

UNITED STATES DEPARTMENT OF LABOR

FRANCES PERKINS, Secretary

WOMEN'S BUREAU

FRIEDA S. MILLER, Director

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CONTENTS

# EMPLOYMENT OPPORTUNITIES IN CHARACTERISTIC INDUSTRIAL OCCUPATIONS OF WOMEN

By

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## CONTENTS

	Page
Letter of Transmittal.....	iii
What Kinds of Jobs May Need Women?.....	iv
Part I. Description of the Occupations Selected for Study.....	1
Assembly.....	3
Methods of Assembly.....	4
Training Women in Assembly Techniques.....	4
Importance of Assembly Jobs for Women.....	5
Assembly of Aircraft.....	5
Assembly of Fine Instruments.....	7
Assembly of Machine Tools.....	9
Assembly in Shipyards.....	10
Assembly of Ammunition and Firearms.....	10
Electrical Assembly.....	11
Inspection.....	14
Inspection as an Occupation for Women.....	15
Training of Women Inspectors.....	16
Systems of Inspection.....	16
Skills Required in Inspection.....	18
Operation of Machines.....	19
Women as Machine Operators.....	20
Training for Machine Operation.....	23
Skills Required for Machine Operation.....	23
Simplification of Machine Operation.....	24
Proficiency of Women in Various Machine Operations.....	24
Operation of More than One Kind of Machine.....	24
Grinding Processes Numerous in Metal Work.....	25
Many Machine Operations Require Special Skills.....	26
The Problem of Heavy Work.....	27
Packing and Wrapping.....	28
Tool-Crib and Storeroom Work.....	30
Other Characteristic Occupations.....	31
Burring and Filing.....	31
Coremaking.....	32
Part II. Probable Opportunities for the Employment of Women.....	34
Shifts from One Skill to Another.....	34
Change to New Products, and Continuance of Demand.....	35
The Electrical Industry.....	36
Lamps and Tubes.....	36
Radio Sets.....	39
Other Electrical Appliances.....	40
Professional and Scientific Instruments.....	41
Small Metal Products.....	42
Kitchen Products.....	42
Needles and Pines.....	43
Miscellaneous Hardware.....	43
Other Small Metal Products.....	43
Transportation Equipment—Automobiles and Aircraft.....	44
Automobiles.....	44
Aircraft.....	45
Fabricated Plastic Products.....	47
Sources Referred to in Text.....	49
Chart: Extent to which women employed in six selected industries were doing assembling, inspection, and machine operating.....	2

## LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF LABOR,  
WOMEN'S BUREAU,  
Washington, October 11, 1944

MADAM: I have the honor to transmit a study directing attention to certain industrial occupations in which women have demonstrated marked success, and which may be expected to continue to afford many opportunities for women.

This report is one of a series of inquiries the Women's Bureau is making in fulfillment of its obligation to investigate indications as to types of jobs likely to present future employment opportunities for women. It also illustrates the way in which women's work in industry during the war has extended over a varied range in occupations having great similarity to those in which women long have been employed and in which they undoubtedly will continue.

The report has been prepared as one part of the Bureau's program to outline probable conditions for women workers in the reconversion and postwar periods. It is chiefly the work of Elisabeth D. Benham of this Bureau's Research Division, cooperating with Mary Elizabeth Pidgeon, Director of the Research Division.

Respectfully submitted.

FRIEDA S. MILLER, *Director.*

HON. FRANCES PERKINS,  
*Secretary of Labor.*

## WHAT KINDS OF JOBS MAY NEED WOMEN?

Women workers long have shown marked ability to perform particular industrial processes that require care, patience, and skill.

In prewar years, and to a far greater extent during the war, women have been employed on these types of work, in which they could use their characteristic abilities. Outstanding among occupations for which women thus have demonstrated special aptitudes are:

Assembly of small articles—requiring deftness, accuracy, and patience.

Inspection of many types—requiring conscientious care and attention to details, and sometimes involving quite expert procedures.

Operation of various machines—requiring close following of instructions, and care in performing correct processes and in preventing spoilage of materials.

Tool-crib and stockroom work. Burring and filing. Coremaking. Wrapping and packing.

Not only war industries but peacetime manufacturing as well will need types of operations at least very closely allied to those so skillfully done by women, both before the war and in much larger numbers during the war.

The rapidity with which women can be employed on such jobs depends on prompt change-over to peacetime production. The extent to which such work can continue depends on sound methods to assure a high level of employment and the consequent distribution of buying power.

During the war large numbers of women have had valuable experience in detailed operations that are the same as or very similar to those that will be needed when production for civilians is resumed. These women can play an important part in meeting consumers' demands for such products as the following:

Electrical equipment for lighting, radios, medical care, and a wide variety of home uses.

Household utensils.

Hardware and other small metal parts.

Interchangeable small parts for automobiles and aircraft.

Scientific measuring instruments.

Certain plastic products.

# Employment Opportunities in Characteristic Industrial Occupations of Women

## PART I. DESCRIPTION OF THE OCCUPATIONS SELECTED FOR STUDY

The particular abilities of women workers have proved an unquestionable asset in certain industrial processes that long have employed women. In many cases allied types of skill may be utilized in several different industries. Consequently it is possible for women to transfer from one industrial job to another in an industry wholly different but requiring similar skills of the worker.

This has been of great advantage both to management and to workers during the war, when occupations in which women excel have engaged enormously increased numbers. It is likely that after the war these operations will continue to offer a large field of opportunity for women workers, owing to the interchangeability of such skills among several industries and the particular aptitudes of women in performing them. There is strong probability that they will employ fewer persons than at the war peak, but still will offer jobs to more women than in prewar days.

Such types of work include, for example, the assembling of small pieces into a whole or a part of the final product, which may involve the soldering, welding, or fitting together of parts with hand tools such as tweezers, pliers, or screw drivers; the inspection of parts or assemblies, which may range from a simple examination by sight or touch to the expert use of a precise measuring instrument; the operation of various types of machines, in some cases requiring the setting-up of the machine; a number of kinds of cleaning or polishing; and the wrapping and packing of the product, especially when this entails handling relatively small units.

Assembly, inspection, operation of certain machines, and the wrapping and packing of small articles long have been occupations employing many women. As far back as 1907 and 1908 when the study of woman and child wage earners was made by special direction of the Congress, women were assembling filaments for electric lamps, locks, jewelry, and metal articles among other things, and were operating drill presses, punch presses, and other machines in making nuts, bolts, screws, tin cans, hardware, and so forth (1).<sup>1</sup>

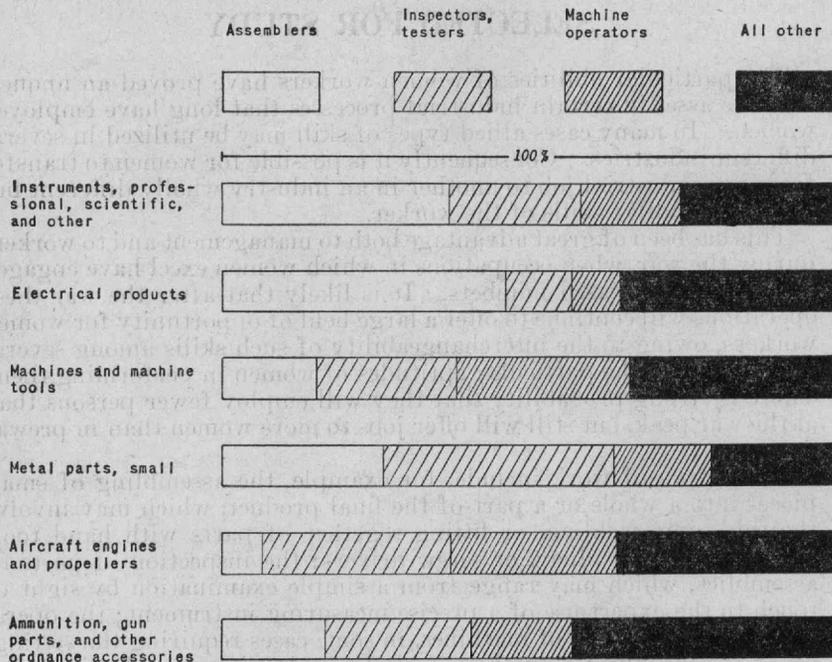
During the present war far greater numbers of women than before have gone into such occupations in war industries. A 1942 study of more than 125 war plants in a large industrial State found that three-fourths of the women with occupations reported in the electrical, in-

<sup>1</sup> References in parentheses throughout this report are to "Sources Referred to in Text," p. 49.

strument, aircraft engine and propeller, machine, metal parts, and ammunition plants combined were assembling, testing or inspecting, operating machines, or packing and wrapping. Typical is the report from an electrical plant recently visited, where the employment manager stated that women have been found to be more adapted than men to assembly work.

But it is not alone war industries whose products require assembling, inspecting, and machine operations to be done. After the war

EXTENT TO WHICH WOMEN EMPLOYED IN SIX SELECTED INDUSTRIES WERE DOING ASSEMBLING, INSPECTING, AND MACHINE OPERATING<sup>1</sup>



<sup>1</sup>From a sample of 70 plants in a large industrial State, 1942.

as before, women will do such work in many industries, probably in numbers considerably greater than in 1939 if not so great as at the war peak. For example, there would appear to be a relatively sure demand for such products as the following, the making of which requires the operations referred to: A variety of electrical appliances, such as buzzers, fuses, meters, plugs, switches, coffee-makers, and toasters; automobile parts; small metal products such as bolts, nuts, screws, pins, and needles; delicate parts of such machines as typewriters and other office equipment, sewing machines, and instruments for measuring and testing; and such long-time employments of women as the weaving of textiles, or the making of clothing, shoes, and paper products. Wrapping and packing occupations also are required in a number of the foregoing, and on an extensive scale in various food industries as well.

Two points should be made at the outset of this discussion, and they are points that cannot be repeated too frequently. In the first place, the employment of women will rise or fall with the soundness of the entire economy—with the rapidity with which conversion to peacetime production can be made, and the extent to which a high level of employment can be developed and maintained.

Secondly, the ever-changing processes of industry, new public demands and the decline of earlier demands incident to new discoveries, new methods of production, will continue to mean shifts in employment. Some highly specialized skills may become obsolete, others need to be developed; but at the same time there are certain skills that are admirably exercised by women and that are likely to be usable, or adaptable in some closely allied form, in a variety of industries to the extent that the country's economy enables those industries to exist.

The following pages will describe some of the work performed in various industries by women in such occupations as assembly, inspection, operation of machines, and a few others. Possibilities then will be discussed for postwar demands for the products of a few of the chief industries that undoubtedly will continue to employ many women in such occupations, as for example various branches of the electrical industry, transportation equipment, certain small metal parts, and plastic products.

### ASSEMBLY

Among the operations that long have been usual for women in many industries are those of the type known in general as assembly or assembling jobs—that is, the putting together of parts. These vary widely in method used and in degree of skill. To screw together two parts of the plug for an electric toaster, for example, seated at a bench and using a small hand screw driver, is one of the simplest types of assembly. Somewhat more difficult is the assembly of an induction coil unit for an automobile. Wire is wound on a soft iron core, the electrical connections are soldered, and the unit is put into a metal or plastic housing.

When a number of parts are to be fitted together, it becomes necessary to have as a guide some sort of pattern or instructions. Usually this is in the form of a blueprint, and it is an important part of the worker's job to know how to read or interpret this accurately. Finally, there are very expert and complicated types of assembly sometimes involving hundreds of pieces, often requiring a thorough knowledge of the use of the mechanism being made. Examples are the work of the watchmaker, or the final assembly of scientific instruments or of machine tools.

The Dictionary of Occupational Titles compiled by the United States Employment Service defines assembler as "A general term used to designate a worker who assembles mechanical units or fabricated parts to form complete units or subassemblies, using hand tools or machines. Usually specifically designated according to the part he is assembling, the article he is assembling, or the stage of assembling he is performing."

### Methods of Assembly.

Assembling of small parts may be done while seated at a work bench. It may or may not be organized on an assembly-line or belt-line system. Where larger parts are concerned, and more space consequently is needed, floor assembly is the method used, and this also may or may not be done on an assembly line.

The entire occupation for some individuals as a part of the assembling process may be the operation of a machine, such as a punch or drill press to make the holes through which screws are to go; others may perform some part of the preparation for making the parts fit or smoothing them, using a scraper or a hand file; or the parts may be fastened together with bolts or screws (using hand wrenches or screw drivers). More complicated methods of fastening parts together, requiring definite learning periods, may be by riveting, soldering, or welding (for which methods differ). The weight and size of the machines or of the hand tools used in these various processes depend on the weight and size of the parts being assembled.

Electrical assembly involves some techniques that are quite different from those involved in preparing and fitting together small metal pieces. However, in either type of assembly accuracy and fine work are involved and there is an overlapping in machine and electrical industries in the kinds of skills required by these occupations. Processes in the latter industry include cutting and insulating of wires, connecting them according to a prearranged pattern by the use of screws or solder, and so on. When a great number of wires are used the pattern may become quite intricate, as for a switchboard or an airplane panel board. Coil winding and armature winding are among the types of work involved in electrical assembly.

Persons who have learned the various techniques just mentioned should find their services of use in any one of a number of industries. Furthermore, if they have started with the easier processes they may be considered partly prepared for assembly jobs requiring other skills, which they can add to those initially acquired. For example, as has been indicated, in many of the more intricate jobs a knowledge of blueprint reading is essential. By adding such knowledge to her other skill, a woman who has successfully done some simple assembly can advance to a more difficult type of work.

### Training Women in Assembly Techniques.

The extent to which women are learning some of the techniques involved in assembly may be judged by reports on cumulative enrollment from July 1, 1943, through April 30, 1944, in vocational classes offering supplementary training to employed women, thus adding to the skills they already were practicing. Altogether these accounted for about three-fifths of all women enrolled in such classes. They were as follows:

	Women enrolled	
	Number	Percent of total
Aircraft assembly	31,723	71
Aircraft riveting	39,991	70
Welding (all kinds, in all industries)	50,201	28
Electric welding, heavy	44,680	30
Blueprint reading	14,866	26

## Importance of Assembly Jobs for Women.

That assembly jobs are far from new for women has been referred to. In World War I the Women's Bureau found women substituted for men as assemblers in some 30 industries studied at that time, as solderers in 9, as welders in 7 or 8, and as riveters in at least 4 (2). In discussing the work of women in such occupations, the Bureau stated:

Women had been employed as assemblers of small metal parts before 1914. The war not only extended their employment for the first time in this capacity to many factories making delicate machines or instruments, but it sent them into machine shops where parts of medium size were assembled. During 1918, women were substituted for men in assembling very delicate instruments, locks, typewriter parts, sewing-machine parts, adding-machine parts, rifles, airplane parts, hardware, cutlery, tools, gears, transmissions, and joints of automobiles; centrifugal governors, and radiators for engines; electric motors, switches, and switchboards; bombs and shells; in the assembling of many other parts; and in aiding in machine erection. \* \* \* Two-thirds of the firms reporting on 1919 labor conditions had retained their women assemblers (3).

