can be used for many more products.

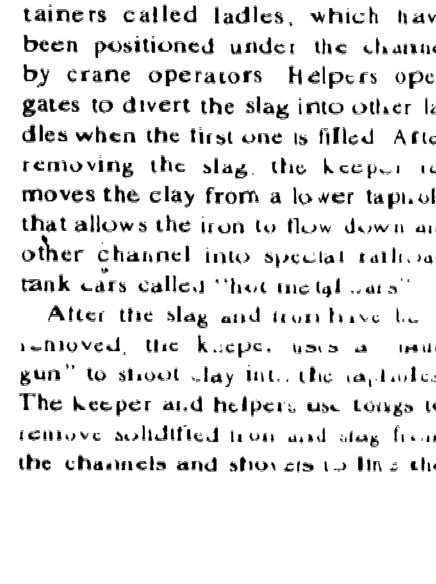
Steel furnaces. Steel is made by heating iron or scrap steel to remove some of the carbon and other impurities and adding chemical agents such as silicon and manganese. By varying the amount of carbon and chemical agents contained in the final product, thousands of different types of steel can be made—each with specified properties that are suited for a particular product. For example, stainless steel is rust resistant and heat resistant and is used in products which need those qualities such as razor blades.

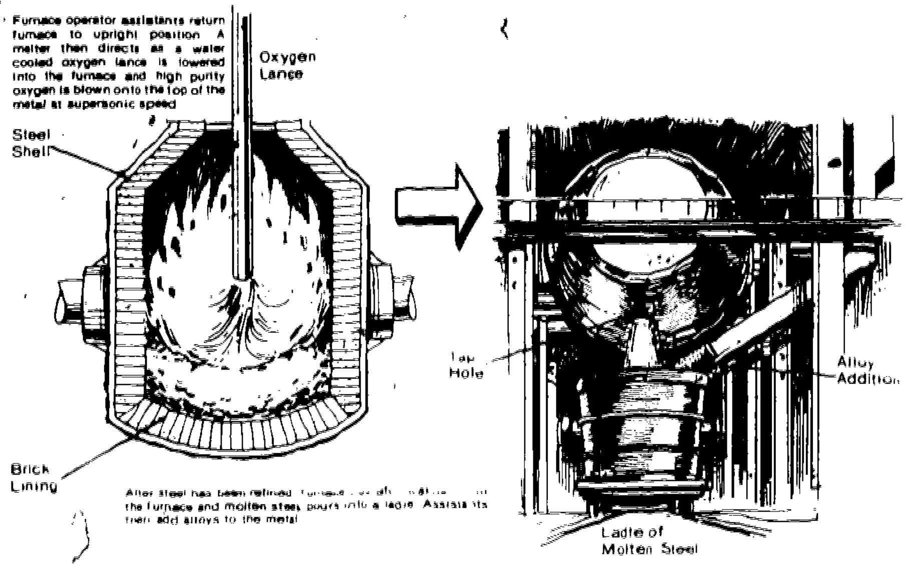
Steel is made in three types of furnaces: basic oxygen, open hearth, and electric. More than 60 percent of all domestic steel is made in basic oxygen furnaces (BOF's) and about 20 percent in open hearth furnaces. Both produce similar kinds of steel, but BOF's do the job faster and are expected to replace many of the open hearths now in operation. For many years electric furnaces were used mainly to produce high quality steels such as stainless and tool steel. They now produce large quantities of regular steel and account for about 20 percent of total U.S. steel output.

Although the steelmaking procedure varies with the type of furnace used, the jobs associated with the various processes are similar. Since basic oxygen furnaces account for most of the U.S. steel, the jobs connected with them will be used as an illustration of those in other steel furnace operations.

A *melter* (D.O.T. 512.132) supervises workers at a steel furnace. Melters receive information on the characteristics of the raw materials they will be using and the type and quality of steel they are expected to produce. The melter makes the steel according to the desired specifications by varying the proportions of iron, scrap steel, and limestone in the furnace, and by adding small amounts of other materials such as manganese, silicon, copper, or chrome. The melter directs the workers who load furnaces with these raw materials and supervises the taking of a sample of liquid steel that is tested to insure the steel has the desired qualities. The melter must coordinate the loading and melting of the raw materials with the steel molding operation to avoid delays in production.

