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Employment Opportunities for Women

WOMEN'S BUREAU
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U. S. DEPARTMENT OF LABOR, James P. Mitchell, Secretary

The value of engineering and engineering education in securing this peaceful world cannot be overemphasized. The engineer has made many contributions in developing our national economy and our military preparedness program. In our highly complex technological society, the engineer is the creator of our modern tools of production. His efforts are largely responsible for America's great productive capacity and industrial superiority.

—Dwight D. Eisenhower

UNITED STATES DEPARTMENT OF LABOR

James P. Mitchell, Secretary

WOMEN'S BUREAU

Alice K. Leopold, Director

EMPLOYMENT OPPORTUNITIES
FOR WOMEN IN
PROFESSIONAL ENGINEERING

Women's Bureau Bulletin No. 254

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BUREAU OF ECONOMIC ANALYSIS
WASHINGTON, D. C. 20540

PROFESSIONAL AND TECHNICAL EMPLOYMENT OPPORTUNITIES FOR WOMEN IN THE UNITED STATES

Women's Bureau, Bureau of Economic Analysis

LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF LABOR
WOMEN'S BUREAU,
Washington, March 31, 1954.

SIR: I have the honor to transmit a new bulletin which reports upon current trends and attitudes relating to women's prospects for the engineering career.

A report on women engineers was stimulated in part by the procurement of occupational data from the 1950 Census, together with information obtained through a survey conducted by the Society of Women Engineers and made available to the Women's Bureau. The main purpose of such a report at this time, however, is to provide information in answer to the increasing number of inquiries raised by counselors and students about the outlook for women in a field where men are presently very much in demand.

This bulletin was prepared by Lillian V. Inke, Chief of the Employment Opportunities Branch, and Mildred S. Barber, who did the basic research. Substantial help with Census and Society of Women Engineers' survey data was provided by the Bureau's Statistical Branch. Both Branches are part of the Research Division, of which Mary N. Hilton is Chief.

Respectfully submitted.

ALICE K. LEOPOLD, *Director.*

HON. JAMES P. MITCHELL,
Secretary of Labor.

Acknowledgments . . .

are made to several organizations and agencies for assistance in the preparation of this bulletin, specifically:

- (1) The National Society of Professional Engineers, for their technical review of the manuscript;
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- (3) The U. S. Office of Education, for supplying detailed information on educational requirements and institutions;
- (4) For their courtesy in providing the photographs used in this report, acknowledgment is made to the Chrysler Corporation (figs. 3-b and 5); Illinois Institute of Technology (fig. 2); Lockheed (fig. 6); Sylvania Products, Inc. (fig. 3-a); Miller Co., Chicago (fig. 4); and Westinghouse (fig. 1).

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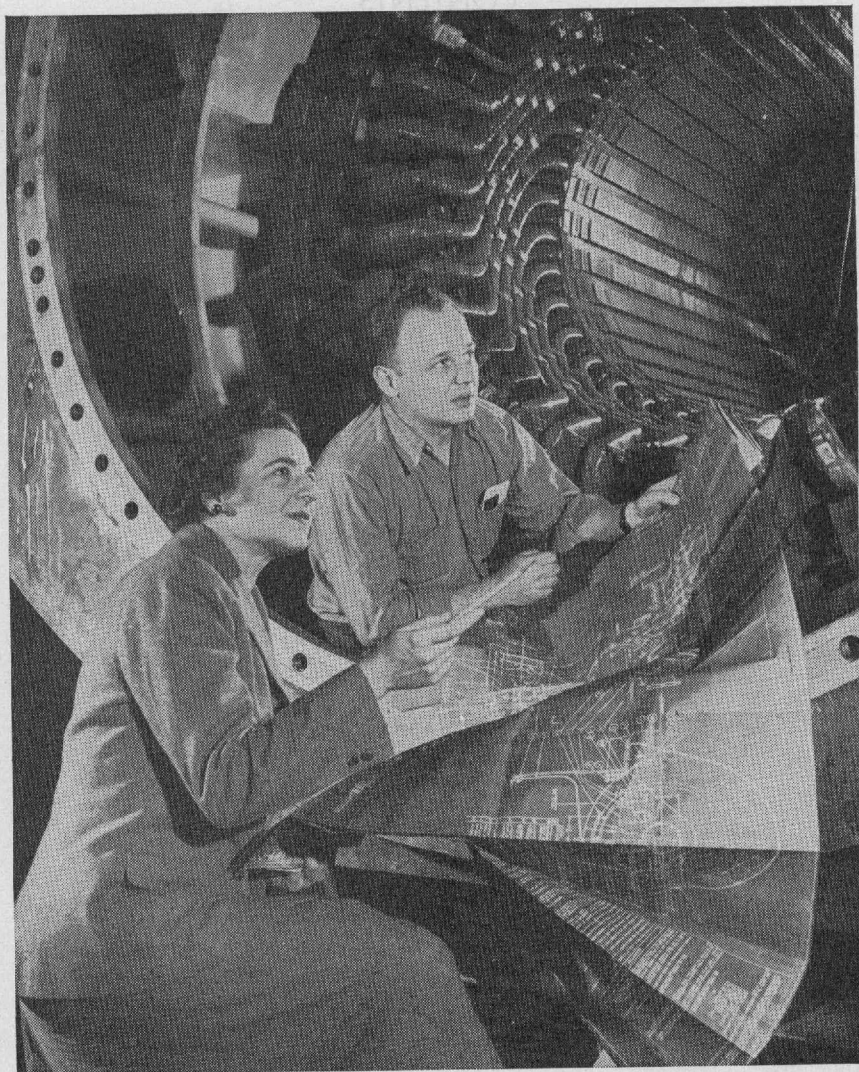


Figure 1.—Women Engineers Often Attain Positions of Responsibility and Achievement in Large Industrial Firms.

