UNITED STATES DEPARTMENT OF LABOR

BULLETIN OF THE WOMEN'S BUREAU, NO. 50

EFFECTS OF APPLIED RESEARCH UPON THE EMPLOYMENT OPPORTUNITIES OF AMERICAN WOMEN

[PUBLIC—No. 259—66TH CONGRESS]

[H. R. 13229]

An Act To establish in the Department of Labor a bureau to be known as the Women's Bureau

Be it enacted by the Senate and House of Representatives of the Unted States of America in Congress assembled, That there shall be established in the Department of Labor a bureau to be known as the Women's Bureau.

SEC. 2. That the said bureau shall be in charge of a director, a woman, to be appointed by the President, by and with the advice and consent of the Senate, who shall receive an annual compensation of $5,000. It shall be the duty of said bureau to formulate standards and policies which shall promote the welfare of wage-earning women, improve their working conditions, increase their efficiency, and advance their opportunities for profitable employment. The said bureau shall have authority to investigate and report to the said department upon all matters pertaining to the welfare of women in industry. The director of said bureau may from time to time publish the results of these investigations in such a manner and to such extent as the Secretary of Labor may prescribe.

SEC. 3. That there shall be in said bureau an assistant director, to be appointed by the Secretary of Labor, who shall receive an annual compensation of $3,500 and shall perform such duties as shall be prescribed by the director and approved by the Secretary of Labor.

SEC. 4. That there is hereby authorized to be employed by said bureau a chief clerk and such special agents, assistants, clerks, and other employees at such rates of compensation and in such numbers as Congress may from time to time provide by appropriations.

SEC. 5. That the Secretary of Labor is hereby directed to furnish sufficient quarters, office furniture, and equipment for the work of this bureau.

SEC. 6. That this Act shall take effect and be in force from and after its passage.

Approved, June 5, 1920.

U. S. DEPARTMENT OF LABOR
JAMES J. DAVIS, SECRETARY
WOMEN'S BUREAU
MARY ANDERSON, Director

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UNITED STATES DEPARTMENT OF LABOR,
WOMEN'S BUREAU,
Washington, August 11, 1925.

SIR: I have the honor to submit a report on the effects of applied research upon the employment opportunities of American women.

Among the functions assigned to the Women's Bureau by its organic act is advancement of "the opportunities for the profitable employment" of wage-earning women. This bulletin on the "Effects of Applied Research upon the Employment Opportunities of American Women" marks only the second expenditure the bureau has been able to make in the exercise of this function, because resources available to the bureau at the outset did not permit the simultaneous fulfillment of all the mandates of the organic act. Activities for the first five years of the bureau's life have been concentrated chiefly upon the promotion of the welfare of wage-earning women in the occupations and industries in which women had already been employed before the bureau was created. This concentration does not mean that the advancement of the wage-earning woman's opportunities for favorable employment is regarded as less important than the other mandates embodied in the organic act. It means only that the bureau recognized the obvious first claim on its resources to be the initiation of a continuous series of investigations designed to make clear to the public the present conditions of woman labor, because this knowledge is essential both to continuous improvement of such conditions and to intelligent advancement of women's employment opportunities.

It is plain from the facts presented in this report, however, that the many fundamental changes initiated during and since the World War in industrial processes must claim increasing attention from this bureau, as such changes are exerting marked influences upon the breadwinning opportunities of women dependent for support upon wages earned in industry and commerce.

MARY ANDERSON, *Director.*

Hon. JAMES J. DAVIS,
Secretary of Labor.

EFFECTS OF APPLIED RESEARCH UPON THE EMPLOYMENT OPPORTUNITIES OF AMERICAN WOMEN

PART I

INTRODUCTION

Wage-earning women do not work at jobs that are created or held in an industrial and social vacuum. That the public knows. It knows that women in factories make things that men and women in and out of factories desire or need; that the things made are fashioned out of materials passed along by people at work in other factories, in the mines, in the open fields, or in the forests. The public knows that women have been forced out of the home into factories and mills by the accumulating momentum of invention and large-scale production. It has accepted the new industrial system as an accomplished fact. Protests against the "woman invasion of industry" have long since died away. Seven decades of the woman invasion, chiefly into industries that beneficently robbed the home of its slow and toilsome hand production, have failed to develop the predicted loss of love for home and family. In recent years, therefore, the public has turned its attention to the improvement of the conditions under which women are working in the world of industry and commerce.

However, although the public has recognized that the forces of invention and economic necessity which drew woman out of the home and into the business world are the forces that must keep her there; although it recognizes that both of these forces are still exerting a powerful influence upon the occupational activities of men and women; it has not as yet given effective recognition to the fact that women are not fixed in industry though they are fixtures of industry. It seems to have been taken tacitly for granted that the circumstances which drew women into office, factory, and mill with little or no conscious participation of Nation, State, or municipality must distribute women over the field of industry, and that such circumstances are in no way subject to the control or influence of the public generally or even of those persons actively interested in advancing the employment opportunities of women.

The rapid developments of the past decade stress the importance of keeping in mind that the jobs which women hold in industry are living parts of the whole industrial organism, and as such are undergoing constant changes and are reacting to conditions throughout the industrial body; that changes are frequently initiated at times and places wholly remote from the thousands of wage-earning women now at work in American industries; and what is more important than all, that changes are frequently set in motion by deliberately framed and carefully executed policies. Some of these policies are political, others are civic, still others are purely industrial, and some are of scientific or educational origin. To all of them, however, women, as responsible members of the electorate, have an obligation. Failure to discharge the obligation does not cancel it. An intelligent discharge of the obligation can not be achieved without full knowledge of the forces that are affecting the employment opportunities of women throughout the field of industry and commerce.

The purpose of this bulletin is to discuss these opportunities as affected by a single factor, namely, scientific research applied to industrial processes and commercial systems. Later in these pages will be found descriptions of conspicuous changes which have occurred in the employment opportunities of women in certain industries as a result of the application of research. The unmistakable import of the data is that the employment opportunities of women are often advanced, shifted, retarded, or set back as a result of scientific research, but that the net result is an expansion of the occupational area open to women. The assembly of facts makes it equally clear that the results of research are applied not with hostility to women, not with indifference, nor yet with friendliness. They are applied usually with no reference at all to the effect on breadwinning opportunities of American women. The setback has come through default as the advancement has come through accident, tradition, and the relative availability of man and woman labor in a locality, such circumstances playing their usual rôle in the allocations of the new occupations resulting from research. Of course, in the initiation and prosecution of research projects the possible influence on either men or women wage earners is rarely, if ever, taken into account. Indeed, in the prosecution of fundamental research, industry itself is not considered.

"The scientist makes discoveries usually without any idea of their industrial application," writes an officer of a national organization of men concerned in the development of a practically new American industry. "It is the function of the engineers to learn of the findings of the scientists and to make applications of them." But in the application as in the achievement of the results of scientific research,

there is no perceptible thought given to the effect of the changes on the employment opportunities of women or to the possibility of applying the results with selective judgment as to occupational allocations.

SUMMARY

Changes resulting from research.

Applied research has exerted and is exerting a dominant influence on the employment opportunities of women[1] in American industry and commerce in the following ways:

First. By finding commercially available methods of using dormant natural resources for the upbuilding of new industries, and for supplying raw materials for old industries.

Second. By placing nature's raw materials with synthetic substances; that is, by materials scientifically compounded.

Third. By the creation of new products from materials already well known.

Fourth. By converting the waste of one industry into raw materials for another industry or into commercially valuable by-products.

Fifth. (Inextricably related to the factors stated above.) By developing new processes of, and new mechanical equipment for, manufacture.

Sixth. By devising automatic machinery for the manufacture of interchangeable parts.

Seventh. By inventing new mechanisms for, and new facilities of, communication.

Eighth. By promoting new commercial methods and devices for accounting and distributing old and new products.

General effects of such changes on employment opportunities for women.

In discussing the general effects of scientific research upon the employment opportunities of women, it should be kept in mind that this factor does not operate alone. There are many contributing factors having varying degrees of influence, often modifying, sometimes nullifying, the logical result, of the factor of scientific research—at least for a time. Among such complicating or contributing factors are the relative availability of man and woman labor at the time when, and in the locality where, changes due to research are put into effect; the traditions concerning the suitability to women—or the reverse—of certain industries and occupations; and

[1] Manifestly the employment opportunities of men are affected in a corresponding and often in a relatively greater degree, but the scope and purpose of this report confine the discussion to the influence of the factors upon the breadwinning opportunities of women.

the lack of facilities for training women to meet the requirements of the new occupations. These factors have always exerted an influence upon the employment opportunities of women, and it is not to be expected that they will be impotent when scientific research develops new processes or new materials for old products, or products different from those already known from old or new materials by the usual or changed processes. The influence of tradition, however, is wearing down with the spread of women over the field of industry, and all signs point to a growing tendency to discard tradition and to apply tests in determining what occupations are suited to women. Labor supply must always be reckoned with, however, and the same is true of other factors though in a less degree. All of them must be taken into account when weighing the results of the industrial and commercial developments due to scientific research. But in general the effects of such developments upon the employment opportunities of women, stated without explanation or illustration, are—

First. That the new industries growing out of the utilization of hitherto dormant resources have opened new employment opportunities to American women, though the occupations performed are sometimes those in which women in other countries have earned their bread for centuries.

Second. That the development of new raw materials, whether from the extended utilization of natural resources, from a synthesis of new substances, or from a conversion of the waste materials of one industry into the basic materials of another, has had a variety of effects, such as opening absolutely new occupations to women; shifting certain occupations from women to men, while increasing the number of women employed in other occupations in the same industry; increasing the actual but decreasing the relative number of women; increasing both the actual and the relative numbers; keeping open old occupations that would otherwise have been closed for lack of raw materials.

Third. That the inventions of new products and new methods of communication have enormously increased the employment opportunities for women, though in many cases the activities performed differ little or not at all from those of occupations now regarded as peculiarly suited to women.

Fourth. That all of the changes in methods are accompanied by a conscious effort to eliminate costly waste of material or excessive labor, to reduce hazard, and to improve working conditions generally, thus reducing the number of occupations from which women rightly are debarred because of the physical strain involved.

Fifth. That whenever the changes in processes give rise to occupations involving the handling of chemicals in large quantities, even though mechanical devices only are used in such occupations, women are not employed; except as chemists engaged in the more or less routine analysis of materials, the services of women are drafted for the occupations which follow the chemical processes.

Sixth. That the increase in transportation facilities and the development of long-distance transmission of power are increasing employment opportunities for women by permitting industries to range away from the base of power, the raw materials, and even the markets, in search of adequate supplies of women workers who, because of their inability to leave home, would otherwise be without employment opportunities.

Seventh. That the calculating and recording inventions and the new commercial methods, brought into existence to keep distribution and accounting abreast with expanding industry, have enormously increased women's opportunities for clerical employment, and have likewise opened opportunities for employment in positions requiring greater skill, better training, and more administrative ability.

Eighth. That the increased opportunities for the employment of women growing out of the foregoing developments in applied research do not necessarily increase the total number of women in industry and commerce beyond the growth occasioned by the growth in the adult woman population. An analysis of census figures indicates that the increased opportunities are resulting in a continued relief of the congestion of woman labor in the older so-called woman-employing industries—a relief started by the shortage of male labor during the war.

Ninth. That the wider distribution of women over the field of industry and commerce and their advancement into better occupations have not, on the whole, reduced the number nor impaired the quality of the employment opportunities of men, for neither men nor boys have taken the places in the old industries deserted by women. The numbers of both man and boy wage earners have increased more than the numbers of woman and girl wage earners during the decade represented by the last population census. This fact should not convey the idea that occupations have not been shifted from men to women, from women to men, and from both to machines, as a result of applied research; it is only to show that the net

increase in the number of women's employment opportunities resulting from applied research has not been accompanied by a net decrease in the employment opportunities for men.

Furthermore, it must not be understood that each of the foregoing general effects of scientific research upon employment opportunities flows only from one or another of the changes in materials and processes described in these pages. Any one of the changes may bring about many of the results named if followed through a series of industries or even through all branches of a single industry. So also may one of the general effects come from a combination of developments in materials, methods, and products. The causes, like the effects, are interlocking. This fact makes it of greater importance that their operation should command the careful study of those interested in advancing the employment opportunities of American breadwinning women.

The changes and effects in true perspective.

The changes of the past decade in methods and materials of manufacture and in the systems and commodities of commercial intercourse that are exerting a lasting and far-reaching influence upon the employment opportunities of women have in many instances the quality of romance and the character of new adventure. Yet an important and instructive truth is that these changes and consequences, though startling and far-reaching, are frequently not new in kind but only in the rapidity of occurrence and in the extent of their application. For example, amazing developments in the utilization of once dormant natural resources were forced by war embargoes on importations of many essentials of manufacture. These developments had spectacular effects at times on the employment opportunities for women—the effects being enhanced inevitably during the war by the shortage of male labor. But natural resources have always been a dominant factor in determining occupational activities, from the landing of the colonists to the present day. The difference lies in the fact that in the earlier period of limited knowledge the resources utilized were such as were obvious, easily accessible, and readily usable by simple though slow and laborious methods. In the later periods, particularly during the past decade, scientific research, under the forced draft of a war necessity and then under the momentum of the war-born effort, has uncovered new resources in old localities and has quickly found ways to use known but dormant resources in both old and new sections of the country. The results arrested public interest, but their quality of romance was imparted more by the war (enforced rapidity of action) than by any revolutionary principle of action. Just as the motion picture compresses a whole season of bud and bloom into a swift, dramatic

process of a few minutes, so the emergencies of the past few years speeded into visibility the age-old influence of natural resource upon the employment opportunities of women and men alike. A glance back will establish the validity of this statement and enhance the importance of the historic and current fact as a concrete suggestion to those who would advance the employment opportunities of women.

