EMPLOYMENT OUTLOOK IN
MACHINE SHOP OCCUPATIONS

Job prospects
Duties
Training
Earnings
Working conditions

UNITED STATES DEPARTMENT OF LABOR • BUREAU OF LABOR STATISTICS
OCCUPATIONAL OUTLOOK SERIES • BULLETIN No. 895

Cover picture.—Machinist using a micrometer to measure a part being machined on an engine lathe. Working to close tolerances is an important part of a machinist's job.

NATIONAL ARCHIVES PHOTO.

UNITED STATES DEPARTMENT OF LABOR
L. B. Schwellenbach, *Secretary*
BUREAU OF LABOR STATISTICS
Ewan Clague, *Commissioner*

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LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington, D. C., March 27, 1947.

THE SECRETARY OF LABOR:

I have the honor to transmit herewith a report on the employment outlook in machine shop occupations. This is one of a series of occupational studies prepared in the Bureau's Occupational Outlook Division for use in vocational counseling of veterans, young people in schools, and others considering the choice of an occupation. The present study was prepared by Richard H. Lewis and Calman R. Winegarden with the assistance of Abraham Ringel. The Bureau wishes to acknowledge the cooperation received from other Government agencies and from unions, trade associations, trade periodicals, and companies in the machine shop field.

EWAN CLAGUE, *Commissioner.*

HON. L. B. SCHWELLENBACH,
Secretary of Labor.

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EMPLOYMENT OUTLOOK IN MACHINE SHOP OCCUPATIONS

Introduction

Machine shop work represents an important field to a young person interested in the choice of an occupation. Because of the size of the field—well over a million workers were employed at the wartime peak in 1943—opportunities arise for many men to enter each year. Machine shop jobs are the largest single group of skilled jobs in manufacturing, and therefore offer many workers the chance to earn better-than-average wages. Furthermore, machine shops are widespread throughout the country, and are found in many different industries, so that openings occur in every State.

The machine shop worker is a key figure in this age of metal. His work is essential in the manufacture of automobiles, railway cars, airplanes, farm machinery, and a thousand other products. In addition, he makes and repairs machinery used to manufacture these products, and even the machine tools which make all other machines. It is easy to see the critical importance of machine shop workers in our economy.

Machining is one of the five principal methods of shaping metal; the others are casting, forging, rolling, and stamping. Casting, one of the oldest methods, consists of pouring molten metal into a mold and letting it harden into the shape of the mold. Forging, once done by the old-time blacksmith with his hammer and anvil but now more commonly done by a forging machine, involves heating the metal to soften it and then pounding it into shape. Metal is made into sheets or bars by rolling or squeezing it between large rolls, as is done in a steel rolling mill. Sheet metal can be further formed by stamping it with a die shaped like the final products.

Machining differs from these other methods in that it involves cutting, shaving, or grinding a piece of metal down to the desired shape, or drilling holes in it. To machine hard metals is not easy; and the process is an expensive one, because it takes so much time. But the advantage of machining is that it can be very precise; and where each thousandth of an inch counts, machining is the method most commonly used. In the manufacture of many metal products, machining begins where casting, forging, or rolling leaves off: the piece of metal is first shaped roughly by one of these methods, and then finished to precise measurements by machining. Metal objects which must fit together exactly, as in the moving parts of an engine, must usually be machined.

The place of machining among metalworking processes is shown by the way an automobile is made. The body and fenders are *stamped* out of *rolled* sheet metal. The engine, chassis, and transmission system have many parts which are first *cast*, such as the cylinder block, or *forged*, such as the axles, and then finished off by *machining*. Many other parts of the engine and frame are machined from rolled steel. Finally, the rolling mill which makes the steel sheets and bars, the drop-hammer which forges the axle blanks, the dies which stamp the fenders and body, the molding machine used in the foundry where cylinder blocks are cast—all of these contain parts which have been machined.

Machine Shops and Machine Shop Work

Nature of Machine Shop Work

Machining is done by machine tools, and a machine shop is simply a workplace in which machine tools are used. A machine tool is a power-driven machine which firmly holds both the piece of metal to be shaped and a cutting instrument, or "tool," and brings them together so that the metal is cut, shaved, ground, or drilled. In some, the tool is moved and the metal held stationary; in others, the metal is moved against a stationary tool.

The most common kinds of machine tools include the engine lathe, turret lathe, grinding machine, boring mill, drilling machine, milling machine, screw machine, shaper, and planer. The operation of lathes is known as "turning." The piece of metal being cut is rotated against the cutting tool held in the machine. Boring mills and drilling machines are among the machines that make holes in metal. Grinding machines remove metal with a power-driven abrasive wheel. Milling machines shape metal with a saw-toothed cutting tool. Planers and shapers are used to plane flat surfaces. A screw machine is a type of lathe.

Some machine shops manufacture metal products and others do maintenance work—making or repairing metal parts for equipment in use. The manufacturing shops are of two main types—job shops and production shops—depending upon the way their production is organized.

In job shops, the earliest developed, a wide variety of products may be made, with relatively few of each kind. Some job shops produce parts to order for a number of different manufacturers

General view of a small job machine shop. Before the war this plant made dairy and milk plant equipment. In this wartime scene, the shop is turning out submarine valves and aircraft parts.

NATIONAL ARCHIVES PHOTO

for use in their products. In other cases, the job shop is a department of a plant making finished products, such as certain types of machinery, which either are custom-made or of which a wide range of models must be produced to meet the special needs of the users. For example, a company manufacturing pumping equipment may have an order from a city for six specially designed pumps in connection with a sewage disposal project. The machining needed in the making of these pumps would be done in a job shop.

Production shops, on the other hand, make large quantities of identical parts. Very commonly their output goes into products such as automobiles or household appliances, of which large numbers of units of the same model are sold. In this way, the machine shop of an automobile parts manufacturer may be called upon to turn out thousands upon thousands of gears of the same design, or a company making radios will have its machine shop produce a great many of a particular radio part. A production shop, like a job shop, may be an independent concern which sells to other companies or may be a department of a plant manufacturing metal products.

There is also an intermediate type of shop, in which the quantities of identical parts made are greater than in job shops and smaller than in strictly production shops. Many plants manufacturing machine tools have shops of this kind.

Maintenance shops make or repair parts for metal equipment and are usually operated in connection with the business that uses the equipment. Thus, a large textile mill or a cigarette factory is likely to have a machine shop which makes replacement parts for the machinery in the plant. Most maintenance shops are departments of manufacturing firms; but they are also found in every kind of business that uses metal equipment, as, for example, in railroad repair shops, electric power plants, and large office buildings.

Whether a shop is a job, production, or maintenance shop has a lot to do with the way its work is carried on and the duties of its employees. Because of the variety of the work in job shops, most of the machine tool operators must know how to do a number of different types of work. They must know the working properties of different metals and how to adjust the machine tools to make parts of many different shapes and sizes. Moreover, job shops are usually small, and this, together with the frequently changing nature of the work, means that their workers are often called upon to shift from one type of machine to another. In some cases an individual worker may carry through to completion all the machining operations on one part. For these reasons, the job shop must employ a number of men who are all-round workers—able to operate all the standard types of machine tools, and having a broad knowledge of machine-shop practices. Maintenance shops are similiar to job shops in their operation and may employ an even higher proportion of all-round workers.

Production shops, because of the large quantities of identical parts produced, are able to use many workers who can do only simple, repetitive operations on one machine. The work is planned in such a way as to limit the skill and responsibility required of the operator.

Many production shops employ skilled specialized workers to set up the machine tools (adjust the controls and set the cutting tools in place for proper machining of a desired object), which is the most complicated part of the job. When a job has been set up for him, the operator merely has to place the rough metal bars or castings into the machine, watch its operation, and check the dimensions of the work. Very often production shops use a number of "special purpose machines," which are designed to perform only one certain operation and therefore do not need special adjustments. These machines are highly automatic and the operators need little skill. As a result of the simplified methods possible in production shops, the proportion of skilled workers with wide experience is much smaller than in job and maintenance shops, where versatility and individual skills are important.