As recently as the summer of 1942, a Women's Bureau report of women's work in war industries in an important industrial State found that more than one-third of the women reported were assemblers, and that women constituted one-fourth of all assemblers in the plants visited. Only 6 percent of these women were replacing men; 92 percent of them had been doing that work before the war, and the few remaining women assemblers were doing work new to the plant. The importance of assembly as a job for women in the various industries surveyed in this State is shown in the following:

<i>Industry</i>	<i>Percent women assemblers were of all women</i>
Electrical products.....	47
Instruments, professional, scientific and other.....	37
Metal parts, small.....	26
Plastic products.....	17
Ammunition, gun parts, and other ordnance accessories.....	17
Machines and machine tools.....	15
Chemicals and drugs.....	13
Aircraft engines and propellers.....	7
Rubber products.....	2

## Assembly of Aircraft.

A very great number of parts go into the finished airplane. For example, the midwing section alone of a certain type of plane has some 10,000 different kinds of parts, which are assembled into a unit measuring about 20 by 12 feet (4). Some parts are very small. One of the smallest electrical devices for aircraft use is a 10-ampere switchette weighing one-third of an ounce (5). Such a condition makes possible a very great subdivision of work and furnishes many jobs well within the strength of the average woman. The assembly of the plane sections is done in a variety of major subassembly departments, and the extent to which these functions are broken down into separate divisions varies from plant to plant.

Early in 1942 the Women's Bureau studied women's work in aircraft plants, and found women employed generally in detail and small sub-assembly. The amount of work done on detail assembly in the bench

departments varied with the organizational set-up of the plant, with a general tendency toward an increasing break-down of operations with more subassemblies and bench work. Women as bench workers were on operations preparatory to assembly. They were using small jigs to form subassemblies, fitting parts together with hand tools, wrenches, screw drivers, scrapers, and the use of arbor or power presses to force the parts close together, drilling holes with portable drills, cutting with hack saws, inserting screws, clips, and dimpling by hand and machine (6). Deft fingers and the ability to work with painstaking accuracy on small details are valued attributes. Certain of these operations are similar to work done before the war on the smaller parts for automobiles, though there is likely to be much more of the finer work in an airplane than in an auto.

In the detail-assembly department of one large plant, three-fourths of the workers were women. They were sorting, hand forming, filing, burring, and riveting as well as putting parts together with hand tools. In another plant women were 85 percent of all workers on detail assembly, 3 being foremen of riveting.

Riveting is the operation that builds up most of the subassemblies and final assemblies. Though not a large group at that time, women were on all the various types of riveting. Not only were they working on jig subassemblies of ribs, spars, and bulkheads, but they were attaching the metal skin to the control surfaces and wing panels.

At the time of the Women's Bureau survey of aircraft plants in the spring of 1941 it was estimated that in the fuselage department from 20 to 25 percent of the jobs could be done by women provided they were trained in riveting, which is the most common job throughout assembly. In wing assembly about 35 percent of the jobs could be done by women, in control-surface assembly nearly 70 percent, in cowling and tank assembly about 20 percent, in final assembly about 15 percent.

Spot welding, a process that is substituted for riveting on an increasing number of assemblies, requires little training and women were being employed with marked success. A few full-fledged women welders also were manipulating acetylene torches; these welded rods joining brackets to steel tubing on engine mounts, tanks, landing-gear parts, and other parts. A woman welder being paid a journeyman's rate of \$1.32 an hour was reported as one of the most efficient in the group with which she worked; the others were men. Parts plants making manifolds, cowls, airscoops, and tanks were employing women gas welders.

The proportion of women on the major fuselage and wing and final assembly was very small and most plants had none at all. In two plants, however, women worked alongside the slowly moving assembly lines installing such parts as pulleys, levers, pedals, radio tables, switch panels, and controls. Women working in a team were installing parts of the hydraulic system for landing gears. In the wing-assembly section of one plant 68 percent of the workers were women. In the earlier stages of assembly women were operating dimplers and all types of rivet machines, drills of all sorts, band saws, small brakes, rolls and shears. In fuselage assembly (another plant) 52 percent were women. The foreman wanted 800 more "right away."

A vivid picture of women's progress in this industry is presented by the two trips made to a final-assembly plant. When first visited in

December 1941 it was stated that the nature of the work did not lend itself well to the employment of women. Fifteen months later about a third of the factory workers were women and their production had far exceeded expectations. Since parts were made elsewhere, much of the work was assembly.

Aircraft-engine plants visited by the Women's Bureau late in the summer of 1943 had women working with men, assembling engines, tearing them down after testing, and reassembling. In one plant women did 40 percent of the assembly work. Men did the jobs requiring heavy lifting, otherwise work was the same for both. Most plants avoided much lifting in engine assembly by having engines mounted so that they could be turned mechanically to different positions.

### Assembly of Fine Instruments.

The making of aircraft, optical and fire-control, and surgical and dental instruments has been of great importance during the war. Aircraft instruments are for indicating, measuring, recording, or controlling the flight and navigation of a plane. Fire-control instruments are predominantly optical, such as panoramic sights, gunsights, periscopes, telescopes, and binoculars. The demand for surgical and dental instruments has increased to supply medical units of the Army, Navy, and Air Corps. At the same time, instruments for the automatic control of industrial processes have been developing, and probably will increase in importance after the war.

Many of these instruments are relatively small, light in weight, made up of many intricate parts and assemblies. The light work, the many small parts, and the painstaking requirements of certain operations make instrument manufacture a field well adapted to the employment of women. That their employment has greatly increased is shown by the proportion of all wage earners who were women in October 1943, as estimated by the Bureau of Labor Statistics, compared with the report of the Census of Manufactures for October 1939.

*Number of women  
per 100 wage earners*

	1939	1943
--	------	------

Professional and scientific instruments and fire-control equipment	15	43
Photographic apparatus	26	37
Optical instruments and ophthalmic goods	33	43

The final assembly of some instruments is akin to watch making. It calls for a high degree of skill and responsibility, a thorough knowledge and understanding of the use of the instrument, and a practical knowledge of the field in which it is being used. The fact that even two women were reported in a Women's Bureau survey as final assemblers and instrument makers shows that they might become a substantial part of the final assemblers if management were open-minded to the possibilities of employing them.

The Women's Bureau made a special survey of the instrument industries in the fall of 1941. At this time the policy as to the employment of women varied greatly among the plants, their proportion of all factory workers ranging from about 3 to nearly 50 percent. Later, in 1942, 9 instrument plants were visited in one industrial State, and more than a third (37 percent) of the women they employed were assemblers, all of whom were on work done by women before the war.

In the prewar period 44 percent of women's jobs in the plants reporting had been in assembling.

Most of the pressure-actuated aircraft instruments consist of a metal or plastic case, bezel or snap rings, front glass, dial, pointers, and a number of internal parts or subassemblies. In one of three large plants women did practically all the work on these subassemblies, while in the other two most of it was done by men. In a large plant that manufactures Navy and commercial barometers, automobile altimeters, and compasses similar to aircraft instruments, women have been employed extensively for many years and assembled aircraft altimeters during the war of 1914-18.

Another type of instrument is based on the gyroscopic principle. In one of the two plants inspected, women assemblers were classed as unskilled repetitive workers doing light bench work. In the other they did the major part of the assembly work.

Various news stories indicate an increased employment of women making aircraft instruments:

Gyro-horizons and compasses, instruments necessary for safe, accurate navigation of aircraft, are so delicate that all work must be done in washed-air, pressure-controlled rooms. Women have proved especially adaptable to this work.

An antiaircraft detector is assembled and largely machined by women.

A watch company makes altimeters and fine telescopes, as well as navigation watches and clocks. Before war production began, the firm employed 40 percent women; in 1942, 60 percent; now (June 1943), 80 percent.

A firm making automatic pilots for airplanes found it necessary to train girls with little or no previous mechanical experience to perform the exacting work required in the assembly of these devices.

In the manufacture of most dental and surgical equipment women did little but minor subassemblies. However, in one plant making clinical thermometers they were employed on all major processes. Sphygmomanometers, which measure blood pressure, also were largely the product of women's work. Here they did all the assembly.

Binoculars were the only fire-control instruments on which women were employed extensively at that time. They were mounting and setting optical parts such as lenses, Porro prisms, and reticles into the case, and staking and making minor adjustments of the position of the parts. Similar work was being done by women on telescopes, aircraft sights, and small gunsights. Later (January 1943) women were reported to be 80 percent of the employees in a department assembling Navy binoculars.

In another plant making Army range finders, fuze setters and fire-control mechanism, a visit in December 1943 found women doing electrical-parts-assembly bench work, and subassembly of units. Some of this is precision work and women were considered somewhat better than men. The instruments were assembled on a wheel truck that kept the work at bench level and enabled it to be turned in any position. The truck had been made in the plant to ease the work for both men and women. In final assembly women were helpers to the men. The men were first-class mechanics but the women were gradually learning enough about the job to go on with some of the assembly when the men were absent.

In a plant making sighting and fire-control instruments visited in July 1943, women were on subassembly using small hand tools. All were required to read blueprints.

Instrument assembly was found in shipyards where women worked with the instruments of navigation and control. They disassembled, cleaned, repaired, reassembled, and calibrated such instruments and meters as tachometers, thermostatic contact makers, hydrogen detectors for submarines, shaft revolution indicators, heat and pressure gages, and compasses. They also disassembled, cleaned, repaired, reassembled and alined the optical parts of telescopes, gunsights, binoculars, navigation instruments, and range finders.

### Assembly of Machine Tools.

Assembly is an important part of the manufacture of machine tools. It demands the precise leveling of machines on the floors, the exact alinement of the various units with one another, and many fitting operations involving scraping, filing, tapping, and other hand and machine processes. As customarily organized, one man has done a considerable variety of work requiring both experience and strength, since many parts handled are heavy.

When the Women's Bureau visited 15 major machine-tool plants in the summer of 1942, only 8 were employing women on production and in these the proportion of women among all factory workers was only from 2 to 8 percent. Assembly accounted for nearly a fourth of all production workers; only 2 plants were employing women as assemblers, though with greater subdivision women could have done much more of the work. In 1 of the 2 plants where women were assembling, the work was so organized that women were not required to handle any part weighing more than 18 pounds; they were filing, burring, and polishing and using hand drills and arbor presses on some of the smaller parts. In the other plant, women not only were doing these simple, light operations but had been given the responsibility of putting together parts of some of the subassemblies, such as the cross-feed screw nuts, the taper attachment shoes, fitting the gears on small shafts, and making lever and hand assemblies. They had proved so satisfactory here that a large proportion of the women to be hired in the future were to be placed in the assembly department. At the time of the survey 70 percent of the women production workers were on assembly jobs. One of the companies visited was planning to employ women as final assemblers to do light fitting as well as polishing and cleaning on the smallest machines manufactured.

Studies of various machine industries made by the Bureau of Labor Statistics in 1942 also show relatively few women assemblers. Most women were performing the least-skilled bench operations. An exception was the mechanical power-transmission-equipment industry, where women were half of all bench assemblers and three-fourths of those described as "Class C," the unskilled group. The products, ball and roller bearings, gears, drives, shafts and so on, are relatively small (7). A ball bearing used in an aircraft instrument is described as 0.015 inch on its outer diameter and with balls so tiny that 3,000 would fit in a thimble. The entire bearing consists of six of these balls, a race, two rings, and an outer casing (8). It can easily be imagined how fine a process the assembly of such tiny parts must be.

In later Women's Bureau visits, toward the end of 1943, women in one plant were found doing bench assembly work which was not repetitive. They were using drawings, and considerable training and experience were required. A few women were employed here in the

welding department. They were considered good at intricate work. Another plant visited at nearly the same time was still making some of its prewar products, full-fashioned knitting machines. Here about 75 women were employed on textile-machine needles doing fine speed work at benches that required great finger dexterity and excellent sight. Though none of the women had been there over a year, they were said to be much better than men and may be retained after the war. Many women were doing needle-filling, which involves slipping and fitting small needles into the groove of a rack on a small bar.

### **Assembly in Shipyards.**

A great many small parts go into the building of a ship. There also are many fittings for the living and working quarters on board that are the same as or similar to articles made in other industries. For these reasons many shipyard operations are well within women's capacity.

In 1943 the Women's Bureau visited 35 shipyards that had women on production work and found women doing assembly work on a great variety of items. These included valves, couplings, waterpumps, Diesel engines, manifolds, metal furniture, locks, water tanks, ammunition boxes, lockers, rifle cabinets, switchboards, stanchion parts, ammunition-hoist parts, stiffeners, parts for watertight doors. In one yard women assemblers filed surfaces to true, fitted gears to shafts, and made subassemblies. Some were proficient enough to assemble an entire unit, such as the mechanism controlling the training of a gun.

### **Assembly of Ammunition and Firearms.**

From an occupational standpoint, the chief value of women's experience in work on ammunition and rifles is in the techniques there acquired that may be applied to peacetime products. Only a minimum of these products should be required after the war, and with curtailment in their manufacture workers now making them will shift to other industries. Assembly of certain ammunition components is a perfect example of the work first considered essentially suited to women—the handling of very small units, requiring deftness, precision, and patience. This included the putting together of percussion elements, primers, boosters, booster cups, and fuzes in many varieties and sizes. It is probable that hundreds of small operations are needed to complete these various parts.

Work on mechanical time fuzes may be taken as an example of processes women were performing. One of the Government arsenals inspected by the Women's Bureau in 1941 reported 96 percent women in the mechanical-time-fuze department, where 3 years before only 2 percent were women. It is interesting to note that many women for such operations were recruited from needle-trade occupations, where their abilities had been developed in fine embroidery.

A mechanical time fuze is made up of more than 100 parts varying in size from a fraction of an inch to several inches. All the sub-assembly work is concerned with tiny parts and employs women almost exclusively. The assembly of the movement is divided into progressive steps similar to those of building up a watch or small clock. Much of the work is intricate; small tools are used—tweezers, files, screw drivers, hand drills, and others—and some of the assemblers wear a jeweler's loupe (eyeglass). Operations include the inserting of wheels

and movement parts; screwing, staking, and peening (drawing, bending, or flattening) subassemblies in place; setting escapements, firing pins, firing arms, and testing their action. Finally the movement is fitted into the fuze case.

In the making of small arms, assemblers were not a major occupational group; they composed only 2 to 5 percent of the workers in the plants. Women constituted 8 percent of the assemblers in plants inspected by the Women's Bureau in 1942, and the plant employing them on the widest array of assembly work had 17 percent. Women could do most of the small-arms subassembly and much of the final assembly, depending on the weight of the weapon.

In several Canadian gun and rifle factories visited by the Bureau in January 1942, half the assemblers on shoulder rifles were women, and it was expected that eventually women would comprise three-fourths. They were doing subassembly on machine guns and were beginning to work on final gun assembly with satisfactory results.