This Electrical Engineer Is Checking Construction of a Generator Against Her Design.

I. ENGINEERING MANPOWER AND WOMEN'S PROSPECTS

Women Are Singled Out in 1953

. . . There is no question at all but that more women should be enrolled in our engineering schools. This is one of the ways of dealing adequately with the present and potential shortages in this area.

This statement was made in November 1953 by the Director of the Office of Defense Mobilization, Arthur S. Flemming, to representatives of a large group of American colleges and universities. It was made, not in a speech about opportunity for women, but as one of several manpower policy suggestions to educators about the need for maintaining an adequate supply in the Nation of professional and scientific personnel.

Engineering Manpower a Priority

Early in World War II the manpower agencies of the Federal Government encouraged programs to assess the Nation's specialized manpower and to provide for a continuing supply. Toward this end, a National Roster of Scientific and Specialized Personnel established in 1940 was utilized as a kind of perpetual inventory of specialized skills. A succession of Government agencies carried responsibility for the Roster until 1950, when it was taken over by the National Science Foundation.

In 1951, a Committee on Specialized Personnel, under the Office of Defense Mobilization, initiated new studies of manpower resources and requirements, as a result of the demands of the Korean emergency upon both the defense and civilian fronts. Among the occupations named as essential in supply-and-demand forecasts from Pearl Harbor until the present, engineers have been generally given priority attention in nearly all studies of manpower requirements. By 1953, women were being specifically mentioned by a number of employers and educators as a good potential source of necessary engineering manpower, even though the threat of war had become less imminent, and defense production cut-backs were in progress.

The Short-Lived Engineering "Surplus" Prediction of 1949

Except for a brief period following World War II, the outlook for women engineers was probably more favorable in the decade 1940 to

1950 than at any previous time. In 1949, however, a number of agencies issued reports forecasting an increase in the number of engineering graduates which would more than adequately meet the needs of an economy returning to peacetime production levels. It was thought that the number of students currently enrolled in engineering courses as a result of the wartime recruitment drives and later, of expanded veterans' training, would exceed the demand for new engineers in a few years. At the same time, many people thought that the leveling-off of production, which in the early postwar period created some shifts and separations of personnel, would seriously affect women's opportunities in nontraditional careers such as engineering. Large numbers of women left the labor market following the war. The fact that among them were many women who had been employed as draftsmen or scientific and engineering aides gave the impression that an unfavorable trend for women was developing in the field of professional engineering.

Actually, it is unlikely that experienced professional engineers, either men or women, were very much affected by the production changeover in the postwar years, although new graduates were less in demand for a short while. Following the outbreak of the Korean conflict in 1950, the cautious attitude toward the recruitment of engineering students was immediately reversed, and the outlook for engineers has remained optimistic ever since, even with the curtailment of defense production following the close of hostilities in Korea.

Engineers in War and Peace

Clearly, the need for engineering manpower is not solely the result of war or the threat of war, but arises out of the concept of the Nation's economy as based upon unlimited productive capacity. This concept, in turn, creates industrial patterns that call for a continuous search into practical applications of scientific discoveries.

Some industrial leaders believe that, although estimates of engineering manpower needs must be based upon the predictable factors of supply and demand, it would not be practical to try to set limits upon the number of engineers that the Nation can use effectively. First of all, there are natural limitations on the number of young men and women who can, and wish to, undertake this career. More important, however, the development of science and technology depends upon a substantial supply of experienced engineers, and this continually creates a demand for new entrants. For example, the Fourth Quarterly Report in 1951, of Defense Mobilizer Wilson, while it dealt with production quotas related to the "mobilization base," nevertheless recognized also the need for additional technical manpower which grows out of increasingly complex machines and processes.

An example was given of the time required to design the B-47 bomber in contrast to man-hours expended on the development of an earlier model:

The B-47 jet bomber, now entering volume production, required 2 years for design, 2 more years to reach test flight stage, and 2 more years to start assembly line production. A B-47 is made up of some 72,000 parts exclusive of nuts, bolts, and rivets. The B-47 requires 40 miles of wiring compared to 10 miles for the B-29. A B-47 contains over 1,500 electronic tubes. The wing skin must be tapered in thickness throughout its entire length from five-eighths inch at the body joint to three-sixteenths inch at the wing tip. The first B-47 plane required 3,464,000 engineering man-hours compared to 85,000 man-hours for the first production model of the B-17.

Statements have been made by various aircraft engineers that the engineering manpower required to produce jet airplanes is from three to ten times as great as for other types of airplanes. In the United States, the production of jet aircraft in volume for civilian passenger service has not even begun. It can be expected that, if military aircraft building is curtailed, manufacturers will turn to mass production of new designs in turbo-propelled civilian airliners, a field in which the British have already made considerable progress.