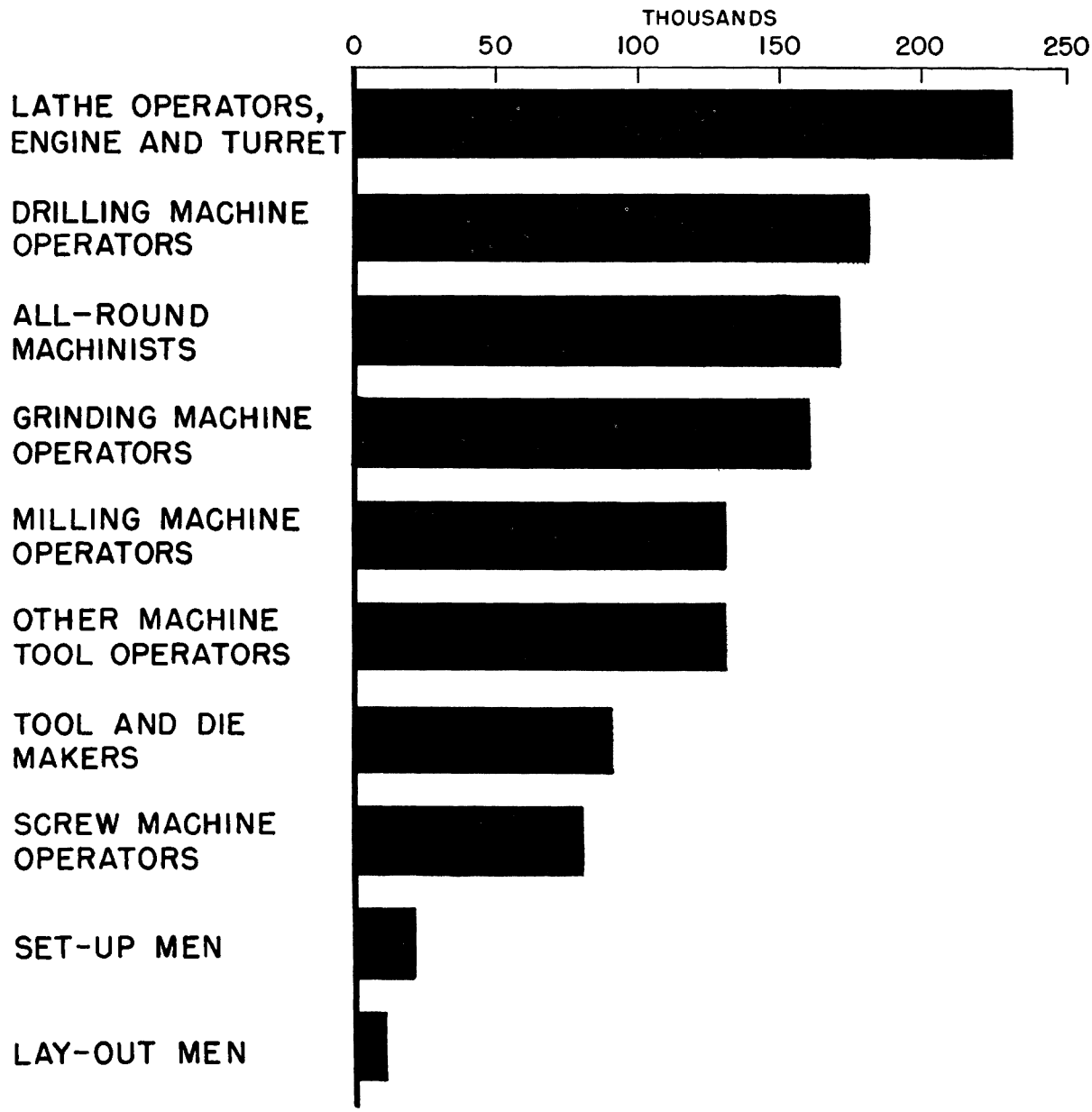
Number and Kinds of Machine Shop Jobs

Machine shop workers are the largest occupational group in metalworking and one of the most important groups in all industry. At the peak of war employment, in December 1943, about 1,200,000 workers were employed in the skilled and semiskilled machining occupations. In addition, there are many thousands of other workers, such as inspectors, helpers, and laborers, who are also employed in machine shops. Estimated employment as of December 1943 for the occupations most directly involved in machining operations is shown in chart 1.

CHART 1

EMPLOYMENT IN MACHINE SHOP OCCUPATIONS

DECEMBER 1943



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Of these workers, tool and die makers are the most skilled. Tool makers build the cutting tools which are used in machine tools, the jigs and fixtures which hold the work while machining operations are performed, gages for measuring the work, and various special attachments. Die makers build the dies used in forging, stamping, die casting, and plastics molding.

The basic machine shop job is that of the all-round machinist. Machinists are employed mainly where workers are needed who are qualified to perform any of the operations in a machine shop rather than to work on only one type of machine. Thus, jobs for machinists are found mainly in jobbing and maintenance shops, relatively few being found in production shops.

The specialized operators of machine tools make up the bulk of the workers in machine shops. These workers may be either relatively skilled men who can handle a variety of work on one type of machine, including the making of adjustments on the machine, or they may be less-skilled operators whose duties are confined principally to placing the workpiece in the machine and watching its operation.

Two other specialized jobs found in many machine shops, particularly production shops, are those of set-up men and lay-out men. Set-up men adjust and prepare the machine tools for operation by less-skilled employees. Lay-out men mark guide lines on metal so that operators can know where to machine and how much material to remove.

Where Machine Shop Workers Are Employed

Because of their importance in making metal products, machine shop workers are employed principally in the metalworking industries. Nearly every industry, however, employs some machine shop workers in maintenance work. In 1940, a fairly typical peacetime year, about 70 percent of all the workers in the machine shop occupations had jobs in metal industries like machinery, automobiles, and iron and steel. From chart 2 it can be seen that in 1940 the largest single group of these workers, within the metalworking industries, was in plants manufacturing machinery and similar products, which employed about 27 percent of the total. Second in importance was the group of industries making iron and steel and iron and steel products (such as plumbing and heating equipment, castings, and hardware), accounting for 15 percent. The automobile industry, with 12 percent, and electrical machinery plants, with 7 percent, were the next largest employers of machine shop workers.

Most of the remaining machine shop workers were found in the maintenance shops of a large number of nonmetalworking industries, including, for example, railroads, public utilities, and plants making such products as cotton textiles, paper, cigarettes, chemicals, and food. Even though the number of machine shop workers in most nonmetal industries is small, these industries, taken together, are important as a source of employment for machine shop workers since they provided almost a third of the jobs for them in 1940. Moreover, in many cases the machine shop jobs rate among the better job opportunities in the plant and its locality, as, for example, in many textile mills in southern towns.

The wartime demand for munitions resulted in a great expansion of employment in metalworking industries. The number of machine shop workers doubled, and the proportion of total machine shop workers who were employed in these industries increased from 70 percent in March 1940 to over 80 percent in December 1943. Chart 2 shows that the largest relative gain in employment of machine shop workers occurred in aircraft plants. There was also a sharp increase in the automobile industry, which during the war produced a large quantity of aircraft engines, tanks, and other munitions, as well as trucks for military use. The number of machine shop jobs in the machinery and electrical machinery industries more than doubled, most of this rise occurring in plants converted to war production. The iron and steel industry group also increased substantially its employment of machine shop workers, largely in newly built ordnance plants and in plants converted to ordnance manufacture.

The ending of the war has tended to restore the prewar status of the industries in terms of their relative importance as sources of jobs for machine shop workers. The production of aircraft, ships, and ordnance has fallen to a fraction of the wartime output, while employment gains have been made by many of the nonmetal industries whose activities were restricted during the war.

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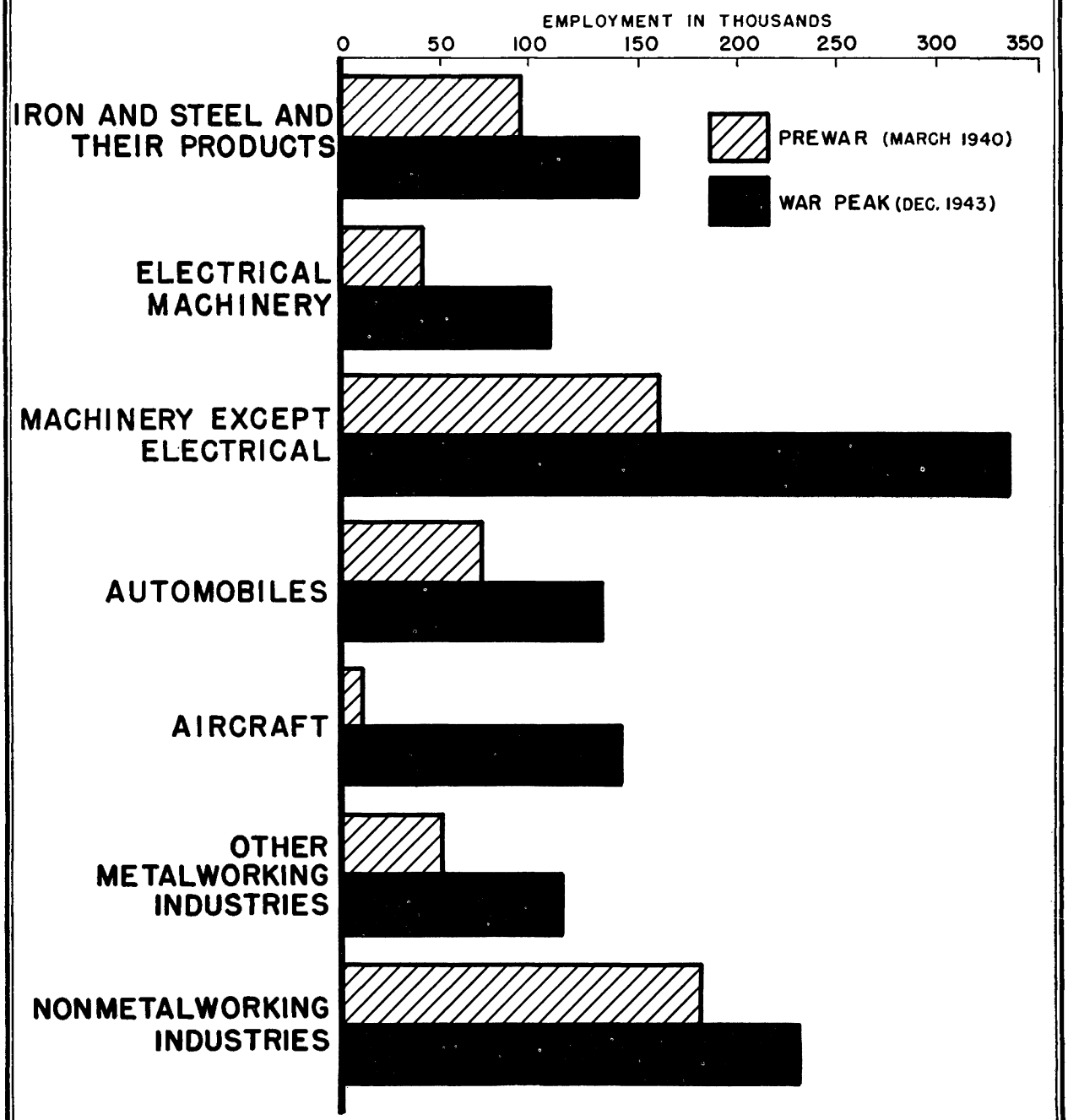
CHART 2

EMPLOYMENT OF MACHINE SHOP WORKERS BY INDUSTRY

PREWAR AND WAR PEAK



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PLANTS, OTHER THAN NEW PLANTS, ARE CLASSIFIED BY INDUSTRY ACCORDING TO THEIR PRINCIPAL PRODUCTS IN 1939

Percent of machinists and tool and die makers employed in each region and State, March 1940 [1]

Region and State	Percent of total
United States	100. 0
New England	12. 6
Maine	. 6
New Hampshire	. 5
Vermont	. 3
Massachusetts	6. 1
Rhode Island	1. 3
Connecticut	3. 8
Middle Atlantic	25. 9
New York	10. 7
New Jersey	5. 5
Pennsylvania	9. 7
East North Central	37. 2
Ohio	10. 1
Indiana	3. 8
Illinois	9. 1
Michigan	10. 6
Wisconsin	3. 6
West North Central	4. 7
Minnesota	1. 0
Iowa	1. 2
Missouri	1. 6
North Dakota	. 1
South Dakota	. 1
Nebraska	. 2
Kansas	. 5
South Atlantic	6. 9
Delaware	. 3
Maryland	1. 7
District of Columbia	. 5
Virginia	1. 4
West Virginia	8
North Carolina	. 7
South Carolina	. 3
Georgia	. 7
Florida	. 5
East South Central	2. 6
Kentucky	9
Tennessee	. 8
Alabama	. 7
Mississippi	. 2
West South Central	2. 7
Arkansas	. 2
Louisiana	. 4
Oklahoma	. 4
Texas	1. 7
Mountain	1. 2
Montana	. 2
Idaho	. 1
Wyoming	. 1
Colorado	. 3
New Mexico	. 1
Arizona	. 1
Utah	. 2
Nevada	. 1
Pacific	6. 2
Washington	. 9
Oregon	. 4
California	4. 9

[1] Sixteenth Census of the United States, 1940, Population, Volume III, The Labor Force, Reports by States, Parts 2 to 5. Based on the number of males reporting themselves employed as machinists, die makers, or tool makers. Excludes those employed on public emergency work.