A basic oxygen furnace is a giant pear-shaped steel container lined with heat-resistant brick. The furnace can be tilted from side to side to receive raw materials and discharge steel and slag. The *furnace operator* (D.O.T. 512.782), under the direction of the melter, controls the operation of the furnace. To begin the operation, the furnace operator's first assistant uses controls to tilt the furnace to receive a load or "charge" of steel scrap and molten iron. A *scrap crane operator* (D.O.T. 921.883) adds scrap steel and is followed by a *charging crane operator* (D.O.T. 921.883) who adds the liquid iron made by the blast furnace. After the assistant rights the furnace, the furnace operator, who works in a control room overlooking the furnace, uses levers and buttons to low-





er the oxygen lance [illegible] oxygen into the furnace at supersonic speeds. The furnace operator also controls the addition of lime, which combines with impurities in the iron to form slag, and the addition of any chemical agents that are required to give the steel the desired properties. If the chemical reactions in the furnace become too violent, the furnace may overheat, causing slag and iron to splash out the top. Thus the furnace operator must pay close attention to conditions in the furnace, regulate the oxygen flow, and if the furnace does overheat, direct the rocking of the furnace to cool it.

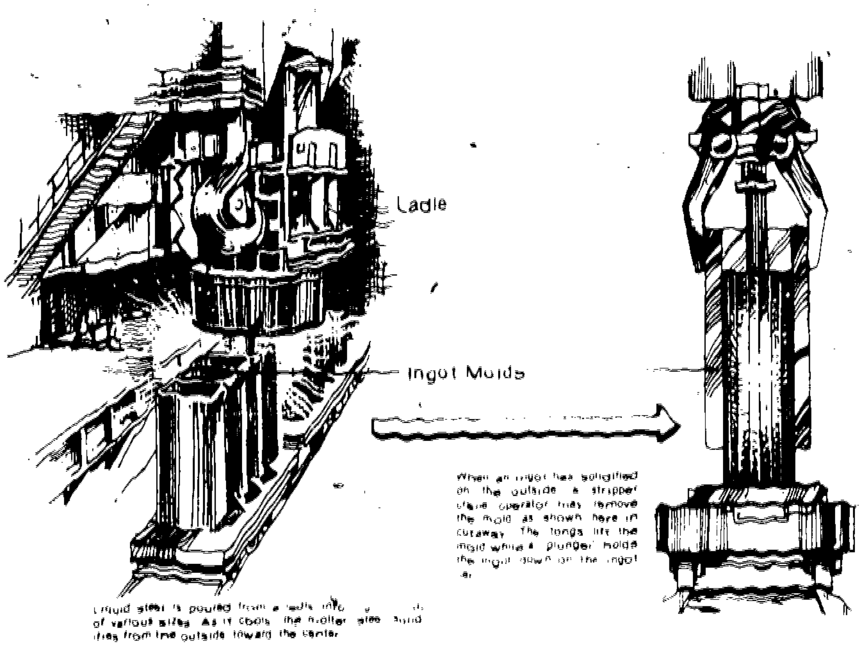
By observing the various [illegible] ments in the control room, the furnace operator knows when the steel has almost the correct composition. The first assistant then tilts the furnace while the second assistant and helpers, working from behind a heat shield, use a long handled spoon to take a sample. The sample is sent up to the lab where metallurgists determine how close the steel is to the product desired. Based on this information, the furnace operator determines how much longer and at what temperature the furnace should operate. When the furnace operator has determined that the steel has the specified qualities, the first assistant tilts the furnace towards a waiting [illegible] The steel flows through a tap hole in the side of the furnace and into the ladle. The second assistant and helpers may add chemical agents to the ladle while the steel is poured. By continually tilting the furnace at a steeper angle the first assistant can keep the slag above the taphole, preventing it from flowing into the ladle. Eventually, the slag is poured through the taphole into the slag pot. The assistants and helpers then use handtools to clean out the taphole and furnace lip.

The liquid steel usually is solidified into large blocks called "ingots." A *hot metal crane operator* (D.O.T. 921.883) controls an overhead crane which picks up the ladle of liquid steel and moves it over a long row of iron ingot molds resting on railroad flatcars (ingot buggies). The *steel pourer* (D.O.T. 514.884) operates a stopper at the bottom of the ladle to let the steel flow into these molds. The steel pourer also examines the molds to see that they are clean and smooth and often is a helper in taking a sample of the steel for chemical analysis. As soon as the steel has solidified sufficiently, an *ingot stripper* (D.O.T. 921.883) operates an overhead crane which removes the molds from the ingots. The steel now is ready to be shaped into semifinished and finished products.