New Work in Both Known and Unexplored Fields

There are many phases of engineering in both known and unexplored fields to be developed for civilian peacetime uses. Some of these were suggested at the Mid-Century Conference on Resources for the Future, which took place in December 1953 under the sponsorship of the Ford Foundation. More than 1,400 representatives of industry, labor, and scientific research, conservation experts, and Government officials reported on progress and potential expansion in such fields as: Urban redevelopment and reconstruction; the possibilities for creating new textiles and products from wood and synthetic materials; extension of the Nation's recreational and wildlife facilities; redirection or adaptation of water resources, with consequent implications for industrial power and agricultural production; new methods and resources in relation to mineral extraction; and, finally, the unexplored areas of nuclear energy and solar energy for power and heating purposes.

On the basis of an industrial survey of 495 establishments in 1952, the National Society of Professional Engineers predicted that peacetime demands arising out of increasing mechanization in such pursuits as food production and processing, the manufacture of textiles and communications equipment would require a continuing supply of engineering manpower. Their conclusions were expressed as follows: "It was clearly evident from the reports [*i. e.*, of 495 employers] that, while the demand for engineers may decrease slightly in the near

future as our defense program begins to level off, the need for engineers will be a continuing one at a high level as we maintain progress in the various fields of human comfort."

In the past, pessimistic observations have been made about the displacement of manpower by machine-power. It has become apparent, however, that manpower displacements because of technological progress are temporary, and that scientific advance creates needs for additional manpower in high-level technical pursuits, as well as among production workers. Against this background, the engineer is of primary importance as the worker who transfers and translates scientific discovery into practical uses.

Forecast in 1954

Current forecasts of the job outlook for engineers describe the prospects as excellent for both men and women. The number of new engineering graduates is not expected to meet the estimated demand for an average of 30,000 new engineers per year. Since many of the new graduates of the next few years will doubtless enter the Armed Forces, the shortage of civilian engineers is expected to continue for a number of years. As might be anticipated, women are being encouraged to prepare for the engineering profession, in order to ease the shortage or to become a part of the manpower resources in this technical field.

II. IS OPPORTUNITY EQUITABLE?

Concerning the Economic Outlook

If the economic outlook changes for men engineers, it is likely to change disproportionately in relation to women. When engineering prospects are good for men, they are apt to be almost as good for women; when they decrease for men, women's opportunities in engineering are likely to be curtailed more than men's, out of proportion to the total manpower need. This observation is based upon the record of employment practices for occupations in which women constitute a minority. In engineering, women comprise only about 1 percent of the total. In all types of nontraditional employment, women must be prepared to meet this kind of situation, especially when competition for jobs is sharp.

Traditional Attitudes

In 1952, wide circulation was given in a technical journal to a training plan prepared by an engineering teacher whose stated objective was the encouragement of greater numbers of young women to enter engineering and science courses. The plan proposed that

qualified young women be trained as subprofessional, rather than as professional, engineers, in order to release the professional engineer "for more important work in the Nation's interest." Among the arguments to support the direction of young women into science classes, the following comment was offered:

Women have certain inherent characteristics which stand them in good stead. For instance, they are conscientious, they know how to use their hands, they are careful about detail, and quite important, they are not adverse to trying something new. Witness, for example, their proclivity to change the furniture around in the house about every three days to see if they can find a more efficient arrangement. This is exactly the procedure that our research scientists use; that is, if you don't know if something will work or not, try it and see. Quite often in scientific studies the going gets pretty rough and girls, being more sensitive and nervous than boys, sometimes become emotionally disturbed by overwork and the fear of failure. These troubles, for the most part, can be solved by the strategic use of a few kind words and a little human understanding. Girls will work their hearts out for you if you handle them right, which usually requires nothing more than a sincere interest in their welfare.¹

These views were probably expressed in part to counteract the fears of the timid employer or the school faculty member who has not had experience with women engineers (or who, perhaps, could recall a trying experience of some sort with a woman employee or student); instead, they may raise doubts where none previously existed. The statement illustrates, in addition, the kind of generalizations that are apt to be made about women, generalizations which, because rooted in tradition, tend to persist beyond the establishment of objective data which discredit them.

Separating Fact and Fancy

Facts about women's suitability for nontraditional vocations such as engineering, are often interwoven with threads of fiction or prejudice. The different kinds of questions involved are nevertheless separable, and each may be dealt with appropriately, even if not answered to complete satisfaction.

Women's Mechanical Aptitude

It has been popularly assumed for many years that women have certain inherent characteristics, among which mechanical aptitude is lacking. Indeed, the volume of data accumulated in recent years through psychological testing shows that boys excel as a group in mechanical aptitude and girls in clerical aptitude. Notably, this is true of the findings of the United States Employment Service from the administration of the General Aptitude Test Battery to thousands of school girls and boys. But the GATB has also demon-

¹ Morris, Fred C. Plan for training women in engineering. *Journal of Engineering Education* 43:174-176, November 1952.