Because so many machine shops are in metalworking industries, the bulk of them are found in the northeastern and middle western sections of the country, where these industries are concentrated. Some machine shop employment, however, is scattered throughout the country in railroad repair shops and the maintenance shops of other industries. There are machine shop jobs in every State. From the table on p. 7 one can get an idea of where the job opportunities are located.

Working Conditions

What It's Like To Work in a Machine Shop

Machine shop work cannot be described by painting a simple picture of a typical machine shop. If you think about the many industries that have machine shops and the different types of machine shops, you can see that one machine shop can be very different from the next, depending upon its size, whether it is a job shop, maintenance shop, or production shop, and what kinds of products it makes.

Shops can range from the large modern shop with long rows of machine tools busily chewing into metal, to the small maintenance shop occupying a little corner of the factory floor in which a few standard machine tools have been placed. In general, the work surroundings compare favorably with those in other types of metalworking activities.

Most machine shops are relatively clean and free from dust, compared with many steel mills and iron foundries. However, some machine shops are dirty and hot, because they are near the heat-treating or casting departments of a plant. There is usually considerable noise in a large shop. Most machine shops are well-ventilated, and good lighting is provided to aid in achieving the accuracy which is so important in machining operations. Large establishments, particularly production shops, often have overhead cranes or other materials-conveying devices.

Great physical strength is not required for machine shop work. The workers, however, usually must stand at their jobs most of the day, and be able to move about freely. Since continuous attention is required when the machine is in operation, the work may often be rather tedious, especially on simple and repetitive machining jobs. Where the work is varied and complex, and the standards of accuracy high, the worker can consider himself a real craftsman and experience the satisfaction that this feeling gives to the conscientious and capable person. Because the work is not physically strenuous, many women are employed as machine tool operators. However, most of them are employed in some of the less-skilled machining operations, practically none being found among the tool and die makers and all-round machinists and relatively few among the skilled machine tool operators.

Hazards in Machine Shop Work

The danger of serious accident in machine shops is relatively small. Workers are sometimes injured by flying chips of metal or by the sharp points of cutting tools. In cleaning away metal chips or shavings from the machine it is possible for the worker to be hurt if he is not careful. However, ordinary safety precautions are usually sufficient to keep the machine tool operator from harm. The industries in which machine shop workers are employed generally have average or better-than-average safety records, in comparison with manufacturing industries in general.

Other Conditions Affecting the Work

The great majority of machine shop workers are members of unions. There are a number of labor organizations in this field, some of the more important of which are the International Association of Machinists (independent), the United Electrical, Radio and Machine Workers of America (CIO), the United Automobile, Aircraft, and Agricultural Implement Workers of America (CIO), and the Mechanics Educational Society of America (independent).

The extent to which seasonal lay-offs can affect the employment of machine shop workers is largely dependent upon the type of industry. Maintenance workers usually tend, however, to have relatively steady employment no matter which industry they are in. The automobile industry is an example of one that has usually had marked variation in activity at different times of the year. In addition to affecting workers in the

automobile industry itself, these changes also influence the regularity of the employment in many tool and die jobbing shops which supply special dies and jigs to automobile plants.

Outlook for Machine Shop Employment

The number of jobs for machine shop workers in the future depends upon the production trends of the industries in which they are employed and also upon the effects of technological changes.

Trends in Metalworking Industries

Since metalworking industries employ by far the bulk of the machine shop workers it is to these industries that we must look for the chief indication of what is likely to happen to machine shop employment. Metalworking industries have many machine shop workers in maintenance jobs, but the greater number are in production jobs. The number of jobs for these workers is affected directly by the demand for the industries' products.

Prospects are favorable for a high level of activity over the next several years in the metalworking industries. Although somewhat below the wartime production peaks, the volume of output expected will be considerably above the totals in the years immediately preceding the war. Despite the fact that progress in restoring civilian production has been somewhat retarded by materials shortages and labor disputes, employment has thus far been maintained fairly well.

Many of the most important metalworking industries currently have particularly strong demands for their products. The accumulated demand for automobiles should mean that this industry, one of the largest employers of machine shop workers, will have a high volume of production for several years. The manufacturers of machinery, both electrical and nonelectrical, have a large volume of orders from companies which are expanding their productive capacity or replacing existing equipment with more efficient machinery. As construction activity continues to gain there will be heavy demands for many types of metal products used in construction. Plumbing and heating equipment is just one important example. The needs for many types of consumer goods such as electrical appliances, refrigerators, radios, and vacuum cleaners will help to keep metalworking activity at a high point over the next several years, unless a sudden drop in general business activity occurs.

Favorable employment conditions in these industries for the next several years should help to provide opportunities to get into the machine shop field, but in considering the desirability of entering this field, the long-run prospects for the employing industries are more significant. This is particularly true because many of the occupations require as much as a 3- to 5-year learning period. The conditions prevailing after the end of this training period are more important in deciding whether to begin machine shop training than are the conditions at the time of entrance into training. The long-run trends of activity in metalworking industries are related more to the basic nature of the demands for metal goods than to the temporary accumulation of demand, which is the important factor in the immediate future.

Metal goods are more durable than most other types of goods. This means that they can be used longer and that purchase of new goods to replace the old can often be postponed. A large proportion of metal products is machinery and other industrial equipment. When the business outlook appears favorable, manufacturers often buy additional equipment; when things look bad they may even hold off buying needed replacements. Because metal goods are durable and much of the demand for them is so strongly influenced by general business conditions, there have often been great variations from year to year in the quantity produced.

The trend of metal products output, although marked by extreme ups and downs, has been generally upward for many decades. Between 1899 and 1914 there was a substantial increase in activity in metalworking industries, as shown by employment trends in chart 3. During World War I there was a great jump in employment in these industries, with the big gain in shipbuilding the most important factor. After the drop in the depressed postwar year of 1921, employment in the group, stimulated partly by the strong demands for automobiles and other consumer goods, rose again until it approached 3 million in 1929.

The extremely sharp fluctuations in the trend in metalworking activity between prosperous and depressed periods are shown in chart 3 by the substantial dip in employment that occurred between the high level of 1929 and the bottom of the depression in 1932 and 1933. By 1937, employment in these industries had risen until it slightly exceeded the 1929 mark. The trend was again sharply downward in 1938, but by 1940 the long-run upward movement was resumed.

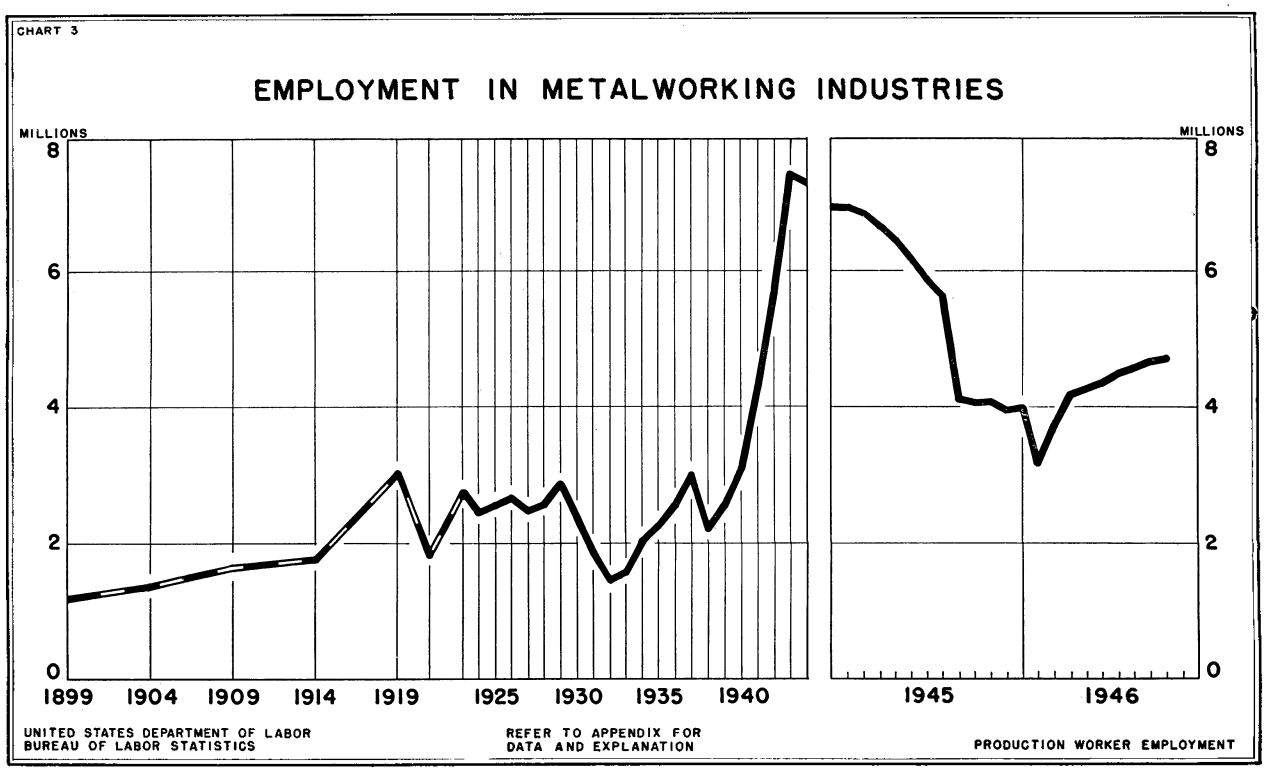
The Second World War, bringing its almost insatiable demands for production, affected all parts of the American economy, but nowhere was its influence greater than on the metalworking industries. The military machine needed vast quantities of metal munitions—ammunition, aircraft, ships, tanks, and transport vehicles. The result, as chart 3 shows, was that employment in the metalworking industries more than doubled from 1940 to 1943.

The first big jump came in 1941, when the defense program was getting into full swing, but the rise continued at an undiminished rate in 1942 and 1943 as entry into the war brought the country into a full-scale armament program.