Rolling and finishing. The three principal methods of shaping steel are rolling, casting, and forging. (Forged steel usually is made in forging shops. Occupations in those shops are described elsewhere in the *Handbook*.) About 90 percent of the steel processed in steel mills is shaped by rolling. In this method, heated steel ingots are squeezed into longer and flatter shapes between two massive cylinders or "rolls." Before ingots of steel are rolled, they are heated to the temperature specified by plant metallurgists. The heating is done in large furnaces called "soaking pits" located in the plant floor. A *soaking pit crane operator* (D.O.T. 921.883) maneuvers an overhead crane to lift the ingots from small railcars and place them in the soaking pit. A *heater* (D.O.T. 613.782) and *helper* (D.O.T. 613.885) control the soaking pit operation. They adjust controls, which regulate the flow of air and fuel to the burners, to maintain the correct temperature in each pit, and by watching dials they determine when the ingot is uniformly heated to the required temperature.

When the ingots are needed in the mill, the crane operator places them on an ingot buggy, which carries them to the first rolling mill, sometimes called a "primary" mill. Here, the ingots are rolled into smaller, more easily handled semifinished products called blooms, billets, and slabs. Blooms generally are between 6 and 12 inches wide and 6 and 12 inches thick. Billets, which are rolled from blooms, have a smaller cross section and are longer than blooms. Slabs are much wider and thinner than blooms.

Rolling ingots into blooms and slabs are similar operations; in fact some rolling mills can do both. In the mill, the ingot moves along on a roller conveyer to a machine that resembles a giant clothes wringer. A "two high" rolling mill has two grooved rolls that revolve in opposite directions. The rolls grip the approaching red hot ingot and pull it between them, squeezing it thinner and longer. When the ingot has made one such pass, the rolls are reversed, and the ingot is fed back through them. Throughout the rolling operation, the ingot periodically is turned



Liquid steel is poured from a ladle into ... of various sizes. As it cools, the molten steel solidifies from the outside toward the center.

When an ingot has solidified on the outside, a stripper crane operator may remove the mold as shown here in cutaway. The tongs lift the mold while a plunger holds the ingot down on the ingot car.

90 degrees by mechanical arms called "manipulators," and passed between the rolls again so that all sides are rolled. This operation is repeated until the ingot is reduced to a slab or bloom of the desired size. It is then ready to be cut to specified lengths.

A *roller* (D.O.T. ...82), the worker in charge of the mill, works in a glass enclosed control booth located above or beside the conveyor line. This employee's duties, which appear to consist principally of moving levers and pushing buttons, look relatively simple. However, the quality of the product and the speed with which the ingot is rolled depend upon the roller's skill. The roller regulates the opening between the rolls after each pass. If the opening is set too wide, more passes will be needed to get the required shape, and production will be slowed. If the opening is too narrow, the rolls or gears may be damaged. Long experience and a knowledge of steel characteristics are required for a worker to become a roller. A *manipulator operator* (D.O.T. 613.782) sits in the booth beside the roller and operates controls that correctly position the ingot on the roller conveyor before each pass.

Upon leaving the rolling mill, the red-hot slab, billet, or bloom moves along a conveyer to a place where a ... (D.O.T. 613.782) controls a heavy hydraulic shear that cuts the steel into desired lengths.

In a rolling mill that has automatic controls, a rolling mill attendant is given a card that has been punched with a series of holes. The holes represent coded directions as to how the ingot is to be rolled. The attendant inserts the card into a card "reader" and presses a button to start the automatic rolling sequence. When this process is used, the roller's job is shifted from operating the controls to directing and coordinating the rolling process.

Of increasing use in shaping steel into slabs, blooms, and billets is the continuous casting process, which eliminates the necessity of producing large ingots that in turn must be reheated and then put through the primary mill. In one type of continuous casting, a ladle of liquid steel, a water cooled mold of the desired product shape (for example, a bloom) and a cooling chamber are set above the plant floor. A series of rolls descend from the cooling chamber to the floor. Liquid steel is poured into the mold. The steel cools and solidifies along the bottom and lower sides of the mold. Passing down through the chamber, the steel is further cooled by a water spray. The rolls control the molded steel's descent, support its weight, and straighten it as it moves toward the plant floor. The molded steel is cut to the desired lengths as it emerges from the rolls. Continuous casting requires fewer workers than the pouring and rolling of ingots require.