A United States plant making naval torpedoes was inspected in the summer of 1943. Here women were doing most of the assembly, which was fairly complicated. One person put together the entire front part or the entire after-body, including all the mechanism. Women were learning the complicated assembly of the gyro, which demands great precision. They were taught to work with considerable independence and responsibility.

### Electrical Assembly.

As has been mentioned, the nature of electrical assembly involves characteristic processes some of which are quite different from those required in the fitting together of metal parts. Others, such as welding and riveting, are fairly similar in metal and electrical assembly. Coils and armatures must be wound; electrical connections must be prepared, wire insulated and connected with complicated instrument systems. Many of these are operations that long have been performed well by women.

Furthermore, electrical-assembly work cuts across the various industries that have been discussed, and others also, as well as occurring in the more specifically electrical industries themselves, such as radio, batteries, generating appliances, communications equipment, and so on. At least some parts of great numbers of products are actuated by electricity, as machine tools, automobiles, ships, and airplanes. In other industries there are shops where electrical repair or maintenance work is done, as in steel mills and foundries. In establishments visited by the Women's Bureau, the work forces in these departments frequently had larger proportions of women than those in the plant as a whole. Often the work the women did was decidedly skilled.

In October 1939 women were a third of all wage earners in the inclusive Census group "electrical machinery" and by February 1944 Bureau of Labor Statistics estimates considered them to be nearly half. As already noted, assemblers were 47 percent of all women in electrical plants visited by the Women's Bureau in a 1942 survey in a large industrial State, and 92 percent of these were doing work that had been done by women before the war.

Most of the chief branches of the electrical industry were covered by two studies of the Bureau of Labor Statistics, one in August 1937, the other 5 years later (9). Comparison shows some increase in the

utilization of women: They comprised a little less than half of all assemblers in the early study, more than half in the later. While in 1937 no women were classed as skilled, in 1942 they were nearly a fourth of Class A bench assemblers. The proportion of all assemblers who were women varied considerably in the different branches of the industry. In 1942 they were approximately as follows:

<i>Industry branch</i>	<i>Percent women among all assemblers reported</i>
Electric lamps and radio tubes.....	100
Insulated wire and cable.....	79
Electrical measuring instruments.....	79
Wiring devices and supplies.....	78
Electrical appliances.....	68
Carbon products.....	66
Communications equipment.....	62
Radios and phonographs.....	52
Batteries.....	47
Generating, distribution and industrial apparatus.....	34
X-ray and therapeutic apparatus.....	23

Core and coil winding may be considered a part of assembly and in the 1942 study women were two-thirds of all reported on these jobs. They were more than half the solderers, but less than a fifth of the riveters and welders.

An important electrical industry that since its earliest days has been a large employer of women is the manufacture of radios. A Women's Bureau study of this industry in 1929 found one plant in which 84 percent of the women hired during the year were put on assembly work, in contrast to 33 percent of the men so placed. This does not represent the proportion at any one time but is a rough indication of the work done by men and women. Large numbers of women, many more than men, were hired for the assembly of sets, receivers, speakers, condensers, and transmitters. Only as assemblers of consoles and cabinets were the men hired in this plant outnumbered by women (10). In the more recent study, made in the summer of 1942 by the Bureau of Labor Statistics, women were more than half of all assemblers, though none were reported as skilled bench assemblers, or as floor assemblers of any grade (11).

Recent visits to electrical plants have found women doing bench work—assembling small parts of thermostats, wiring and soldering elements, and armature winding. In one plant making communications equipment, the majority of the assemblers were women. In another making motors and generators the work was subdivided so that one group of girls put brushes, screws, and rings on the lower part of rotors; they were then passed to another group who inserted two bakelite panels in the upper part and a metal partition through the middle; the third group fitted the rotor over a bakelite insulator. Men put on the final heavy cage.

Women in the electric shop of a steel mill did assembling on A. C. motors. In another they took apart and reassembled small motors, being classed as helpers. Even in a plant making guns, howitzers, and mortars, visited in November 1943, women in an electrical-assembly department worked on small mechanisms, cables and harness, connecting, soldering, and so on. Some made cables of different sizes and types. Some assembled an entire small mechanism, using a special type of blueprint easy to follow. There were 75 different types to be assembled, so work was not repetitive.

In shipbuilding, considerable electrical assembly is required, and women work on fittings for electric-wiring systems, conduit pipes, lamps, and small switches, and repair and assemble telephones. On board ship they are helpers to the electricians who install switches, lights, telephones, instruments, and fuse boxes. In one yard a woman was reported as able to make the entire telephone installation, with another woman as helper. She had learned to read engineering blueprints and could make all installations from the print. In another yard women were doing electrical wiring, working from simplified blueprints or drawings.

In aircraft production, among the first occupations thought suitable for women were some of those in the electrical workroom. These include wiring and assembly of switch, junction, and jack boxes, work on the instrument panels, and a great variety of other processes. Sometimes parts needed reworking to insure an accurate fit. Most of the work in the electrical, radio, and instrument-panel divisions requires manipulative dexterity of a high degree, and these divisions were among the first to offer new opportunities to women. In 1942 the Women's Bureau found women working on the assembly and preparation of electrical systems—cutting wires, attaching fittings and lugs with screw drivers, arbor presses, and soldering wire to contact points. They were laying out wires on routing boards or jigs, bending them around pegs until a complete harness was assembled. They laced groups of wires together, gave them a protective cover of shellac, and installed them in conduits; soldered on lugs, and attached designations for the final assembly into the plane. The definition of a single type of electrical assembly in the aircraft industry as given in the Dictionary of Occupational Titles (Supplement, Edition II, July 1943, p. 83) gives an idea of the various operations that may be involved. The operations may be subdivided.

\* \* \* measures and cuts insulated wires of a specific size and kind, using a wire cutter or pliers; tapes fittings on the ends of the wires; threads the wires through conduits and solders the ends to a plug; laces together the wires protruding from the open end of the conduit; wires parts, such as switches, meters, light sockets, and terminal panels, using an assembly sketch as a guide; attaches fittings to junction boxes, using nuts and bolts, inserts wires through openings into box and connects them to specific parts; connects wired junction box to testing apparatus and verifies wiring by connecting the box to testing lights.

A western aircraft plant put 25 women—the first hired—on electrical and radio assembly in the early spring of 1941. In 3 weeks the units produced per week increased by 25 percent, some even by 50 percent. Women fitting 63 different wires into a junction box cut the time from 2 hours to 90 minutes. In this plant a fuselage frame starts down a powered conveyor line. As it passes the various stations, girls install throttles, controls, instrument panels, and so on. Nowhere does a man touch it (12). In the electrical department of another aircraft plant the Women's Bureau found that about 60 percent of the workers were women, who were chiefly sorting, splicing wires, assembling parts, and making installations. On a visit to this plant a year later, it was stated that women's work was not distinguished from men's except that women could not hold jobs that required lifting.

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The instruments used on airplanes to control their engines, such as tachometers, manifold pressure gages, and electrical thermometers, are dependent on electrical transmission for their indications. In plants visited by the Women's Bureau as early as 1941, women were employed on much of the work of making these instruments. They were doing part of the winding of armatures, field coils, and stators; coil taping and forming; assembling armatures and commutators; soldering and connecting wires; and other electrical operations.

At an airport visited in November 1943, women in the shops did a great variety of light bench work, assembling radio harness for planes, soldering, and so on. Some six or seven new electrical harnesses are made for each plane, and women do a great variety of small assembly on them.

Machine-tool making involves some electrical work, such as the wiring and installation of motors, switch boxes, and electric panels. Of 15 such plants inspected by the Women's Bureau in 1942, 8 employed women on production and 2 of these used them for electrical assembly. The work of these women consisted of wiring panel boxes, soldering, cutting wires, attaching wires to terminals, and similar bench operations. A third company planned to put women on panel wiring soon. Work tables with pigeon holes had been constructed for the various parts to be used, and the women were to follow numbered diagrams that had been broken down and simplified by the engineering department.

In another machine-tool plant visited in 1943 women were doing electric-panel-board assembly exclusively and were considered better than men ever had been. Management would like to have women on this work after the war. At least one electric panel board is assembled for each machine made. The boards are a little different for each, but there are some similarities and panels fall into four general types. The girls followed blueprints at first but had learned to work so well that usually they could get along without them.

## INSPECTION

Most types of manufacture provide for inspection of the product, usually at various points in the manufacturing process. This is a prominent feature, for example, in the metal-goods and machinery industries, where greater and greater precision is demanded in the product. Parts must fit accurately in order to function according to the high standards required. Parts also must be interchangeable, so that replacements may be made from stock on such equipment as machines or automobiles. This precision is secured by inspection at various stages of production, which may involve merely looking at the part for obvious defects or may require exacting measurements for variations from required dimensions of not more than one-thousandth, or perhaps a ten-thousandth, of an inch. With the trend toward greater accuracy, there have been perfected measuring devices so largely automatic that some inspection processes are quickly and easily learned. This trend also calls for more inspectors, whether men or women, in relation to workers on production. Besides inspection at various stages of production, examination is made also of parts that may be shipped in from other plants for use in a more complete assembly.

Testing is a form of inspection. It may involve determination of certain qualities, such as hardness of a piece of metal. It is often the trial of a completed mechanism to see that it functions as it should. A very simple form of testing is to screw an electric light bulb into a socket to see whether or not it will burn. Very elaborate tests are made of airplane engines by setting them up and running them in a testing cell, keeping watch of various gages and making careful records of performance. Such a test may take 4 to 5 hours.

### Inspection as an Occupation for Women.

The report of women's employment made nearly 40 years ago—in 1907 and 1908—shows that women were engaged as inspectors at that time. In the making of incandescent electric lamps, women even then comprised about four-fifths of all workers. They were testing carbons, filaments, coil testing, and doing the final inspection. The report states "The operators engaged in this inspection must have a great deal of experience and judgment \* \* \*." They also were inspecting bolts and screws, type, tin plate, cutlery, gun barrels, and parts of locks. Of the last named the report states, "This is exacting work, since the inspector must note and reject imperfect parts for the most trifling error." In can factories women were testing finished cans for leaks (13).

During the First World War, women's employment in the metal industries increased greatly and they were substituted for men as inspectors as well as in other occupations. The description of their work is not unlike a present-day description: "Here very often parts have to be accurate to the thousandth of an inch. Women employed as inspectors had to learn how to use gages, read micrometers, and vernier calipers. Many learned to read blueprints and to use the Scleroscope (for testing hardness)." Women were reported as replacing men inspectors in 27 different industries. About two-thirds of the firms reporting on the relative output of men and women declared women to have been as fast or faster than men. One firm stated that its records showed women to have turned out 20 percent more than men on 3-inch trench-mortar shells. Of the firms describing conditions in 1919, over 70 percent had continued to employ women for inspection (14).

One-sixth of the women employed in over 125 plants, in a large industrial State surveyed by the Women's Bureau in 1942, were inspectors or testers. Three-fourths of these were doing what had been women's work before the war, about 15 percent were replacing men, and 11 percent were on work new to the plant. Inspection as an opening for women varied in importance by industry, as the following shows:

	<i>Percent of all women who were inspectors and testers</i>
Metal parts, small.....	38
Aircraft engines and propellers.....	31
Plastic products.....	28
Ammunition, gun parts, and other ordnance accessories.....	24
Machines and machine tools.....	23
Instruments, professional, scientific, and other.....	22
Rubber products.....	13
Electrical products.....	11
Chemicals and drugs.....	4

While inspection was a new occupation for all the women reported in aircraft parts and chemicals and drugs, it was a prewar occupation for all in plastic and rubber products (15).

Officials interviewed by the Women's Bureau often speak of inspection as being well suited to women if parts and gages handled are not too heavy. The foreman in a machine-tool company reported that women picked up the work faster than men, followed instructions better, and were more careful in making precise measurements and checks. In aircraft plants women inspected small parts and castings for defects and tested for hardness. Foremen stated that men were apt to become bored with this type of work and that women were more satisfactory. In one aircraft-parts plant women were replacing men on highly skilled inspection work and were very successful. According to the superintendent of inspection, women at the end of a 3-months' training period were the equal of men with 6 months' experience.

### **Training of Women Inspectors.**

Women's Bureau studies of war plants show some of the policies regarding on-the-job training. In one plant women were learning to be inspectors while doing some productive process. These usually were short runs of different kinds of work. A girl would learn to use one gage applicable to the work in progress; the next run of work might require another type, and thus the girl learned the various types gradually. Under a similar system in another plant women were receiving the kind of training that would make them all-round inspectors. Rarely were as many as 200 parts of one type made. This plant considered women most skilled and most useful as inspectors. In a third plant a combination method was found suitable. Women who disliked to change were allowed to learn one type of inspection and could achieve great speed, which was a valuable asset. Others who would find the repetition monotonous were taught the different methods. Their versatility made them equally useful.

In one of these plants women taking the inspection course attended 6 hours a week for 12 to 14 weeks. They learned blueprint reading and the use of all precision instruments, and acquired an understanding of shop processes. As to details, they learned the tools used in setting up work for inspection, such as plates, squares, and protractors of various kinds; several different kinds of micrometers, some 20 different kinds of gages, dial indicators, and comparators. Most of the students in these classes were women.

During the second half of 1943 and the first 4 months of 1944, nearly two-thirds of all persons enrolled in the Government classes for inspectors' supplementary training were women. About 5,150 of these were in aircraft plants alone, some 8,500 in all other industries.

### **Systems of Inspection.**

Inspection may be delayed until the product is finished, and this would be a suitable method for a very simple article. Usually, however, it has been found more and more necessary to make frequent checks at various stages of the work. This is especially true when many parts are brought together to make a finished whole. All must meet the standards set up by the engineers or they will not fit together and adequately serve their purpose. Inspection saves time and mate-

rial. If a deviation from standard is caught at the right moment it may be corrected. Inspection may show faulty working of some machine, which if not adjusted would result in a continued production of scrap and a waste of the machine operator's time.

Under a customary system in plants visited by the Women's Bureau, inspection starts with machine operators who do some checking on their own work. General or roving inspectors make spot checks at the machines. Then final inspection is done at benches or on a line. A variety of gages are used.

In the aircraft plants, women inspectors in 1942 were engaged chiefly in checking to order specifications such incoming purchased parts as valves, rivets, bearings, and clamps. They inspected small castings for internal defects, using Magnaflux testing equipment, and tested the hardness of metal on Rockwell, Brinell, or Scleroscope testers. During fabrication, forming, and assembly, inspection is continuous, and women were employed in departments where they constituted a substantial part of the group, such as in the fabric, electrical, and tubing sections. By the spring and summer of 1943 there had been a great increase in the employment of women in the inspection of aircraft parts.

In machine-tool factories studied in 1942, the organization and arrangement of inspection differed from plant to plant. Women were doing in-process inspection, and a few made the final inspections of small parts. Most read blueprints and used a variety of precision instruments. Some plants had inspection centers where any work done in a department was thoroughly checked before being sent on for further processing. The line or general inspectors, employed on the floor by some companies to go through the departments and check on any work that appeared to need it, usually are highly skilled workmen capable of doing any kind of work, and no women were so employed.