Increases in employment occurred in all of the metalworking industry groups, but the greatest gains were made by the producers of ships and aircraft. These two industries employed a total of 155,000 production workers in January 1940; by December 1943 well over 2 million were needed to staff the aircraft plants and shipyards.

The last months of 1943 marked the high point of the war as far as employment in the metal industries was concerned. Some of the first cutbacks in munitions production, combined with the effects of drafting workers into the armed forces, caused a gradual decline in employment in these industries during 1944 and the first 6 months of 1945. With the end of hostilities in Germany and Japan, employment took a sharp dip in the fall of 1945. Since then, employment in the metal industries tended, except for the period of major strikes in early 1946, to increase slowly but steadily through the first 10 month of 1946 even though employment in aircraft and shipbuilding continued to decline.

The picture we thus have of the long-run trends in the metalworking industries is one of generally steady growth between 1899 and 1929; depressed conditions during much of the thirties, but with a high measure of recovery toward the end of that



decade; a phenomenal expansion during World War II; and some postwar reduction that still leaves employment considerably above what it was in the prewar years.

In looking at the future of metalworking it seems likely that with continued growth of population and national income, and development of new products, a long-range upward trend in the volume of output is in prospect. Metal products will continue to be an important part of total industrial production, and there is nothing to indicate that the upward trend in metalworking activity has reached its limits. New uses for metal are constantly being found, and the mechanization of industry (which requires metal equipment) is continuing. Some of the substitutes for metal products, such as plastics, compete effectively with metal only for certain uses. It must be remembered, however, that, as shown in chart 3, the metal industries have been severely affected by business depressions.

Outlook for Machine Shop Workers in Nonmetal Industries

Although only a relatively few machine shop workers are employed in any single nonmetal activity, such as textile manufacturing, oil refining, woodworking, or trade and service, taken as a whole these fields provide a substantial number of machining jobs. Since the machine shop workers in these industries are engaged in maintenance work, repairing and replacing parts of machines and other equipment, the number employed in a particular industry does not necessarily vary directly with its output. Machine shop workers are usually only a very small part of the total employment in a nonmetalworking industry. In general, employment of maintenance workers in an industry tends to remain fairly constant over short periods but moves upward or downward with substantial changes in the volume of production. In most industries, a certain number of maintenance workers is needed even when production falls to very low levels.

There are some nonmetal industries whose needs for machine shop workers are closely related to the volume of production. An example of this is plastics fabricating, which uses machine shop workers to make the molds in which many plastic products are formed.

Prospects are good for a rise in machine shop jobs in nonmetal industries in the next several years. Many of these industries are increasing their output to take care of the strong demands for their products, as the consuming public, with employment and pay-rolls at high levels, rushes to the stores to buy food, clothing, shoes, and other nonmetal goods. In addition, many industries were unable to keep enough machine shop workers during the war and will try to hire more to have the number needed for efficient operation.

An important point affecting the long-run requirements for machine shop workers in these industries is that increased mechanization of plants, although tending to reduce the needs for other employees, creates more jobs for maintenance workers. The nonmetal industries also tend to be more stable in their rate of production, and maintenance has a fixed importance in their operation. This means that these industries will continue to offer regular employment to a large number of machine shop workers.

Effects of Technological Changes on Machine Shop Employment

It is characteristic of industrial operations that there is a continual striving to find ways of increasing efficiency and thereby reducing production costs. This effort leads to better ways of organizing production and to the introduction of new machines which are faster, larger, and more automatic in their operation. Thus the tendency in all manufacturing operations is to cut the amount of labor time needed to produce a given part.

These improvements, while reducing the employment required for a certain volume of output, do not necessarily result in a lowering of total employment needs. Very often by reducing costs and, in turn, prices, it has been possible to reach a wider market of potential consumers, and thus increase production more than enough to offset the reductions in labor requirements. In this way, although many products take fewer man-hours per unit to produce than they did years ago, many more people are now employed in their manufacture.

Technological changes cannot, however, be ignored in considering the prospects for employment in any particular industry or occupation. This is because they affect the amount of employment which will result from a given volume of production in the future. In the case of machining processes, there have been many recent technical changes which may have an important effect on the number of jobs there will be for machine shop workers. During the war, under the necessity of increasing rapidly the output of metal products, the development of new machines and techniques was intensified and hastened. Many of these developments should carry over into the future with even greater force.

The greatest reductions in labor costs usually come through the introduction of new types of machinery. In the machine shop field, increasing use has been made of highly automatic, special purpose machines. These machines are designed to perform one particular operation, and are used when large quantities of parts are needed. In addition to providing for high speed and efficient operation they usually eliminate much of the skill needed by the operator.

Another important technical development which is greatly influencing the number of man-hours needed in machining processes is the growing use of high-speed carbide cutting tools. Because these cutting tools are harder, it is possible to machine metal with them at much higher speeds than formerly were possible. Consequently the rate at which machine tools dig into metal has been increased in many cases as much as from 3 to 5 times. This has resulted in substantial reduction of the time required to machine many parts. Many of the older machine tools are unable to operate effectively at the high speed made possible by the development of these new cutting tools, but new machine tools, which are heavier and stronger than the older ones, will make it possible to utilize more fully the new higher speeds.

Among the other changes in machine tools which may affect the time required for many machining operations or the skills required of the operator are the use of electronic controls and hydraulic mechanisms.

Greater use may be made in the future of profiling attachments. When these are used the movement of the cutting tool is guided by a rod which as it moves along follows the shape of a model of the desired object. On these machines intricate objects can be shaped by partially skilled operators, and one operator can control a number of machines simultaneously.

In addition to changes in machinery, changes in the organization of machine shop processes can also influence the number of workers and the types of workers required. One important innovation has been to use set-up men to adjust machine tools, turning over the rest of the operation to semi-skilled operators. In other ways, jobs have been subdivided so that the difficult parts can be done by skilled operators, while the more routine steps can be performed by less-skilled operators. Another method by which machining time can be reduced is to begin the machining operation on pieces of metal that are already close to the dimensions of the part being made. This can be done by working from a casting or forging of the part, rather than from a rough bar or block of metal. Technological advances in casting and forging, making these processes more precise or economical, would encourage their use in some cases where rolled shapes have previously been used. In addition, when castings or forgings are made with greater precision, the amount of machining required to turn out the finished part is reduced.

Still another way that technological changes can affect machine shop employment needs is through the substitution of other processes in fabricating operations which have usually been done by machining. This can come about through the greater use of stampings, die castings, or plastic parts in place of machined parts. There is also some possibility that powder metallurgy, by which metal products are pressed into shape from powdered metal, may become more important. Since machining is an expensive process, industries can be expected to continue the attempt to obtain precision parts by the use of other methods.

Future Trends in Machine Shop Employment

Taking into account the production prospects of the industries which employ machine shop workers and the probable effects of continuing technological changes it would appear that the number of machine shop jobs should be maintained at or slightly above the present high levels for several years. Looking further into the future the indi-

cations are for an employment trend below both the high points of the war period and the levels that should prevail in 1947, but employment should remain considerably higher than the prewar levels. Eventually, the general long-run upward movement of metalworking activity should be resumed, and this would tend to raise machine shop employment. Because the machine shop field is so closely related to metalworking, however, employment in machine shops is likely to be especially hard hit by severe business depressions.

The incentives to reduce the costs of producing a unit of product will be no less strong in the future than in the past. Current and prospective technological changes will bring about further relative reductions in the number of man-hours required for machining. Not only will the amount of labor required to machine a given part be less, but the present tendency to utilize a larger proportion of less-skilled operators instead of skilled all-round workers will continue with even greater effect.

The generally favorable trend of employment in machine shops means that qualified new workers should be able to enter the field without much difficulty in the next several years and be assured of continuing employment. Before deciding whether to go into machine shop work, it is necessary to get a complete picture of the opportunities in this field in order to have an idea of the relative prospects of the individual occupations. For this reason the outlook for each of the significant occupations in machine shops is presented in detail in the following sections of this report, along with a discussion of duties, qualifications, training, earnings, and other information on the occupation.

Opportunities in Individual Occupations

All-Round Machinists

The job of all-round machinist requires a knowledge of all the machine shop skills necessary to make and repair metal parts for all kinds of machinery and metal equipment. Historically, this craft is the basic and original machine shop occupation; as division of labor progressed in some types of shops, workers began to specialize in one or another of the tasks of the all-round machinist, and the other machine shop occupations developed.

At the peak of wartime employment, in December 1943, about 170,000 men were working as all-round machinists. There were, in addition, thousands of men with training as all-round machinists but employed in other machine shop occupations, such as set-up man, lay-out man, and machine tool operator.

Duties

Variety is the main feature of the all-round machinist's work. His training enables him to plan and carry through all operations needed in turning out a machined product and to switch readily from one kind of product to another. He knows how to work from blueprints and written specifications, can select the proper tools and materials required for each job, and can plan the proper sequence of cutting and finishing operations. When necessary, he lays out the work by marking the surface of the metal to show where machining is needed and to indicate the shape and depth of the cuts. In laying out work he uses a number of marking tools and measuring instruments, including the scriber, center punch, surface gage, protractor, and calipers.

In general, he is able to set up and operate such standard machine tools as lathes, planers, milling machines, grinders, shapers, boring mills, and drilling machines. In setting up machine tools for operation, the machinist must be expert in a number of details relating to both the machines and the cutting tools. He selects the proper cutting tools necessary for each cut he is to make, fastens the cutting tools and the work in proper relation to each other, and sets controls which determine the sequence of cutting tools if there are more than one, the speed at which the tool or work moves, and the depth of the cut with each motion. When the machine is ready to be operated, he makes a sample cut and checks the accuracy of the set-up with such precision measuring devices as gages and micrometers. After machining, he may finish his work by hand, using files and scrapers, and may assemble the parts by welding. His knowledge of shop practice, of the working properties of such metals as steel, cast iron, aluminum, and brass, and of what the various machine tools do makes it

possible for him to turn a block of metal into an intricate, precise part.

Training

The machinist trade can be learned in two ways. According to most authorities, a formal apprenticeship, usually covering 4 years, is the best way to learn the job. On the other hand, many have qualified without an apprenticeship, picking up the machinist trade over a number of years of varied shop experience and home study. However, this takes a longer time than apprenticeship and the training may be incomplete.