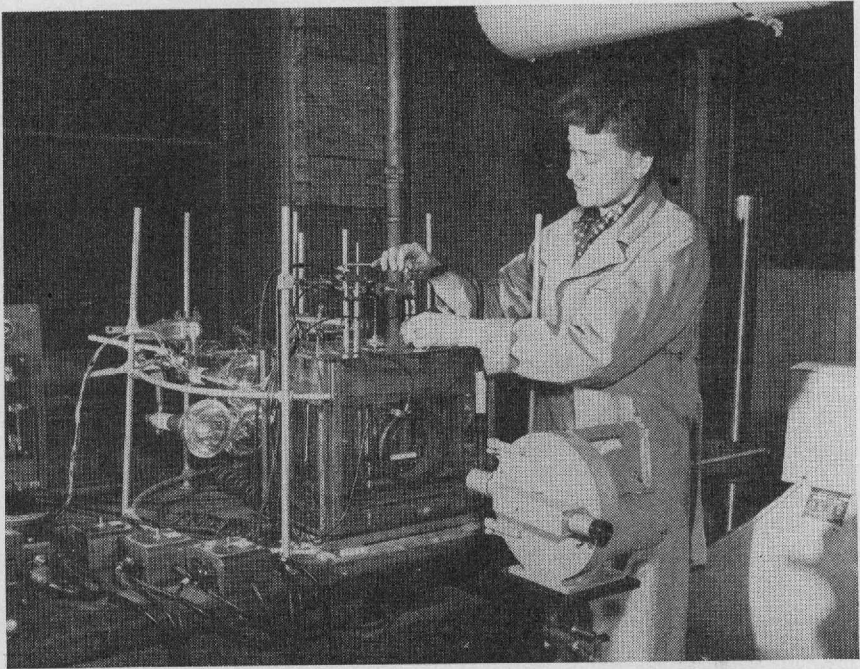


Figure 2.—Engineering Schools Offer Opportunities to Qualified Women Teachers.

An Assistant Professor of Mechanical Engineering Is Shown Making Adjustments on Apparatus Constructed for Research in Heat Transfer in Boiling.

strated that individual differences among boys and girls exceed group differences. Furthermore, the tests do not distinguish between innate or acquired characteristics, and the extent to which the differences in many aptitudes between boys and girls may be matters of environmental conditioning is not known.

Obviously, those women who find their way into mechanically based careers are in the minority, but many of them exceed, individually, the average requirements for men. This is particularly true of women engineers: There were very few women engineers between 1886 and 1940, but the proportion of outstanding women among them was high. Similarly, of the cooperative engineering schools replying to inquiries of the Women's Bureau in 1953, a majority of those that had women students enrolled reported that the women were above the class average, scholastically.

Women's Temperamental and Physical Suitability

The temperamental (or emotional) suitability of women for engineering is a point on which there are no verifiable data, because temperament cannot be measured. However, employer experience

with successful engineers, both men and women, shows that an individual who has the temperament for engineering will test high in the vocational proficiencies and aptitudes that can be measured. Thus, since temperament cannot be separated from other personal qualifications, it seems fair to assume that personal qualifications as a whole will include temperament.

Most professional engineering jobs are accomplished at a desk, even in field construction work. Except for military service under combat conditions, many engineering jobs require no more physical exertion than wielding the compass and slide rule. Individual women are known to work at jobs in which they test planes under exceedingly hazardous conditions, or to climb into over-sized machinery to inspect it. These women undertake such tasks by choice, and are undoubtedly more physically fit to execute them than many men.

The Industrial Environment

Social obstacles confront women engineers. The engineer's environment is predominantly men's and the few women who enter engineering must be acceptable to, and willing to work with men, sometimes almost exclusively, even if self-employed as engineering consultants. If a job sometimes requires a woman to work with men crews in isolated areas, social custom tends to prohibit her participation. In recent years, many employers, notably the Armed Forces, have demonstrated that this problem can be resolved without great difficulty. As the numbers of women increase, of course, the social barriers diminish in importance. In this connection, an employer can resolve his own doubts by employing more than one woman engineer at a time.

Training Opportunities

Perhaps because of the predominantly men's environment of engineering schools, many women engineering aspirants have obtained the impression that training opportunities for them are very limited. The fact is that almost every course of engineering studies which is connected with a coeducational institution admits women. Reference is made to appendix 2, which lists accredited engineering schools. It can be seen that there are an adequate number in all regions of the country to accommodate women. Of course, some engineering schools exclude women, just as some Liberal Arts programs do, and universities are not always consistent in their admission practices for the Liberal Arts and the specialized schools under the same administrative roof.

It might be expected that cooperative engineering programs, which provide for alternating periods of classroom study and paid employ-

ment related to the studies, are more restrictive to women students than academic engineering courses. This, however, is not the case.

Among the 20 or so cooperative engineering programs conducted in 1953 at well-established universities and college-level technical institutes, 18 reported in a Women's Bureau survey concerning their experience with, and attitude toward, women students. Eight of the institutions had one or more women students in 1953, and another eight indicated that they would be willing to accept qualified women, even though several of these had never previously tried to place women students. Only two appeared to be opposed to admitting women, but there were indications that even they might be persuaded to open their courses to individual women.

It is not always easy for the school with a cooperative program to find suitable employment for its students, and five of the eight schools which had women enrolled in 1953 reported that women were especially difficult to place under the work-study plan. On the other hand, three schools had no problem in finding employment for women and were very encouraged about their experience with women cooperative students.

Nearly all of the cooperative programs with women students, including some which found that women created special problems of placement, reported that their women students were usually exceptional in scholarship. The majority of faculties reporting on cooperative programs were very much in favor of encouraging larger numbers of women to enter engineering training. A few respondents in administrative positions expressed opposition to women, in contradiction to the school policy of acceptance.