Inspection that keeps pace with other processes is well illustrated in the work on percussion fuzes and powder-train time fuzes. For one of the more complicated types, 38 operations are listed, including machining, assembly, and five inspections of parts or of assemblies, done in many cases by women. In the making of barrels for small arms there are 41 principal machine operations. In this sequence there are over 30 inspections, including visual, gage, and Magnaflux, hardness testing, and inspection of line straightening. Women participated in most of these.

A typical large plant making automobile accessories, electrical equipment, and radios both before and during the war, formerly placed great reliance on final inspection. War demands for increased exactitude and speed developed the system of full inspection of parts at every step—10 percent spot checking on minor dimensions and 100 percent on major and critical ones. The inspection staff has been increased to more than 6 times its former size, though the total force is only something more than double the prewar force. For detail inspection at benches, the company has long employed women on small parts where delicate finger touch is an advantage.

At the head of the system for securing precision in this plant is the set-up inspector—a man seasoned and expert. He devotes his whole time to first samples of parts coming off a machine, checking them according to the operation lay-out sheets and blueprints involved, as

prepared by the tool lay-out engineers. When he tags a part as correct it is turned over to a floor inspector with instruction as to what to look for. As a rule each floor inspector checks on the output of 25 machines and is responsible for seeing that parts produced are of the quality approved by the set-up inspector. When qualified men floor inspectors left to enter the services women were trained to replace them with very favorable results. When gages are light they have been found most capable (16).

### Skills Required in Inspection.

It can be seen from the discussion of training and of inspection systems that the skills required vary greatly with the product, the type of set-up, the degree of subdivision, and so on. Some types are simple repetitive operations that demand but little judgment. Many gages and testing appliances are simple and quickly learned. Some plants keep women on one type of appliance exclusively, others introduce them to the use of several, often a considerable number. Illustrating work that was relatively simple, though fatiguing because very fast and monotonous, is the inspection by women of belt links for ammunition. They sat beside a rapidly moving belt piled with links. Each woman took off as many as she could inspect. Any that were missed passed the line of workers again. Each link was placed over a small gage. If defective, a red light flashed. After the belt was installed, the women had to learn to look above and not at it. Individual records showed 15,000 or 16,000 links inspected in 8 hours, with one unusual record of 20,000.

Other kinds of inspection follow an involved process that places a great deal of responsibility on the worker, who must have considerable experience. This is especially true of certain testing operations. An example is the work of women in two small-arms factories, inspecting gages used in checking on the plant product. Since the accuracy of the products manufactured depends on the correctness of the gages and dies, this work requires great care and skill. Also necessary is a certain knowledge of mathematics, and use of a wide range of measuring instruments. Typical of the devices used in this work were optical comparators, shadowgraphs, Carl Zeiss toolmakers' microscopes, Pratt and Whitney supermicrometers, vernier height gages and depth gages, calipers, micrometers, Rockwell hardness-testing machines, and Johansson gage blocks. Gage inspection was done by women in some cannon factories also. Only college graduates were employed.

An even heavier responsibility rests on a group of some 60 women who work in New York City as inspectors for the gage division of the Inspection Board of the United Kingdom and Canada. They inspect the gages that are used in the checking of all munitions for the lend lease program to insure interchangeability of parts. They use precision instruments that measure within millionths of an inch. In recruiting women to be trained for this work the board looked for college and university graduates with an "analytical mind" who had majored in mathematics or physics. The first four began their special training in January 1941. They are still at work. The first-class technical assistant in charge thinks these women are less like "prima donnas" than most men doing the same exacting work.

Calibration of instruments is a responsible job done by women, and covers testing, adjusting, balancing, and measuring their performance

according to definite standards. Calculations and computations may be necessary and the calibrator of the more intricate instruments needs a working knowledge of mathematics and the principles of physics involved. In all but one of the plants visited by agents of the Women's Bureau only men did this work. In the one exception a woman was calibrating suction gages, which are among the simpler instruments. In the making of gyroscopic instruments women were doing practically all the testing on the smaller rotors, including testing of spring tension, making run tests to ease parts, and vibration tests to detect the slightest friction in movement.

In one plant manufacturing fittings and castings and doing precision work, intelligent girls with a better-than-average education were selected to make final inspection tests. They checked all parts in operation, doing any necessary adjusting with hand tools. They then figured out various test problems to check the use of the instruments.

Another exacting type of inspection in which women participated to varying degrees in several plants visited is in the testing of aircraft engines. The engine is set up, with propeller attached, in a testing cell. The operator or operators direct and watch the "test run" through the window of an adjoining room. There is a control panel with as many as 79 instruments, most of which are similar to those on the instrument panel of large aircraft. The engine is run at different speeds, and acceleration, idle, and dive tests are performed. Pressures and temperatures are observed and recorded; fuel and oil consumption under various conditions, and operation under various propeller settings and speeds, are checked. The operator who is working alone must watch the engine and the panel board, make calculations, and keep records (17).

After an aircraft engine has been tested, it is disassembled and all parts are given close inspection for flaws, signs of wear, and failure to function or possibility of such failure. In a plant where men had always done this work, a few women had recently been employed and a new group was being trained.

In the engine plants women were found doing the computing for the log sheets, using a slide rule. In one plant testing was done by a team of a woman and 1 or 2 men. About 80 girls were so employed. Usually they learned the work in about 2 months. In another plant where women were operators in the test cells, they did practically all the work but ordinarily there was 1 skilled man with every 6 women. At an air station where engines are tested after flights, a woman operator works alone and is entirely responsible for the engine. Another operator in the same space and testing another engine may act as relief, since tests take from 5 to 8 hours.

## OPERATION OF MACHINES

The war industries make extensive use of metals, and their fabrication into the various required parts includes shaping by means of machines or hand tools. The chief machines for shaping metal products by the removal of particles of the material, known as machine tools, are milling machines, drilling, reaming, and honing machines, gear-cutting machines, broaches, grinders, and automatic, engine, and turret lathes.

Such equipment is produced in a great variety of types and sizes. Each machine may be built for either of two purposes: (1) To perform various operations on miscellaneous pieces or (2) to perform the same operation or operations on quantities of one piece. The first type is for short runs, is extremely flexible, and ordinarily is operated by a skilled machinist. The second kind of machine is for mass-production purposes, and often has groups of tools working at the same time; it may be partly or fully automatic, so that the operator has only to load, start, stop, and unload it. Besides machine tools, other common metal-working machines are punch presses for punching holes in stock or for cutting small parts out of stock, and forming or stamping machines or presses for shaping metal parts.

The proportion of all workers who operate these diverse machines varies with the product. Factories assembling airplanes and automobiles from purchased parts will have relatively fewer machine operators than plants that make the smaller parts or the entire product from the raw materials. In the machine-tool plants studied by the Women's Bureau, about half the men and nearly two-fifths of the women were in the machining units, most of them operators. In the making of small arms, nearly two-thirds of all factory employees worked on machines.

In aircraft-assembly plants not more, and usually less, than 10 percent of all employees are in the machine shop. Bureau of Labor Statistics studies show that in 1940 13 percent of all employees in automobile manufacture were machine-tool or punch and press operators, compared with about one-fourth of those in automobile-parts plants. Bureau of Labor Statistics studies of the manufacture of aircraft parts show that about one-fifth of the workers on the first shift operate such machines (18).

An example of the extent to which machine operation is necessary in metal fabrication is the making of the 30-caliber Browning machine gun (air cooled). This has 189 parts, with 1,800 separate machine operations. The large amount of metal that must be removed by gradual machining is shown in the work done on a number of the parts. The raw stock and forgings for one type of gun weigh 100 pounds, the finished steel parts only 18 pounds. Among the major components are the gun-body forging, weighing 45 pounds in contrast to the finished gun body's 5½ pounds, the barrel forging weighing 10 pounds and the finished barrel 6, the slide-butt forging weighing 22 pounds and the finished slide butt 4.

### Women as Machine Operators.

Though the number of women operating machines in metal-goods plants has increased so greatly during the war, this is by no means a new type of occupation for women. In the early survey of 1907 and 1908 it was stated that "a very large proportion of women employed in this group of industries are working as machine operators \* \* \*" (19). Some of the machines particularly noted, with the product worked on, were as follows:

Brass ware and other metals.....	Foot and power presses. Stamping presses. Drill presses.
Cans and boxes, tin.....	Punch presses.

Clocks and watches.....	Automatic screw machines. Lathes. Drill presses. Milling machines.
Hardware.....	Power presses. Dial presses. Milling machines. Lathes. Automatic screw machines.
Nuts, bolts, and screws.....	Cutting machines. Nut tapper (drilling operations). Punch presses.
Stamped ware.....	Forming presses.

A study of the position of women during and after the First World War revealed that more than four-fifths of the women substituted for men in metal-working industries were put on machine processes fairly similar, in occupation if not in method, to those performed today on metal work (20). Women were very successful, and well over half of the firms reporting had retained women on each type of machine in 1919, as the following shows:

<i>Machines</i>	<i>Percent of firms retaining women in 1919</i>
Gear cutters and shapers.....	86
Grinders and polishers.....	69
Milling machines.....	68
Drill presses.....	66
Punch presses.....	59
Lathes.....	57

Every one of the firms employing women on milling in this World War I survey reported favorably on their work. One element entering into their success undoubtedly was the fact that the parts being processed usually were small. To set up work correctly in milling machines requires considerable skill, though to operate the machine after it is set up requires little. Some women were able to set up their machines and grind the tools after a month's practice, some took as much as a year. Three firms keeping actual output records found that women averaged more than men on identical work.

In the First World War more firms substituted women on drilling than on any other occupation. Most of the work was done on light and medium machines having from 1 to 16 spindles. Not only were holes rough-drilled, but they were reamed to overcome drilling defects, tapped to produce internal screw threads, counter sunk and counter bored to enlarge the upper end or to form a shoulder at the lower end. The great majority of the firms reported that women were more attentive and conscientious than men. Some of the women put in their own tools and ground them. Figures as to output on identical work under the same conditions were secured from 3 firms. In 2 of the 3, women's output exceeded men's.

The lathe performs a greater variety of processes than does any other machine, and on the whole operating a lathe calls for greater ability and judgment. More than two-thirds of the firms surveyed after World War I reported women's output on lathes as equal to or greater than men's. Their success is all the more significant because, compared to other kinds of work, they had failed most frequently in this due to lack of experience or to insufficient strength. In a list of 10 lathe operations performed by women on shells they had learned

on 6 to set up the work, test the cut, grind the tools, shift the belts, and clean the machine. Of 20 firms reporting on the relative production of men and women on turret lathes, 5 stated that women produced as much as men, 5 that they produced more, and 10 that they produced less.

When only a small amount of metal must be removed to bring the work to correct measurements, or when a smooth surface is wanted, it is ground or polished. Also, there is much grinding or sharpening of tools in connection with all machine-shop work. An employer using women to grind the bores of cylinders said, "Women have better eyes for symmetry." In one establishment a woman on automatic saw grinding operated 14 machines, a man with longer experience 5. In another plant the average output of women on rough and finished tool grinding was nearly twice that of men. A firm that reported a smaller output for women than for men on polishing stated that the quality of work done by the women was better (20).

A State survey in 1942 covering more than 125 war plants reported that over one-tenth of the women employed were operators of machine tools or of punch and forming presses. It is not surprising that the proportion was considerably greater than this in certain industries, as appears in the following:

<i>Industry</i>	<i>Percent of all women who were machine-tool or punch- and forming-press operators</i>
Machine and machine tools.....	29
Aircraft engines and propellers.....	27
Instruments, professional, scientific, and other.....	18
Ammunition, gun parts, and other ordnance accessories.....	17
Metal parts, small.....	16

It is of significance that larger percents of the women at work on the punch, forming, and drill presses had been similarly employed before the war, though certain other machine occupations reported were new to women in the plants studied.

<i>Occupation</i>	<i>Percent of women on prewar occupations</i>
Punch- and forming-press operators.....	67
Drill-press operator.....	41
Lathe and screw-machine operator.....	25
Grinding-machine operator.....	9
Milling-machine operator.....	7
Gear-cutting-machine operator.....	None

The New York Department of Labor made a survey of the replacement of men by women in the first year of United States participation in the present war. Data were secured from reports of plants that were granted relaxation from State labor laws in connection with war production (21). Of the plants reporting substitution of women for men, almost half were manufacturing iron and steel and other metal products, machinery, and transportation equipment. The proportion of plants that had replaced men with women on the chief machine processes was as follows:

<i>Occupation</i>	<i>Percent of plants that replaced men with women</i>
Drill-press operator.....	33
Filer, grinder, buffer.....	15
Milling-machine operator.....	17
Lathe operator.....	17
Punch-press, power-press operator.....	12
Screw-machine operator.....	7

The extent of women's employment on machines in a mass-production industry is illustrated by the Women's Bureau survey of small-arms manufacture in 1942. Women were about one-fifth of all machine operators in the factories inspected, but their utilization varied greatly from plant to plant and department to department. They were 6 percent of the workers in the lathe and screw-machine departments, though not all operated machines. In some machining departments the proportion of women ran as high as 60 percent; yet one plant had no women so employed. In one plant almost 80 percent of the drill-press operators and 30 percent of the milling-machine operators were women. Three plants employed women extensively on turret, engine, and bench lathes, while two others had no women on such work. One plant had 21 percent women in its barrel-machining department, where they operated milling machines, engine and automatic lathes, drill presses, grinders, broaches, reamers, and other specialized machines.

### **Training for Machine Operation.**

Women, ordinarily not familiar with machines, need more training than men for some of these operations, but they are quick to recognize this need. Instructors state that women bombard them with questions, and demand more attention on their training projects. They are much more meticulous in following detailed instructions, and are less likely to slur over or pass up specifications.

Training for machine operation in general includes learning the names of tools and parts of the machine, care of tools, reading of blueprints, and use of measuring instruments, as well as the actual operation of the machine, often of a number of machines.

During the 10 months ending April 30, 1944, some 33,600 employed women had enrolled in supplementary classes for machine-shop practice, more than a third of all such trainees. In addition, about 7,000 women were in training as aircraft mechanics (maintenance) or automotive mechanics and outside or marine machinists.

A report made by the supervisor of training in a New England school as to women's capabilities in such instruction is typical—that the women listened more carefully than men to instructions and were more painstaking in their work. They were slower than men at first, but their spoilage was less. He stated that women were able to work to close tolerances in a very short time.

### **Skills Required for Machine Operation.**

The basic metal-working machines cannot be listed in order of ease or difficulty of operation, since this varies according to size, type, and so forth. The most complicated machine, requiring the greatest skill to set up ready to operate, may be the most automatic, the most easily learned, and the simplest to run.