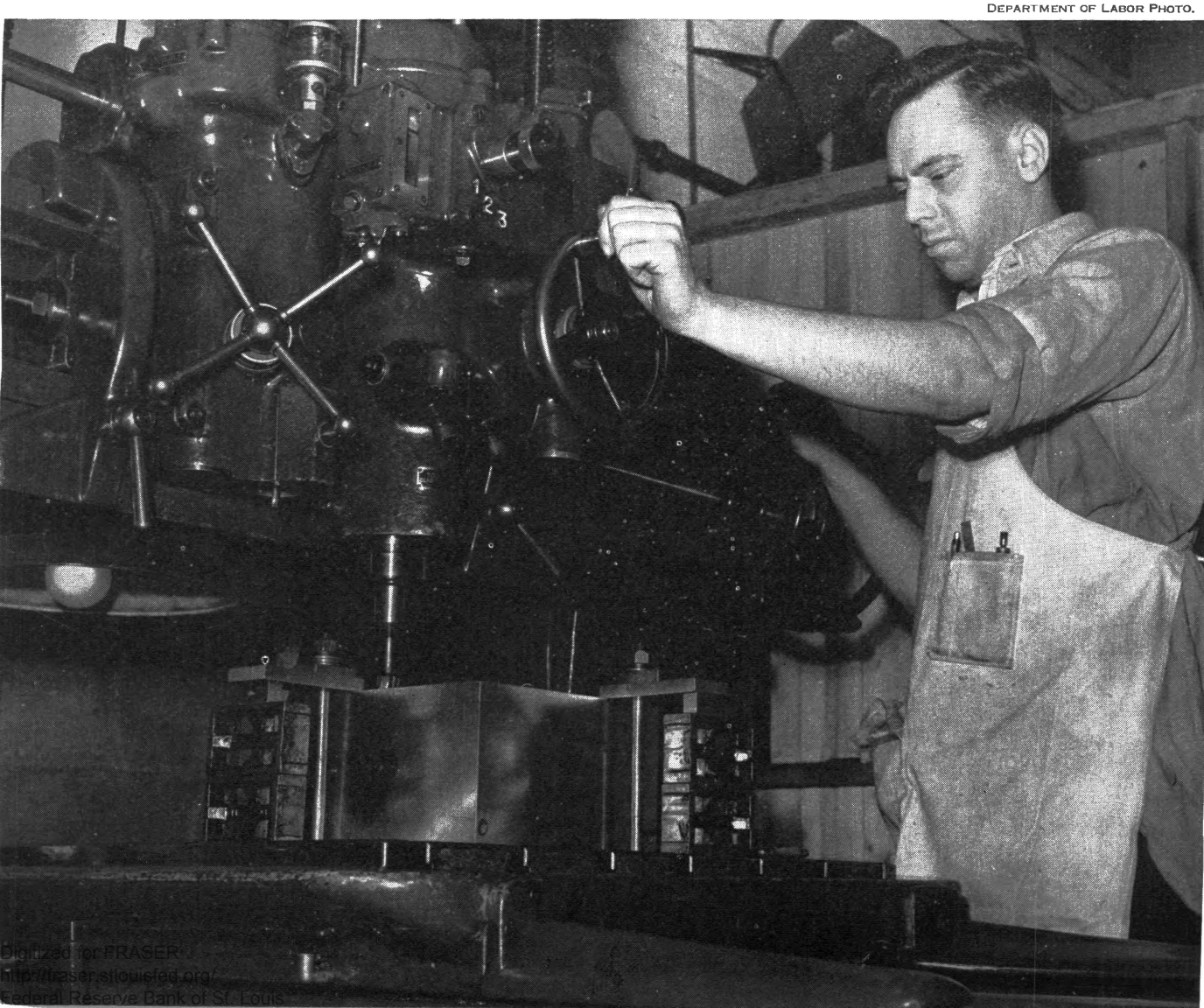
An apprentice must be mechanically inclined and be temperamentally suited to very careful and exact work; otherwise he will be handicapped in his training. Another important aptitude necessary to become a machinist is an ability to visualize the finished product from a rough drawing or blueprint. A high school or trade school education is desirable preparation for machinist training, and some employers require such preparation.

Where Employed

The majority of all-round machinist jobs are in maintenance shops in plants which use machinery in the manufacture of their products, such as textile mills, automobile factories, oil refineries, and

Machinist using a boring mill to machine a hole in a gear box. The boring mill is one of a number of machine tools which an all-round machinist can operate.

DEPARTMENT OF LABOR PHOTO.



printing plants. Many of these all-round jobs are also found in manufacturing shops (including job and production shops) which make machinery and metal parts, such as machine tools, tractors, and railroad equipment. In general, work in job and maintenance shops is more diversified and requires greater all-round skill.

In production shops such as those found in the automobile and electrical appliance industries, there are large numbers of men trained as all-round machinists but not usually employed as such; these men specialize in a single machine shop function, such as lay-out, set-up, or operation of one type of machine tool. As a result, they may in time partly lose the other skills which they had acquired in becoming machinists. However, they are still much more versatile than those without machinist training, and if necessary, they can readily relearn that which was lost through lack of practice.

Employment Outlook

The number of all-round machinist jobs during the next few years should equal, or even exceed, the wartime peak, because of the increased need for machinists in maintenance shops, where the bulk of these jobs are found. Many nonmetal-working industries were affected by wartime curtailment of production or by labor shortages and consequently did not employ as many machinists in their maintenance shops as might otherwise have been expected. Since some of the largest of these industries, such as textiles, have very favorable postwar prospects, they should be taking on machinists for several years. In manufacturing shops as a whole, there will be somewhat fewer all-round machinist jobs than during the war. However, these shops will need additional men with machinist qualifications to work as skilled, specialized machine tool operators and as set-up men. They will also hire all-round men to provide for their future needs for supervisory workers.

Openings for apprentice machinists should be numerous during the next 2 or 3 years although many have already begun training. It must be remembered, however, that in the metalworking industries many of these apprentices, after they complete their training, will be placed in specialized jobs where they will work on only one type of machine.

Employers will be taking on apprentices because they realize that many new men must be trained if even the present number of machinists is to be maintained. Owing to the depressed condition of industry before the war and the difficulties in training apprentices in wartime, relatively few entered the trade over a period of many years. Now there are many all-round machinists closely approaching the age when death or retirement will take them from their jobs. To provide for their replacement, it is conservatively estimated, over 40,000 new machinists must be trained during the next decade.

Apart from job prospects for the immediate future, there are longer-run employment trends to be considered. In manufacturing shops the number of jobs requiring all-round machinists to fill them may be expected to show a slight, gradual decline after the next several years. Continuing technical changes will reduce the skill needed in many machining operations, permitting the substitution of less-trained men for machinists. Machinist training will continue, however, to offer considerable advantage to men going into these shops. Machinists are generally preferred for the specialized machine tool operator jobs, which often pay as well or better than all-round jobs. They also will have many chances to get jobs setting up machines for groups of semiskilled operators. Moreover, all-round machine shop workers must continue to be hired in order to supply the necessary supervisory staffs—the lead men and foremen—which are extremely important in the modern mass-production shops where there is a large proportion of workers with a narrow range of skill.

In maintenance shops, the number of all-round machinist jobs should remain fairly steady, and may even show some growth over a period of many years. The increasing mechanization of industry will expand the need for men to keep production equipment in good working order, and this may mean more jobs for maintenance machinists.

Earnings

Although the pay of all-round machinists compares favorably with that of other machine shop workers, it is often lower than the earnings of highly skilled machine tool operators, many of whom work on an incentive basis. In January

1945, average straight time hourly earnings of production machinists in some of the major metalworking industries were as follows: Machine tools, $1.13; tool and die jobbing shops, $1.22; other machinery (except electrical machinery) industries, $1.19. Maintenance machinists earned about the same, or slightly more. Since that date, there have been substantial wage increases in many industries employing machinists. For example, in early 1946, hourly rates in some of the largest automobile companies were raised 18 or 18½ cents.

Chances for Advancement

The promotional opportunities for all-round machinists are good. Many advance to foreman of a section in the shop, or to other supervisory jobs. With additional training some develop into tool and die makers. Highly skilled and experienced machinists sometimes have the chance to start small machine shops of their own.

Tool and Die Makers

Tool and die makers are essentially highly trained machinists who specialize on tool or die work. Theirs is the most skilled job in machine shops and is also one of the larger skilled fields in metalworking—about 90,000 were employed at the wartime peak in December 1943.

Duties

The function of tool makers is to make the cutting tools used on machine tools, and the jigs, fixtures, and other accessories which hold the work while it is being machined. They also make the gages and other measuring devices needed for precision work. Die makers construct the dies which are used in such metal-forming operations as forging, stamping, and pressing, and they also make the metal molds used in die-casting metal and molding plastics. Tool and die makers must have the broad knowledge of the all-round machinist, including blueprint reading, laying out work, setting up and operating machine tools, using precision measuring instruments, understanding the working properties of common metals and alloys, and making shop computations. In addition, they must be able to work to closer tolerances than those usually required of machinists and must do a greater amount of precise hand work. These requirements, plus specialization on tools and dies, distinguish tool and die makers from all-round machinists.

Apprentice tool and die maker using a shaper to form a die part. Tool and die makers know how to operate all standard machine tools.

DEPARTMENT OF LABOR PHOTO.

Training

To learn this work requires rounded and varied machine shop experience, usually obtained through formal apprenticeship or the equivalent in other types of on-the-job training. A tool and die apprentice ordinarily covers 4 or 5 years, including mainly shop training in various parts of the job. In addition, during the apprenticeship, courses such as shop arithmetic and blueprint reading are usually given in vocational schools. After apprenticeship, a number of years of experience as a journeyman is often considered necessary to qualify for the more difficult tool and die work.

Since tool and die making is the most exacting type of machine shop job, persons planning to enter the trade should have a great deal of mechanical ability and a liking for painstaking work.

Where Employed

Although tool and die makers are employed in many different metalworking industries, a large proportion of the jobs are concentrated in a relatively few industries. Of these, the automobile industry is the most important. Also very important, both because of the number employed and because of the high level of skill required of the workers, are tool and die jobbing shops. These

shops, which usually are small, make tools, dies, jigs, and fixtures, and other machine tool accessories for other companies on individual order; the tool and die makers in these shops must be able to take on almost any kind of job. Many tool and die makers are employed in other machinery industries, including those making electrical machinery. During the war the aircraft industry hired many tool and die makers. Among the nonmetalworking industries that use these workers is the fabricated plastic products industry, which employs die makers to make the molds in which plastic products are formed.