In spite of the growth of the Nation from a few seaboard colonies to a country of over a hundred million people, the streams of occupational activity are still flowing in channels marked out by the natural resources of land and sea in the pioneer days of the Nation's history. The English lady, the German and Dutch housewives, and the indentured and slave women coming to Maryland and Virginia in the seventeenth century had their work laid out for them by the fertile soil which, cultivated in large estates, yielded not only abundant food but the tobacco that had the double value of a commodity and a purchasing medium. On the other hand, the stony soil of Massachusetts, Rhode Island, and Connecticut yielded barely enough food for the settlers, but the sea afforded a great variety of fish that proved marketable in Europe and the West Indies. Fishing required nets and fishing boats. Marketing fish required fish merchants, ships, ship equipment, and shipping crews. The grudging soil yielding no uniform abundant crop such as tobacco for a purchasing medium, the settlers made the articles they could not buy and which they required for their daily use. They spun and wove, and made cloth into clothing. From the plentiful animal resources they made leather from skins and shoes from the leather; they turned trees into logs, logs into lumber, and lumber into structures and into the myriad of frames and handles required for tools, utensils, and horse-drawn implements; they built their own flour mills and iron foundries, and in all these activities the women of the Colonies had a share, even in the work in the flour and saw mills. The basic physical conditions and the obvious natural resources in the New England States, as elsewhere in the country, set the tasks and made the permanent channels through which the occupational activities flowed in increasing volume even to the present time. For Massachusetts is still first in fisheries—though the fish mean more than food to-day. Scientific reasearch has found ways of making fish skins into leather, and fish scales into pearls. It has converted waste fish and fish waste into fertilizer. It has, in short, stimulated and extended the importance of an industry already old in Massachusetts and in other seaboard States.

The South still raises its cotton and tobacco primarily, though the occupational channels are enlarging in response to the growing use of hitherto unused resources. Research, when our Nation was cut off from its imported supplies of fine ceramic materials, found

ways to use the china and art-pottery clays of the South for the manufacture of the wares to which we were accustomed. The development was speeded by an unexpected shortage and resulted in the birth of a new industry in the South and new employment opportunities to southern breadwinning women, though the occupations thus opened are as old as civilization to women of other countries. It is true that the industry is still an infant, and the employment opportunities are correspondingly limited; but the industry is growing, and is feeding upon a wealth of natural resource in raw materials which make the South a logical place for its upbuilding, while extensive transportation facilities make it practicable for the potteries of Ohio, New Jersey, and other States to draw upon the South for such materials as they can not get more advantageously from overseas.

Under the impact of unparalleled demands, scientific research compassed with surprising rapidity the skill to supply the Nation with the optical-instrument and chemical glass which could no longer be imported but which was indispensable to American medicine, to all the physical sciences, to industry, and to the daily needs and creature comforts of civilian life. Suddenly, at the command of concentrated research, rose a new industry in America—and with it new employment opportunities for women—out of the sand, the soda, the lead, the lime, the baryta, and the other raw materials stored away in American soils.

Unquestionably, the developments affecting the employment opportunities of women which seem newest in kind are the results of investigations initiated for the purpose of finding new material for old products and of making new products out of old materials. Not only do these forces seem like new forces of far-reaching influence, but they are usually responsible for new processes, which in turn bring into existence new mechanical equipment—all affecting directly or indirectly the employment opportunities of women. As shown in the illustrative descriptions submitted later in this report, such research methods have found out the secret of the silkworm's process of manufacture; have produced from wood pulp, cotton waste, and other cellulose substances, something similar to the worm's viscose secretions, and have borrowed the principle of the silkworm's spinneret for drawing the viscose liquid into fine filaments. As a result of the discovery, American girls—some of them working in wartime powder plants where they turned this same cellulose into explosives—are now preparing thread for the manufacture of the lustrous new artificial silk, or rayon, used in combination with the cotton, the wool, and the natural silk in woven and knit goods made by hundreds of thousands of other girls in textile mills, women having found employment in American cloth-making industries since colonial days.

In a word, out of this triumph of research came new raw materials, a new product, a new industry, and new employment opportunities for American women in occupations which, though analogous to some of the work done for centuries by the Chinese, Japanese, Italian, and Spanish girls who reel the filaments from the silkworm cocoon, require such a degree of ability and training that some of the manufacturers of rayon employ only high-school graduates. And all this—as an important commercial and industrial factor—has come about in the short span of half a dozen years. The research that first produced artificial silk as a laboratory achievement, however, is nearly half a century old.

Another striking example of the dramatically swift development of new raw materials—but in this case for maintaining an old product—is afforded by the perfume industry. Until a few years ago the flowers gathered by the peasant girls of France, Bulgaria, and southern Italy and the cloves and spices of the far East furnished the great bulk of materials for the American aromatic industry, as they furnished a large share of the finished perfumes sold in the American market. Within the past decade, however, chemical research has discovered how to extract and to build up the perfumes of a thousand blooms and the flavors of acres of orchards from lumps of soft coal, which are but the residue of long dead forests and of millions upon millions of buried blooms. These discoveries, which have linked the manufacture of perfumes and flavors in a vital relation to the production of medicinals,[2] have transferred an important source of the industry's raw material from the flowering fields of Europe and Asia to our own by-product coke ovens. Unfortunately, the 1923 census of manufactures does not report the numbers of men and women employees separately, but it is stated that the increase in the value of perfume materials during the past decade (1914 to 1924) was over 400 per cent.[3] Even after full allowance is made for the reduced purchasing power of the dollar during this period, the increase in the industry due to the swift development of a new raw material remains spectacular.

Of course, these and many kindred discoveries of the past decade are new in the sense that the resulting raw materials or products, or both, are new and have opened, or bid fair to open, additional

[2] "Products which to-day are known as perfumes and solvents, tomorrow may become very important drugs. Processes * * * used in the building up of fine perfumery substances are producing valuable drugs for the relief of pain and the curing of diseases * * *." (Isermann, S., Perfumes and flavors. *In* Chemistry in Industry * * * ed. by H. E. Howe. New York, Chemical foundation, 1924. p. 293.)

[3] "In this country, for instance, in 1914 the production of perfume and perfume materials was valued at about sixteen million dollars; in 1924, in accordance with census returns, it is about eighty-five million dollars, or an increase of over 400 per cent." (Isermann, S., op. cit., p. 288.)

employment opportunities for women. But they are not new in the sense that they present the first examples of successful search for new materials and new products. The phenomenal speed by which they were achieved under the stress of circumstances has made them stand out as unparalleled in the history of manufacture. While the speed of achievement was dramatic and carries a lesson discussed later in these pages, the discovery of new raw materials or of new products resulting from research and affecting the employment opportunities of women has been paralleled in comparatively recent industrial history. Paper manufacture, for example, a one-time conspicuous employer of women, depended for its raw materials upon the rags collected by the "ragmen" in this country and upon the large importations of rags from many overseas countries; but the use of paper gradually outgrew the supply of rags and forced the development of new raw materials. When wood pulp was discovered to be commercially available for certain grades of paper men took the places of women in the basic processes. Because of the resulting growth of the industry, however, the actual number of women increased, though the number of men increased much faster.

A glance back over the effects of research and invention upon the employment opportunities of women in the commercial world will reveal results that are prototypes and some that are parallels of the dramatic developments of the past decade in the field of manufacture. It is a little more than half a century since "the search for knowledge loosened by wire and wireless the bonds of silence in which intervening miles held the human voice."[4] It is less than a decade since radio really put people the world over within speaking distance of one another. Naturally these achievements are thought of in terms of service to humanity as a whole, but, with a single exception, no changes in the methods of the business world (be they methods of manufacture or methods of commerce) have opened so many employment opportunities to women as the commercial introduction of the telegraph and telephone. What wireless telegraphy and the radio will do, except in their effect on the manufacture of electrical supplies, remains to be seen. As will be observed, however, from the later detailed account of changes in telephone systems, this field affords a striking illustration of the shift of occupations to machines as a result of research and invention. Thus far the shift has been more than offset by the phenomenal increase in the use of the telephone, which has called for a steady increase in the numbers of women in the service of the telephone companies in spite of the changes. What the effect of the great

[4] To American women—a plea. p. 3. (Issued by officers of the General Federation of Women's Clubs; National Civic Federation, Woman's Department; American Association of University Women; Girl Scouts; and Daughters of the American Revolution.)

shift now going on from switchboard operators to automatic switching devices will have on the employment opportunities of women in the telephone business only the next and succeeding census of occupations can say. The growth shown in the use of long-distance service, however, together with the record of net increases in numbers following the introduction of labor-saving devices, furnishes a fair basis for the confidence that progress in methods of communication also will result in net increases in employment opportunities for women whatever shift in specific occupations such progress may occasion.

Finally, how the area of occupations from which women were barred by physical demands has been reduced by mechanical invention was discussed at some length in a bulletin issued by this bureau in 1921.[5] An outstanding fact revealed in the bulletin was that the shortage of male labor forced in a conspicuous degree the application of lifting and holding devices in the manufacture of articles the weight of which was more than women could handle safely or efficiently, and the making of which, therefore, had previously been confined to men. These constituted instructive illustrations of employment opportunities thrown open to women by the application of new methods to the manufacture of old products. Some of these inventions were regarded at first as merely emergency measures for use until male labor was again available, but in many cases both the new measures and the women were retained; in others the methods were retained even after men were restored to the occupations, as such methods were found to promote the efficiency of male labor by eliminating needless human exertion.

On the whole, then, the facts assembled in this report gain full significance only when kept in their true historic perspective. Only in this light will recent developments exerting such far-reaching influences upon breadwinning women appear in their proper relation to the industrial and social body and afford germane and practical suggestions for advancing the opportunities for the favorable employment of women.

[5] U. S. Department of Labor. Women's Bureau. New position of women in American industry. Washington, Govt. Print. Off., 1920. 158 p., pl. (Bulletin 12.)

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PART II

ILLUSTRATIVE DESCRIPTIONS OF CHANGES DUE TO SCIENTIFIC RESEARCH AND THE EFFECT OF SUCH CHANGES ON THE EMPLOYMENT OPPORTUNITIES OF WOMEN

It is safe to say that there is not a single important industry which has not been affected by the progress of scientific research in this or other countries. The usual objective in applying the results of such research is to reduce costs, increase production, and create new products or forms of service. When the objective is achieved, the employment opportunities of men or women or both are affected. Following are some illustrative descriptions of changes due to research and their influence upon the employment opportunities of women in specific industries and occupations.

Dormant natural resources for new and old industries.

One of the most striking examples of the development of a dormant natural resource is that of aluminum. In this connection, the following quotation is of interest:[6]

> To the useful metals of the ancients none was added until aluminum was extracted from clay by the chemists of to-day. It is easy to extract gold and silver which are found as metallic particles in the earth's crust; harder to obtain iron, zinc, copper, and tin, which occur as substances in which the metal is as much hidden as the charcoal in sugar. But it is most difficult to obtain aluminum, which can be extracted only by the aid of the electric current; and that is why it remained unknown for so many hundreds of years. Likewise the metals chromium, vanadium, tungsten, and molybdenum have become available for the benefit of man, who could have no automobile and no mazda light without them.

Aluminum as a constituent of the earth's crust was known to metallurgists of old, but the way to extract it from clays was not discovered until 1854, and it was more than 30 years later that an American, Charles Martin Hall, succeeded in finding ways to produce aluminum commercially. The cost of manufacturing it by Hall's process was excessive, and at that time there was no market for the newly discovered metal. Extensive research over a period of years has reduced the cost of manufacturing and found innumer-

[6] Rose, Robert E. Molecules and man. Wilmington, E. I. du Pont de Nemours & Co., [c 1920]. p. 5.

able uses for the metal. Its ability to withstand organic acids, as well as its high thermal conductivity, renders aluminum especially available for cooking utensils, whether for the home or for the factory. In this field it is replacing tin, iron, and copper. Its nonmagnetic qualities make it useful in electrical work. It is of utmost importance in the production of dirigibles such as the *Shenandoah* and *Los Angeles*.

Aluminum forms alloys readily. When combined with zinc it becomes rigid and easily machined, while retaining its lightness, so that it is extensively used in automobiles and aircraft. In 1888 no aluminum was consumed in this country; in 1923 we produced 129,000,000 pounds.[7] Our rich and abundant deposits of bauxite from which metallic aluminum is secured make the chemists' search for new uses of aluminum—especially to replace metals of which we have none in this country—of importance to the Nation as a whole.

Women play no part in the elaborate chemical process of winning aluminum from bauxite nor in the electrolytic process of reducing it to metallic aluminum. But once the aluminum ingots and plates are turned out, the lightness of the metal and its easily molded quality make it one that women can handle to advantage. In 1914 there were only 364 women and girls engaged in the aluminum industry.[8] The latest census figures on the number of women employed in manufacturing aluminum ware are for the year 1919, at which time there were reported 1,241 women and girls as employees, forming about 13 per cent of the total number of wage earners in this industry.[9] Since 1919 the numbers of persons employed have increased with increased production, but no figures are available to indicate the extent to which women have gained a further foothold in aluminum-ware manufacture. There is good ground for the belief that the extended use of aluminum to replace heavier metals will tend to draw more women into the metal-working industries.