In mass-production industries a machine setter selects the proper tool, which has been sharpened; fixes it in the machine; and adjusts the machine for the work in progress. Often an indicator is set to determine the point at which the process is to be stopped. The machine operator then takes hold. If quantities of the same piece are processed, the run may keep her busy for a day or two. She has merely to load and unload the machine, to start and stop it. Under this arrangement an operator may run 6 to 8 machines. It may be more practical to keep the worker—whether man or woman—con-

tinuously on the one type of operation, and there may be no economic advantage in teaching the setting up, tool grinding, and so on. The operator may, however, make spot checks of the dimensions of the parts as they are finished. In small-arms manufacture, the usual practice was to have machine setters for all machines.

*Simplification of Machine Operation.*—Various things can be done through planning and design to simplify work for the operator. As one executive has said, "Owing to development and design, the machine tool now does the physical work which formerly was done by the operator. The machine tool has within itself the precision and the power needed to get the job done. All that the operator has to do is to have the intelligence and the dexterity to operate the machine." It was pointed out in connection with a precision grinding operation that it is the machine that is precise.

In some machine-tool plants, good tooling has replaced individual skill. In one case, for example, the inside chasing of threads was eliminated by standardizing the thread and size of hole and then buying 4 or 5 expensive taps by which the job could be done with much less skilled attention. A woman operating a rifling machine had to perform 32 separate operations, but the company had developed a system of laying out the cutters and tools to be used, in proper order; also tools were correctly ground for the work.

*Proficiency of Women in Various Machine Operations.*—There is plenty of evidence in Women's Bureau reports that women are doing some of the skilled preparatory work—the set-up, selection of tools, their grinding, and so forth—and working to blueprint specifications rather than with dimensions automatically governed by the machine. Women have demonstrated ability for independent work. For example, in the toolroom of one large plant visited, 8 women were grinding cutters and taking care of tools, 1 was repairing dies and was learning to make them. The women were improving steadily, but it is obvious that in work that requires a considerable training period for any new employee, they would have to be there from 9 months to a year before they would be really useful. In the same plant two women were learning to do skilled machine repair. In one small-arms plant the largest single occupational group of women, aside from inspectors, were those in the toolroom, where 40 percent were women. The toolroom force for all plants was 11 percent women. They were most frequently making cutters, reamers, end mills, gages, and drawbars. Some women were setting up their own machines and more were learning this part of the work. In another plant women in the tool crib sharpening tools did as good work as any man. Two had been there a year and needed no help of any kind.

In the machine shop women were placed on the less complicated machines. However, they were not mere routine workers but had learned blueprint reading and set-up on the job so that they could take increasing responsibility. On turning precision bearings and hand wheels, women made better records than men and earned more production bonus, and at least one was doing her own set-up work. Some women on precision grinding were working to one or two thousandths of an inch and checking their work.

*Operation of More Than One Kind of Machine.*—Even where work is simplified, more skill is required if the operator is shifted from

one machine to another. Whether or not this is done depends chiefly on the demands of the work. Toolrooms for maintenance of plant equipment are far more likely to shift workers from machine to machine than are departments doing machining of the product. Having one person run more than one machine was a rather common practice in small-arms plants. Either a series of operations was performed on one part, using one machine at a time, or concomitant operations were performed by keeping all machines going at once. Where several machines are operated at one time, the speed is not so great and the machining cycle is longer. Examples of combinations of machines operated both by men and by women are as follows:

Cincinnati power mill No. 0-8, hand mill, and drill press.

Brown & Sharpe mill No. 000, 3 machines operated by one person.

Fellows gear shaper, 3 machines operated by one person.

Cincinnati mill No. 1-12 and a drill press.

Automatic profiler and a drill press.

Natco drill (multiple spindle), Leland Gifford drill, and Cincinnati mill No. 0-8.

Hand mill, bench profiler, and two Cincinnati mills No. 0-8.

Pratt & Whitney profiler and 3 hand mills.

Two hand mills and one Milwaukee mill Model H.

Progression in machine operation for women in aircraft-assembly plants appeared often to be from jig drilling to sensitive drilling; when the operator had attained skill in sharpening and changing her drills, if she worked in a production shop she might be upgraded to operating a milling machine. In a plant making many small parts for aircraft engines, a girl who became bored with a monotonous job could be advanced to more complicated machines or more skilled inspection. In upgrading women it was found that it took about 4 months to make a hand screw-machine operator and about a year to make an all-round grinder.

*Grinding Processes Numerous in Metal Work.*—In a survey of machine-tool plants women were found employed to a greater extent on grinding than on any other kind of machining, though much of it was precision work done to very close tolerance. They do all kinds of grinding such as magnetic, chuck and surface grinding; centerless, internal and external grinding; tool grinding, and so on. In one plant women grinding involute cutters and gears operated two machines each. They performed their own set-up and dressed their own wheels. It had taken them about two months on the job to learn the set-up work. In the same plant a woman grinding tapers on shanks was doing her own set-up work and was allowed practically no tolerance, according to a company official. In another plant several women who were form grinding also set up their own work. Each new set-up had at least to be checked for every tool ground, and the tolerance allowed was but .0002 inch. In another factory women on surface grinders were at first allowed a tolerance of .0005 inch but later were upgraded to more difficult work on which they were permitted only .0002-inch leeway. One of them, employed only 10 weeks at the time of the survey, already was performing a complicated set-up involving compound angles and requiring the use of sine bars and Jo blocks.

Women grinders on small parts in aircraft-assembly plants were able to follow blueprints, measure with calipers, micrometers, and scales, dress their grinding wheels if necessary, and generally follow

work specifications. Dressing the grinding wheel involves cutting the worn wheel to true the surface. The wheel is mounted on a power-rotated spindle and the surface cut with a diamond-pointed cutting tool (22). Where it was customary for drill-press operators to change and sharpen their own, the women usually were doing this. A few women had full-time jobs dressing the points and grinding the cutting surfaces of drill tools to specified angles and shapes.

*Many Machine Operations Require Special Skills.*—In the machine-tool industry, a great many operations that need special skill and accuracy remain even where process simplification has been accomplished. Though women have been in such plants for only a relatively short time, they already were doing accurate work on jobs requiring, for example, machining to a tolerance of .0002 inch, or a fifteenth part of the diameter of a hair. Where small lots were common, some women already were learning the setting up of their own machines in 6 of the 8 plants having women on production work. One of these had no special set-up men, since women were expected to set up all the machines they operated.

In one plant they were cutting the teeth on broaches on fairly large lathes. They were required to read blueprints and mark out their own work. Each type of cutter on which women were engaged had a different pitch of teeth, so they had to be able to mark out numerous kinds of work. In one of two plants employing women on gear cutting, each operated two to five machines and did her own set-up work.

Machine operators had to be somewhat more versatile in the manufacture of cannon than in some industries, shifting from one type of work to another, since there is not a great volume of production of parts of any one kind. Women did this as well as men, including the setting-up of machines. Machine operators checked their own work with calipers, micrometers, and fixed gages; sometimes they did filing and burring of parts. The extent to which they filed or burred depended on the machining cycle and the number of machines operated.

A few women in the maintenance machine shops of steel mills were operating lathes, drill presses, milling machines, shapers, and grinders. In several plants they were doing part or all of their own set-up work. In at least two plants each worked on a number of machines. In one plant a woman in the carpenter shop running an automatic sharpener worked on all kinds of saws. She learned the work more quickly than the men and did better work.

Workers must be experienced, skilled, and mechanically minded in the instrument field, and for this reason at first women were received very slowly as machine operators in this industry. However, some women worked on small machine-drills and punch presses, milling machines, lathes, and so forth. In two instances women milling operators made their own set-ups. On certain processes the quantity and quality of workmanship was reported as about the same for men and women.

Dental burrs and broaches are manufactured in about 150 styles and are made almost entirely by women, who were straightening, cutting, and inscribing the trade-mark on wire used as raw stock. Semiautomatic and automatic machines are used for forming the ends of burrs. Broaches are ground and tapered on fine carborundum wheels and bars are cut on a special bench machine. The operations are checked under a microscope.

### The Problem of Heavy Work.

Machine tools range in size from those small enough to mount on a bench and weighing only a hundred pounds, to giants that stand as high as a three-story house and weigh several hundred tons. Many of the machines used in making cannon have beds over 200 feet long. In general the large machines are for the processing of large parts. There is the weight not only of the stock but of the jigs and fixtures to be considered. On some machines considerable effort is required to tighten the work in place and later to release it, and tools for this purpose also are likely to be heavy. A large machine may require a tall person with a long reach to manipulate it.

These are not insuperable obstacles to the employment of women, however, and have been met in various plants. Men as well as women are unable to lift by hand all the parts involved without the use of chain hoists or other mechanical lifting devices, and such devices are very generally a part of the equipment of most large modern machine shops. Power chucks are installed in some cases to avoid the necessity of exerting great physical effort in tightening pieces in the machine. It is probable that newer factories will be provided with these labor-saving devices, whether men or women are to be employed. The increased production possible would make them an economy, and they save workers' time for the job skills.

Women have been able to do a considerable share of the work on larger parts in small-arms manufacture, due to management's constant search for improved production techniques to lighten machine operations. New fixtures were designed to replace the heavy arbors for holding the cutting tools; benches or machines were raised or lowered to improve work lay-out and reduce lifting; conveyors were installed to slide parts from one machine to another. Through use of these measures women in one plant comprised from a third to considerably over a half of all machine operators in the various departments making large parts.

Proper selection of the workers for the job also is important. In both small-arms and cannon plants it was stated that tall women are chosen for work on the larger machines, since they can more readily reach the multiplicity of controls. A woman more than ordinarily robust may be perfectly capable of exerting the necessary force to manipulate the levers, hand wheels, and turnstiles. There still will remain work that is beyond the average woman's strength but well within that of the average man and in some cases of the exceptional woman.

There remains the possibility of separating light work from heavy so that women may be assigned to the light work. Both light and heavy pieces often were processed on the same machine in the machine-tool industry, and at least one employer expressed the opinion that a readjustment, while perfectly possible, would be less efficient. In another plant, with a different arrangement of the flow of work, small tools in two machining departments already were separated from the medium and large, the lighter work being at one end of the room, the heavy at the other. The smaller parts were being routed separately in these two departments, though no women were employed there nor was their employment anticipated. In two plants, such separation of work on turret lathes had been made in order to give the smaller work

to women. In small-arms factories women most frequently were employed in the general machining departments where smaller parts were made. In the plant making the most extensive use of women they were 57 percent of all workers in such a department.

Women operated the same makes and types of machines as men in a large plant making aircraft engines. Women operated all 35 types of machines used in this mass-production plant, and at the time of visit they constituted a third of all machine operators (600 of 1,800). The only difference was that men were used in departments where heavy parts of engines were worked on, where machines were larger and the parts, jigs, and fixtures heavier. Both men and women operators were taught to follow blueprints, inspect their own work, see that the machines were running correctly, do their own degreasing and some of their own set-up. There were, however, skilled set-up men, 1 for every 8 to 10 operators, whether men or women. Other establishments reported practically the same arrangement.

### PACKING AND WRAPPING

Unless the finished product moves out of the plant under its own power there is usually necessary some kind of packaging, wrapping, or crating to prepare the article for shipment. Packing of small finished products or of small parts for assembly in another plant is especially suitable for women. In one of the aircraft-engine plants, for example, 85 to 90 percent of the wrapping and packing of spare parts for replacement was done by women. Packaging furnishes protection to the item and, in peacetime, eye appeal to the consumer. The finished package must be strong, compact, neat, and often attractive. Though not calling for much skill, packing does require some dexterity and usually considerable speed. Stamping or labeling may be done in packing departments; sometimes also loading and unloading and other operations that may be designated as warehouse work.

In the wartime metal industries surveyed by the Women's Bureau, packing operations were being performed by women. In small-arms-ammunition plants, for example, women set up cartons, packed cartridges in pasteboard containers and then in the cartons, and hand-pasted labels on the outside. They were doing similar work in factories making artillery ammunition. In some instances each completed fuze was placed in an individual cardboard container. Boxes were taped and dipped in wax to make them waterproof. Women were employed also in stamping or stenciling on the container information as to the kind of fuze, primer, or booster it contained, the lot number, and any other essential data. Usually final packing is done in boxes of fairly large size by men, as the work at this stage is too heavy for women.

About 30 percent of the packers in small-arms plants were women, and most of them were counters, sorters, wrappers, and packers of spare parts. Parts greased or oiled were wrapped in heavy oil paper before packing in envelopes, cartons, or boxes. A few women were nailing metal strips around large packing boxes.

With some types of packing, speed is the chief essential. In a tin-ware plant a girl was packing gallon cans. Working very rapidly, she picked up 4 with one hand and 2 with the other from a moving conveyor and placed them in a carton, which another girl set up and

opened for her; this second girl then closed the carton and sent it along another conveyor to an automatic gluing machine. Women feeding packaged safety matches to a machine that wrapped them had to work quickly and pay close attention, as the packages passed them very rapidly on a moving belt.

The foregoing apply to newer war plants, but wrapping and packing long has been a type of job performed by women. A few descriptions of women's work as packers of metal products in 1907 and 1908 (23) follow:

*Hardware*—The small articles \* \* \* are usually packed in cartons by the dozen, the gross or singly. \* \* \* Sometimes the articles are first wrapped in tissue paper to keep them from getting scratched or tarnished. \* \* \* Care is required \* \* \* to get the packages up in neat and attractive form and to see that each has the specified contents.

*Needles and pins*—The long strips of paper (filled with pins) from the sticking machine come to the folders, who cut them into proper lengths for a paper of pins, then fold each paper and place \* \* \* a dozen papers in each box. Cheap pins \* \* \* are wrapped in packages.

*Nuts, bolts, and screws*—Bolts (with the nut screwed on), are sorted, inspected, piled together, packed in paper cartons or boxes, sealed and labeled.

*Stamped and enameled ware*—Labels were stamped, pasted, and stuck to the ware, the ware was wrapped in a sheet of paper, another label pasted on the outside and the parcel set aside. \* \* \* Hollow articles, like pails, which can be put one inside another or "nested" are stacked as high as the wrapper can reach.

In food industries Women's Bureau studies report a great deal of packing and wrapping done by women, both in war and in peace times. A study of these operations made by the New York Department of Labor in 1936 reported on nearly 10,000 women, practically 60 percent of whom were in food industries, most of the remainder packing cosmetics and drugs. In meat plants women have long packed sausages, wrapped hams, arranged sliced bacon in cartons or cellophane wrappings, or put chipped beef into cellophane envelopes or glass cans. In all cases care must be taken that the resulting package has an attractive appearance. At the same time considerable speed is required. Some packaging is done by machine—for example, the filling of pound containers with lard. Cartons are set up with an inner lining, the lard is poured and cooled, and the packages are closed automatically. Girls are employed at different points on the line to see that all is going smoothly, to take off defective packages, and generally to prevent anything from interfering with rapid progress.