Employment Outlook

The biggest factor in the job outlook for tool and die makers, in view of the fact that the automobile industry is the most important single employer of these workers, is the expected large volume of automobile production. High output of automobiles will also tend to maintain employment in tool and die jobbing shops, many of which serve the automobile industry and which are another major source of jobs in this occupation. In many other peacetime industries—such as the refrigerator, electrical appliance, and agricultural machinery industries—production prospects are good, and this will contribute to the demand for tool and die makers. Moreover, the tooling up for the new products which numerous firms are planning to manufacture will provide tool and die maker jobs, since new dies, jigs, fixtures, and gages will be required.

In spite of the upward trend of employment in many industries using tool and die makers, the actual number of jobs in the occupation may be no higher than the wartime total. The reason for this is the dropping off of aircraft and ordnance production, which during the war provided jobs to many tool and die makers. Nevertheless, opportunities in tool and die making should be good, because there has been little increase in the supply of fully qualified tool and die makers in recent years and because replacement needs have been growing in importance.

During the war the number of tool and die makers increased, but not as rapidly as some other metalworking jobs, partly because it was not possible to train qualified tool and die makers in the short time available. As a substitute, much tool and die work was broken down into simpler jobs which less-experienced workers could do under the supervision of tool and die makers. At the same time, working hours were greatly increased. However, although these were useful wartime expedients, most employers do not consider them satisfactory for peacetime and strongly prefer using fully qualified men, working a standard week. As a result, there is a demand for trained tool and die makers in many plants. Although many apprentices have been taken on since the end of the war, openings should continue to be fairly numerous for several years.

Replacement needs are an important factor, because many tool and die makers are approaching ages at which they are increasingly likely to drop out of the labor force because of death or retirement. During the next 10 years, such drop-outs may create upward of 20,000 openings for new workers.

After several years, the accumulated demand for automobiles, electrical appliances, and similar consumer goods will have been met and the employment of tool and die makers will probably drop slightly from its high postwar level. However, large numbers of these workers will still be needed, not only to repair and replace the tools and dies normally used by industry, but also to retool plants for new models and new products. Moreover, although improved metalworking equipment will tend gradually to cut down the number of machine shop jobs, tool and die makers, because of their role in making the tools and dies needed to produce and use this equipment, will be less affected than other machine shop workers. It is also unlikely that technical advances will very much reduce the skill needed in this occupation. Finally, the trends toward greater use of die casting, stamping, and plastics molding will tend to increase die maker employment in connection with these processes. These factors, as well as continuing replacement demand, make it reasonably certain that those who enter the trade during the next several years will find good employment opportunities for many years to come.

Even in the event of a general business depression, with machine shop employment temporarily falling to a low level, experienced tool and die makers, because of their all-round skills, would have fairly good chances to get lower-rated ma-

chine shop jobs. Thus, from the point of job security, they may have a considerable advantage over other machine shop workers.

Earnings

Tool and die makers are the highest-paid machine shop workers. In January 1945 their average straight time hourly earnings were $1.55 in tool and die jobbing shops, where skill requirements tend to be highest but where employment often varies greatly from season to season. In the machine tool industry during the same period, they averaged $1.35 an hour. Tool and die makers employed in plants making other types of machinery were earning $1.29 an hour, straight time. Wages in these industries have been increased since the date mentioned.

The earnings of tool and die makers vary widely among areas. For example, those employed in tool and die jobbing shops in the Detroit area were averaging approximately $1.75 an hour in January 1945.

Chances for Advancement

Tool and die makers often rise to better jobs. Many have advanced to shop superintendent or other responsible supervisory work, or to such positions as tool designer. Another avenue of opportunity is the opening of small tool and die jobbing shops.

Shipyard worker using a drilling machine to make holes in a steel bar. The work is typical of some of the less-skilled machine tool operating jobs.

OWI PHOTO BY HOLLEM.

Machine Tool Operators

By far the greatest number of machine shop workers are employed as machine tool operators. Their employment at the wartime peak reached an estimated 910,000, or more than 75 percent of the total in machine shop occupations. Unlike the all-round machinists with whom they are often confused, machine tool operators usually work on a single type of machine tool, such as a lathe, milling machine, planer, or shaper, and most of them cannot carry a job through all its different stages.

Duties

Machine tool operating jobs may be divided into two main classes, according to the skill required. The skilled machine tool operator does widely varying kinds of machining. Working from blueprints or lay-outs, he sets up his machine for each machining operation, adjusts the feed and speed controls, and measures the finished work to see if it meets specifications. He knows how to sharpen cutting tools when they become dull and understands the machining qualities of various metals. In brief, his work is very much like that of the all-round machinist, except that it is limited to a single type of machine tool.

The majority of machine tool operators are much less skilled than the machine tool specialists described above and do work which is repetitive, rather than varied. A typical job of one of these workers consists mainly of placing rough metal stock into an automatic machine tool, watching the machining operation for signs of trouble, and measuring the finished work with specially prepared gages which simplify measurement. He may make minor adjustments to keep the machine tool in operation, but must usually look to more-skilled men for any major adjustments that may be needed. For each machining operation, a skilled machine tool specialist, set-up man, or machinist installs the cutting tools and sets the controls, and after a trial cut turns over the actual running of the machine tool to the operator. Some operators have slightly more responsible jobs in that their work is less repetitive and greater accuracy is required of them.

Machine tool operators, skilled and semiskilled alike, are designated according to the kind of ma-

chine tool which they operate—for example, engine lathe operator, turret lathe operator, drilling machine operator, grinding machine operator, milling machine operator. There are many other kinds of machine tool specialists, each of whom knows his particular machine tool.

As shown in chart 1, the various machine tool occupations differ greatly in the number of workers employed. Among the more important of these occupations are lathe operators, grinding machine operators, drilling machine operators, milling machine operators, and screw machine operators. The operation of other types of machine tools—such as boring mills, shapers, planers, and gear cutters—constitutes a smaller field of employment. There are also differences in the proportion of skilled jobs, as against semiskilled, found in connection with the various kinds of machines. For example, a relatively large number of engine lathe operators are classed as skilled. In contrast, relatively few grinding machine operators are so designated.

Training

As one would expect, the training of the two main classes of machine tool operators differs greatly. The skilled machine tool specialist is trained on the job, although formal apprenticeships are not provided in this occupation. It is usual to begin as a learner in a machine shop and to spend from 1½ to 3 years on a particular machine tool. In addition to machine work, training may include instruction in blueprint reading, shop arithmetic, and similar subjects. Many employers take only high school or technical school graduates as learners. Although the training of the specialist is shorter and much less varied than that of the all-round machinist, the trained specialist is able to operate a single type of machine tool as well as any machinist. Unlike the machinist, of course, he has experience on only one type of machine. However, many men who completed machinist apprenticeships are employed as skilled machine tool operators.

On the other hand it is much quicker to learn to be a semiskilled machine tool operator. Although a high school or trade school education is considered desirable, it is not essential. In general, on-the-job training of not more than 6 months is sufficient to qualify for this kind of work.

Where Employed

Although skilled machine tool specialists are employed in all types of machine shops, most of them work in production shops. The proportion of these specialists varies greatly among production shops, however, depending on the extent of job break-down and the kind of machining done. They form a smaller percentage of the workers in job and maintenance shops, where an all-round knowledge of machine shop practice is generally preferred. Nevertheless, a substantial number of skilled operators are employed in these shops, working under the guidance of all-round machinists.

The employment of semiskilled machine tool operators is confined mainly to production shops and is concentrated particularly in such mass production industries as automobiles and radios. Because of their limited training, few can be used in either job or maintenance shops. In production shops, under close supervision, they can efficiently do routine work and free more-skilled men for the complex work.

Employment Outlook

In the next few years, job prospects for skilled machine tool specialists are likely to be good. The number trained in this work during the war is not large compared to the needs of the expanding peacetime industries, such as automobiles and electrical appliances. Possible shortages of all-round machinists may also tend to create openings for skilled specialists. In addition, some employers will continue to train specialists in preference to training all-round men, because it costs less. As a result of these factors, there should be opportunities for beginners to learn the work.

Over a longer period, the growth of specialization in machine shop work, a development greatly speeded by the war, will surely continue. This trend may offset technical advances which otherwise would reduce the need for skilled operators.

The employment outlook for the semiskilled operator is less favorable. Peacetime employment of these workers will be high, but it is hardly expected to approach the level of the war years, when large numbers were hired by metalworking industries and hurriedly trained. Many of these wartime workers were women who have since returned to their kitchens and teen-agers who have gone back to school. However, in most areas there

are likely to be more experienced workers than jobs of this type and, therefore, few openings for trainees.

Those who do get jobs as semiskilled operators have fairly good prospects for continued employment in the future. The gradual simplification of machine tool work through greater use of automatic machines may widen their field of employment. On the other hand, technical advances which increase the efficiency of machine tools will tend to hold down the total number of jobs in this occupation.

Earnings

Many machine tool operators, especially the less-skilled operators, are paid on an incentive basis and hence often earn as much as machine shop workers of greater skill. In January 1945, average straight time hourly earnings of men working as first class (A) operators in the machinery industries (excluding tool and die shops and plants making electrical machinery or machine tools) were as follows, by type of machine tool: Engine lathe and milling machine, $1.16; grinding machine, $1.20; and turret lathe, $1.17. Second class (B) operators of these machines averaged from 4 to 13 cents an hour less. Third class (C) operators earned, on the average, from 9 to 15 cents an hour less than second class.

Chances for Advancement

Skilled machine tool specialists may be promoted to such jobs as set-up man or supervisor (on machines on which they have specialized). If they can get experience on several different kinds of machine tools, they also can develop into all-round machinists. Semiskilled operators generally have little chance for advancement since they are employed mainly in production shops, where the work is very repetitive and where there are few opportunities to develop additional skills.

Set-up Men

The set-up man is a skilled specialist employed in machine shops which carry on large-volume production. His job is to install cutting tools and adjust the controls of machine tools so that they can be run by semiskilled operators. This is one of the smaller machine shop occupations—about 20,000 were employed as set-up men at the wartime peak in December 1943.

The usual practice is to assign a set-up man to a number of machine tools, which are often of one type, such as the turret lathe. The set-up man works from blueprints, written specifications, or job lay-outs in order to set the cutting tools in place and to adjust, for each machining operation, the guides, speed and feed controls, working tables, and other parts of machine tools. After setting up and adjusting a machine, he makes a trial run to see if it is working properly, and then turns it over to the regular operator. During the machining operation he makes all important adjustments needed for accurate production.