The mazda lamp of to-day, in whose manufacture so many women are employed, is another interesting example of the effect of scientific research in opening up avenues of employment for women. This type of lamp has tungsten filaments which give three times as much light per unit of electricity consumed as the carbon filament used prior to 1912. The phonograph record is played with a stylus made of tungsten. But more important in modern industrial development is the value of tungsten in toughening steel. Hard steels

[7] Metal Industry, November 1924, p. 450.
[8] U. S. Bureau of the Census. Census of manufactures: 1914. v. 2, p. 908.
[9] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919, p. 298.

would not have been industrially available if chemical research had not discovered methods of toughening with tungsten the steel used for tools to machine the hard steels. The cutting edge of the ordinary steel tool would have been entirely destroyed as a result of the friction against hard steel castings, whereas the tungsten high-speed tool steels can cut hard steels five times as fast and maintain sharp cutting edges. Tools of this type invented in the nineties have revolutionized machine-shop methods.

Tungsten occurs, however, in irregular pockets in the earth, and, in view of the increasing demand for the product, the underground mining necessary to secure it from the deposits in the United States is expensive and of doubtful efficiency. Accordingly, many chemists believe that another metal, molybdenum, can be used in place of tungsten, both for hardening steel and for the filament in electric lamps. Molybdenum is of frequent occurrence in the granite rocks of the United States, and is a metal of which very limited use has been made as yet. Its use in place of tungsten, if proved feasible, would give this country an ample domestic supply of metal essential to a very large number of industries, many of them large employers of women now and some offering to women increasing employment opportunities from year to year.

While women have no part in the manufacture of tungsten steel or other alloys of steel, the indirect importance of such manufacture to women wage earners is evident. Much of the work which women do in instrument manufacture, in electrical-goods manufacture, and in the metal-product industries would not be possible were it not for the recent discoveries of ores that give to steel qualities other than those obtainable from pig iron alone. In the manufacture of smaller parts out of the rare new minerals, however, women are finding a new field. One firm manufacturing tungsten and molybdenum products states that 70 per cent of its factory pay roll is made up of women, who are employed on light assembling jobs and on light machines, such as riveting machines.

The rare earths had been known to chemists for many years, but it was Baron Auer von Welsbach who discovered a practical use for two of them, thoria and ceria, both obtained from monazite sands by a complex chemical process. He produced the incandescent gas mantle, of which approximately 100,000,000 are used in this country each year, both for artificial and natural gas lighting and for gasoline and kerosene lighting. To a large extent these mantles are made by women. Just how many are employed in the industry is not known, but two firms reporting stated the proportion of women in their factories to be about 80 per cent. The mantles, when made of cotton, are knit into cylindrical form by women. They are then bleached and thoroughly washed before being treated with a solu-

tion of thorium and cerium nitrates and small quantities of strengthening substances. The fabric, after being cut into suitable lengths is closed at one end with asbestos thread. It is then dried and shaped and "burned off," inspected, and finally dipped into a solution of collodion to make possible the shipment of the delicate mantles.

There are many metals known to science that have not yet been brought into the service of man. As the metallurgist and chemist find uses for them, the refinement of metal work will grow, and with each demand for a finer quality of material comes the need for more instruments and better methods of testing. In these fields alone, the expansion of the metal industry through the use of new metals brings unmeasured employment opportunities for America's breadwinning women.

New synthetic substances.

It is doubtful whether the discovery of a new raw material has had so great an effect upon so many industries and such different industries as has the development of the synthetic plastics. They are an outstanding illustration of the effect of a man-made substance on industrial employment. Synthetic plastics have been called structural materials, but they could with equal truth be called finishing materials, as they can be worked into lacquers and varnishes. They may lay claim to the name of a new product, as they appear in the jewelers' windows side by side with the pearls made of fish scales or those grown in the oyster's shell. They appear as compounded gems of many colors and myriad forms. But "structural materials" best fits the character of synthetic plastics, because they enter into the structure of the product of so many industries. In spite of the multiple uses and expanding importance of synthetic plastics, their characteristics are not familiar to the public. A vivid description of both their quality and their uses was made available a few years ago in these words:[10]

> Without going into the question of their variations and relative merits we may consider the advantages of the pyroxylin plastics (another term for synthetic plastics) in general. Here we have a new substance, the product of the creative genius of man, and, therefore, adaptable to his needs. It is hard but light, tough but elastic, easily made and tolerably cheap. Heated to the boiling point of water, it becomes soft and flexible. It can be turned, carved, ground, polished, bent, pressed, stamped, molded, or blown. To make a block of any desired size simply pile up the sheets and put them in a hot press. To get sheets of any desired thickness, simply shave them off the block. To make a tube of any desired size, shape, or thickness, squirt out the mixture through a ring-shaped hole or roll the sheets around a hot bar. Cut the tube into

[10] Slosson, Edwin E. Creative chemistry. * * * New York, Century Co., 1921. p. 132–144.

sections and you have rings to be shaped and stamped into box bodies or napkin rings. Print words or pictures on a celluloid sheet, put a thin transparent sheet over it, and weld them together, then you have something like the horn book of our ancestors, but better.

Nowadays such things as celluloid and pyralin can be sold under their own name, but in the early days the artificial plastics, like every new thing, had to resort to camouflage, a very humiliating expedient since in some cases they were better than the material they were forced to imitate. Tortoise shell, for instance, cracks, splits, and twists, but a "tortoise shell" comb of celluloid looks as well and lasts better. Horn articles are limited to size of the ceratinous appendages that can be borne on the animal's head, but an imitation of horn can be made of any thickness by wrapping celluloid sheets about a cone * * *.

The precious red coral of the Mediterranean can be perfectly imitated by taking a cast of a coral branch and filling in the mold with celluloid of the same color and hardness. The clear luster of amber, the dead black of ebony, the cloudiness of onyx, the opalescence of alabaster, the glow of carnelian * * * are now within the reach of everyone, thanks to this chameleon material. Mosaics may be multiplied indefinitely by laying together sheets and sticks of celluloid, suitably cut and colored to make up the picture, fusing the mass, and then shaving off thin layers from the end. That chef d'œuvre of the Venetian glass makers, the Battle of Isus, from the House of the Faun in Pompeii, can be reproduced as fast as the machine can shave them off the block. And the tesserae do not fall out like those you bought on the Rialto.

The process thus does for mosaics, ivory, and coral what printing does for pictures. It is a mechanical multiplier, and only by such means can we ever attain to a state of democratic luxury * * *.

[This pyroxylin plastic appears in] handles for canes, umbrellas, mirrors and brushes, knives, whistles, toys, * * * blown animals, card cases, chains, charms, brooches, badges, bracelets, rings, book bindings, hairpins, campaign buttons, cuff and collar buttons, cuffs, collars, and dickies, tags, cups, knobs, paper cutters, picture frames, chessmen, pool balls, ping-pong balls, piano keys, dental plates, masks for disfigured faces, penholders, eyeglass frames, goggles, playing cards—and you can carry on the list as far as you like.

Celluloid has its disadvantages. You may mold, you may color the stuff as you will, the scent of the camphor will cling around it still. This is not usually objectionable except where the celluloid is trying to pass itself off for something else, in which case it deserves no sympathy. It is attacked and dissolved by hot acids and alkalies. It softens up when heated, which is handy in shaping it, though not so desirable afterwards. But the worst of its failings is its combustibility. It is not explosive, but it takes fire from a flame and burns furiously with clouds of black smoke.

But celluloid is only one of many plastic substances that have been introduced to the present generation. A new and important group of them is now being opened up, the so-called "condensation products * * *."

* * * Now Prof. Adolf von Baeyer discovered in 1872 that when phenol and formaldehyde were brought into contact they seized upon one another and formed a combine of unusual tenacity; that is, a resin. But * * * chemists in those days were shy of resins. Kleeberg in 1891 tried to make something out of it and W. H. Story in 1895 went so far as to name the product "resinite," but nothing came of it until 1909, when L. H. Baekeland undertook a serious and systematic study of this reaction in New York * * *.

Later Dr. Baekeland turned his attention to the phenol condensation products, working gradually up from test tubes to ton vats * * *. He found that when equal weights of phenol and formaldehyde were mixed and warmed in the presence of an alkaline catalytic agent the solution separated into two layers, the upper aqueous and the lower a resinous precipitate. This resin was soft, viscous, and soluble in alcohol or acetone. But if it was heated under pressure it changed into another and a new kind of resin that was hard, inelastic, unplastic, infusible, and insoluble * * *. It is called "bakelite" after its inventor.

The two stages in its preparation are convenient in many ways. For instance, porous wood may be soaked in the soft resin and then by heat and pressure it is changed to the bakelite form and the wood comes out with a hard finish that may be given the brilliant polish of Japanese lacquer. Paper, cardboard, cloth, wood pulp, sawdust, asbestos, and the like may be impregnated with the resin, producing tough and hard material suitable for various purposes. Brass work painted with it and then baked at 300° F. acquires a lacquered surface that is unaffected by soap. Forced in powder or sheet form into molds under a pressure of 1,200 to 2,000 pounds to the square inch, it takes the most delicate impressions. Billiard balls of bakelite are claimed to be better than ivory because, having no grain, they do not swell unequally with heat and humidity and so lose their sphericity. Pipestems and beads of bakelite have the clear brilliancy of amber and greater strength. Fountain pens made of it are transparent, so you can see how much ink you have left. A new and enlarging field for bakelite and allied products is the making of noiseless gears for automobiles and other machinery, also of airplane propellers.

Celluloid is more plastic and elastic than bakelite. It is therefore more easily worked in sheets and small objects. Celluloid can be made perfectly transparent and colorless, while bakelite is confined to the range between a clear amber and an opaque brown or black. On the other hand, bakelite has the advantage in being tasteless, odorless, inert, insoluble, and noninflammable. This last quality and its high electrical resistance give bakelite its chief field of usefulness * * *. Bakelite is used in its liquid form for impregnating coils to keep the wires from short-circuiting and in its solid form for commutators, magnetos, switch blocks, distributers, and all sorts of electrical apparatus for automobiles, telephones, wireless telegraphy, electric lighting, etc.

Bakelite, however, is only one of an indefinite number of such condensation products. As Baeyer said long ago: "It seems that all the aldehydes will, under suitable circumstances, unite with the aromatic hydrocarbons to form resins * * *."

A phenolic condensation product closely related to bakelite and redmanol is condensite, the invention of Jonas Walter Aylesworth * * *.

Condensite is anhydrous and infusible, and, like its rivals, finds its chief employment in the insulation parts of electrical apparatus. The records of the Edison phonograph are made of it. So are the buttons of our bluejackets. The Government at the outbreak of the war ordered 40,000 goggles in condensite frames to protect the eyes of our gunners from the glare and acid fumes.

* * * Formaldehyde will attack almost anything, even molecules many times its size. Gelatinous and albuminous substances of all sorts are solidified by it. Glue, skimmed milk, blood, eggs, yeast, brewer's slops may by this magic agent be rescued from waste and reappear in our buttons, hairpins, roofing, phonographs, shoes, or shoe polish * * *.

There seems to be no limit to these compounds and every week the journals report new processes and patents.

The foregoing sketch of the characteristics and uses of some of the synthetic plastics affords almost a panoramic picture of the industries which are concerned in the discovery and application of this new material. Every old or established industry mentioned is a conspicuous employer of women and the comparatively new industries named are employing women in some cases to a marked degree. Speaking of celluloid and pyralin substances before the Ways and Means Committee of the United States House of Representatives in 1921, a witness said:[11]

This [industry] has been wholly developed since the invention of this material by an American 50 years ago, and ground has hardly been scratched in the useful application of this wonderful substance. It is impossible to accurately arrive at the total number of persons employed, but we think a conservative estimate to place the number at 75,000.

A manufacturer of celluloid products, speaking before the same committee, said:[12]

* * * We moved our factory away from Newark * * *. We took it up to the tops of the Pennsylvania hills, up in the Pocono Mountains * * *. We employed last year 375 girls, * * * those girls * * * we picked up and trained, that never had been in a factory before and did not know what it was.

Discussing the growth of his branch of the industry, this manufacturer of celluloid articles said:

We [three concerns] are all new concerns * * *. The latest information is that the industry has started west, that new factories have opened in Chicago and in Louisville * * * and one in San Antonio, Tex.

The service manager of another firm whose manufacture of plastic compounds is a by-product activity growing out of the vast tonnage of what otherwise would be waste in the manufacture of its main product, writes:

Our most extensive employment of women occurs in our pyralin factory where approximately 250 women are employed as small-machine operators and finished-goods inspectors.

The personal-ornament industries have been stimulated and expanded especially during the past five years by the introduction of the plastic compounds. As the United States census of manufactures does not keep separate the data on industries using any given raw or structural materials, it is not possible to say at this time just how

[11] U. S. Congress. House of Representatives. Committee on Ways and Means. Tariff information, 1921. Hearings on general tariff revision before the Committee on Ways and Means. Washington, Govt. Print. Off., 1921. p. 147.

[12] Ibid., p. 161–164.

many women are affected by the increasing use of these plastics in the manufacture of artificial jewelry and other personal ornaments; but since this work has always been regarded as particularly suited to women, it is safe to say that a new and easily handled raw material will expand the employment opportunities of women as it expands the personal-ornament industry.

It is not necessary to go farther down the list of industries affected by the discovery of this single new structural material to demonstrate the far-reaching influence of such changes on industrial processes. Without the testimony quoted and without the confirmation of the official manufacturing census it is clear that the introduction of a new substance, extremely light, durable, and capable of manifold uses, must exert an increasing influence upon the employment opportunities of women, for not only does such material enter into a larger number of products in daily use, but it gives rise to a growing volume of new products. In the manufacture of these, women can participate without the drag of tradition which checks their entrance into many occupations underlying manufactures long regarded as the peculiar product of man labor.

New products for old uses.