There were, in 1953, probably not more than 20 women enrolled in cooperative engineer training programs, but this was not because of admission restrictions. As a matter of fact, the cooperative schools may have had some difficulty in filling their quotas for men as well as women, partly because of the increasing emphasis in recent years on the extension of the academic curriculum for engineers into the humanities and arts. A similar trend is also noticeable in other professional training, for example, medicine. (This is discussed a little more fully in Section IV, "Information for the Prospective Woman Engineer.")

The total number of women enrolled annually in engineering schools of all types indicates that women have hardly begun to take advantage of the training opportunities open to them. In 1952-53, only 33 women obtained the first degree in engineering from United States schools, 15 received the master's degree, and 4 the doctorate. For the 1953-54 school year, a total of 816 women engineering undergraduates

were enrolled in 210 schools, contrasted with 170,909 men undergraduates. Dropouts will further reduce this number.

Opportunities for Professional Status

With reference to the point of view that women, as a group, should be trained in larger numbers primarily for subprofessional engineering jobs—a position held by some training and manpower specialists (see page 4)—the development of additional subprofessionals is unquestionably a sound and practical way to release professional engineers for occupations which make greater demands upon their talents and training. If the training plan for women is limited to this objective, however, it defeats the goal of making the best possible utilization of manpower resources; this would be neither to women's interest nor to the Nation's.

At this stage of development of womanpower resources for engineering, a limited approach is not necessary; it tends to discourage the relatively few qualified young women who wish to study engineering, and it may restrict opportunities for women graduates who seek full professional status.

In this connection, the Committee on Specialized Personnel, of the Office of Defense Mobilization, in its report of December 9, 1953, takes the following position: "For the most part, the female graduate [*i. e.*, in engineering and the sciences] has been held down as far as advance in classification and remuneration is concerned. Such action on the part of management is totally unrealistic, and in order to promote the development of our high potential of female scientists and engineers, this unrealistic sex barrier must be broken."

Case histories are available of women in industry who, although fully qualified as professional engineers, have been relegated to subprofessional or dead-end jobs. One large manufacturing firm, in a letter to the Women's Bureau in 1953, was laudatory about the proficiency of the women engineers on the staff but frankly pointed out, at the same time, that advancement for women was restricted, as a matter of policy.

On the other hand, many employers have adopted a nondiscriminatory policy. Women engineers appear to be acceptable particularly to manufacturers of electrical and electronics equipment, and in the aircraft industry. A survey made by the National Society of Professional Engineers in 1951 reported, "The consensus is that women engineers are well received where they are now employed." Among 495 employers (with 3,948 plants) represented in the NSPE survey, 65 percent of the respondents stated that they would hire women engineers if they were available; 45 percent had found it "feasible" to use women engineers; and 23 percent had women engineers on the staff.

Figure 3.—Women Chemical Engineers Are Found in a Variety of Industries.

- a. In Electrical Manufacturing, Chemical Engineer (right) Works on Fluorescent Tubes.**



- b. In Automotive Manufacturing, Chemical Engineer (above) Tests Motor Parts.**

Interrupted Employment: A Risk for Employers of Women

One indisputable career barrier for women is founded upon the hard fact that some women engineers may be poor risks financially. An employer's investment in on-the-job training for an engineer is much greater than for most of his personnel; it has been calculated as high as \$10,000, by some firms. If a woman engineer resigns or leaves employment for a long period because of marriage or home responsibilities at the point where she has reached her peak of utilization in a particular business or industry, her withdrawal not only inconveniences the employer but strengthens the prejudice against women.

The Defense Mobilization Director, Arthur S. Flemming, recognized the objections to interrupted work patterns of women in his address before the Association of Land Grant Colleges and Universities in November 1953, when he encouraged the enrollment of women engineers; he commented as follows:

It is true that, in many instances, women graduates of engineering schools would work a while and then marry and raise their own families. For a period of time they would not be available for engineering positions. But later on in life they would be available. And in the event of an emergency a large number of them would be willing to return to work even though it called for real sacrifice on their part to do so.

Some employers have concluded that it is against their own interests to establish policies which are prejudicial to women employees in general because some women find it necessary to withdraw from employment. A large electrical equipment manufacturer told the Women's Bureau in 1953 that it has maintained a nondiscriminatory policy toward women for many years, and that the company program has developed, and will continue to train, women professional engineers to do the same work as men, despite the fact that some of them may leave for marriage and family responsibility.

In Brief

Many more potential women engineers are in the population than have taken advantage of training opportunities, as the women's enrollment in engineering for 1953-54 indicates. Greater numbers of them would undoubtedly consider the career if traditional attitudes against women were relaxed. On the other hand, a number of women prefer marriage to a career and some cannot manage both a career and marriage after employment and training on the job. These facts create a risk, and some employers who are willing to gamble on hiring a woman engineer in a time of critical need may reject the idea as production demands decrease, or may maintain a general policy of under-utilization of women engineers.

The claim that women as a group are potentially better subprofes-

sional than professional engineers is either an unjustified assumption, or a compromise offered by employers who wish to avoid the risk of developing women as full-fledged engineers.