In order to become a set-up man, it is usually necessary to qualify first as an all-round machinist or as a skilled machine tool specialist, since the job requires a good background in machine shop practice as well as a thorough knowledge of the operation of at least one type of machine tool. In many cases, a man obtains the needed experience through working in job shops and then gets a set-up job in a production shop.

The employment outlook for set-up men is favorable for the next few years, because of the expected high production of metal products and because of the shortage of operators qualified to set up their own machines. Over a longer period, the trend toward specialization in machine shop work will tend to provide continued employment.

Earnings in this occupation compare favorably with those of all-round machinists. In January 1945 average straight-time hourly earnings of set-up men in some of the important industries employing them were as follows: Machine tools, $1.34; tool and die jobbing shops, $1.13; other machinery industries, $1.17.

Lay-Out Men

The lay-out man is a highly skilled specialist whose job is to make guide marks on metal before it is machined to indicate to the machine operators the kind of machining needed. This is not a large occupation; at the peak of wartime employment there were only about 10,000 jobs of this type.

Working from blueprints or written specifications, the lay-out man marks guide lines, reference points, and other instructions to operators on rough castings, forgings, or metal stock. He uses a wide assortment of instruments, including the scriber, with which he marks lines on the surface of the metal; the center punch, used to indicate the centers on the ends of metal pieces to be machined or drilled; the keyseat or box rule, used

for drawing lines and laying off distances on curved surfaces; dividers, for transferring and comparing distances; L- or T-squares for determining right angles; and calipers and micrometers for accurate measurement.

Not only must the lay-out man work with extreme accuracy, but he has also to be familiar with the operations and uses of each of the standard machine tools. In general, it takes from 6 to 10 years to develop this skill, including the machinist apprenticeship or equivalent training needed to learn the fundamentals of machine shop practice. A high-school education, including courses in geometry, trigonometry, and mechanical drawing is often required; additional preparation in a trade or technical school is considered desirable.

Like other specialized machine shop workers, lay-out men are employed mainly in production shops. Some are also found in job and maintenance shops, particularly in the former.

Employment opportunities for lay-out men are likely to be very good for a long time to come. The trend toward employing skilled lay-out men in conjunction with semiskilled machine tool operators in production shops is expected to continue, particularly in view of a possible shortage of machine shop workers able to make their own lay-outs.

DEPARTMENT OF LABOR PHOTO.

Laying out a flange. This job requires blueprint reading, a broad knowledge of machine shop work, and the skillful use of marking and measuring instruments.

Opportunities for Training in Machine Shop Work

The necessary training for machine shop jobs can be obtained in several different ways. The method used depends on which particular occupation is the goal and on the kind of training available in the community.

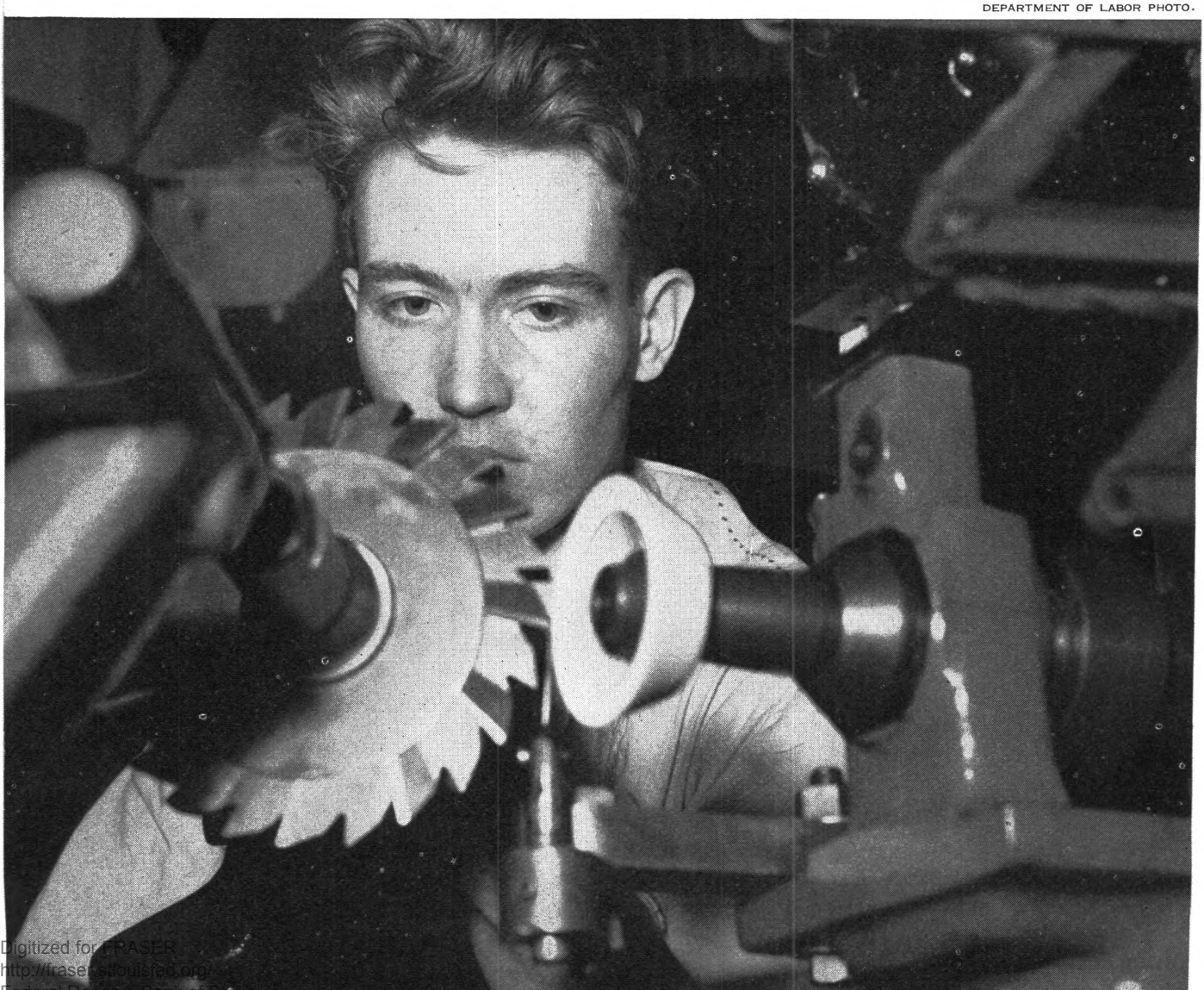
Apprenticeship

The main route to skilled jobs in machine shops is apprenticeship, in which a young man is hired with the purpose of teaching him a trade through working along with, and under the guidance of, experienced craftsmen. In a formal apprenticeship, a written agreement is made between an employer and an apprentice providing that the apprentice receive thorough training in the trade and setting forth the conditions of the apprenticeship.

Typical agreements specify a term of apprenticeship for machinists of not less than 8,000 hours

Apprentice machinist sharpening a milling cutter on a grinder. Learning to sharpen cutting tools is one part of the varied training given apprentices.

DEPARTMENT OF LABOR PHOTO.



of employment—usually extending over 4 years—and of 10,000 hours, or 5 years, for tool and die makers. The first 1,000 hours of employment are usually a try-out period during which the agreement may be canceled at the request of either party.

The standards of apprenticeship are usually set up by representatives of employers and employees who are familiar with the minimum training that is necessary in the occupation. In setting up a training schedule, consideration is given to the type of work being done in the shop in which the apprentice is employed and the facilities available for training. A typical work program for machinist apprentices involves up to 2,000 hours of work on lathes, and up to 1,000 hours on each of such machine tools as the grinder, boring mill, and milling machine. It also includes lay-out work, assembly, heat treating, and welding. Tool and die apprenticeships are similar, but in addition require considerable work on dies or cutting tools.

Apprenticeship agreements also provide for about 12 hours a month of classroom instruction in related technical subjects, such as mechanical drawing, shop mathematics, and properties of metals. This instruction may be given within the plant where the apprentice works or in a local trade school.

Although the usual term of apprenticeship is 4 or 5 years, the period can be shortened under certain conditions. Men working in lower-grade machine shop occupations, such as that of machinist helper, can sometimes transfer to an apprentice classification and have their experience credited toward completion of the apprenticeship. Veterans may be able to get similar credit for machine shop experience in the armed forces. In some cases, trade school courses also may be used in this way.

In selecting young men for apprenticeships, employers take account of their records in school, their physical condition, and their moral character. Graduation from high school is often required, and courses in high school mathematics, physics, and machine shop work are considered desirable preparation. Usually the minimum age for apprentice jobs is 16, and the maximum, 23. However, this maximum age limit does not generally apply to veterans. Sons of machinists or tool and die makers frequently receive preference for apprentice openings.

Earnings of apprentices usually start at from one-fourth to one-half the journeyman rate. In the course of training, their wages are periodically increased, provided progress in learning the trade is considered satisfactory. Veterans in training under the GI Bill of Rights receive, in addition to their apprentice pay, a monthly allowance from the Government of up to $65, if they have no dependents, or up to $90 if they have dependents. Combined pay and allowances, however, may not exceed the journeyman rate and may not be more than $200 a month for men with dependents or $175 a month for men without dependents. The allowance may continue for as long as 4 years. Disabled veterans can get similar assistance under the Vocational Rehabilitation Act.

Upon successfully completing his training, the apprentice is rated as a journeyman and is usually given a certificate showing this. In many cases, his employer presents him with a set of hand tools or with a cash bonus of as much as $200.

Since not all apprenticeships provide adequate training, it may be helpful for a young man considering such a job to find out if the shop making the offer has registered its program with the appropriate agency in the State or with the Apprentice Training Service of the U. S. Department of Labor. Apart from formal apprenticeships, proper training as a machinist or tool and die maker may be obtained through the programs for all-round learners provided by some companies.

Other On-the-Job Training

On-the-job instruction, other than apprenticeship, is used to train machine tool operators. In this type of training, the purpose is to produce specialists on particular machines, rather than all-round workers. Usually no formal agreement is made between the employer and the learner, as the trainee is usually called.

A learner is assigned to a single type of machine tool, say an engine lathe or milling machine. At first he works under the close supervision of an experienced operator or of a machinist, beginning with very simple tasks and gradually taking on a little more responsibility. If the learner is to be a semiskilled operator, his training period is usually over within 6 months. If, on the other hand, he is headed for the job of skilled specialist, training continues for an additional year or two and includes such subjects as laying out work and setting up a machine tool.

Learners generally get higher wages than first-year apprentices. Veterans in learner jobs may qualify for monthly allowances from the Government.