The searchlight of ingenuity has been playing over the fiber world all through the centuries to discover materials out of which, and methods by which, more and better clothing and other covering could be made. It was, indeed, a boon to the young United States, dependent upon Europe for wool and flax, not only when the cloth-making possibilities of cotton were discovered but when the cotton gin was invented, making large-scale cotton-fiber production possible; when a spinning machine was constructed by which cotton roving could be spun for the warp as well as for the woof of cloth; and when drawing and roving frames were successfully operated for producing cotton thread stronger than some linen thread. These American inventions, all successful in the last years of the eighteenth century, together with a favorable cotton-growing soil and climate in the Southern States, made cotton much more available to American people than any other fiber. Other machines were quickly invented, until in 1814 cotton spinning and weaving were done in one building by power machinery, "the first complete factory in the world." The amount of cotton shipped from the South to New England grew from 500 bales in 1800 to 90,000 bales in 1815.[13]

The burden of cotton-cloth production immediately fell upon the women of the early communities. Men had been fullers of wool and weavers of wool and linen in Europe and they continued to ply

[13] Scherer, James A. B. Cotton as a world power. New York, Frederick A. Stokes Co., [c. 1916]. p. 175.

these crafts in the Colonies; but no tradition existed concerning cotton-cloth making in the New World, the first use of cotton dating from the time of the settlement of the early Colonies. From the very beginning cotton-cloth manufacture developed as a woman's industry. In the first factories in which only yarn was made, Gallatin estimated that there were employed seven times as many women and children as men.[14] The first power looms were operated by women. Descriptions of cotton mills in which all work was done by machinery show that only two occupations which had been done by woman in the days of household manufacture had been taken from her, while occupations nonexistent in colonial days had been opened to her. The two occupations lost were the cleaning of cotton and the dyeing and finishing of cloth. Carding, drawing and roving, spinning, spooling, warping, dressing, drawing in, and weaving of cotton materials were all done by women in the early mills.

Since 1860 numerous inventions have greatly simplified the operations while at the same time they have improved the quality of the goods and increased the speed of output. The simplification was brought about in the first instance to meet continuous changes in the character of the labor supply available for cotton mills. In the North, women of the type of the early cotton-mill operators ceased to work in cotton mills and became teachers and nurses during and after the Civil War. Their places had to be filled from the ranks of newly arrived men immigrants. In the South, the policy of drawing upon mountaineer families temporarily increased the supply of men more than the supply of women operators.

In spite of the simplification, which has enormously increased the per capita output, and in spite of the change in the relative supply of man and woman labor, the actual numbers of women have increased 194 per cent since 1850, as compared with a 580 per cent increase in the numbers of men during the same period.[15]

The growth of the cotton industry in this country, however, has not stopped the search for other materials from which to make clothing and other covering. The silkworm's cocoon spinning has long been the envy of man, and many years have been spent in efforts to imitate the silkworm's method of producing a silk fiber. Chemists, working with different materials, but, like the silkworm, producing a semiliquid substance which, when passed through fine capillary openings (the silkworm's spinneret) hardens immediately into fine fibers, have succeeded in making not one but several kinds of fibers of high luster. These fibers are not silk but are new

[14] U. S. Congress. American state papers: Finance, v. 2, Report on Manufactures, 1809. Washington, 1832. p. 427.

[15] See appendix Table I.

fibers which have never existed in nature. They have been named "rayon" by the men who are spinning and weaving them into threads and clothes. As yet they have not the strength of raw silk when wet and are not as a rule used alone for fabrics requiring much washing and heavy wear, but are used in combination with raw silk or cotton and wool to add luster or give color design and two-color effects to clothes—effects which can not be obtained with nature's products alone. Chemists are constantly at work studying methods whereby rayon fibers of greater strength and fineness can be produced. Just as cotton roving has been spun into threads strong enough for warp as well as for woof ever since Samuel Slater built his spinning machine in 1790, so some one in the years to come will find the way to make cloth strong enough for hard wear entirely out of the new product, rayon.

That rayon already has found its place among textiles is evidenced by the fact that the world production of rayon in 1923 was 90,000,000 pounds—an amount almost 50 per cent higher than the world's production of silkworm silk in that year.[16]

The manufacture of rayon as an industry in the United States began in 1911, when 320,000 pounds were produced by one company. In 1919 three companies were operating and the production had grown to 8,004,798 pounds. The figures on production in the United States for the years following are here presented:[17]

	Pounds
1920	9,000,000
1921	18,000,000
1922	26,000,000
1923	35,490,000
1924	38,850,000

In 1924 there were five firms that had produced 500,000 pounds or more each and several establishments were operating that reported a smaller production. At the beginning of 1925 two other large companies started operations. In the seven large establishments manufacturing rayon in 1925, the fibers were made by the viscose process in some plants, by the Chardonnet process in one plant, and from cellulose acetate in others.

All plants, regardless of the chemical processes involved in manufacturing the lustrous fiber, have need for women's service. This demand occurs not in the departments that convert wood or cotton cellulose into the crude rayon thread, but primarily in the operations which turn the crude thread into marketable skeins. In the earlier processes of manufacture, in which the cellulose substances are

[16] Textile World, February 7, 1925, p. 321.

[17] Compiled from manufacturers' reports by the Textile World, May 24, 1924, February 7, 1925.

treated with various chemicals under differing temperatures until reduced to liquid form and are then forced through spinnerets, emerging as fine filaments, the work involved requires highly experienced supervisors and strong laborers. An official of a large rayon factory stated that women help in the chemical part of the manufacture of rayon only, as testers of chemicals to be used in the manufacturing process and as testers of the mixtures at final stages of the manufacture. But once the fine filaments have been coagulated and caught up into threads and purified, rayon manufacture becomes a woman's industry. After the thread has been wound into skeins on reeling machines, girls snap the skeins on wooden pegs to pull out the kinks and then carefully examine the threads for grade. Much of the product is shipped in skein form, but the larger plants wind the rayon onto bobbins, then double it and twist it onto spools and tubes ready for knitting or weaving mills. The latter processes are analogous to those which women perform in the raw-silk throwing mills. The new occupations which rayon production has opened to women in this country are the reeling of crude thread into skeins, the inspecting and grading of skeins, and routine chemical analysis.

Not only has the commercial production of this man-made fiber opened a few new occupations to women but it has tended to increase the numbers of women in textile manufacture. There are no figures available as to the total number of women employed in rayon manufacture. Information on numbers employed was obtained from two firms producing more than 40 per cent of the 1924 tonnage. These firms employed approximately 7,000 wage earners, of whom 42 per cent, or about 2,900, were women. Applying the production rate per person in these plants to the total production in all plants during 1924, and assuming that the proportion of women employed was the same in other factories as in these two plants, there would be approximately 7,000 women working in rayon plants in 1924.

At the present writing the market for rayon continues to exceed the present production capacities of plants, so that the future for women in this new industry is bright. Rayon does not seem to have taken the place of older fibers in textiles, but rather to have made a place for itself. Whether further research resulting in strengthening the fiber will also find ways whereby it can be produced into cloth by methods less laborious than that of world-old weaving, only the future will tell. Already rayon net is formed by pressing the substance over a roller. Should a similar means be found of making material corresponding to tightly woven cloth, the employ-

ment of women in the older textile industries would undergo far-reaching changes. The ceaseless search for new and better methods of making new or better fabrics holds unmeasured possibilities in employment opportunities for women in the textile industries. Discussing the future of chemically treated cellulose one chemist said five years ago:[18]

> It may by one operation give us fabrics instead of threads. A machine has been invented for manufacturing net and lace, the liquid material being poured on one side of a roller and the fabric being reeled off of the other side. The process seems capable of indefinite extension and application to various sorts of woven, knit and reticulated goods * * *. In short, we seem to be on the eve of a revolution in textiles.

Development of new branches of old industries.

Nearly 100 years ago (1832) a report to the Secretary of the United States Treasury showed that 16 women were employed in American glass factories painting the glass or covering the demijohns manufactured in the establishment. They were not, therefore, engaged in glass manufacture at all. In 1850 the United States Census of Manufactures reported 97 women wage earners and nearly 5,600 men wage earners in American glass factories. During the three decades next succeeding, there was a steady and substantial increase in the numbers of men. While the percentage of increase in the numbers of women was great, the actual numbers involved were so small that the rate of increase resulted in a total of fewer than 750 women in 1880.[19] During the next 10 years the number more than doubled, but even then there were fewer than 2,000 women engaged in American glass factories. In 1900 there were over 42,000 men and more than 3,500 women glass workers. Five years later, when the United States Census of Manufactures was taken, the number of men had increased by nearly 12,000, but the number of women had decreased slightly. In 1909 there were but approximately 4,500 women as compared with approximately 76,000 men, and as late as 1914 the women in glass industries numbered but 4,999 as compared with 76,909 men.[20] In 1919, however, the number of men had increased only 4,305, while the number of women had increased by 5,411, or about 108 per cent.[21] Furthermore, there are evidences that since the publication of the 1919 Census of Manufactures and the 1920 Census of Occupations the increase in the numbers of women in the glass factories has been even more marked than in the five-year periods ending 1919 or 1920.

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[18] Slosson, Edwin E. Creative chemistry . . . New York, Century Co., 1921. p. 121.

[19] See appendix Table II.

[20] U. S. Bureau of the Census. Census of manufactures: 1914. v. 2, p. 836.

[21] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919. p. 388.

An officer of a national ceramic organization, in answer to a question as to the recent increases in the numbers of women in the glass industry as a result of scientific research, writes:

> One need but to go into a glass factory and note the large number of women employed there to-day and compare this with the almost total absence of women 10 or 15 years ago to appreciate what science, as applied by the engineers, has done in making lighter and more comfortable manufacturing processes.

The reference of the writer above quoted to "the almost total absence of women" doubtless refers to the fact that until the second decade of the twentieth century occupations open to women in the glass industry were sharply restricted to certain branches.

In the report on the conditions of woman and child wage earners in the United States made in 1911 on the basis of an investigation completion in 1908, occurs this statement:[22]

> Glass in some of its forms was produced in that year (1905) in 399 establishments, distributed in 21 States, and * * * in the latter part of 1907 and in the first half of 1908, these numbers had been somewhat increased. In not all of these establishments, however, were women and children employed. The making of window glass, for instance, offers no employment to women and very little to children, and in a general way this is true of all varieties of so-called building glass * * *. While it is true that in the manufacture of plate glass women were formerly used in large numbers as polishers, they have since been almost entirely superseded by machinery.

In another section, the same report says:[23]

> The finishing and leer rooms employ practically all of the women and girls in the [glass] industry * * *.

Such was the occupational status of women in the American glass industry at that time. In the great divisions of building glass, which includes plate, window, and other structural glass, and in other branches of glass manufacture, there were few women. In 1921, however, the representative of one of the greatest glassmakers in America told the Committee on Ways and Means of the United States House of Representatives that his firm employed between 8,000 and 10,000 men and possibly 1,000 women aside from the clerical forces. This proportion about bears out the figures of the 1919 Census of Manufactures, which shows that women constituted approximately 12 per cent of the labor force in the glass industry.[24]

Underlying the half century of relatively inconspicuous advancement in the employment opportunities of women in the American

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[22] U. S. Department of Commerce and Labor. Report on condition of woman and child wage earners in the United States. v. 3: Glass industry. Washington, Govt. Print. Off., 1911. p. 15.

[23] Ibid., p. 281.

[24] U. S. Bureau of the Census. Fourteenth census: 1920. v. 10, Manufactures, 1919. p. 831.

glass industry, as compared with the marked increases of the past 10 years, is a combination of forces involved in the manufacture of glass. Dominant among these were, first, the perseverance of old methods of glassmaking, practically until the close of the nineteenth century, followed by certain fundamental changes in processes and by the creation of new products, both of which situations grew out of inventions and researches started or stimulated by the war; second, the shortage of male labor due to the war occurred in the same period in which these fundamental changes in processes and the creation of new products took place. Until the close of the nineteenth century the methods of making glass involved chiefly a high degree of craftsmanship, arduous labor, and usually uncomfortable working conditions. The occupations which women performed were, therefore, rather sharply restricted to the finishing, polishing, decorating, inspecting, covering, and miscellaneous auxiliary labor, usually performed in rooms remote from the primary and rougher manufacturing processes.[25]

While no fundamental changes in the methods of making glass occurred until the early decades of the twentieth century, the substitution of gas for coal as a heating agency in the nineteenth century made better glass possible, and the discovery of natural gas in 1880 made glass cheaper. The two developments together made the use of glass more popular, the consequent growth of the industry resulting in the increase in the number of women employed during the last decade of the nineteenth century. In 1896 the automatic machine for making wide-necked bottles and in 1903 the machine for making all sort of bottles were invented, but the increased numbers of women following these changes were due to the growth of the industry and the consequent larger number of women required in the usual occupations rather than to the advancement of women into new glassmaking occupations. As a matter of fact, the advancement of women's employment into new occupations in the glass industry was not marked until after the outbreak of the World War, when the American scientists and industrial leaders had to find methods and materials for making the optical and instrument glass which is indispensable in peace or war. Practically all of this glass had been imported before 1914. To meet this emergency many private and public agencies focused their research facilities upon the subject. The United States Geological Survey sought and found among our own natural resources the necessary raw materials. The Navy Consulting Board, the National Research Council, the United

[25] U. S. Department of Commerce and Labor. Report on condition of woman and child wage earners in the United States. v. 3: Glass industry. Washington, Govt. Print. Off., 1911. p. 297–333.

States Bureau of Standards, the Carnegie Institution, and other kindred bodies with varying degrees of cooperation from commercial firms directed a battery of experimentations upon the problem of optical and instrument glass manufacture. In 1918 the Nation was not only making all its own optical and scientific glass but was sending supplies abroad. During the past five or six years the new American industry has had to share its markets with foreign competitors, but it is still here and growing in spite of some recent setbacks. The service manager of a large and important manufacturer of optical and instrument glass stated during February, 1925:

> In the plant works we largely use women in the inspection department and in radio and optical work. We have found that the girls are better fitted for this service than men, as their movements are quicker, especially in the cutting of glass. A woman will cut in a day twice as much as a man and on the inspection of it, her work is far superior.