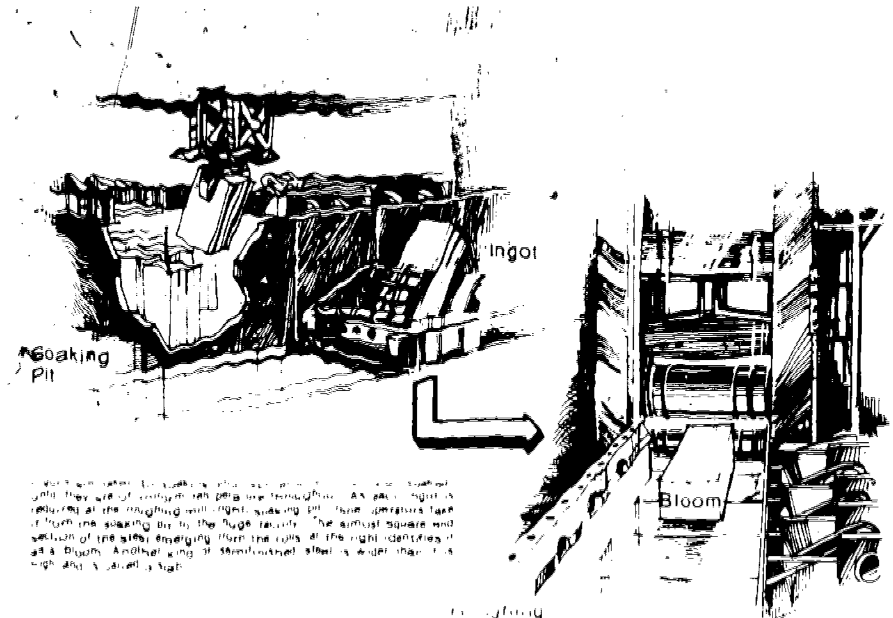
After the steel is rolled or cast into primary shapes, most of it is put through finishing operations. Slabs, for example, can be reduced and shaped into sheets, and billets can be made into wire and pipe.

Steel sheet is the most important finished product made by the iron and steel industry. To make sheets, a slab is first heated in a furnace similar to the soaking pits described earlier, and then run through a hot strip mill. The hot strip mill is a continuous series of pairs of rolls, similar to the two at the primary mill. As the slab moves through each pair of rolls, it becomes thinner and longer. Edge guides control its width. After passing through the last pair of rolls, the sheet is wound into a coil. If the customer prefers a thinner sheet or an improved surface, the product may be cold rolled in another mill.

Having obtained information on the characteristics of the sheet desired, the roller at the hot strip mill refers to a printed guide to determine the necessary gauge between each pair of rolls, and the speed at which the slab should travel. Working in a pulpit, the roller uses controls to set the gauge on the last series of rolls, while the *speed operator* (D.O.T. 613.782) works controls that adjust the speed of the rolls and conveyor. Unless problems develop, the jobs of these two workers are repetitive. However, if the sheet should begin to buckle between rolls, due to the steel's composition or temperature, these two employees must readjust the gauge and speed of the rolls in an attempt to avoid damage to the sheet.

Under the direction of the roller, a *rougher* (D.O.T. 613.782) and assistant use handtools to adjust the gauge and edge guides for the first series of rolls (called the roughing mill). A *rougher pulpit operator* (D.O.T. 613.782), following the rougher's instructions, signals the furnace crew for additional slabs and operates controls to position the slab on the conveyor and guide it into the rolls.

13



The operator uses controls to remove the mandrel and drop the billet on a conveyor for further processing.

[illegible] includes [illegible] pipe. These products are made from billets. To make drawn wire the billet is rolled into a long, thin, round product called a rod. A *wire drawer* (D.O.T. 614.782) operates equipment that pulls the steel rod through a die. The die has a tapered hole, one end of which is smaller than the rod. As the rod passes through the hole it is made thinner and longer, and becomes wire. The wire drawer positions the rod in the die [illegible] [illegible] checks the [illegible] for [illegible] and defects.

[illegible] *piercing mill operator* (D.O.T. [illegible]3.885) controls machinery that makes seamless pipe. The operator moves levers that drop the hot billet from a conveyor into a trough and pass it between two barrel-shaped rolls. [illegible] the billet and force an end of it along [illegible] a sharp plug or mandrel. The mandrel smooths the inside wall of the billet and makes the diameter of the hole uniform.