It is in the national interest, not only for a continuing period of partial mobilization, but also for the expansion of the country's productive capacity, to encourage qualified women to enter the engineering field.

Women themselves will continue, for some time to come, to carry the major responsibility for development of equal opportunity in engineering. Because they are so few in number, individual women are likely to represent women engineers as a whole in the minds of faculties and employers. Clearly, the standards for the training and employment of women engineers are more exacting than for men. As a result, a majority of successfully employed women are apt to be outstanding in the field.

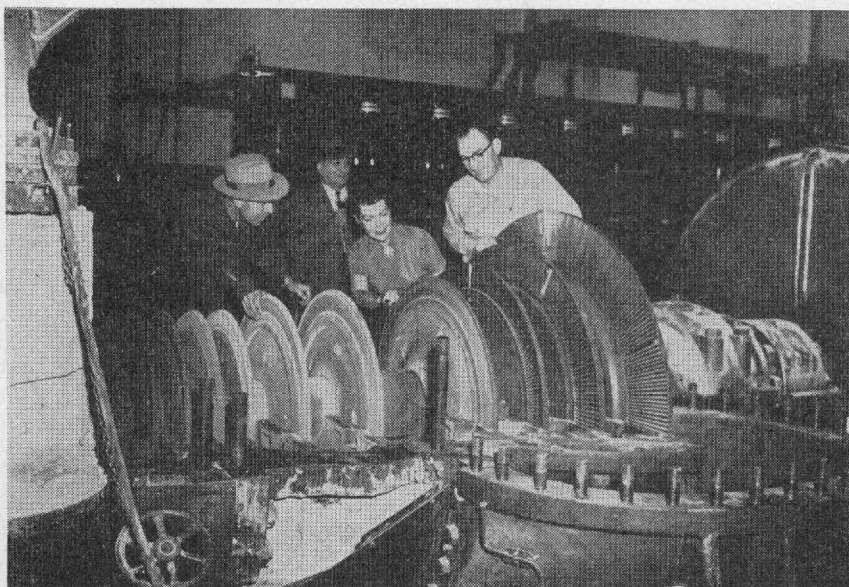
There is no doubt that equity in opportunity for women engineers is not universally practiced. Most successful women engineers who have achieved full professional rank have met some prejudices and discouragement, but they tend to agree that the serious career barrier must usually be confronted early during the school years. Katharine Stinson, 1953 President of the Society of Women Engineers, believes that the college engineering course constitutes a good screening process for women, and that once the training requirements are met, the problems of employment will not be so difficult. Some women engineers go so far as to say that wherever cases of discriminatory practice are found in industry, they are apt to be the result of problems created in part by an individual woman: she may be "too overtly aggressive" or she may find ordinary competition in this field too difficult and be unable to meet it.

Counselors of women aspirants to the engineering career can do a great deal by presenting frankly the complex facets of the problem of equitable opportunity and relating them to the individual student. The point where the vocational choice is being made is most appropriate to provide encouragement to the qualified and, at the same time, to show that women's career problems are somewhat different from men's, and not entirely a matter of vocational potential.

III. TAKING INVENTORY

How Many Women Professional Engineers in 1950-53?

A distinguished, but exceedingly small, number of women entered engineering year after year from 1886 to 1940, when the total census count of employed women engineers was 730. By 1950, the decennial census reported 6,475 women employed as engineers, almost a ninefold



**Figure 4.—Some Women Engineers Go Into Business for Themselves.
Mechanical Engineer Demonstrating a Turbine to Prospective Buyers.**

increase in little more than the same number of years. However, subsequent data, based upon a sample of the 1950 census tabulations, point toward a need for modifying some of the early conclusions concerning this remarkable expansion among women professional engineers.

Women Classified as Engineers in 1950 Census

Sample data from the 1950 census show that only 41 percent of the women engineers had completed 4 years or more of college, and about 17 percent did not have as much as 4 years of high school. It is, of course, possible for an engineer to achieve professional status without completing college; in earlier years, a number of men engineers were self-educated and perhaps did not complete even a formal high-school course. In lieu of formal education, however, an engineer is required to substitute for, or supplement, education with job experience. Therefore it is hardly possible for anyone without the formal course of training to achieve recognition as a professional engineer before reaching maturity. It would be even less likely today for women to become professionally recognized engineers without substantial college background. A few women have arrived at the engineering career after having prepared for some other vocation, but usually in maturity and with a background which includes some college education. Age, then, together with education, should provide some

reasonable basis for evaluating the professional status of the women classified as engineers. A summary is presented on information on age and education of women classified as engineers in 1950:

Table 1.—Estimate of Number of Employed Women Classified as Engineers, by Selected Age and Education Groups, 1950

Age and education	Number	Percent
Total women reported as employed ¹ -----	6, 475	100
Women 20 years of age and over with 4 or more years of college-----	2, 650	41
Women 25 years of age and over with 1 to 3 years of college--	975	15
Women 20 to 24 years of age with 1 to 3 years of college--	170	3
Women 20 years of age and over with 4 years of high school--	1, 280	20
Women with less than 4 years of high school, or 14 to 19 years of age (1,142), or with years of school not reported (245)-----	1, 400	22

¹ Total number reported (6,475) is based on the full census count; all other numbers are based on a 20-percent sample.

Source: U. S. Department of Commerce, Bureau of the Census. 1950 Census of Population (unpublished data).