The multitudinous forms in which candy is put out indicate the amount of wrapping and packing that must be done. Wrapping often is done by automatic machines. In candy factories studied by the Women's Bureau in 1920 and 1921, 45 percent of the women were wrappers and packers, such women comprising 96 percent of all persons on these processes. These operations in the main require speed rather than judgment or skill.

The following description of women packing biscuits (crackers) from the 1907-08 study of woman and child workers shows the kind of skill involved in many packing processes, regardless of the product:

The packers stand on each side of a table along which a moving runway carries the biscuits about at the level of the packers' waists, while another carries along the empty cartons about at the level of their heads. The lids and flaps of each carton still stand up straight when it reaches the packer, so that no time is lost in opening it. Taking the carton in her left hand, the packer takes up a handful of biscuits in the right hand and places them in the

carton. A good packer will nearly always fill a box with two handfuls of biscuits, and quite often will do it with only one. A packer is expected to watch carefully to see that she does not pack any misshaped or broken or scorched biscuits; she must not pack her carton either too tight or too loose; she must be sure that the biscuits are all turned one way; and she must not accept an imperfect carton for packing (24).

Packing and wrapping and other concomitant occupations are important in both cigar and cigarette manufacture. At one time packing of cigars was a skilled occupation, as cigars were sorted by color and shade before being packed in boxes. With the introduction of foil or cellophane wrapping, sorting and shading became less important, and more women were employed on the simpler processes as well as in banding and labeling.

The putting of cigarettes in the standard-size packs has long been done by machines, usually operated by women. The development has been to make the machines more and more automatic and capable of performing more processes, such as the pasting on of the revenue stamp and the putting of the wrapper around the package. Hand packing is done only when the type of container is used so infrequently that the use of a machine is not justified. Speed and deftness are required in this work. A Women's Bureau study of these industries in representative States and communities (1929 and 1930) showed that about 13 percent of the women in cigar factories and 42 percent of those in cigarette factories were in the packing departments.

In the clothing industry the amount of wrapping, packing, boxing, labeling, and so forth is likely to depend on the fineness and price of the article. Full-fashioned hosiery is carefully paired, banded, labeled, and boxed to make an attractive appearance on the department-store counter, while children's cheap socks may be merely bundled up wholesale to be spread out in the "5 and 10". Men's shirts may be sorted for size and sleeve length, and a certain number of each size put together according to the orders of the wholesaler or retailer. All this work is done by women, and is quickly learned, though it does require dexterity and care.

### TOOL-CRIB AND STOREROOM WORK

Tools used in making the product, purchased parts from screws to castings, patterns, chemicals, many different items, must be kept so as to be quickly available. The attendant must know the stock and its arrangement, keep track of all that is given out, see that non-consumable items like tools are returned, and in general do a store-keeping business. This is an occupation relatively new for women in any considerable numbers in the present war. However, many women now are performing this work very successfully, provided the attendant need not handle large and heavy as well as small and light materials.

Storerooms and stockrooms had women employees in most of the aircraft plants visited by the Women's Bureau. Supplies such as sheet metal, extrusions, bars, clamps, nuts, bolts, rivets, and parts are kept in bins and on shelves and racks. Many of the parts to be stored and issued are small and can be handled easily by women. Much of the work is of a semiclerical nature, keeping stock records of the

receipt and disposal of parts, perpetual inventory reports, filing requisitions and orders.

Similar jobs were held by women in the toolrooms, where tools, templates, small jigs, and dies are stored, maintained in condition, and issued, and women could do this type of work to a greater extent. Only a small number of women were found in the toolrooms, but in all cases where there were women it was planned to augment their numbers. When women can increase their general mechanical background and knowledge of the names and uses of tools, more of them can be considered as tool-crib workers. One firm estimated that it could use almost 300 additional women tool-crib attendants and clerks if labor-supply conditions made it necessary.

In small-arms plants more women were employed as stockroom attendants than as tool-crib attendants. Twelve percent of the stockroom workers were women acting as stock-record clerks and storekeepers, filling cribs and boxes with parts and supplies, and putting up orders to be routed to the plant. Seven percent of the tool-crib attendants were women, who handled the smaller tools, jigs, and fixtures, checking them in and out and keeping records. This work requires a knowledge of the different articles, which women were acquiring gradually on the job. Women did similar work in cannon plants. In the tool cribs they did a certain amount of grinding of milling cutters and reamers.

Women were employed as tool-crib attendants in only 3 of the machine-tool firms surveyed. In 1 of these women were known as tool dispatchers, since they took tools to the machine operators so that the latter need not leave their machines.

In steel mills women were employed in both tool cribs and store-rooms. In foundries they were reported as storeroom laborers, tool cleaners and grinders, and toolroom attendants. In the pattern-making shop they gave out and stored the smaller patterns.

Women have proved very satisfactory in toolrooms of shipyards. They have learned quickly and are orderly and efficient. In one yard the toolroom served a thousand people a day. The women waited on them and got them away from the window much faster than men did. Once a week files were gone through and misfiled slips pulled out. Formerly there would be a peach basket full of such slips; with women on this job there were only about 15 slips incorrectly filed. Girls spell and write better and are more accurate and serious about the work.

## OTHER CHARACTERISTIC OCCUPATIONS

In a few occupations particularly characteristic of the metal and machinery industries—for example, in filing and burring and core making—women frequently are engaged. As with other occupations discussed, the size and weight of articles to be handled determine whether or not women can do these types of work satisfactorily.

### **Burring and Filing.**

These operations sometimes are reported with other bench work. But "bench work" may be the operation of a small machine mounted on a bench, or assembly, or inspection, or the sorting of parts. In

general, bench work involves work on small articles and often may be done while seated.

A favorite introductory job for women in aircraft-assembly plants inspected by the Women's Bureau is burring and filing in the machine-shop and metal-fabrication departments. Rough edges, small projections, and irregularities are removed from machined parts, fittings, castings, and sheet-metal parts with emery cloths, burring tools, and files, the work sometimes being to close dimensions along prescribed lines. Larger burrs or surplus metal are machined off on lathes and stationary grinders and the insides of holes are cleaned with burring attachments on drill presses. Many women do bench burring and filing and as an entry job it affords them training and experience in the use of hand tools and clamps, scribing, and the handling of metals and sometimes of templates and machines.

The Women's Bureau survey in small-arms plants found more women doing this type of work than any other with the exception of machine operating and inspection. Machine operators quite frequently burr and file parts that they machine. But in addition there are many full-time filers, burrers, precision filers, and polishers. About 16 percent of the burrers, filers, and polishers in the plants with detailed information were women, and in one instance the proportion was 30 percent. Women generally worked on the smaller parts, using files, scrapers, portable burring machines, high-speed lathes, belt sanders, disk grinders, and emery cloth. In all the plants there still were a great number of men working on small parts, as filing of gun parts has been considered precision work requiring considerable skill. But women had demonstrated their ability to pick up the techniques involved and more and more were being placed on precision filing and work on heavier parts.

In cannon manufacture as well there is a great deal of filing, burring, and polishing of parts. While women worked chiefly on small parts some were on heavier articles. Most of this work was done at benches with the worker seated, but some on large pieces was done standing.

In one of the aircraft-engine plants visited about 75 percent of the burring in the machine shop and subassembly departments was done by women.

During the First World War, 11 of the 278 metal-working plants studied by the Women's Bureau had replaced men with women on filing. Of 10 firms reporting, 7 stated that women did as much or more work than men. However, only 3 had retained women in 1919.

### Coremaking.

Coremaking is done entirely in foundries. The core, around which the molten metal flows at pouring time, forms the interior opening or hole in a hollow casting. The core is made separately from the mold that shapes the outside of the casting. Most cores are made of a special type of sand, sometimes reenforced by wire or rods, and baked. Each sand core is used only once and is broken up to free the casting.

Women were doing this work at least as early as 1907 and 1908. The description of women's work given at that time shows that the process has changed very little.

The women, standing or sitting at long tables on which each had a space about 3 feet square, filled the core boxes with the sand mixture, tamped it down to the proper density, removed the core box, and carried the cores to the

oven. They were never employed upon heavy or intricate work, this being done by men.

In spite of this fact the work done by women is distinctly skilled. For a week or so after learners begin, at least 90 percent of their work is spoiled. Within two weeks, however, they can learn to make the simplest forms well, and within three or four months they can do ordinary work; but it takes at least a year for the average woman to learn to make well all the varieties of cores which may fall to her department. Removing the core boxes without breaking the angles or corners of the more intricate cores is an operation which requires both natural dexterity and experience. \* \* \*

\* \* \* The making of each core is a bit of constructive work calling for much more than the mere repetition of mechanical movements. Usually a woman is called on to make several different kinds of cores during a day, which also tends to keep the work from becoming mechanical (25).

In 1917-18 some plants employed women as coremakers for the first time, while in others where they had worked on light and simple cores for 15 or more years they were employed on more intricate and heavier work. Two-thirds of the firms reporting retained women on this occupation after the war.

A series of biennial reports by the Bureau of Labor Statistics on wages and hours in foundries and machine shops from 1923 to 1931 showed that women ranged from 7 to 10 percent of all coremakers covered. However, since only about 1 plant in 10 had any women coremakers, their proportions where employed must have been considerably larger. One of the important considerations is the size and weight of the core and core box, determined by the size of the casting to be made (26).

Of 13 foundries visited by the Women's Bureau in 1943, at least 11 employed or had employed women on coremaking or other core-room work. One plant used a process that did not require the conventional core. Where especially noted, women usually made small cores only. In one the small parts required very delicate work, such as women are best suited to do.

## PART II. PROBABLE OPPORTUNITIES FOR THE EMPLOYMENT OF WOMEN

The first section of this report has discussed certain industrial processes that women's special aptitudes particularly fit them to perform in industry—namely, assembling, inspecting, wrapping and packing, and the operating of certain machines.

These operations have been examined primarily in relation to their performance by women in war manufacturing, as for example in metal-products and electrical industries, and in the manufacture of aircraft, ships, and munitions.

Some of these industries—munitions for example—no longer will feature largely in the country's economy after the war. Others probably are due for considerable cuts. The indications are that ship-building, an industry requiring many heavy and difficult operations, will employ only very minor proportions of the enormous groups of women it has engaged during the war, and the manufacture of aircraft may be considerably reduced from the peak of its output and employment.

But there are other industries that will enjoy an increased, or at least a very large, peacetime demand. Many of these have production processes similar to those discussed here, which were performed by women in large numbers before the war and to a very greatly increased extent during the war.

A wide variety of electrical appliances will continue to be in increasing demand, and many of the small metal products on which women have worked are necessary for daily use of the people. Interchangeable small parts as well as accessories will be needed, probably on an extensive scale, for postwar automobiles, and such aircraft as will continue in production. Evidence points toward the increased use of measuring instruments of various types on which women have been widely employed in the developing programs of industrial discovery, scientific advance, and improved household and transportation devices.

The outlets for the skills women have developed in assembling, inspecting, machine operating, electrical manufacture, will be in the industries of coming demand. This section of the report, therefore, will consider some of the evidences of such demand for certain products in the fields of electrical devices, small metal products, automobile and aircraft accessories, plastic parts, and so forth. Of course the need for women's work will continue to a large extent in other industries that long have employed them, as for example in the textile, clothing, and shoe industries.

### Shifts From One Skill to Another.

Any discussion of future employment must take into consideration possible shifts from the use of one material to another or from the

use of one method to another. But when this occurs and demands for old skills decline, new skills, often of an allied type, are called for. This point might be illustrated by changes in ways of preserving food, brought on to a considerable extent by war conditions. With the shortage of metal there has been an increased use of glass containers in place of tin cans in commercial canning. The glass industry estimated a production of about 92 million gross of glass containers in 1943 compared with 76 million gross in 1939. Some of these, of course, represented the greatly accelerated use of containers at home to preserve victory garden products.

Even more significant for the postwar period may be the development of the quick-freezing processes, which had increased 35 percent in employment in the 2 years from 1937 to 1939. This growth may mean that the peacetime demand for tin cans will not return to its pre-war level, and the wartime demands for glass containers also may decline. But with change of method, and decline of one type of need, new products are required along some other line, as food must be provided and cared for.

The changed method requires a different container, a cardboard carton instead of a tin or glass can. An extension of the freezing method and a newer development is the use of frozen-food lockers in homes. These have been in use on farms for some time, and just before the war in many city homes as well. Models of such freezers about the size of a gas stove have been shown lately, although manufacture will have to await the fortunes of war. These freezers usually would supplement rather than replace the regular home refrigerator and thus if their production means decline in the use of tin cans it offers good prospect of new jobs to workers in the electrical equipment field, as well as to those making the cabinet containers.

Another development in food preserving is dehydration, used largely as a means of saving shipping space. Unless the dried product can be made as palatable and attractive as either canned or frozen foods, this method may not present much competition after the war.

### **Change to New Products, and Continuance of Demand.**

A critical factor in postwar employment is the time element. How long will accumulated demands provide jobs? How soon will these jobs be available? As to the first point, the pent-up demand for motor vehicles and accessories, for example, represents several years' work at the 1939 level. Demand for certain electrical equipment represents only about a year's work. For many items no long-time estimate can be made.

Surveys of consumer demands have on the whole been realistic, recording not all who wish for a certain article, but only those who feel that they will be able to finance the purchase. For many families jobs must come first before plans can be made for large-scale purchases. This emphasizes the importance of the second point. Reconversion must come promptly to build up more purchasing power for those who do not now see their way much beyond the present.

There are many young married couples who due to war conditions have not yet established a home as they would normally do on marriage. A special Census survey indicated that in March 1944 there were more than two and a half million women with husbands in the armed forces, nearly half of them under 25. The Census estimates that more than

a million and a half marriages took place in 1943. These families need homes and equipment for homes, but they must have jobs first of all.

Not only are there young couples starting out, but many families of all ages have low incomes. Census data for 1939, for families of 2 or more persons with no income but wage or salary and not living on farms, show that 31 percent (4.3 million families) had incomes of less than \$1,000; and over two-fifths of these families had 4 or more members. These must feel more secure before they can plan for buying. Such a number of families with unfulfilled demands clearly argues that the development of a high level of employment and wages will further increase markets on all the home fronts. Jobs for all will mean jobs for women in the occupations they can do best. Building a million new homes means immediate work almost exclusively for men, but fitting and furnishing these homes mean many jobs for women.

### THE ELECTRICAL INDUSTRY

In October 1939, there were about 100,000 women wage earners in the electrical-machinery-industry group, one-third of all its employees. By October 1943, Bureau of Labor Statistics estimates indicated  $3\frac{1}{2}$  times as many, some 350,000 women, or nearly half of the total wage earners. Many, perhaps, most, of the electrical items now being made for the Army or the Navy are quite similar to those that will be in demand for civilian use in the postwar period—radios, lamps, batteries, wire and cables, and so forth. The greatest reduction due to priorities probably has been in household equipment—electric ranges, vacuum cleaners, toasters, and various smaller electrical appliances in daily use. This fact indicates that there will be considerable demand for replacement of such articles now wearing out. Moreover, a great variety of new electrical products had been developed but not widely used before the war, and some of these will be much more generally employed after the war to advance health and convenience in homes, work places, and public centers.