War years witnessed another important advancement in the glass industry of this country. For years Irving W. Colburn had attempted to make a machine that would produce commercial flat-drawn sheet glass. Not until 1916, however, was the invention perfected and not until October, 1917, after Mr. Colburn's death, was drawn glass made on a commercial basis. This process is practically automatic and eliminates the larger part of the strenuous work formerly involved in manufacture of flat glass. Consequently, its adoption meant a lessening of the number of skilled men required in flat-glass factories per unit of production and a slight increase in numbers of women employed.

These two changes in glass manufacture, the production of optical and scientific glass and the introduction of automatic machinery, together with increased production of pressed and blown glassware in this country, have been accountable for the conspicuous advances of women into glassmaking occupations.

Although the manufacture of red earthenware on a commercial scale began in Ohio in 1839, the making of table china is but 50 years old in this country. China making is one of the oldest industries in the world and one in which hundreds of thousands of European and oriental women have always worked for bread, but in this country it is a young industry. From its inception women have been employed to finish the white ware and to decorate it. In 1919 about 7,700 women and girls were employed in the manufacture of tableware and other kinds of pottery.[26] Until the World War cut off our supply of white clays from England and finished chinaware from European china-manufacturing centers, however, we did

[26] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919. p. 452.

not discover ways and means for using the kaolin of good china-making quality that exists in our South Atlantic States, nor did we manufacture the finer grades of household china. The impetus given to research for materials and methods of making these grades by our lack of foreign supply for a few years has resulted in a steady, if slow, growth of the household-ware industry both in quality of product and in quantity of production. The general secretary of the American Ceramic Society, writing under date of March 31, 1925, says:

> Manufacture of household china has secured a firm foothold in this country. I do not know how many companies there are engaged in the manufacture of household china, but the numbers are slowly increasing and the individual factories are growing in size.

Naturally the manufacture of finer grades of china calls not only for a higher grade of skill—for porcelain manufacture is still very much of an art—but also for more people in the finishing and decorating departments than does the ordinary household ware. As these are the fields of service which have been open to women in the past, the expansion of the industry affords much opportunity for women in positions requiring skill and artistic ability.

To quote again from the letter of the general secretary of the American Ceramic Society:

> Women are employed in the finishing of the wares. They trim and polish the new fired ware prior to its being biscuited in the first fire. Women then sort the biscuit ware and clean it ready for glazing. If there is to be any underglaze decorations, women are employed almost exclusively in this. After the glazed ware is drawn from the glaze kiln it is again sorted by women, and if overglaze decorated it is decorated by them.

Although some of these tasks require no training, the decorating of china offers excellent opportunity for women's services if they can acquire the training necessary for the performance of this service.

The increased use of tiles for floor and wall covering has also increased the opportunity for women's employment. Here they are used to trim, sort, and classify tiles, and sometimes to glaze them. The beginning of a chemical porcelain manufacturing industry in this country within late years has resulted in the use of women as trimmers, finishers, and decorators of this ware.

The discovery of ways and means of using our South Atlantic kaolin and ball-clay deposits for china, pottery, and tile manufacture may have a far-reaching effect upon women's services. Recourse to the deposits of excellent material available in Georgia, North Carolina, and South Carolina, together with the growing market for ceramic products in the South, is resulting in the establishment of ceramic industries in this section of the country.

Whether the finer pottery wares, the making of which requires numerous women, will be manufactured here in any quantity is yet to be determined. Attention should be focused upon this southern development, so that trained southern women may be available, should the porcelain and chinaware or art pottery grow in this section, abundant in raw materials and power for such development.

New raw materials and new processes in an old industry.

Until 1853 all paper was made of rags. In the early mills women cut rags by hand on a scythe fixed in a post, or a long knife.[27] In addition they sorted the rags for color and quality; and when the rags had been beaten to pulp and the pulp made into sheets by men, the women inspected these sheets.

Even when machinery cut the rags and beat the paper, the sorting and inspecting continued to give employment to many women. A description of a room in the first American mill to make paper by machinery, the Gilpin mill on the Brandywine, reads:[28]

> * * * a large salle on the lower floor, where more than 30 women were seated on high stools at a long table placed before the windows, each one having a knife to pick the motes from every sheet; and they were dressed becoming their occupation, with a clean apron as smooth as if an iron had just been run over it.

As a consequence, even as late as 1850, when complete paper-making machines were in use, women and girls formed 43.5 per cent of the number of employees in paper mills, the total force being 6,785.[29]

The demand for paper, however, far exceeded the supply of rags. For many years the search for materials has been continuous. In 1853, paper made from straw was exhibited by Marie A. C. Millier and Jean T. Coupier, and some paper was made by this process. It was not until 1867, however, when caustic soda was applied to broad-leaf woods and the treatment of long-leaf coniferous woods by the sulphite process proved successful, that making paper of rags ceased to be the important method of manufacture. As soon as wood-pulp processes[30] of making paper were perfected, wood pulp was used to a much larger extent than rag paper, until 90 per cent of paper stock is now made of wood. But there was no place for women in the cutting of logs into chips or converting the chips into pulp, and only on high grades of wood-pulp paper were women

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[27] Crane, E. B. Early paper mills in Massachusetts. *In* Collections of Worcester Society of Antiquity, v. 7, p. 121.

[28] Montgomery, Elizabeth. Reminiscences of Wilmington in familiar village tales. Ancient and new. p. 40.

[29] See appendix Table III.

[30] In 1920 there were four processes of treating wood pulp: Sulphite, mechanical, soda, and sulphate.

needed to examine, sort, and count the sheets. Factories making paper of rags still employ women not only in sorting and in the initial cutting of rags but in tending machines which cut the product into sheets. Women also are employed on some of the finishing work—inspecting, sorting, and counting still being done by women. In spite of the great increase in numbers of men as a result of the use of a new raw material for paper machines the actual numbers of women have increased with the growth of the industry though the percentage which women form of the total force has decreased from 43.5 in 1850 to 8.9 in 1919.[31]

Changes in raw materials are not yet at an end for the supply of rags is still too small to meet the demands for the making of paper money and the finer grades of paper. The search for a raw material which will take the place of rags and yet make the same quality of paper has been conducted for some years and is still being carried on. Nor has the last word been said about paper made from wood pulp, simply because the long-leaf conifers, most valuable for newspapers, are fast disappearing. New methods of using other kinds of wood pulp or some other material for the cheaper papers have been and are being discovered.

Whether the next discovery will call for women in equal numbers with men, or whether their services will not be needed, no one will know until the engineers make practical the scientists' laboratory discoveries.

A new material to meet an old need.

All attempts to use rubber proved unsuccessful until Goodyear discovered that sulphur and lead compounds mixed with rubber and heated to a given temperature made a product which did not get sticky in hot weather nor harden in cold weather. The immediate effect of this invention was the production of rubber boots and shoes, rubber and elastic fabric, rubber hose and belting, and molded goods. By 1857 the production of such rubber sundries as water bottles, bulbs, and handballs was begun. After 1880 rubber was put to many other uses, but the greatest development of the industry followed the production of pneumatic tires for automobiles. Although the mixing formulas for different products are numerous, fundamentally the Goodyear discovery is still the basic method of treating rubber.

In the first factories making rubber boots and shoes and rubber garments a large proportion of women were employed. These women not only cemented the parts together and got them ready for shipment, but they also did the cutting of the vulcanized ma-

[31] See appendix Table III.

terial. Men prepared the mixture and coated the fabric upon which the mixture was spread. In the factories making druggists' sundries many women were employed to make such sundries by hand. As the cutting of vulcanized materials became a machine process, and after the making of druggists' sundries changed from the hand to a hot press operation, women ceased to be employed in these capacities. In the manufacture of hard-rubber goods man became the dominant factor. So, too, in tire and inner tube production, which represented more than half the value of goods made of rubber in 1923, while women found some employment, most of the work was done by men.

However, although the changes in principal rubber products opened more employment opportunities to men than to women, still women made substantial gains in the rubber industry. In 1919 there were more than 30,000 women employed as compared with 1,558 in 1850.[32]

As is well known, the rubber industry is depending for raw materials now, as heretofore, upon importations of natural rubber, for although the United States uses three-fourths of the world's rubber output, it grows none of it:[33] but a new development in the form of a synthetic rubber—made entirely out of domestic materials—has been standing on the threshold of America's rubber industry for a number of years. In the judgment of scientists[34] and industrial leaders,[35] its entrance as a commercial factor is a question of but a short time, for as a laboratory achievement the manufacture of artificial rubber is no longer new. Two automobile tires of synthetic rubber, also a piece of rubber made of potatoes, were exhibited in New York in 1912.

That these changes will affect women in the rubber industry is almost inevitable. Even though such changes result in no shift of occupations from men to women or women to men, or from both to machines, the development of a purely domestic source of raw material will at least remove the industry's basic essentials of manufacture from the uncertainties of foreign control.

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[32] See appendix Table IV.

[33] Slosson, Edwin E. Creative Chemistry. New York, Century Co., 1921. p. 156.

[34] Slosson, Edwin E., op. cit., p. 163.

[35] The financial editor of the New York Commercial in a series of articles running in May of 1925, says: "Within the last year or so, in fact, the chemist has learned to make artificial silk, artificial rubber, artificial leather, and in addition has actually created any number of things that never existed before at all. Some of these products have not been perfected and, at the present stage of their development, a few compare poorly with the natural products which ultimately they may supplant, but the perfecting of synthetic leather, rubber, and other products is only a matter of time; perhaps a very short time." (Farrell, Hugh. State of the investor in the development of chemistry. New York Commercial, May, 1925.)

New products from old materials.

Snuff, chewing and smoking tobacco, cigars, and cigarettes are products of different periods. In the eighteenth century the tobacco consumed in the United States was almost all in the form of snuff and chewing and smoking tobacco products, for which the Virginia tobacco crop was well adapted. In the early years of the nineteenth century, Connecticut tobacco was worked into cigars by women in tobacco growers' families. Later Spanish tobacco was made up into cigars in the Territory of Louisiana by Cuban cigar makers. And still later, when a variety of tobacco suitable for cigar wrappings was grown in Connecticut, Pennsylvania, New York, Ohio, and Wisconsin, every town near the tobacco fields had its local cigar factory. The cigarette was unknown in this country until the latter part of the nineteenth century. It was introduced throughout Europe by the soldiers fighting in the Crimean War, and later the demand for cigarettes spread to this country.

In the chewing, smoking, and snuff branches of the industry in the United States in 1850 about 14 per cent of the employees were women.[36] There has been a steadily increasing proportion of women until in 1919 they constituted almost one-half the number of persons employed.[37] This increase is due to the fact that, while the operations of cutting and grinding once done by men's hands are now done by machine, the hand operations which women performed—that is, sorting for quality and size and stripping—are still largely hand processes. The custom of putting smoking tobacco into bags and pasting on labels also has given increased employment to women in this branch of the industry.

The census of 1860, the first to list cigars, shows that only 9 per cent of the cigar makers were women.[38] Cigar manufacturing was a hand industry, carried on in small shops, until 1869, when a cigar-shaping mold was introduced from Germany. In 1878 machinery was invented to aid in stripping, bunching, and rolling cigars. These machines were introduced very gradually, women being employed to operate them until women were employed in every process except mixing the tobacco for correct flavor, pressing it, and making cigar boxes. As a result of the use of machinery and of an available supply of skilled women in the days when the manufacture was being shifted from the small shop to the factory, there were reported, in 1919, 79,569 women and girls employed in manufacturing cigars, these forming almost 60 per cent of the cigar-factory workers.[39]

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[36] See appendix Table V.
[37] Idem.
[38] Ibid.
[39] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919. p. 490.

Almost as soon as cigarette manufacture began, machines were invented to cut, dry, and shred the tobacco. Later a machine for rolling the cigarettes was invented. As a result the industry started on a factory basis and continued on that scale with the rapidly increasing demand for cigarettes. From the beginning the industry has been a larger employer of women than of men. In 1919 there were 13,932 women and girls employed, constituting more than 55 per cent of the force.[40]

As a result, therefore, of the increased use of the cigarette and the introduction of machinery in the chewing, smoking, and snuff branch as well as in the cigar branch of this industry, in 1919 there were 104,328 women and girls employed in tobacco manufacture.[41] They constituted more than 58 per cent of the tobacco industry employees.

New methods of producing familiar products.

The art of hermetically sealing packages was not introduced into this country until 1825. Even then all attempts to can food products by cooking in a common iron kettle over a cordwood fire proved but indifferently successful. In 1860 it was discovered that calcium chloride when added to boiling water would increase the temperature many degrees, thus making it possible to overcome the lack of sufficient heat which had made the cooking-kettle process unsuccessful. As the Government, faced by Civil War emergencies, was ready to use any canned goods available at this time, canneries quickly sprang up. By 1870 there were 6,713 adults employed in canning occupations.[42] Of these employees 61.2 per cent were women. At this time cans were made by hand by tinkers in the canning factory. The women prepared fruits and vegetables by hand and filled the cans with these and with sirups. Then men cappers soldered the top on each can with a tinner's copper. Other men for the processing lowered the pans of cans into boiling water. In 1874 the combination closed kettle for cooking with superheated water or live steam was invented. Next came a filling machine. In 1885 the first automatic can-making equipment was operated. As this was perfected, can making ceased to be done as a regular part of cannery work, can-making factories becoming independent establishments where the automatic machinery was tended by women and children.