It is extremely unlikely that the 1,400 women with less than 4 years of high school or only 14 to 19 years of age, or the 1,280 women 20 and over with only 4 years of high school, are professional engineers. The group of 170 who are 20 to 24 and have 1 to 3 years of college are also in doubtful professional status. These three groups together constitute a total of 2,850 women who are classified as technical engineers, but who are probably engineering aides and technicians, and not professional engineers.

In the next group of 975, or women 25 years of age or over with education of 1 to 3 years of college, there may also be some subprofessionals, particularly among those with only 1 year of college, but no further information is available to show a breakdown of the educational attainment. However, since these women were old enough (at least 25 years of age) to have had some qualifying work experience, it would seem reasonable to identify them as professional engineers. Of course, the remaining 2,650 women with 4 years or more of college may be regarded as engineers with professional status. Thus, about 3,600 women can be identified as professional engineers in 1950, three-fourths of them having qualified by college training and the remainder partly by college training and partly by experience.

Contrasted With Men Engineers

In contrast to women, the men classified as engineers in the 1950 census were an older group, and their group educational attainments were higher. Comparable sample data on education and age of men show that the median age of 525,256 men classified as engineers was 38, while the median age of 6,475 women classified as engineers was 31 years. Further, 54 percent of the men had completed 4 years or more of college as against 41 percent of the women. In view of these facts, it is a fair assumption that a substantially greater proportion of the men than women who were reported as engineers in 1950 were professional engineers. Besides, there must have been a large number of men who were not counted as engineers in 1950, although they had professional rank in this field.

Many men engineers must have been reported in other occupational classifications such as those covering high-income sales personnel (wholesale or retail), executive and management jobs, classifications composed of proprietors and owners (of various types of business, including engineering firms), and possibly even in certain kinds of scientific research or development. On the other hand, women engineers who achieve professional status are much more likely to describe their vocation in terms of the engineering classification, regardless of the job combinations in which they work, or the kinds of titles to which they may have transferred their engineering skills.

Common-Sense Conclusions About the Number of Women

In summary, then, it is practical to consider the total number of men engineers reported as such in 1950 as close to the actual number of men professional engineers. It is also a commonsense deduction, in the absence of verifiable and accurate data, to estimate the number of women engineers in 1950 at closer to 3,600 than to 6,475. The 1950 total of professional women engineers, therefore, instead of being almost nine times the 1940 total of 730 women,² was probably more nearly five times that number. Both an examination of such detailed data as are available and conjectures based upon occupational classification trends and practices support this conclusion.

Proportion of Women to Total

In relation to the total number of engineers, the proportion of women, even at the census count of 6,475, was only 1.2 percent in 1950. If the number is cut to an estimated 3,600, as suggested by the foregoing discussion, women engineers in 1950 comprised roughly 0.7 percent of the total. This is a doubling of the proportion of women

² Compare with earlier reports based on preliminary 1950 census estimates; for example, in "Expanding Occupational Opportunities for Women," by the Bureau of Labor Statistics, *Monthly Labor Review*, April 1953.

in relation to the total, over the 1940 Census. It indicates that women have maintained a snail's pace, in the 68 years of their engineering advance up to 1950. Such a leap in progress, following the snail's pace of the previous half century, may indicate the beginning of an accelerated trend for women in this field.

Women Engineers Today: Group Traits

It would be not only interesting, but helpful, to be able to make, with complete confidence, a series of generalizations about the characteristics and achievements of women professional engineers. Unfortunately, the 1950 census data present a number of difficulties, as mentioned in the preceding discussion, and only meager information is available from other sources.

To try to fill a gap in the information, the Women's Bureau in 1953 undertook a cooperative project with the Society of Women Engineers, to survey their membership, by assisting with tabulations from questionnaires. Members of the SWE are women college graduates in engineering, or women with a minimum of 6 years of paid engineering experience at a level equivalent to the training required of a graduate engineer, and also women who, although they may have degrees in related scientific fields, particularly architecture or the physical sciences, have acquired, in addition, at least 2 years of engineering experience at the professional level. Because the SWE had a membership of only 300 or so at that time, it was considered useful to add to the canvass of members an additional 300 on the SWE mailing list, for the purpose of obtaining some facts about personal characteristics, education, employment experience, geographical distribution, age, marital status, and income.

Facts From 1953 Survey of the Society of Women Engineers

Of approximately 600 questionnaires sent out by the SWE, 264 replies were received and tabulations made by the Statistical Branch of the Women's Bureau. A summary of the findings is presented here.

(1) *Employment Status at Time of Survey*

Almost four-fifths of the group surveyed were employed, and 9 out of 10 of the women employed were working at full-time jobs.

(2) *Geographic Region of Training and Current Employment*

Of the women employed in the South, about 45 percent had received undergraduate training in the South; of those employed in the West, 52 percent had been trained in the West; 76 percent of those employed in the North Central States had been trained there; and 86 percent of those employed in the Northeastern States had done their preparatory work in the same region.

(3) *Region of Undergraduate Training for SWE Group as a Whole*

About three-fifths of the women questioned reported that they obtained their undergraduate training in the Northeastern States. Less than 10 percent of them secured training in the South. Seventeen percent were trained in the North Central region, and 13 percent in the West.