#### Lamps and Tubes (27).

The making of light bulbs and of radio and other tubes involves many of the same basic processes, including assembly of very delicate parts and inspection and testing. In 1939, women composed more than three-fourths of all wage earners making electric lamps. A study by the Women's Bureau in 1929 showed that about 83 percent of the workers on radio tubes were women in contrast to 46 percent on receiving sets (28).

There is sure to be a postwar demand for replacement and improvement of existing light fixtures in many homes, besides the considerable home building expected after the war that will call for new lighting equipment. An expert in this field estimates that an average of 10 fixtures will be required for each new home, not counting several portable lamps. It has been suggested that workers who have become accustomed to good lighting in modern war plants will not be content in peacetime with ill-lighted homes.

Farms too, in recent years, have seen a considerable extension in use of electricity, greatly accelerated by the Rural Electrification Admin-

istration. In the report of that agency for 1941 it was stated that the proportion of farms with electricity had increased from 11 percent in 1934 to 35 percent in 1941. But even in 1940 more than 7 million homes still were lighted with kerosene or gasoline—the great majority of these in rural areas—and this indicates a wide field for growth in the use of electric lamps in farm homes (29).

The great need for improved street and highway lighting has been emphasized in the war period by the blackouts and dimouts with their accompanying increase in accidents and crime. Even in peacetime over 60 percent of all traffic accidents occur after dark, when only one-third of the traffic is moving. The city of Detroit, by installing modern street lighting on certain main thoroughfares, reduced dusk-to-dawn fatalities on those streets by more than 83 percent. The National Safety Council points out that “most urban streets have the same type of street lighting that existed many years ago. Such systems are wholly inadequate \* \* \* from a safety standpoint” (30).

The war also has increased the attention paid to good lighting in industrial plants, now more generally recognized as essential for speed, accuracy, and safety in production. For example, a large machine plant recently listing the gains made with the installation of improved lighting, stated that there was a 25-percent reduction in scrapped pieces, a 5-percent increase in production per man-hour, and a 50-percent reduction in accidents.

The Illuminating Engineering Society lists primarily for industrial plants the following advantages of good lighting (31):

1. Greater accuracy of workmanship, resulting in an improved quality of product with less spoilage and rework.
2. Increased production and decreased costs.
3. Better utilization of floor space.
4. More easily maintained cleanliness and neatness in the plant.
5. Greater ease of seeing, especially among older, experienced employees, thus making them more efficient.
6. Less eyestrain among employees.
7. Improved morale among employees, resulting in decreased labor turn-over.
8. Fewer accidents.

It is probable that most of the larger plants on war production, especially those that have been newly built, are well lighted. But a new market among small manufacturers who during the war period have had too low a priority rating to buy new equipment probably will be opened in the future. Comparatively few of some 130 war plants studied by the Women's Bureau in one large industrial State in 1942 were reported as having inadequate lighting, but a prewar study of industries in another State showed lighting to be haphazard in many plants, in some instances both good and wretchedly bad in the same plant. Though undoubtedly there has been improvement, there are many cases where further advance is needed.

Other electrical equipment has important health uses and is likely to find an increased demand in the postwar market. Infra-red lamps producing heat, and ultra-violet or “sunlight” lamps, are accepted generally for therapeutic purposes. Their use expanded 10-fold in the decade before the war and there is every likelihood that when they again become available on a large scale their production and sale will increase enormously. Most ultra-violet lamps require a transformer and are of the floor type, but one had been developed that could be screwed into any 120-volt socket, making its use in homes of the utmost

convenience. It is not now available but will be again after the war. A sun lamp for use in industry is designed to expose large numbers of workers at once to the ultra-violet rays (32).

About 5 years ago a germicidal lamp was developed that uses ultra-violet rays. Such lamps have been installed in many hospitals, and their use is being extended to surgical and dental offices, schools, business offices, and factories. Many more establishments eventually will use such equipment to maintain public health and to free workers, patients, and children from colds and more serious diseases. It may in time find a wide-spread use in individual homes as well.

Such sterilizing lamps also have many other factory uses to protect customers as well as employees. For example, a soft-drink plant employs this equipment at every stage from preparation of the syrup to washing, filling, and capping its bottles. A plant selling safety shoes to workers sterilizes those that have been tried on. Ultra-violet lamps are used to destroy bacteria in the air as it is drawn into the air-condition ducts. Another use for ultra-violet rays is in their action on light-sensitive films and papers, as in photostat machines and in printing of movie films.

Infra-red lamps are being used extensively to produce heat for industrial purposes, and drying processes are considerably hastened as a result. A company that had to finish in a very short time 5½ million buckles for war products found the bottleneck was in drying the lacquer on the buckles. The process required an hour to dry a batch and necessitated that they be shaken in the trays every 15 minutes. A simple installation of eight 260-watt infra-red-ray lamps with suitable reflectors enabled 1,500 buckles to be dried satisfactorily in 2 minutes. No more space was needed. Electric heating is a great improvement on old methods of dehydrating food, since it makes it possible to remove more moisture and thus insure a product that stores well in the tropics.

There have been many shifts from filament to fluorescent lights, which produce a bright, glareless light admirably suited for precision work. Fluorescent lamps were introduced in 1938 and their use has grown very rapidly. Sales of the tubes increased from 7.1 million in 1940 to 24 million in 1941 and 33.6 million in 1942. A tiny fluorescent lamp no larger than a marble could, it is estimated, burn for 6 months with about one cent's worth of electricity. Such a lamp could be used where constant light is necessary, as to mark a stairstep, for example, or a keyhole. The fluorescent in the immediate future may provide less employment than the filament lamp, because the latter still will be necessary in large quantities for uses to which the new type is not well adapted. Fluorescent lamps, though considerably longer lived than the filament lamps and giving off a much smaller amount of heat, are more expensive, and as they perform best when not turned on and off frequently, thus far they are less well adapted for home use than the filament type (33).

Electron tubes, the making of which involves processes similar to those in making light bulbs, are essential to the radio. They also have a variety of other uses, some well established and sure to be in increasing demand, others newly developed and likely to grow into much wider use.

The first such tube was made in 1907, an evacuated glass bulb containing three simple elements, a cathode or metal filament, an anode

or plate, and a small metal screen or grid. This tube is essentially a valve, and can be incorporated in an electric circuit to control or change current in many ways. It can act as a switch or be used as a measuring device. A year ago there were 750 different types in use, all variations on the same principle. The following examples indicate the wide variety of uses to which these tubes are put.

A vacuum-tube oscillator connected to a quartz crystal is used to produce smoother food products by emulsification, as homogenized milk. This is done by supersonic or sound waves of such high frequency that they are inaudible to most human beings. They accelerate chemical reactions and transform crystal structures. They may be used to treat seeds to stimulate growth, and for various other purposes in food and chemical industries.

Through use of electronic tubes in spray painting of irregular objects, the objects and the particles of paint are charged in such a way that the paint is deposited uniformly on all surfaces, doing a better and a quicker job at a lower cost. This is done by producing the same type of electrostatic charges that make people jump when they touch metal after walking across a rug on a dry, cold day. A sharper, faster-cutting sandpaper is produced by this method, with every particle of the abrasive material alined with the sharpest points upward. Another application of electrostatic fields includes smoke precipitators for chimneys and air cleaners to remove dusts, pollen, or other foreign particles.

Many electronic tubes are used as the basis of a control device. The well-known "electric eye" that opens a door has other uses. It can measure the vitamin content in a liquid, turn on lights in school factory when needed, or regulate the heat in industrial furnaces by reaction to the color of the flames. Such tubes are incorporated in the newer machine tools to hold the speed constant regardless of the load. These and a multitude of other things are done at high speed and with great efficiency.

### Radio Sets.

An enormous postwar demand for radios is almost certain. Many existing sets have deteriorated, if not worn out completely, during the years in which consumers could not buy freely. A United States Chamber of Commerce report in the fall of 1943 indicated that over 2½ million families hoped to buy radios immediately after the war.

Moreover, nearly 6 million housing units were without radios in 1940 (34). Nearly three-fourths of these were rural homes, many no doubt without electricity. This indicates a considerable new market for radios, whether battery-operated or obtained after electricity has been installed. In 1939 more than 1½ million battery sets were made. In that year also there was a great increase in demand for portable sets, which came about through development of small, light batteries; one portable introduced that year weighed less than four pounds. A combined battery and plug-in device made some of these sets more useful, and would appeal to farmers anticipating the extension of electric lines.

There undoubtedly will be demand for radios adapted to the reception of the newer frequency-modulation broadcasting, which is said virtually to eliminate static and is known to the trade as FM. In the fall of 1941 there were 120,000 FM sets in use, compared to 15,000

in January of that year. In February 1943 there were 47 stations built or building for such broadcasting (35). A wide market for this development will be in schools and colleges, where the use of radios is growing constantly. It was reported in March 1944 that more than 100 school systems, colleges, and universities had taken first steps toward obtaining their own FM broadcasting systems as a means of furthering education (36).

Considerable attention has been given of late to the use of radio communication as a safety feature on trains, connecting engine and caboose, one train with another, or trains with stations. Some experimental installations have already been made (37). The "walkie-talkie", a military development, probably will find many peacetime uses, especially by police and fire departments; also perhaps by plant executives, construction gangs, forest rangers, and ranchmen. A two-way radio system weighing little more than 5 pounds, stated to be as easily operated as a telephone, already has been advertised (38).

### Other Electrical Appliances (39).

The Chamber of Commerce report referred to on page — indicated an immediate postwar demand for more than 1.5 million electric irons, 1.4 million vacuum cleaners, and not far from 1.1 million electric kitchen mixers. The number last named about equals that of vacuum cleaners and that of the group mixers, whippers, and juicers produced in 1939.

The extent to which household equipment is being reconditioned in the present emergency is illustrated by the experience of an electrical company in a middle-western city. In making a canvass of residential customers for one month, the company restored 137 electric appliances to use; took 89 to the dealer for repair; sent 50 to the factory for repair; recommended that 196 be sent to the dealer for restoration; and made 124 minor repairs in the home.

The demand undoubtedly will increase greatly for certain types of equipment that were introduced prior to the war but had not come into widespread use. For example, in 1937 there was developed a new window-mounted room cooler, which could be installed easily and quickly and was remarkably silent. These would be useful in homes, small offices, hospital rooms, and elsewhere, and could be moved from one room to another. In 1939 some 28,000 air-conditioning units were produced, described as portable and self-contained. There also was introduced in 1937 an electrically heated bed cover that consumed on an average about as much electric energy as a 100-watt household lamp.

Since women can be employed more easily on small articles than large, the statement that electric motors are getting smaller and more powerful is of interest. A 3-horsepower motor has been developed that weighs only 7 pounds. Formerly the standard 3-horsepower motor weighed 105 pounds. A recently developed 30-horsepower motor is 5 inches in diameter, 13 inches long, and weighs 57 pounds. The Census of Manufactures shows a great increase in the number of fractional-horsepower motors produced, about  $11\frac{1}{4}$  million in 1939 compared with not quite 5 million in 1929.

There is a long list of miscellaneous electrical products, often small, often with a wide variety of uses, on which women well might

be employed, especially as assemblers and inspectors. Among them may be listed the following:

Batteries	Insulators	Switches
Bells	Lightning arresters	Switch boxes
Burglar alarms	Meters	Telephone and telegraph apparatus
Buzzers	Microphones	Toasters
Circuit breakers	Panel boards	Transformers
Coffee makers	Plugs	Waffle irons
Curling irons	Relays	
Fans	Sockets	
Fuses	Spark plugs	

## PROFESSIONAL AND SCIENTIFIC INSTRUMENTS

A great variety of articles for many different purposes are included in the general term "instruments." Among the most common and best known are thermometers and barometers, cameras, compasses, surgical implements, dental chairs, and sterilizers. Many new navigation instruments have come into use in airplanes and have been improved rapidly under pressure of war demand. All these items will continue to be in considerable demand in the postwar period. In the fall of 1943 women constituted 43 percent of all wage earners making professional and scientific instruments and fire-control equipment.

Gages, micrometers, and the like are a type of instrument used to insure greater precision in manufacture. The frequent inspection of parts at all stages of processing has become a commonplace in war industries. (See discussion of inspection.) Measuring instruments have been developed in great diversity, some designed for use by workers with little experience. For example, an electric check-gage indicates undersize by a red light and oversize by green, while an amber light shows the measurement to be within accepted limits. It is described as quickly and easily set for extremely accurate work. Women have done very valuable work in the use of many of these instruments for inspecting products, and in the careful inspection of the master gages themselves. With the growing emphasis on precision, which is especially necessary if parts are to be interchangeable, there is likely to be permanently a growing market for all types of measuring devices to be used in metal-products plants (40).

The use of instruments for automatic control has become an integral part of manufacturing, especially in continuous-process industries such as chemicals or paper making. Examples of the variables to be measured and held within certain limits are temperature, pressure, flow rate, amount, speed, electrical qualities, humidity, viscosity, color, and opacity. A familiar control instrument is the thermostat, which kept houses at a temperature of 65 degrees last winter.

In the textile industry, for example, one of the most important fields for electronic instruments is in the measurement and control of moisture. Satisfactory processing depends on the right amount of humidity in the air and this varies with the type of fiber being used. The principle of the phototube has been applied to the spectrophotometer, which can distinguish two million shades of color accurately and record them automatically on a graph. An electronic relay recently developed stops all motion in a machine the instant a thread breaks. Control of temperature in drying of fabrics is important,

since if it is too low time is lost, if too high the goods will be harsh and have lost its luster.

Some instruments have moved from the laboratory into the factory. Many types of civilian motor vehicles have received their test through a trial run, but military requirements are more exacting and there is no time for a run-in. Instead, tank transmissions, for example, are given a noise test, long a laboratory test but now standard in the factory through the use of recording instruments. Noise is an index of the fit and assembly of gears and bearings. Another important move from laboratory to factory is the use of an instrument for continuous control of arc welding. By checking current consumption an experienced man can detect anything wrong with the weld.

Many instruments, often very intricate ones, are in constant use in research laboratories. While this is a limited field, it may well be a growing one.

### SMALL METAL PRODUCTS

There is a long list of small metal articles in daily use, the demand for which grows with the population. Included are many household utensils, tools, and all the miscellany that fills the shelves of the hardware store. Due to restrictions on use of metals, many of these are not being made in normal numbers. A recent survey by the War Production Board's Office of Civilian Requirements indicates a shortage of many of these everyday necessities. If not more than 30 percent of the demand could be met, the shortage was considered severe (41).

#### Kitchen Utensils.

A severe shortage is reported of a large variety of kitchen utensils that may be made of aluminum, of vitreous enameled ware, of tin, or of other stamped and pressed metal. In 1939 about a fourth of the wage earners in these industry groups combined were women.