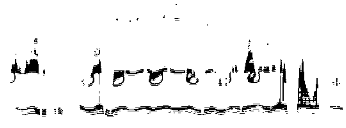
Maintenance, Transportation, and Plant Service Occupations. Large numbers of workers are required in steel plants to support processing activities. Some maintain and repair machinery and equipment, while others operate the equipment that provides power, steam, and water.

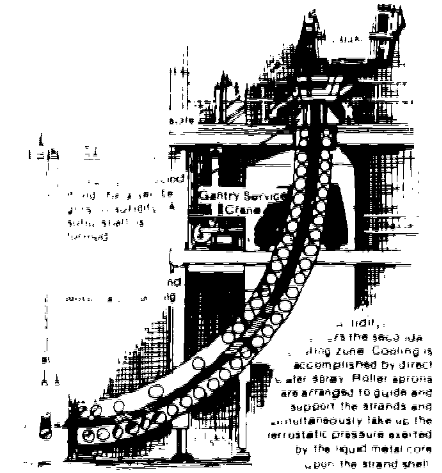
Machinists and machine tool operators make and repair metal parts for production equipment. Diemakers use machine tools to form dies, such as those used to make wire. *Roll turners* (D.O.T. 8[illegible]1.884) use lathes, grinders, and other machine tools to refinish the steel rolls used in the rolling mills.

Millwrights overhaul machinery and repair and replace defective parts. Electricians install wiring and fixtures and hook up electrically operated equipment. Electrical repairers (motor inspectors) keep wiring, motors, switches, and other electrical equipment in good operating condition.

Electronic repairers install and maintain the increasing number of electronic devices and systems used in steel manufacturing plants. Typically, this equipment includes communication systems such as closed circuit television, electronic computing and data recording systems, and measuring, processing, and control devices such as X-ray measuring or inspection equipment.

Bricklayers repair and [illegible] the brickwork in furnaces, soaking pits, ladles and coke ovens as well as mill buildings and offices. Pipefitters lay out, install, and repair piping that is used to carry the large amounts of liquids and gases used in steelmaking. Boilermakers test, repair, and rebuild heating units, storage tanks, stationary boilers, and condensers. Locomotive engineers and other train crew members operate trains that transport materials and products in the vast yards of iron and steel plants. Other skilled workers operate the various boilers, turbines, and switchboards in factory powerplants.





[illegible] the second [illegible] cooling zone. Cooling is accomplished by direct water spray. Roller aprons are arranged to guide and support the strands and simultaneously take up the ferrostatic pressure exerted by the liquid metal core upon the strand shell.

Other types of maintenance and service workers include carpenters, oilers, painters, instrument repairers, scale mechanics, welders, loaders, riggers, janitors, and guards. Many laborers are employed to load and unload materials and do a variety of cleanup jobs.

Administrative, Clerical, and Technical Occupations. Professional, administrative, clerical, and sales workers constitute about one-fifth of the industry's total employment. Of these, the majority are clerical workers, such as secretaries, stenographers, typists, accounting clerks, and general office clerks.

Engineers, scientists, and technicians make up a substantial proportion of the industry's white collar employment. Several thousand of these workers perform research and development work to improve existing iron and steel products and processes, and to develop new ones.

Among the technical specialists employed in steelmaking are mechanical engineers, whose principal work is the design, construction and operation of mill machinery and material handling equipment. Metallurgists and metallurgical engineers work in laboratories and production departments where they have the important task of specifying, controlling and testing the quality of the steel during its manufacture. Civil engineers are engaged in the layout, construction and maintenance of steel plants and the equipment used for heat, light, and transportation. Electrical engineers design, lay out and supervise the operation of electrical facilities that provide power for steel mill operation. Chemists analyze the chemical properties of steel and raw materials in laboratories. Laboratory technicians do routine testing and assist chemists and engineers. Drafters prepare working plans and detailed drawings required in plant construction and maintenance.

Among the employees in administrative, managerial and supervisory occupations are office managers, labor relations and personnel managers, purchasing agents, plant managers and industrial engineers. Working with these personnel are several thousand professional workers, including accountants, nurses, lawyers, economists, statisticians, and mathematicians. The industry also employs several thousand sales workers.