Persons without previous machine shop experience may be hired directly as learners, or lower-grade machine shop workers may be upgraded to this work. Men whose lack of education or whose age disqualifies them for apprenticeship can often get into machine shop work through learner jobs, particularly those for semiskilled operators. The requirements for trainees in the skilled machine tool specialist's work often closely approach those for apprentices.

Trade or Vocational Schools

There are many trade schools, public and private, which offer a 1- or 2-year course in machine shop work. These courses cannot qualify men as machinists, tool and diemakers, or machine tool operators. However, many employers, in filling apprentice or trainee jobs, give preference to graduates of a good trade school. In some cases, those who have completed a trade school course may be allowed to go through apprenticeship or other on-the-job training in less than the usual time. Before enrolling in one of these schools, the prospective student should find out if the courses are considered satisfactory by employers and unions in his town and if the school is properly accredited. (See: How to Get More Information About Machine Shop Jobs, p. 25.)

Choosing a Machine Shop Occupation

As we have seen, a man who wants to get into machine shop work may be able to choose among several different routes into the field. Of course, there are a number of factors, such as individual aptitudes, which have to be taken into account in deciding what kind of job a person should seek. In addition, the availabilty of each type of work in a particular commmunity has to be considered. These problems cannot be solved here, but what can be done is to compare the various possibilities with respect to employment prospects, earnings, opportunities for promotion, and job security.

In many ways, the job of learning to be a semiskilled machine tool operator has the least to offer. For one thing, there are likely to be few openings for trainees during the next several years. Moreover, although the earnings of experienced operators are not far below those of more-skilled machine shop workers, their promotional opportunities are much more limited, and their chances of being among the first to be laid off when business is declining are greater. On the other hand, operators after a few months on the job generally earn more than first- or second-year apprentices. There is also the possibility, in some cases, of a man beginning as an operator and taking an apprenticeship at a later date. Finally, it should be remembered that, although there are disadvantages to this occupation compared with other machine shop jobs, the necessary investment of time and effort in learning the work is relatively small. Thus, a machine tool operator who left machine shops for another line of work would lose less than would a highly trained man.

Trainee jobs leading to the occupation of skilled machine tool specialist generally provide much better opportunities. There should be many openings, in the period immediately ahead, for inexperienced men to begin specialist training. Trainees' earnings are often higher than those of apprentices and the learning period is shorter. Experienced specialists often receive about as much pay as all-round machinists, and in some cases more. They have fairly good chances for promotion, although their opportunities are more limited than those of journeymen, and favorable prospects for continued employment in the future.

In general, a machinist or tool and die maker apprenticeship is the most desirable course. As we have seen, getting equivalent training any other way is difficult. It is true that apprentices' pay is relatively low at the start (except for veterans receiving allowances under the GI bill) and that journeymen often earn no more than less-skilled men. In the long run, however, those who complete an apprenticeship are likely to fare better than other machine shop workers. For one thing, a wider range of jobs is open to them. A journeyman machinist, for example, can not only work as an all-round machinist but can also qualify as a set-up man or skilled operator on any standard machine tool. Because of this ability to do different kinds of work, journeymen have the best chances to get and to keep jobs. They also can transfer more readily than less-skilled men from one plant to another. Moreover, there is the fact that most supervisory jobs in machine shops are

filled by promoting experienced journeymen. During the next few years, there should be many openings for apprentices.

There is one other way of going into the machine shop field which has not been previously considered here. This has to do with the opportunities for engineering school graduates. Many employers take on these college trained men, give them a year or two of experience in machine shop jobs, and then, if the men show promise, assign them to engineering, sales, or supervisory positions. It is believed by many in the field that this combination of engineering education and practical shop experience gives a man the best chance to rise to an executive job in metalworking industry.

To sum up, it would seem that the best advice to a young man planning to go into machine shop work is that he seek the highest level of skill which his abilities permit and available openings allow.

How To Get More Information About Machine Shop Jobs

There are many sources of information about machine shop jobs and training. Young men interested in apprenticeships or trainee openings may consult the nearest local office of their State employment service. They may also write to or visit the local headquarters of unions having machine shop workers among their members. Veterans may get information, especially about Government financial aid, at the nearest office of the Veterans' Administration or Veterans' Information Center. Information about trade school courses can be obtained from local public school systems or the State superintendent of public instruction. Questions regarding the standing of private trade schools may also be sent to the National Council of Technical Schools, 839 Seventeenth Street NW., Washington 6, D. C., or to the American Vocational Association, 1010 Vermont Avenue NW., Washington 5, D. C. The addresses of machine shops in one's community can be found in the classified section of the local telephone book, under such headings as "machine shops," "die makers," "machinery," "railroad companies," and "automobile manufacturing companies."

Additional Bureau of Labor Statistics Information on Machine Shop Work

Employment and pay-rolls.—The Employment Statistics Division of the Bureau of Labor Statistics provides monthly estimates of employment, hours, earnings, and labor turn-over for each of a large number of individual industries, including the various metalworking industries which employ the bulk of machine shop workers. This information is published in the Monthly Labor Review[1] and in free mimeographed releases each month.

Occupational wage rates.—Detailed information on wage rates in machine shop occupations in many industries is contained in publications of the Bureau's Wage Analysis Branch. Also included are data on such related subjects as unionization, incentive pay, bonuses, and vacations. Recent studies include Wage Structure of the Machinery Industries, January 1945; Wage Structure of the Machine Tool Industry, January 1945; and Wage Structure of the Machine Tool Accessories Industry, January 1945. Mimeographed copies of these studies will be furnished free upon request.

For January 1945, there are also local summaries covering each city of 100,000 population or more. Information of this type for October 1946 or January 1947 will be available in the near future.

Industrial hazards.—Statistics on work injuries in each of a large number of industries, including many metalworking industries, are collected by the Bureau's Industrial Hazards Division and appear in the Monthly Labor Review and in free mimeographed releases.

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[1] The Monthly Labor Review is for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price: 30¢ per copy, $3.50 per year.

Appendix

Employment in metalworking industries,[1] 1899 to October 1946 [2]

	Production worker employment (in thousands)
1899	1,173
1900	[3]
1901	[3]
1902	[3]
1903	[3]
1904	1,364
1905	[3]
1906	[3]
1907	[3]
1908	[3]
1909	1,656
1910	[3]
1911	[3]
1912	[3]
1913	[3]
1914	1,789
1915	[3]
1916	[3]
1917	[3]
1918	[3]
1919	3,023
1920	[3]
1921	1,850
1922	[3]
1923	2,726
1924	2,464
1925	2,560
1926	2,664
1927	2,493
1928	2,565
1929	2,856
1930	2,370
1931	1,849
1932	1,455
1933	1,565
1934	2,034
1935	2,233
1936	2,547
1937	2,980
1938	2,203
1939	2,569
1940	3,076
1941	4,258
1942	5,686
1943	7,466
1944	7,306
1945:	
January	6,972
February	6,953
March	6,852
April	6,684
May	6,464
June	6,196
July	5,881
August	5,608
September	4,113
October	4,049
November	4,062
December	3,942
1946:	
January	3,997
February	3,185
March	3,737
April	4,173
May	4,264
June	4,349
July	4,460
August	4,581
September	4,667
October	4,681

[1] Metalworking industries included are iron and steel and their products; electrical machinery; machinery, except electrical; transportation equipment, except automobiles; automobiles; and nonferrous metals and their products.

[2] Sources: Published employment series of the Bureau of Labor Statistics were used for the period, 1929 to October 1946. Preliminary employment estimates for 1923 to 1928 were derived from unpublished Bureau data, and are not entirely comparable with the estimates for later years. The series covering 1899 to 1921 are based on Employment in Manufacturing, 1899–1939, by Solomon Fabricant (National Bureau of Economic Research, Inc., 1942). Fabricant's data were adjusted to the 1929 level of the Bureau of Labor Statistics series.

[3] Data are not available.

Occupational Outlook Publications of the Bureau of Labor Statistics

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

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

Occupational Outlook reports are issued as bulletins of the Bureau of Labor Statistics; sometimes they are also published in the Monthly Labor Review (subscription price per year $3.50; single copy, 30 cents). Both the Monthly Labor Review and the bulletins may be purchased from the Superintendent of Documents, Washington 25, D. C.

Two types of reports are issued:

Occupational Outlook Bulletins describe the long-run outlook for employment in each occupation and give information on earnings, working conditions, and the training required.

Special Bulletins are issued from time to time on such subjects as the general employment outlook, trends in the various States, and occupational mobility.

Occupational Outlook Bulletins

Employment Opportunities for Diesel-Engine Mechanics.
Bulletin No. 813 (1945), price 5 cents. (Monthly Labor Review, February 1945.)

Employment Opportunities in Aviation Occupations, Part I.—Postwar Employment Outlook.
Bulletin No. 837–1 (1945), price 10 cents. (Monthly Labor Review, April and June 1945.)

Employment Opportunities in Aviation Occupations, Part II.—Duties, Qualifications, Earnings, and Working Conditions.
Bulletin No. 837–2 (1946), price 20 cents. (Monthly Labor Review, August 1946.)

Employment Outlook for Automobile Mechanics.
Bulletin No. 842 (1945), price 10 cents. (Monthly Labor Review, February 1946.)

Employment Opportunities for Welders.
Bulletin No. 844 (1945), price 10 cents. (Monthly Labor Review, September 1945.)

Postwar Outlook for Physicians.
Bulletin No. 863 (1946), price 10 cents. (Monthly Labor Review, December 1945.)

Employment Outlook in Foundry Occupations.
Bulletin No. 880 (1946), price 15 cents. (Monthly Labor Review, December 1945 and April 1946.)

Postwar Employment Prospects for Women in the Hosiery Industry.
Bulletin No. 835 (1945), price 5 cents. (Monthly Labor Review, May 1945.)

Employment Outlook for Business Machine Servicemen.
Bulletin No. 892 (1947), price 15 cents.

Employment Outlook in Printing Occupations.
Bulletin No. 902 (1947). (In press.)

Special Bulletins

Occupational Data for Counselors, A Handbook of Census Information Selected for Use in Guidance.
Bulletin No. 817 (1945), price 10 cents. (Prepared jointly with the Occupational Information and Guidance Service, U. S. Office of Education.)

Factors Affecting Earnings in Chemistry and Chemical Engineering.
Bulletin No. 881 (1946), price 10 cents. (Monthly Labor Review, June 1946.)

State and Regional Variations in Prospective Labor Supply.
Bulletin No. 893 (1947). (In press.)