In 1887 a capping machine was invented, and as this gained a foothold the skilled man who had done the handcapping disappeared from the trade. A girl tended the capping machine. Then in 1903 came the sanitary can. Since that time machines have been

[40] Idem.

[41] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919. p. 488–490.

[42] See appendix, Table VI.

invented to vine and shell peas, to husk, cut, and silk corn, and to grade fruit and vegetables as to size. The conveyor belt systems which carry materials from one section of the cannery to another have come into use. With every introduction of a machine which prepares fruit or vegetables or sorts and grades them, the number of women employed per canning unit is lessened, but the growth of the industry has been such that the actual numbers of women employed continue to increase. In 1919 there were 107,807 women employed in canning and preserving fruits and vegetables, preserves and sauces, fish and oysters, or of a total number of 198,337 adults employed, women constituted 54.4 per cent.[43]

System of interchangeable parts.

In 1848 machines were perfected whereby watch movements were made. The first sytematic manufacture of such parts at Roxbury, Mass., in 1851, marked the beginning of the system of interchangeable parts which now underlies our entire machine-building industry and which in turn is the foundation of thousands upon thousands of occupations for women.

Men had been the hand watchmakers. Men were employed in the early watch factories to make the new watchmaking machines, but women were employed to operate these machines and to assemble watch parts. In 1870 there were 592 women and 1,202 men employed.[44] By 1880 women workers had increased approximately 106 per cent, whereas men had increased but 77 per cent.[45] In 1919 the manufacture of watch movements and watches employed approximately 8,000 women.[46]

Wherever machines and equipment are made up of numerous small parts, there many women will be found making these small parts. Had the system of uniform parts for uniform machines not been developed in the nineteenth century, there would not have been found in 1919 more than 16,000 women working in machine shops, more than 8,000 making hardware parts, and more than 8,000 making typewriters, calculating machines, or sewing machines.[47]

Wider application of known forces as a result of research.

More than a century went by, after Benjamin Franklin's discoveries in electricity (in 1752) and Volta solved the problem of generating a steady flow of current (in 1779), before the production and use of electric current were made practicable by the invention and

[43] See appendix Table VI.

[44] U. S. Bureau of the Census. Ninth census: 1870. Compendium. p. 810.

[45] U. S. Bureau of the Census. Tenth census: 1880. Compendium, rev. ed., pt. 2, p. 942.

[46] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919. p. 500.

[47] Ibid., p. 378.

commercial development of the dynamo and motor. In fact, the telegraph was the only fundamental invention in the electrical world which came into practical use before the advent of these machines. But with the improved manufacture of these generating agencies the application of electricity for power, heat, light, and sound transference has increased by leaps and bounds. Each invention or discovery was followed by research to make manufacture practical, and such research continues, always with the one aim of producing better parts at less cost to make electrical energy of greater use to mankind.

By the time the dynamo and motor were being manufactured commercially, the incandescent electric lamp had been invented by Thomas A. Edison and the telephone by Alexander Graham Bell. Then followed the quickened adoption of the electric motor for railways and for power transmission in factories, the application of electricity to numerous household and industrial devices, and lastly the development of wireless telegraphy and the radio.

Throughout the years of continued research and the practical introduction of many inventions, women have played an ever-increasing part in the manufacture of electrical apparatus and supplies. Beginning in 1880 with but 72 women, when the total number of adults employed was only 1,204, the number of women increased 1,940 per cent in 10 years, as compared with an increase of 544 per cent in the number of men.[48] This greater increase in the force of women was due in large part to the manufacture of incandescent lamps. In the next 10 years, when the railway was the new objective of the application of electricity but when all uses to which it had already been put were being perfected, the number of men increased at a faster rate than did the number of women. From that time on, however, the increase in the employment of women in the manufacture of electrical apparatus has always outdistanced that of men. The latest census figures are for 1919, when 62,920 women and 695 girls were employed,[49] forming nearly 26 per cent of all employees. Since 1919 the number of women has increased, as this census was taken before the phenomenal manufacture of radio parts had begun.

The extensive employment of women in the manufacture of electrical machinery and supplies has been the indirect result of much discovery and research. Among the outstanding inventions which have increased the opportunities of women, none have had greater effect than those concerned with the utilization of electricity for light.

[48] See appendix, Table VII.

[49] U. S. Bureau of the Census. Fourteenth census: 1920. v. 8, Manufactures, 1919, p. 364.

In 1879 Edison invented the incandescent lamp and two years later 35,000 lamps had been produced by skilled glass blowers and by other specially trained hand workers. This lamp was far from perfect, and the cost of production was such as to render its use prohibitive to the average home. Only after exhaustive research by many other scientists during many years the gas-filled tungsten lamp of to-day was perfected and methods of manufacturing were developed that made a production of 245,000,000 incandescent lamps possible in 1921. Under the methods of large-scale manufacture women were called into the industry in such numbers that to-day they form a major part of lamp-factory employees. The winding and mounting of the fine filaments, stem making, tubulating the bulb, assembling the parts, exhausting and testing the lamps, cementing on the base—all are done by women. The electric-light socket alone, from the molding of the porcelain base to its final assembly, requires 237 different operations in one large factory, and almost all of these are performed by women. In addition, fuse plugs, lever switches, and push buttons are made by women. The parts entering into electric-light bulbs and lighting equipment are so minute that great delicacy of touch is essential for rapid handling. Consequently, women are as dominant to-day in lighting equipment manufacture as they were in the candle-light centuries.

The discovery of the X ray, that penetrates bodies opaque to light, and the invention of the three-element vacuum tube, making wireless telephoning commercially possible, increased the field for women's service in manufacture in proportion to the use made of these inventions. One factory alone employs approximately 600 girls on vacuum tubes for radio sets. The work which women are called upon to do in this production does not vary in general character from that involved in making incandescent lamps. The glass stem and tube are shaped, the filament plate and grad are mounted therein, and the glass blank sealed, and the tube is tested for leaks and for short circuits. Men are called upon only to operate the exhausting machine and do the final testing.

Girls also make many of the individual units which go into radio sets and do much of the assembling, wiring up, and testing. They make the head sets in their entirety. This work is similar in kind to much that they have been doing in the manufacture of telephone apparatus, but the demand for radio sets has greatly increased the number of women who are employed in the electrical industry.

In perfecting methods of manufacture of machines and parts for the utilization of electric power, the muscular strain involved in hand and machine work on smaller electrical apparatus has been reduced to a point where women can perform the work as well as, if not

better than, men. As a consequence, many women have been employed in the generator, transformer, and motor departments. Winding field coils and transformer coils, winding motors, assembling armatures, insulating and taping coils, and performing many other tasks by machine and hand on the numbers of small parts which go into the making of electric power producing and utilizing apparatus are now regular occupations of women. While some of this work calls for but little skill, much requires ability to understand and carefully to follow written specifications.

The application of electricity to household devices and other small miscellaneous mechanisms has extended materially the field of electrical supply manufacture in which women can be used successfully.

The increased use of electricity as power, as heat, as light, and as a conveyor of sound has necessarily increased the women employed in departments preparing materials or parts entering into electrical distributing and measuring equipment. For example, the mica department, where mica for insulation purposes is prepared in the numerous forms and sizes required in electrical equipment, is composed almost entirely of women. In other departments, parts made of plastic compounds, rubber, or porcelain are molded by women. Wire is wrapped and braided with insulating material by women. So tiny are the parts entering into electrical instruments that these parts are formed and the instruments assembled very largely by women's hands.

The application of electricity has been so rapid and so astounding that no one can prophesy what future services it will render. Meanwhile the methods of making products now on the markets are being improved, and even the materials out of which products are being made are changing. The chemist is working to invent better materials for insulating or conducting purposes while the physicist is hoping to find better methods of securing the rare gases used in lamps and bulbs, and the engineer is solving numerous mechanical problems. What effect each discovery will have on the occupations now performed by women no one can say until the resulting manufacturing methods are developed. In an industry in which scientists are given full opportunity to conduct investigations and in which capital is quick to make practical application of laboratory discoveries, changes are bound to come that will be of immediate concern to wage-earning women in the future as in the past.

New methods of communication.

Not until 1876 did the telephone really become an instrument of commerce. The first census report in the United States that marks

telephony as a separate occupation was made in 1880.[50] In that year 147 women and 1,050 men were reported as employed in all the departments of the business. In 1919 the number of women telephone operators was 178,379, according to the census of occupations.[51] The increase in the number of women has been accompanied by changes due to inventions which decreased materially the number of operators required per 100 subscribers, the marked increase in actual numbers of women being due to the improved service wrought by the changes and the consequent growth of the telephone as a factor in the world of business and of social intercourse. Taking only the 20 years ending with 1922 as an illustration, we find that the number of telephones per 1,000 persons in the United States increased in that time from 30 to 130, or 333 per cent.[52] During the same period the wire mileage increased from approximately 4,850,000 to about 35,503,000, or over 630 per cent.[53] The difference in rate of increase between the number of telephones per 1,000 persons and the wire mileage reflects the extension of the telephone into less populous districts.

The conspicuous changes in telephone equipment underlying the expansion of the business are not many. About the close of the last century the magneto switchboard, which made it necessary for the subscriber to "ring central" by twirling a small crank, began to give way to the common battery switchboard whereby "central" is called automatically when the subscriber takes down the receiver. This invention, which registered itself in the public mind only as a great improvement in service, had a very marked effect upon both the conditions of labor and the employment opportunities of women. Under the magneto switchboard system central's response required hand labor from the telephone operator as well as from the subscriber, since the latter by cranking the telephone to call central, knocked down a small metal bar or "shuttle" which the operator had to replace by hand. The development of the common battery switch relieved both the subscriber and the telephone operator of this hand labor. It also reduced the time required to make a "connection," for the signal lights come on automatically when the subscriber takes the receiver off the hook and are so extinguished when the connection is made. When the receiver is replaced, the lights come on again to notify the operator that the conversation is at an

[50] U. S. Bureau of the Census. Tenth census: 1880. Statistics of the population of the United States. p. 746.

[51] U. S. Bureau of the Census. Fourteenth census: 1920. v. 4, Occupations, p. 40.

[52] U. S. Bureau of the Census. Census of electrical industries: 1922. Telephones. p. 28.

[53] Ibid., p. 9.

end. Discussing the effect of this change a Government report issued in 1910 says:[54]

> The time saved by the common battery switchboard is considerable when a large number of calls has to be registered, as the time for a call on the magneto board required 10 seconds for a first or a single call, while 15 to 20 seconds were necessary for a recall or the securing of a second number immediately upon the close of conversation with a former one. With the common battery system both call and recall can be made on an average of five seconds.

By the end of the first decade of this century the old magneto type was holding less than 25 per cent of the telephone field.[55] During the decade ended 1910, the number of women telephone operators increased 475 per cent and during the next 10 years the number more than doubled, the women constituting approximately 94 per cent of the total number of operators.[56]

The effort to substitute automatic devices for personal service did not cease nor relax with the installation of the common battery switchboard; the next conspicuous change is taking place now in the gradual substitution of the automatic switching system whereby the subscriber makes his own connection without the aid of a telephone operator. The New York Telephone Co. expects to complete the substitution by 1940, or thereabouts, having already allocated $65,000,000 to be spent by 1927 for installing the automatic system as fast as the old mechanisms wear out, or other conditions warrant replacement by the new system.[57] When these automatic systems have entirely crowded out the present switchboards, telephone operators will be required only for long-distance calls and for information and complaint calls.

The estimated number of long-distance telephone calls in the United States in 1922 was about 666,000,000.[58] This is an increase of more than 95 per cent over the figure for 1912 and more than 450 per cent over the figure for 1902. Many inventions account for the growth of long-distance telephony, but at least two conspicuous achievements should be named in connection with the phenomenal increase in the use of the telephone for long-distance communication. One is the invention of the Pupin loading coil, which greatly advanced the possibilities of successful long-distance telephony. Some years ago "When Chief Engineer Carty * * * stretched his wires from the Atlantic seaboard to the Pacific coast of the United States, and * * * first made a human voice heard across a con-

[54] U. S. Bureau of Labor. Investigation of telephone companies . . . Washington, Govt. Print. Off., 1910. (61st Cong., 2d sess. Senate Doc. No. 380) p. 16.
[55] Ibid., p. 16.
[56] U. S. Bureau of the Census. Fourteenth census: 1920. v. 4, Occupations, p. 40.
[57] Bell Quarterly, July, 1924, p. 138.
[58] U. S. Bureau of the Census. Census of electrical industries: 1922. Telephones. p. 24.

tinent, there were Pupin coils at intervals of 8 miles in that transcontinental line. In the whole world to-day there are more than three-quarters of a million Pupin coils in use in telephone lines, of which 600,000 are in the United States."[59] Another factor in the growth of long-distance communication is the use of telegraph wires for telephoning in the South and West.[60] As telegraphic messages and the human voice can travel along the wire at the same time the available wire mileage for long-distance use not only is actually increased but is capable of obvious expansion.

The installation of the automatic telephone is as yet too recent to warrant any prediction as to its ultimate effect on the net number of employment opportunities of women in the telephone field. The phenomenal increase in the number of long distance calls, stimulated by the availability of telegraph wires and constant improvements facilitating long distance communication, are unquestionably creating new opportunities, for notwithstanding the increasing use of the automatic switching systems, which eliminate local switchboard operators, the quinquennial report of the United States Bureau of the Census on telephones shows for 1922 a 15.5 per cent increase in the number of women operators[61] as compared with 1917.