Prewar studies in aluminum and enamel-ware plants showed large numbers of women at work there, and the replacements now needed are almost certain to employ at least as many women as formerly, probably many more. The Women's Bureau visited several plants and found that women constituted nearly 28 percent of all employed in 1935 in making aluminum ware. Women were assembling and riveting, operating punch, blanking, and forming presses, and large numbers were wrappers and packers. More than a third of all workers were women as were more than half the inspectors and sorters and the wrappers and packers, in a special study of the enameled-utensil industry made by the Bureau of Labor Statistics in 1940 (42). Women also outnumbered men as enamel beadlers and dippers.

Among the items now greatly needed are tea kettles, flour sifters, dust pans, cans for gasoline or kerosene, garbage cans, and washboilers and tubs. There is also a shortage, less severe, of coffee pots, double boilers, frying pans, covered kettles, saucepans, strainers, lunch boxes, baking pans, and pails and buckets.

The demand for canned foods, put up usually in tin, grew enormously in the decade before the war. From 1930 to 1940 the total population increased by about 7 percent, but the total production of

canned fruits, vegetables, and fish increased by 37 percent, and of all types of tin cans, including those for beer and lubricating oil, by 65 percent. In 1939 women were 28 percent of all workers in the making of tin cans and so forth. The need of foods for the armed forces has greatly accelerated the growth of this industry. It is estimated that the 1944 vegetable pack, exclusive of soup and baked beans, will be about 40 percent above 1939, the fruit pack about 18 percent above; or combining the two, an increase of approximately 35 percent. The shortage of tin due to its requirement for making other war supplies has caused a switch to glass, at least for much civilian goods, but there are many uses for which glass is not suitable. Availability of more tin after the war may increase the making of such containers above the prewar level. On the other hand, the development of the quick-freezing process, with home equipment, may lessen the demand for tin cans. If it does, it will increase the market for other types of containers and will add to the employment in electrical equipment for the making of the home units.

### **Needles and Pins.**

At present, demands are not filled for snap fasteners, metal hairpins, and straight and safety pins, since the making of these small necessities has been somewhat disrupted by priorities. Many new applications may well have been developed for slide fasteners during their extensive use in war equipment.

This industry, which includes slide and snap fasteners and hooks and eyes, though small, has grown quite steadily, especially with the introduction of substitutes for buttons and buttonholes. From 1929 to 1939, employment of wage earners rose by more than 65 percent to an average of 10,403, about half of them women. The relatively new slide fastener, not reported separately in 1929, accounted for nearly half the value of the industry 10 years later. Production of metal hairpins had more than doubled, with the bobby type of pin accounting for more than a third of the total in 1939. Production of hooks and eyes had nearly doubled and that of safety pins had increased by one-half.

### **Miscellaneous Hardware.**

Included in this group are locks and hinges, and all the other small metal parts (aside from nails and bolts and screws) that are used in buildings, in furniture, in luggage and harness, in motor vehicles, and in planes and ships. In 1939 nearly a fourth of the wage earners in such plants were women, and about two-thirds of the value of the product was for building and motor-vehicle hardware. An expanding program of home building and resumption of passenger-automobile production will call for an immediate increase in such small items.

### **Other Small Metal Products.**

A severe shortage has been reported in a long list of other household needs requiring metal—safety razors, flashlights, pliers and wrenches, metal pot scourers, alarm clocks, carpet sweepers, tire pumps, and window screening. Not more than 60 percent of the demand could be met for egg beaters, spatulas, stirring spoons, portable lamps, household thermometers, mouse traps, and insect sprayers. Most of

such manufacture involves the handling of small parts. Taken all together, women are employed extensively on these products, and many of them are articles for which continuing need may be expected. The numbers of workers are not reported separately for each industry, but women were 48 percent of the wage earners making clocks and watches and 26 percent of those making lighting fixtures (not including bulbs).

### TRANSPORTATION EQUIPMENT—AUTOMOBILES AND AIRCRAFT

Before the war, over 31,000 women were in transportation-equipment factories. Most of them worked on smaller parts and accessories, chiefly for automobiles.

#### Automobiles.

A great number of parts and accessories go into the finished automobile. These include the chassis, wheels, springs, axles, and so on; small items such as gears, bearings, locks, and other hardware; accessories—the lighting system, instruments for the panel board, carburetors, spark plugs, and so forth. Many more women are employed in the making of these things than in the plants that finally assemble the motor vehicle. A study by the Bureau of Labor Statistics in 1940 showed that even at that time women comprised nearly a fifth of all employees in the parts division. Forty-two percent of them were assemblers, chiefly of small parts, 18 percent were machine-tool or punch-press operators, 17 percent were inspectors. The proportion women constituted of total employees was greatest in factories producing the following:

	<i>Percent women</i>
Instruments.....	44.0
Carburetors.....	34.0
Coil (wire) springs.....	32.4
Automobile-body hardware.....	34.4
Automobile electrical equipment.....	31.5
Automotive stampings.....	23.7
Bearings.....	21.0

Production of passenger automobiles for civilian use stopped February 10, 1942. Since then the deterioration of cars, and their actual dissolution, has been enormous and presages a very large market for cars and parts as soon as production for civilians can be resumed. The United States Chamber of Commerce in its third progress report of a survey of probable consumer purchases after the war found more than 17 million persons hoping to buy automobiles and appliances. Seventeen million automobiles would mean almost 5 years' work at the 1939 rate of production of all motor vehicles. It is evident that many must content themselves at first with parts and repairs to keep the present cars running, and many probably have this type of purchase in mind. This development would be especially favorable to women's employment.

From two to two and one-half million cars were scrapped entirely in the two years 1942-43. There remain an estimated 24½ million cars in use by private owners and about a million used cars are in dealers' hands or in storage. Five-sixths of the cars now in use are 3 years old or more, and over half will have seen more than 7 years

of service by the end of 1944. Moreover, it is estimated that one customer in every six in need of repair work that involves parts replacement is refused either permanently or temporarily because the required parts are not available. These data reinforce the prediction that enormous numbers of parts for replacement as well as for new cars will be needed as soon as available (43). Of course, in the estimates of need for these products consideration must be given to buying power and this again goes back to the points already discussed. A rapid conversion to peacetime production, and the building of high employment levels, will be needed to assure the availability of cars and the ready market for them, and hence employment in parts manufacture.

#### Aircraft (44).

It is evident that airplane construction after the war must be far below the total numbers of military craft now being turned out, many to replace those that have been destroyed. From Pearl Harbor to June 1944, 171,257 planes have been produced, and they are being turned out at the rate of over 9,000 a month, or 108,000 a year (45). The number of military planes existing at the end of the war, the number of these that will be needed in the postwar military set-up, and the way in which the others may be utilized, all are unknown factors that will affect the picture. Conflicting prophecies continually are being made. The basis of long-time experience existing in the automobile field does not apply in aircraft. However, it is safe to say that postwar uses are likely to include some military needs and considerable extensions over the prewar status in passenger travel, carrying of mail and express, and private ownership.

The work of women in certain occupations in aircraft plants has been described in the first section of this report. Their employment during the defense and war programs has grown very rapidly as one employer after another has found how well suited they are to certain types of work on fine plane parts. When the Women's Bureau first visited 7 major assembly plants, in early 1941, 3 had no women and in the others only a fraction of 1 percent of the employees were women. Less than a year later, when visits were made to 26 plants, women constituted about 4 percent of the factory force, with 3 plants still employing no women. The plant with the largest proportion had about 15 percent women among its factory workers.

A study of aircraft-parts plants made by the Bureau of Labor Statistics in late 1942 showed women to be not far from a fifth of all first-shift workers. Of these women about 19 percent were assemblers, 16 percent were inspectors and testers, and at least 12 percent were operators of machine tools and punch presses. About a year later, estimates by the same agency indicated that women were 32 percent of all workers in aircraft-engine plants and 38 percent of all in plants making airplanes and other parts.

The use of planes for carrying passengers, mail, and express undoubtedly will increase. If rates can be reduced, this service will be in great demand. At the beginning of the war the bulk of domestic airline business was being carried in 361 planes, and Pan American Airways had only 141 planes to cover the Atlantic, the Pacific, and South America. Domestic routes now operating cover a total of about

46,000 miles, transoceanic routes 85,000. In 1941, the last year for which totals could be published, American lines carried 4 million passengers, compared with half a million 10 years before. However, even now, plans for expansion are under way. By November 1943 the Civil Aeronautics Board had on file applications for new routes totaling 560,000 miles (46), some 27 times the distance from New York to Melbourne and return. Considerably more than half of this mileage is for transoceanic routes. There is also talk of a chain of 6,000 national airports, compared with 3,000 about a year ago. An important means of extending the usefulness of civil airlines is through development of feeder lines, with a pick-up type of service for mail and express, and for smaller places landing strips for passenger service instead of large expensive airports. There are some 8,000 cities and towns in the United States with populations of more than 1,000, a size that one company considers it feasible to furnish with air transportation.

The extent to which private flying will furnish a market is extremely problematical. In 1941, 24,000 private planes were registered, 17,000 in the \$2,000 light plane class, carrying the pilot and one passenger. About 80 percent were strictly for private flying or instructional flying. The average period of ownership was less than 4 years. More than half of those who in the past bought planes or took training abandoned flying shortly, chiefly because of the high cost of the plane and its maintenance, inaccessibility of airports, and limited usefulness of the plane due to weather conditions. Total annual cost of operation has amounted to from 40 to 60 percent of the price of the plane. A large proportion of the cost, including such items as insurance and hangar rent, had no connection with the extent of use. New developments are very likely to solve these difficulties, some of them similar to those encountered in early stages of the use of automobiles, which later went into mass production on so vast a scale. Hence plans are being made for manufacture of private aircraft. One firm contemplates producing 5,000 2-place planes a year, to cost \$1,000 each. Another plans 5,000 4-place planes at between \$2,500 and \$3,500. A third is considering the making of 5,000 2- and 4-place planes at \$1,200 and \$3,000.

A specialist in the field of rotary-wing aircraft feels that great harm has been done to future prospects of the helicopter by too much and too extravagant publicity. He states that it has far to go before it reaches anything like perfection. This type of plane could have a greatly extended use in the Coast Guard Service for shore patrol, in agriculture for spraying purposes and for spotting insect infestation, and in the Forestry Service for detecting fires and placing personnel and equipment for fire fighting. Helicopters for the use of the Army were being produced on a new assembly line in the East in the summer of 1944, and experimental models of two improved models had been built. They already have been in service to evacuate wounded men from points inaccessible by other means of transportation. Another 2-place military model is to be produced in quantity in Michigan. A corporation was formed in June 1944 to manufacture a new type of helicopter to carry two passengers and baggage at a cruising speed of 100 miles an hour; 10-passenger and 20-passenger models also have been produced.

## FABRICATED PLASTIC PRODUCTS

Plastics are being substituted for metal in many cases. They are used most extensively as small parts of larger units. Their insulating qualities make certain of these materials especially useful in electrical equipment for aircraft, ships, and motor vehicles. The Signal Corps depends on them for antennae, hand generators, dynamotors, batteries, microphones, head sets, telephone units, and many other items. Many articles for use by soldiers and sailors are made wholly or partly of plastics—bugles, whistles, buttons, bayonet scabbards, canteens, razors, shaving brushes, toothbrushes, and other toilet articles. Other useful applications have been in first-aid kits, goggles, and flashlights. All told, the war has greatly increased their use, since often they have been introduced to save critical metals and have been proved by exacting tests to be equal to, and in some cases superior to, the metal replaced (47).

Some of the occupations found to be so well suited to women are required on plastics as on metals—machine operation, assembly, and inspection—and it well may be that a relatively new industry such as this, which has extended its field of usefulness so rapidly, will be more open-minded toward employment of women than are the older metal trades. In 1939 more than a fourth of the wage earners making fabricated plastic products were women.

A survey of women's work in the industry was made by the magazine *Modern Plastics* and reported in the issue of January 1943. Women were found performing successfully many processes, described as follows:

*Finishing*—Women run drill presses, grinders, lathes, sanders, tapping machines, automatic machines, multiple-spindle drill presses, buffers, paint sprays, hand tools, files, chisels, scrapers, reamers, flexible-shaft machinery.

*Inspection*—Women operate thread gages, plug gages, ring gages, snap gages, multiple gages, dial gages.

*Toolroom*—Women run polishing machines, shapers, lathes, grinders, drill presses, and do hand operations on the molds.

*Press room*—Women run light hand-molding presses; single-ram presses from 3- to 15-inch; double-ram presses from 6- to 8-inch; assemble and disassemble wedges; do preinspection and floor inspection; hi-spot testing.

*Drafting room*—Women do ordinary drafting-room work.

*Laboratory*—Women chemists do the same sort of work that men do.

*Designing*—Women artists do plastics designing.

One plastics mold maker has been extremely successful in using women in the toolroom. These women work on all types of mold operations, including cutting, grinding, polishing, and all the various steps of tooling molds. The company has an extensive training program for women, especially designed to fit toolroom work as distinguished from a general training program applicable to the entire industry.

Plastics include a great variety of substances made according to various chemical formulas. A review of the industry early in 1942 indicated that since 1918 over 105 trade-named products and possibly 60 different types of compounds had been developed. Each type has many grades and degrees of hardness. If color and transparency also are considered there is an almost unlimited list of materials from which to select. No doubt more types have been developed since that review. Whenever these materials are to be used for a new purpose,

extensive tests are made to select the one most suitable. Often a new compound is worked out in the laboratory to meet the situation.

These materials, like the different types of synthetic rubber (classed by the Census in the plastics-industry group), have both their virtues and their defects. The materials must be applied so as to make best use of the virtues, which include light weight, color, durability especially as compared with glass or porcelain ware, high insulating qualities, and in some types transparency. When a plastic replaces metal the process necessarily is changed and often simplified. For example, a gun-barrel sighter made of five pieces of brass and involving two soldering operations was first exactly copied in plastics, but later it was redesigned to be made in two pieces, greatly speeding production and saving materials.

Out of all these war uses much knowledge will have been secured as to the most practical application of the various materials. Where plastics have proved superior to metals or with equal performance have proved less expensive, their use will be continued and expanded.

The many peacetime uses of plastics that had begun to develop before the war undoubtedly will be increased and a great variety of new uses added. Plastic articles that already have been well received include many small items for use around the house, dishes for informal occasions, funnels, sink strainers, measuring spoons, apple corers, cheese graters, shoe and hat trees, and a long list of personal items, such as costume jewelry, cosmetic containers, cigarette cases, and the like. Plastics make excellent toys and are almost perfect for infants' toys. Well over a fifth of the buttons produced in 1939 were of plastics. Other plastic articles separately listed as manufactured in 1939 were electrical goods; housings (for cameras, scales, radios, and so forth); and closures for bottles, cans, and the like.

The use of plastic-blended plywoods in boats and small aircraft is well known. Many of the processes involved in the fabrication of plywood articles are the same as those in ordinary wood. The application of plastics as a waterproofing material takes it into the textile field. The making of articles by molding or casting is perhaps most closely akin to the metal trades.

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