(Detailed discussions of professional, technical, mechanical, and other occupations found in the iron and steel industry as well as in many other industries are given elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

New workers in processing operations usually are hired as unskilled laborers. Openings in higher rated jobs usually are filled by promoting workers from lower grade jobs. Length of service with the company is the major factor considered when selecting workers for promotion. Promotions to first level supervisory positions, such as blower and melter, differ among companies. Some firms determine these promotions solely on seniority while others also consider ability to do the job.

Training for processing occupations is done almost entirely on the job. Workers move to operations requiring progressively greater skill as they acquire experience. A crane operator, for example, first is taught how to operate relatively simple cranes, and then advances through several steps to cranes much more difficult to run, such as the hot-metal crane.

Workers in the various operating units usually advance along fairly well-defined lines of promotion within their departments. For example, to become a blast furnace blower, a worker generally starts as a laborer, advancing to second helper, first helper, keeper, and finally blower. At a basic oxygen furnace, a worker may begin by doing general cleanup work and then advance to furnace hand, second assistant, first assistant, furnace operator, and eventually to melter. A possible line of job advancement for a roller in a

Employee oversees automatically controlled charging of blast furnace finishing mill might be assistant rougher, rougher pulpit operator, rougher, speed operator, and finish roller. Workers can be trained for skilled jobs such as blower, melter, and roller, which are among the highest rated steelmaking jobs, in a minimum of 4 or 5 years, but they may have to wait much longer before openings occur.

To help them advance in their work, many employees take part-time courses in subjects such as chemistry, physics, metallurgy and management. Steel companies sometimes provide this training, often within the plant. Other workers take evening courses in high schools, trade schools, or universities or enroll in correspondence courses.

Apprenticeship is the best way to learn a maintenance trade. Apprenticeship programs usually last 3 or 4 years and consist mainly of shop training in various aspects of the particular job. In addition, classroom instruction in related technical subjects usually is given, either in the plant, in local vocational schools, or through correspondence schools.

Steelmaking companies have different qualifications for apprentice applicants. Generally, employers require applicants to have the equivalent of a high school or vocational school education. In most cases, the minimum age for applicants is 18. Some companies give aptitude and other types of tests to applicants to determine their suitability for the trades. Apprentices generally are chosen from among qualified workers already employed in the plant.

The minimum requirement for administrative, engineering, and scientific jobs usually is a bachelor's degree with an appropriate major. Practically all the larger companies have formal training programs for college trainees. Workers are recruited for these workers directly from college campuses. In these programs, trainees work for brief periods in various operating and maintenance divisions to get a broad picture of steelmaking operations before they are assigned to a particular department. In other companies, the newly hired professional worker is assigned directly to a specific research, operating, maintenance, administrative, or sales unit. Engineering graduates frequently are hired for sales work and many of the executives in the industry have engineering backgrounds. Engineering graduates, as well as graduates of business administration and liberal arts colleges, are employed in sales, accounting, and labor-management relations, as well as in managerial positions.

Completion of a business course in high school, junior college, or business school is preferred for entry into most of the clerical occupations. Clerical jobs requiring special knowledge of the steel industry generally are filled by promoting personnel already employed in the industry.

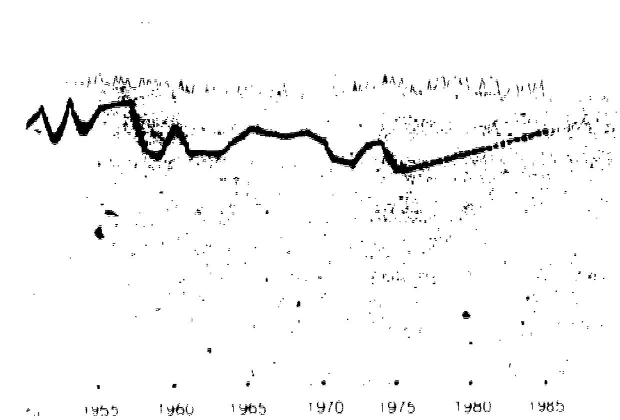
Employment Outlook

Employment in the iron and steel industry is not expected to change significantly through the mid 1980's. Nevertheless, many workers will be hired to replace those who retire, die, or leave their jobs for other reasons. The total number hired may fluctuate from year to year because the industry is sensitive to changes in business conditions and defense needs.