The Morse electric telegraph wire, which made its first public appearance in 1844, claimed a place in the United States Census of Occupations in 1870. At that time it reported 355 women employed not as operators but in the general service of the telegraph companies. In 1920 there were 16,860 women employed as telegraph operators.[62] This increase, however, did not reflect the advance of women as Morse key operators. It marked, rather, the invention of devices which reduced the demands for long training and practice, though the introduction of such devices was gradual, the regular key operators holding their ground fairly well in the face of the successive inventions. As late as 1909 a Government report on telegraphs said:[63]

> The actual receiving and transmitting of messages is carried on in two ways. [Men who] are known as the Morse operators transmit messages by the manipulation of a key which operates a sounder at the receiving end of

[59] Engineering Foundation, New York. Popular research narrative . . . Compiled by A. D. Flinn. Baltimore, Williams & Wilkins Co., 1924. p. 81.

[60] U. S. Bureau of the Census. Census of electrical industries: 1922. Telegraphs. p. 16.

[61] U. S. Bureau of the Census. Census of electrical industries: 1922. Telephones. p. 52.

[62] U. S. Bureau of the Census. Fourteenth census: 1920. v. 4, Occupations. p. 40.

[63] U. S. Bureau of Labor. Investigations of Western Union and Postal telegraph-cable companies . . . Washington, Govt. Print. Off., 1909. 554 p. (60th Cong., 2d sess. Senate, Doc. No. 725.)

the line. The receiving operator, listening to the instrument reproduce the Morse characters, writes the message out in letters of the ordinary alphabet. The Morse operators require considerable training and skill before being able to receive and transmit with rapidity and accuracy. For many years a machine has also been in use for receiving and transmitting messages. The method of operation of the machine consists in first having the telegram * * * transferred in Morse characters to a paper ribbon through which the characters are punched. This ribbon is then placed in a machine which automatically transmits the message to a machine at the other end of the line, which writes the message on another ribbon again in Morse characters. The message is then copied into the ordinary letters on a blank * * *. All that is necessary is a clerk—man or woman, boy or girl—familiar enough with Morse characters to read a message in ordinary characters and punch it on a paper ribbon at the sending end; and then by a simple reversal of the process, the Morse characters are transferred into the ordinary characters at the receiving end. This (the Wheatstone machine) is still in use in some offices but it has been supplanted by two more recent machines which are being increasingly used in the large offices * * *.

One of the machines referred to is the Barclay machine.

The working unit for the Barclay machine consists of three persons, working at two terminals in different cities—two at the sending end and one at the receiving end * * *. [the messages] are handed to the tape perforator, the first girl in the Barclay team * * *. She sits in front of an instrument constructed like a typewriter. A stiff narrow white ribbon feeds through the instrument automatically. The operator presses down the keys, and as she does so dots and dashes are punched in the passing ribbon. When the message is complete, the ribbon is cut and passed to the second girl in the team * * *. She sits before a machine into which she feeds the punched ribbons. The machine is directly connected with the telegraph wire over which the message passes. As the ribbon goes through the machine the perforated portions allow the electrical contact which transmits the message * * *.

At the other end of the wire * * * the third girl of the team finishes the operation. She sits before a machine, the visible parts of which consist of a horizontal cylinder and bar and a small type wheel on an upright rod. Her work is to feed telegraph blanks between the bar and the cylinder or roller, the blanks coming round on the face of the latter * * *. This wheel has different motions which are so controlled as to make it print English characters corresponding to the electric impulses transmitted by the wire with which it is connected, which impulses correspond to the dots and dashes in the perforated ribbon.

The operation of the Rowland machine requires a team of only two girls, one at the sending and the other at the receiving end of the line. The sender operates an instrument which looks like a typewriter. The keys, however, operate type at the receiving end of the line through the medium of the telegraph wire. The receiver simply collects the messages.

Telegraphy has never employed as many women as telephony, probably because the use of long distance has grown so much faster than the use of the telegram. Also, during the last 15 years the use of wireless telegraphy and of the radio has grown enormously.

Wireless messages increased more than 1,830 per cent during the five years ended 1922.[64]

> Radio telegraphy and telephony * * * particularly the latter, have become established modes of communication for many commercial organizations in the conduct of their business. In regions where it would be difficult or impossible to construct and maintain wire lines, the problem is solved by the use of radio. Among the industries thus benefited are fishing, mining, and lumbering.[65]

The radio is too young to have a place in the Census of Occupations of 1920, and no subsequent census enumerations show the sex of persons employed. Regardless of census reports, however, the employment of large numbers of women in the manufacture of radio sets is a fact of common knowledge and is discussed elsewhere in this report. Also, pending the publication of census reports, there may be accepted the obvious effects of radio upon the enlarged opportunities of artists and educators—among whom are many thousands of women—to market their abilities by the provision of home entertainment and instruction.

New commercial service.

A practical typewriter was perfected about 1868 and was introduced to the public in 1873 as the Remington typewriter. The first machines wrote only with capital letters and met with an antagonistic reception by the public. Their value was first recognized by court stenographers, then by lawyers, and later by business men. Even so, typewriter operators were too few in 1880 to be recognized as a separate occupation by the United States Census Office. But by 1890 typewriting and stenography were established as a distinct vocation and as one especially adapted to women, for in that year there were 21,270 women stenographers and typists, forming 63.7 per cent of the total number in the occupation. In 1920, 564,744 women and girls were classed as typists and stenographers. No other occupational groups except those of servant, home farmer, farm laborer, and teacher included so large a number of women. That women have monopolized this occupation is evidenced by the fact that they constitute 91.8 per cent of the total number of stenographers and typists.[66]

Not only, therefore, has the typewriter revolutionized modern business methods, but it has created an occupation calling for more women than have been employed as a result of any other invention.

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[64] U. S. Bureau of the Census. Census of electrical industries: 1922. Telegraphs. p. 26.

[65] Ibid., p. 25.

[66] See appendix Table VIII.

Inventions and discoveries less directly, yet fundamentally, related to women's employment opportunities

In the foregoing pages, the discussion has been confined to the results of such research or invention as has had a direct bearing upon the employment opportunities of women because it was concerned with materials, processes, or products of manufacture or with the equipment essential to the commercial services employing women. The fact should not be overlooked, however, that the influences on the employment opportunities of women do not begin or end with such inventions or discoveries. Obviously when James Watt invented the double-acting steam engine in 1782, laying the basis of the wonderful developments in land and water transportation and in the mining operations of the next century, he sowed the seeds of opportunities for breadwinning women that are growing and ripening to-day. Each perfection and expansion of the steam engine mechanisms increased these opportunities. Fulton's first practical steamboat running up the Hudson in 1807, the boat that he sent in 1811 from Pittsburgh to New Orleans, and the first steamer that crossed the Atlantic in 1819, each marks stages that were second in importance only to the development of the first practical locomotive which, in 1829, connected the agricultural regions of the West with the manufacturing facilities of the East. All these inventions together applied a powerful stimulus to the demands for manufactured goods in the production of which thousands upon thousands of women were involved even a hundred years ago.

Again, the far-reaching changes in blast-furnace methods made in the first half of the nineteenth century did not appear to concern women, since they were not employed in connection with blast-furnace operations, but these changes, together with the inventions and discoveries that followed in quick succession during the latter half of the past century, underlie the whole enormous expansion of American manufactures, trade, and transportation, which together employ several million women to-day and hold unmeasured possibilities for to-morrow.

These are but random illustrations of the fact that the employment opportunities of American women are inseparable parts of the great living industrial organism and that they respond to changing conditions in any part of the body industrial. That these changes are constantly taking place is apparent not only from the illustrative descriptions given in the foregoing pages but from current comments on such subjects in the daily press.

Discussing the revolutionary change recently effected in the wood-alcohol industry by the unexpected development of a process which renders all other processes obsolete, an expert writing entirely from the point of view of the investor said: [67]

> Some of our greatest industries, the oil industry, for example, are subject to hazards of revolutionary change just as great as that which confronts the wood-alcohol industry * * *.
>
> At the times when competition for markets is the keenest, the search for cheapening processes is intensified and the industry which has taken the longest look ahead is the industry that survives. At such times the manufacturer who has failed to guard against the day of keener competition is forced to fall back on cuts in wages and futile attempts to lower costs by raising the value of money.
>
> Nothing valuable is ever accomplished in that way. As long as lower costs are obtained through the elimination of waste of materials and labor—that is, through improvements in processes, society in general and the investor in particular are benefited. For lowering costs after this manner means lowering them by increasing production or, at least, by getting an equal volume at lessened outlay.

[67] Farrell, Hugh. Stake of the investor in the development of chemistry. New York Commercial, May, 1925.

PART III

WHAT THE FACTS SUGGEST

Even a cursory reading of the effects of research upon industrial processes and upon commercial systems will lay bare certain concrete suggestions for advancing the employment opportunities of American women. The first of these suggestions lies in the fact that scientific research has yielded a very material net increase in the number of occupations open to women and that it carries unmeasured possibilities for further increase. Moreover, changes in industry due to research frequently bring improvement in working conditions. Obviously, therefore, women wage earners have a concern over and above that held by women as a whole in the steady progress of research in America.

There have been recent signal recognitions of the concern of all women in the development of well thought out State and National policies looking to the support of sound research in all branches of knowledge. Discussing the importance of organic chemical research to national and home life, one pronouncement on the subject says:[68]

> The growth and fruitage of * * * research in America have been retarded by the lack of public appreciation. This is an indictment of the intelligence of American women as well as of American men. Manifestly it is through the great women's organizations that women will do their most effective work in remedying this grievous national fault * * *.
>
> The numbers of women who have accustomed themselves to group study, group expression, and group action now run into millions and the numbers are steadily growing. The accumulated momentum of this tendency toward concerted action among growing millions of women creates a corresponding obligation for informed decisions and forethinking conduct. The nineteenth amendment has made this obligation doubly binding. For whether we worked for it or not, whether we wanted it or not, American women have now acquired direct responsibility with American men for raising and maintaining a national morale essential to our progress in peace and human weal. We can not escape the consequences of responsibility by refusing to discharge it or by ignoring its existence.

The stake of wage-earning women was specifically recognized in this appeal in these words:

> Manifestly the women who are concerned with enlarging the opportunities of capable women for capable service have a direct interest in the promotion of organic chemical research * * *.

[68] To American women—a plea. p. 3. (Issued by officers of the General Federation of Women's Clubs; National Civic Federation, Woman's Department; American Association of University Women; Girl Scouts; and Daughters of the American Revolution.)

It is true that this quotation applies to only one branch of knowledge, but it is also true that the progress of research in this particular branch is intimately related to the progress of research in all other branches of physical sciences.[69]

The continued advance of chemical research [says a recent publication from a women's organization interested in this subject] is closely related to the steady progress of research in all the physical sciences. This bulletin, therefore [referring to the organization's publication], is another link in the chain of efforts begun in 1921, though in it we are stressing the big, broad fact, stated by President Angell, of Yale, that all sound scientific research "is of the very life blood of human progress" and that "the maintenance of appropriate and fruitful conditions of its growth is a matter of absolutely fundamental significance for humanity."

The collection of facts in these pages makes it plain that research leading to invention and research in physics, biology, and other fields of material facts are making a direct net contribution to the employment opportunities for American women. The Federal Government has a number of research agencies and many research divisions in bureaus regarded as principally administrative. Many of these agencies are engaged in investigations that have a direct bearing upon the employment opportunities of both men and women, as well as upon the conditions of labor surrounding existing occupations. Many States are maintaining research bureaus. In the newer States the principal objective of these bureaus is the development of the dormant natural resources or the better utilization of the resources already under draft for service. In the older States such research activities include efforts to stimulate the elimination of waste by its conversion into usable by-products. In brief, therefore, wage-earning women, as well as wage-earning men, have an additional interest in State and National policies affecting scientific research and its application to industrial processes.

The second suggestion that comes to mind is afforded by the fact that the development of transportation facilities and the methods of long-distance transmission of power have permitted industries to range in increasing distances from markets and raw materials in search of suitable labor supplies. The activities in chambers of commerce and other commercial bodies to secure the location of industries in given communities are quite generally conducted without cooperation or consultation with women's organizations of the communities. As a consequence, there is usually little consideration given to framing the policies of securing new industries in such a way as to provide suitable employment for the daughters as well as the sons in the community; a measure that would guard against a too early disintegration of home life caused by the daughters'

[69] National Civic Federation. Women's Department. Bulletin, November, 1924.

going out of the home and out of the community in search of needed employment opportunities. In brief, the women's organizations of a community have a direct concern in taking part in these campaigns by making surveys to determine what the available woman labor is and whether or not the industries sought for the communities include such as will keep the daughters, as well as the sons, at home. Of course industries can not locate with exclusive reference to labor supplies. Site, freight rates, and transportation facilities will exact due consideration in all cases.

The third concrete suggestion may not be so obvious from the assembly of facts, but its validity is easily established. The vocational training schools and the vocational courses in all educational institutions should be so adjusted as to take into consideration the tremendous changes now going on in industry as a result of scientific research. Especially should the courses take into consideration the adaptability of women for the new occupations developing from such research.

In 1920 this bureau issued a bulletin on vocational training facilities for women, in which were discussed the training courses given in specified States for a range of American industries in which women had made marked success during the war. The summarizing paragraphs in that bulletin asserted that very few of the training facilities then in evidence were being used by women, either because women were " not admitted to these public vocational schools " or because they were " not encouraged to attend." The final summarizing paragraph declared that " the increase in the numbers of wage-earning women, the demonstrated capabilities of women during the war, the decrease in male immigrant labor, and the growing demands of our expanding industries call not only for the admission of women [into a wider range of training courses] but for the same policy among vocational educators of encouraging girls as is now adopted to encourage boys to take such instruction." [70]

In view of the far-reaching effects which scientific research is having upon industrial processes and commercial systems, the Women's Bureau urges such a further liberalization of the policies of vocational training for women as will familiarize them with new materials and new processes and facilitate their entrance into the new occupations as fast as these occupations become sufficiently established and standardized to be made the subject of training courses.