Production of iron and steel is expected to increase as population and income growth create a demand for more automobiles, household appliances, industrial machinery, and other products that require large amounts of these metals. Because of laborsaving technology, however, employment is not expected to keep pace with increases in production. Giant blast furnaces are being built that make more iron per worker than the smaller furnaces they are replacing. Some blast furnaces now have conveyor systems that automatically weigh and transfer raw materials from the storage areas to the furnace. Such systems will eliminate stockhouse jobs such as the scale car operator. Open hearth furnaces will continue to be replaced with more efficient basic oxygen furnaces, increasing the amount of steel produced per worker. Older primary rolling mills will be replaced by continuous casters, which use fewer employees to produce slabs, billets, and blooms. Greater use of computers to control plant equipment, as in hot finishing mills, and to process business records also will increase productivity.

Employment trends will differ among occupations. The number of job opportunities for engineers, metallurgists, laboratory technicians, and other technical workers will increase as the industry's research and development programs expand. Employment of computer systems analysts and programmers also will increase because computers will

Technological advances have enabled the iron and steel industry to meet growing demand without long-run increases in employment



perform more of the work in the steelmaking operations. Some maintenance workers such as electronic repairers will be needed in greater numbers to maintain the increasingly complex machinery used by the steel mills. Employment of other maintenance workers—for example, bricklayers and carpenters, who work extensively on open hearth furnaces—will decline because they work on equipment that is being replaced. Employment in processing occupations is expected to decline slightly as more efficient plant machinery and equipment are introduced.

Earnings and Working Conditions

Earnings of production [illegible] iron and steelmaking are among the highest in manufacturing. In 1976 they averaged $7.68 an hour while production workers as a whole averaged $4.87. To show how earnings vary by occupation and department, wage rates for employees in some of the principal occupations are presented in table 1. However, most steelworkers are paid on an incentive basis—that is, the more they produce the more they earn—and often earn more than the table would indicate.

Most production workers in the iron and steel industry are members of the United Steelworkers of America. Agreements between steel companies and the union include some of the most liberal fringe benefits in industry. Most workers receive vacation pay ranging from 1 to 5 weeks, depending on length [illegible]. A worker in the top 50 percent [illegible] seniority [illegible] 13 week [illegible] cation every 5 years [illegible] workers receive [illegible] vacation once in [illegible] year period. Professional and executive personnel receive similar benefits.

Workers may retire on company-paid pensions after 30 years of service, regardless of age. Employees having 2 years or more of service are eligible to receive supplemental unemployment benefits for up to 52 weeks. Other benefits include health and life insurance, and education and scholarship assistance.

Working conditions vary by department. Work in almost all professional and clerical jobs and many maintenance jobs is done in comfortable surroundings. Workers near the blast and steel furnaces and in the rolling mills, however, are subject to extreme heat and noise. For example, when raw materials such as scrap steel are loaded into a steel furnace a thunderous roar occurs. The temperature in the building which surrounds the blast furnace remains extremely high even in the middle of winter.

[illegible] of [illegible] establishment [illegible] 1976	[illegible] earnings
[illegible]	$6.55
Keeper[illegible]	6.95
[illegible] oxygen [illegible]	
Second [illegible]	[illegible]
Furnace operator	7.80
[illegible] hearth furnaces	
Charging machine [illegible]	[illegible]
Furnace operator [illegible]	8.15
[illegible] and billet mills	
Soaking pit crane operator	[illegible]
Roller[illegible]	8.55
[illegible]	
Rougher[illegible]	
Rollers	[illegible]
[illegible]	
Brickla[illegible]	[illegible]
Millwright	7.20
[illegible]	[illegible]
[illegible]	

Many plants have developed methods to reduce job discomfort. The use of remote control, for example, enables some employees, such as furnace operators, to work outside the immediate vicinity of processing operations. In other instances, the cabs in which the workers sit while operating mechanical equipment, such as cranes, may be air-conditioned. Because certain processes are continuous, many employees are on night shifts or work on weekends.

Sources of Additional Information

For additional information about careers in the iron and steel industry, contact:

American Iron and Steel Institute, 1000 16th St. NW., Washington, D.C. 20036.

United Steelworkers of America, Five Gateway Center, Pittsburgh, Pa. 15222.

What to Look For in this Reprint

To make the *Occupational Outlook Handbook* easier to use, each occupation or industry follows the same outline. Separate sections describe basic elements, such as work on the job, education and training needed, and salaries or wages. Some sections will be more useful if you know how to interpret the information as explained below.

The TRAINING, OTHER QUALIFICATIONS, AND ADVANCEMENT section indicates the preferred way to enter each occupation and alternative ways to obtain training. Read this section carefully because early planning makes many fields easier to enter. Also, the level at which you enter and the speed with which you advance often depend on your training. If you are a student, you may want to consider taking those courses thought useful for the occupations which interest you.

Besides training, you may need a State license [illegible] cate. The training section indicates which occupations generally require these. Check requirements in the State where you plan to work because State regulations vary.

Whether an occupation suits your personality [illegible] important area to explore. For some, you may have to make responsible decisions in a highly competitive atmosphere. For others, you may do only routine tasks under close supervision. To work successfully in a particular job, you may have to do one or more of the following:

- motivate others [illegible]
- direct and supe[illegible]
- work with all types [illegible]
- work with things [illegible]
- and manual dexterity [illegible]
- [illegible] independently [illegible]
- self discipline
- [illegible] as part of a team [illegible]
- [illegible] with details [illegible]
- [illegible] laboratory [illegible] reports
- [illegible] people
- [illegible]
- work in a confined [illegible]
- [illegible]
- [illegible]

[illegible]

[illegible] expected growth [illegible] rate [illegible] The following phrases [illegible]

[illegible]		
Faster [illegible]		
About [illegible]		
Slower [illegible]	[illegible]	
Little [illegible]	[illegible]	
Decline [illegible]	[illegible]	

[illegible] But you [illegible] [illegible] g with you to [illegible] prospects [illegible]

supply information is lacking for most occupations.

There are exceptions, however, especially among professional occupations. Nearly everyone who earns a medical degree, for example, becomes a practicing physician. When the number of people pursuing relevant types of education and training and then entering the field can be compared with the demand, the outlook section indicates the supply/demand relationship as follows:

Excellent	Demand much greater than supply
Very good	Demand greater than supply
Good or favorable	Rough balance between demand and supply
May face competition	Likelihood of more supply than demand
Keen competition	Supply greater than demand

[illegible] few job openings should not stop your pursuing a career that matches your aptitudes and interests. Even small or overcrowded occupations provide some jobs. So do those in which employment is growing very slowly or declining.

Growth in an occupation is not the only source of job openings because the number of openings from turnover can be substantial in large occupations. In fact, replacement needs are expected to create 70 percent of all openings between 1976 and 1985.

[illegible] a whole. Your State employment service can furnish [illegible] information.

[illegible] EARNINGS [illegible]

[illegible] only one type of earnings [illegible] wages and salaries [illegible] for all occupations. Although [illegible] workers receive this form of income [illegible] working overtime, night shifts [illegible] regular schedules. In some occupations workers also receive [illegible] based on sales [illegible] paid a percentage [illegible] payment for each item [illegible]

[illegible] Earnings for [illegible] the same occupation [illegible] is just starting [illegible] established business [illegible]

[illegible] wages, and salary [illegible] workers also receive [illegible] goods and [illegible] Sales workers in department stores [illegible] discounts on merchandise.

[illegible] difficulties in determining [illegible] the Earnings section does [illegible] occupational [illegible] whether a certain job pays more or less than the average for all nonsupervisory [illegible] private industry [illegible]

[illegible] less than workers who have been on the job for [illegible] Earnings also vary by geographic location. [illegible] cities that offer the highest earnings often are those where living costs are most expensive.

What's an ad for the OOQ doing in a place like this?

The career information contained in the reprint you are reading was taken from the 1978-79 edition of the Occupational Outlook Handbook. But the Handbook is not the only source of useful career information published by the Bureau of Labor Statistics. The Handbook's companion, the Occupational Outlook Quarterly, is published four times during the school year to keep subscribers up to date on new occupational studies completed between editions of the Handbook. The Quarterly also gives practical information on training and educational opportunities, salary trends, and new and emerging jobs—just what people need to know to plan careers.

If you were a subscriber to recent issues of the Occupational Outlook Quarterly, you could have learned

- how to write an effective employment [illegible]
- what the long-term employment prospects are [illegible] graduates
- ways to [illegible]
- what's happening in the field of career education
- about career possibilities in such fields as journalism, [illegible] Shorthand [illegible]
- [illegible]

[illegible]

[illegible] Superintendent of Documents) [illegible] Deposit No. [illegible]

[illegible] Superintendent of Documents, Government Printing Office, Washington, D.C. 20402