Finally, the facts discussed in these pages suggest further emphasis on the efforts to expand the opportunities and extend the

[70] U. S. Department of Labor. Women's Bureau. Industrial opportunities and training for women and girls. Washington, Govt. Print. Off., 1921. (Bulletin 13.) p. 48.

facilities of research for women. Unquestionably there is a growing appreciation of the obligations of laboratories in educational and other publicly supported institutions to open up opportunities to the world of affairs. The business world—whether it be in the field of manufacture or in the methods of accounting or distributing the products for manufacture—is no longer indifferent or casual about scientific research. On the contrary, it is inspiring and stimulating research in educational institutions by submitting specific problems in process or materials, or both, to the laboratories of universities and colleges, in many of which both men and women are at work. Business concerns are endowing chairs of research and offering fellowships. Furthermore, they are drafting the researchers—undergraduates, graduates, or teachers of science—from the college and university laboratories.

When women graduate or undergraduate students succeed in finding solutions for the difficulties submitted for study, they make a real advancement toward the responsible and profitable positions in industry, since a firm seriously vexed with a manufacturing difficulty is not likely to refuse to employ the successful researcher because such a worker happens to be a woman. In other words, the laboratories in universities and colleges are training stations from which the door to responsible positions has a tendency to stand as wide open to women as to men. Conspicuous achievements in invention and discovery, important to industry and commerce, are on record to the credit of women, though the record often does not show to what research facilities the women had access.[71] In any case, however, if the door of opportunity which leads from the research laboratories of universities and colleges to responsible and desirable positions in industry and commerce is to be accessible to women, the laboratories must be open to women in fact as well as in theory. The intangible and invisible but effective bar of custom is still up in many of the institutions having excellent research facilities. Women are barred not by regulations but by the tenacity of the tacit assumption that creative research facilities and training "are designed for men." The phrasing of announcements of competitive examinations for research scholarship and fellowship and the official descriptions of scope and purpose of research instruction reflect the extent to which the invisible bar is still up even in the laboratories of many of the colleges and universities having large numbers of women in the academic departments. Without doubt the bar is breaking in many places under the pressure of the general

[71] U. S. Department of Labor. Women's Bureau. Women's contributions in the field of invention: A study of the records of the United States Patent Office. Washington, Govt. Print. Off., 1923. 51 p. (Bulletin 28.)

advance of women, but it is still a real obstruction not only to the women with creative research ability but to thousands of others. For every woman who achieves success in the field of creative research does more than win for herself the opportunity for service in her chosen field. She cuts deep into the tradition that obstructs the opportunities of other women, who are capable of such technical service as is now rendered by thousands of men with and without college training. While industry and commerce have for many years employed women in routine processes, very grudgingly have women been permitted—except in times of national emergency—to share the responsible or technical positions afforded by the Nation's business. The women engaged successfully upon creative research will aid materially in giving to women of all degrees of capability and training an equal chance with men in the ever-increasing opportunities for profitable employment in the rapidly expanding fields of industry and commerce.

APPENDIX

1. Figures in Tables I to VII are taken from United States Bureau of the Census. Ninth Census: 1870, v. 3, pp. 394–408 (for 1850, 1860, 1870). Twelfth Census: 1900, v. 7, Manufactures, pt. 1, pp. 3–17 (for 1880, 1890, 1900). Thirteenth Census: 1910, v. 8, Manufactures, 1909, pp. 520–541 (for 1910). Census of Manufactures: 1914. Abstract, pp. 530–543 (for 1914). Fourteenth Census: 1920, v. 8, Manufactures, 1919, pp. 328–490 (for 1919).

2. The industrial groupings of the 1910 census used throughout the tables are somewhat different from those of other years, because this census combined figures for several branches of industries left separate in other years.

3. Figures for 1850 and 1860 are given for males and females, for 1870 for men over 16 years and women over 15 years, for all other years for men and women over 16 years of age.

TABLE I.—*Actual and relative number of women employed in the manufacture of cotton and cotton goods—census years*

Year	Adult employees	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850	102,524	64,562		63.0
1860	123,153	75,365	+16.7	61.3
1870	112,796	69,839	−7.2	61.9
1880	155,255	91,148	+30.5	58.7
1890	195,444	106,607	+17.0	54.5
1900	262,603	126,882	+19.0	48.3
1910	347,477	150,057	+18.3	43.2
1914	361,307	149,740	−.2	41.4
1919	447,709	189,736	+26.7	42.4

TABLE II.—*Actual and relative number of women employed in the manufacture of glass and glassware—census years*

Year	Adult employees	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850	5,668	97		1.7
1860	9,016	251	+158.8	2.8
1870	12,220	715	+184.9	5.9
1880	18,519	741	+3.6	4.0
1890	37,949	1,885	+154.4	5.0
1900	45,702	3,529	+87.2	7.7
1905	57,534	3,455	−2.1	6.0
1909	80,878	4,593	+32.9	5.7
1914	81,908	4,999	+8.8	6.1
1919	91,624	10,410	+108.2	11.4

TABLE III.—*Actual and relative number of women employed in the manufacture of paper and wood pulp—census years*

Year	Adult employees	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850	6,785	2,950	----------	43.5
1860	10,911	4,392	+48.9	40.3
1870	17,185	6,153	+40.1	35.8
1880	24,965	7,648	+24.3	30.6
1890	30,782	6,767	−11.5	22.0
1900	49,477	7,930	+17.2	16.0
1910	78,406	9,909	+25.0	12.6
1914	88,899	9,391	−5.2	10.6
1919	121,973	10,852	+15.6	8.9

TABLE IV.—*Actual and relative number of women employed in the manufacture of rubber and rubber products—census years*

Year	Adult employees	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850	2,568	1,558	----------	60.7
1860	2,768	973	−37.5	35.2
1870	5,679	2,649	+172.3	46.6
1880	11,301	4,417	+66.7	39.1
1890	19,680	8,311	+88.2	42.2
1900	35,765	13,456	+61.9	37.6
1910	54,168	13,107	−1.1	24.2
1914	74,126	15,030	+14.7	20.3
1919	177,948	31,036	+106.5	17.4

TABLE V.—*Actual and relative number of women employed in the manufacture of tobacco and tobacco products—census years*

CHEWING AND SMOKING TOBACCO AND SNUFF

Year	Adult employees [1]	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850	14,236	1,975		13.9
1860	18,859	2,990	+51.4	15.9
1870	14,610	4,860	+62.5	33.3
1880	25,662	10,776	+121.7	42.0
1890	25,506	10,564	−2.0	41.4
1900	25,714	11,590	+9.7	45.1
1910	[2]			
1914	24,501	10,889		44.4
1919	18,954	9,339	−14.2	49.3

CIGARS AND CIGARETTES

1850	[3]			
1860	7,997	731		9.1
1870	25,181	2,934	+301.4	11.7
1880	49,207	9,108	+210.4	18.5
1890	83,666	24,214	+165.9	28.9
1900	99,930	37,762	+56.0	37.9
1910	[2]			
1914	152,733	84,067		55.0
1919	158,440	93,341	+11.0	58.9

[1] Listed as "Tobacconists."
[2] All tobacco manufactures included in one total; namely, 174,610 persons employed, of whom 48.2 per cent were women.
[3] Not reported.

TABLE VI.—*Actual and relative number of women employed in canning and preserving fruits and vegetables, preserves and sauces, fish and oysters—census years*

Year	Adult employees	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850	211	86		40.8
1860	[1]			
1870	6,713	4,109		61.2
1880	26,923	15,693	+281.9	58.3
1890	55,544	29,842	+90.2	53.7
1900	54,670	26,436	−11.4	48.4
1910	144,812	77,593	+193.5	53.6
1914	192,819	101,766	+31.2	52.8
1919	198,337	107,807	+5.9	54.4

[1] Not reported.

TABLE VII.—*Actual and relative number of women employed in the manufacture of electrical machinery, apparatus, and supplies—census years*

Year	Adult employees	Women employees		
		Actual number	Per cent increase or decrease	Per cent of total
1850				
1860	13			
1870				
1880	1,204	72		6.0
1890	8,758	1,469	+1,940.3	16.8
1900	40,308	6,158	+319.2	15.3
1910	102,003	23,398	+280.0	22.9
1914	110,587	22,167	−5.3	20.0
1919	243,072	62,920	+183.8	25.9

TABLE VIII.—*Women employed as stenographers and typists—census years*

Year	Women stenographers and typists	
	Number	Per cent of all employees
1870	[1] 7	4.6
1880		
1890	[2] 21,270	63.7
1900	[3] 86,118	75.7
1910	[4] 263,315	83.1
1920	[4] 564,744	91.8

[1] U. S. Bureau of the Census. Ninth census: 1870. v. 1, p. 688.
[2] U. S. Bureau of the Census. Eleventh Census: 1890. Population, pt. 2, p. 308.
[3] U. S. Bureau of the Census. Twelfth Census: 1900, Special reports—Occupations, p. ccxxxi.
[4] U. S. Bureau of the Census. Fourteenth Census: 1920. v. 4. Occupations, p. 43.

PUBLICATIONS OF THE WOMEN'S BUREAU

BULLETINS

[These bulletins and reports will be sent free of charge upon request]

No. 1. Proposed Employment of Women During the War in the Industries of Niagara Falls, N. Y. 16 pp. 1918.
No. 2. Labor Laws for Women in Industries in Indiana. 29 pp. 1918.
No. 3. Standards for the Employment of Women in Industry. 7 pp. 1919.
No. 4. Wages of Candy Makers in Philadelphia in 1919. 46 pp. 1919.
No. 5. The Eight-Hour Day in Federal and State Legislation. 19 pp. 1919.
No. 6. The Employment of Women in Hazardous Industries in the United States. 8 pp. 1919.
No. 7. Night Work Laws in the United States. 4 pp. 1919.
No. 8. Women in the Government Service. 37 pp. 1920.
No. 9. Home Work in Bridgeport, Conn. 35 pp. 1920.
No. 10. Hours and Conditions of Work for Women in Industry in Virginia. 32 pp. 1920.
No. 11. Women Street Car Conductors and Ticket Agents. 90 pp. 1920.
No. 12. The New Position of Women in American Industry. 158 pp. 1920.
No. 13. Industrial Opportunities and Training for Women and Girls. 48 pp. 1920.
No. 14. A Physiological Basis for the Shorter Working Day for Women. 20 pp. 1921.
No. 15. Some Effects of Legislation Limiting Hours of Work for Women. 26 pp. 1921.
No. 16. See Bulletin 40.
No. 17. Women's Wages in Kansas. 104 pp. 1921.
No. 18. Health Problems of Women in Industry. (Reprint of paper published in the Nation's Health, May, 1921.) 11 pp. 1921.
No. 19. Iowa Women in Industry. 73 pp. 1922.
No. 20. Out of print.
No. 21. Women in Rhode Island Industries. 73 pp. 1922.
No. 22. Women in Georgia Industries. 89 pp. 1922.
No. 23. The Family Status of Breadwinning Women. 43 pp. 1922.
No. 24. Women in Maryland Industries. 96 pp. 1922.
No. 25. Women in the Candy Industry in Chicago and St. Louis. 72 pp. 1923.
No. 26. Women in Arkansas Industries. 86 pp. 1923.
No. 27. The Occupational Progress of Women. 37 pp. 1922.
No. 28. Women's Contributions in the Field of Invention. 51 pp. 1923.
No. 29. Women in Kentucky Industries. 114 pp. 1923.
No. 30. The Share of Wage-Earning Women in Family Support. 170 pp. 1923.
No. 31. What Industry Means to Women Workers. 10 pp. 1923.
No. 32. Women in South Carolina Industries. 128 pp. 1923.
No. 33. Proceedings of the Women's Industrial Conference. 190 pp. 1923.
No. 34. Women in Alabama Industries. 86 pp. 1924.
No. 35. Women in Missouri Industries. 127 pp. 1924.
No. 36. Radio Talks on Women in Industry. 34 pp. 1924.
No. 37. Women in New Jersey Industries. 99 pp. 1924.
No. 38. Married Women in Industry. 8 pp. 1924.
No. 39. Domestic Workers and Their Employment Relations. 87 pp. 1924.
No. 40. State Laws Affecting Working Women. 55 pp. 1924. (Revision of Bulletin 16.)
No. 41. The Family Status of Breadwinning Women in Four Selected Cities. 145 pp. 1925.
No. 42. List of References on Minimum Wage for Women in the United States and Canada. 42 pp. 1925.
No. 43. Standard and Scheduled Hours of Work for Women in Industry. 68 pp. 1925.
No. 44. Women in Ohio Industries. 137 pp. 1924.
No. 45. Home Environment and Employment Opportunities of Women in Coal-Mine Workers' Families. 61 pp. 1925.
No. 46. Facts About Working Women—A Graphic Presentation Based on Census Statistics. 64 pp. 1925.
No. 47. Women in the Fruit-Growing and Canning Industries in the State of Washington. (In press.)
No. 48. Women in Oklahoma Industries. (In press.)
No. 49. Women Workers and Family Support. 10 pp. 1925.
No. 50. Effects of Applied Research Upon the Employment Opportunities of American Women. (In press.)
No. 51. Women in Illinois Industries. (In press.)

First Annual Report of the Director. 1919.
Second Annual Report of the Director. 1920.
Third Annual Report of the Director. 1921.
Fourth Annual Report of the Director. 1922.
Fifth Annual Report of the Director. 1923.
Sixth Annual Report of the Director. 1924.
Seventh Annual Report of the Director. 1925.