(4) *Level of Training—Graduate and Undergraduate*

Ninety-seven percent of the women surveyed had attended college, and 83 percent of these had undergraduate degrees. About 36 percent had taken some graduate work, and more than half of these had obtained at least the Master's degree. Nine women reported the acquisition of the doctorate degree, and several more were working toward the doctorate.

Only 3 percent of the women either had had no college training or failed to report training.

(5) *Fields of Preparation for Engineering*

About two-thirds of the women reported undergraduate training in an engineering field. Another 27 percent took undergraduate specializations in mathematics, science, or architecture. The remainder had either been trained in such unrelated fields as language or political science, or failed to report the type of training, or had taken no undergraduate work.

Of the graduate degrees obtained, half were in mathematics, physics, or chemistry. The majority of the remaining graduate degrees were in engineering fields and a few were unrelated to engineering.

As to the sequence of undergraduate and graduate work, all but three of the 21 persons with graduate degrees in engineering had taken undergraduate work in engineering. Of 26 whose graduate degrees were in mathematics, physics, or chemistry, 20 had obtained undergraduate degrees based upon specializations in the same fields.

(6) *Time Lapse Between Undergraduate and Graduate Degree*

Of the 52 women with graduate degrees reported, 10 had earned the graduate degree within 1 year of undergraduate work; 11 within 2 years; 14 within 3, 4, or 5 years; and 15 within more than 5 years. (Two failed to report dates.)

(7) *Time Lapse Between Degree and First Engineering Job*

Eighty-one percent of the 207 women who supplied both the dates of their college degrees and the date of their first engineering job had obtained this job during the year (or period) of their attainment of the degree.

About a fourth of the women reporting had received their degrees prior to World War II. However, 18 of these 47 women did not find engineering jobs until, or after, the war period.

All except 18 of the 160 women who received their degrees in 1941 or later had been employed in their first engineering job during the same year (or period) as their graduation from college.

(8) *Starting Salaries on First Engineering Job*

Of the 144 women for whom the necessary facts were available, 15 percent were employed in their first engineering jobs prior to 1941. For this small group, four-fifths had a starting salary on this job of less than \$2,000 a year. Another 20 percent of the women obtained their first engineering jobs during the war years, 1941 to 1945. Two-thirds of these women had a starting salary of \$1,500 to \$2,500 a year.

Thirty-five percent of the women reporting in the survey were employed in their first engineering job between 1946 and 1949. Two-fifths of this group had a starting salary of \$2,000 to \$2,500, and a similar proportion had starting salaries between \$2,500 and \$3,500.

Of the 42 women who obtained their first engineering jobs between 1950 and 1953, about a third had starting salaries of \$3,000 to \$3,500; and the earnings groups of \$2,500 to \$3,000 and \$3,500 or over each accounted for a fourth of the women who secured their first jobs during this time..

(9) *Current Salaries of Women Engineers Surveyed*

Of the 193 women who reported salaries in their present jobs and length of time on the job, 19 percent were earning less than \$4,000. Half of these 37 women had been employed in their jobs for less than 2 years; and half of this group were part-time workers. Only 11 percent of the women in this income group had been in their jobs for 5 years or more.

Thirty percent of the women reporting salary and length of service in the survey were earning between \$4,000 and \$5,000. About 15 percent of these women had been in the jobs for as long as 5 years or more; but almost half (48 percent) had been employed for less than 2 years.

The same proportion of women (25 percent) were earning between \$5,000 and \$6,000 as were earning \$6,000 or more. Over half of the women in the income bracket \$5,000-\$6,000 had been employed for 2 to 5 years, a third had been on the job for less than 2 years, and only 12 percent had served for as many as 5 years. Almost half of the women earning \$6,000 or more had been employed for at least 5 years.

In summary: A fourth of the women reporting present salary and length of employment were earning \$6,000 or more a year; over half were earning between \$4,000 and \$6,000; and about a fifth were earning less than \$4,000. Most of the part-time workers were in this latter group. Less than a fourth of the women reporting (22 percent) had been employed in their jobs for 5 years or more; two-fifths had been employed from 2 to 5 years, and slightly less than two-fifths (38 percent) had been working at their present jobs for less than 2 years.

(10) *Age of the Group*

The median age of women in the survey was 28.9 years. For the employed group (four-fifths of the total) it was a fraction higher—29.3; and for the one-fifth not employed at the time of the survey, a little lower—27.8 years.

(11) *Marital Status*

Of the currently employed women, 51 percent were single, 37 percent were married, and 12 percent were widowed, divorced, or separated.

Among the very few of those employed who were doing part-time work, the majority were either single and still in school, or married with children under 6 years of age.

Two-thirds of the employed women engineers who were married, widowed, divorced, or separated had no children. Of the one-third with children, 3 out of 4 had children under 6, which might be expected in view of the low median age of the group.

Usefulness of the Society of Women Engineers' Survey

Two objections can be raised with respect to the use of the SWE survey as a basis for drawing conclusions about women engineers as

a group. First of all, the replies received represent a very small proportion of the roughly estimated 3,600 women in the United States with professional status in engineering and, therefore, may not be truly representative of women engineers. In addition, the SWE is a relatively new organization, having been incorporated in 1952 (although organized meetings were held as early as 1949), and at the time of the survey there was some concentration of membership in the north-eastern part of the United States.

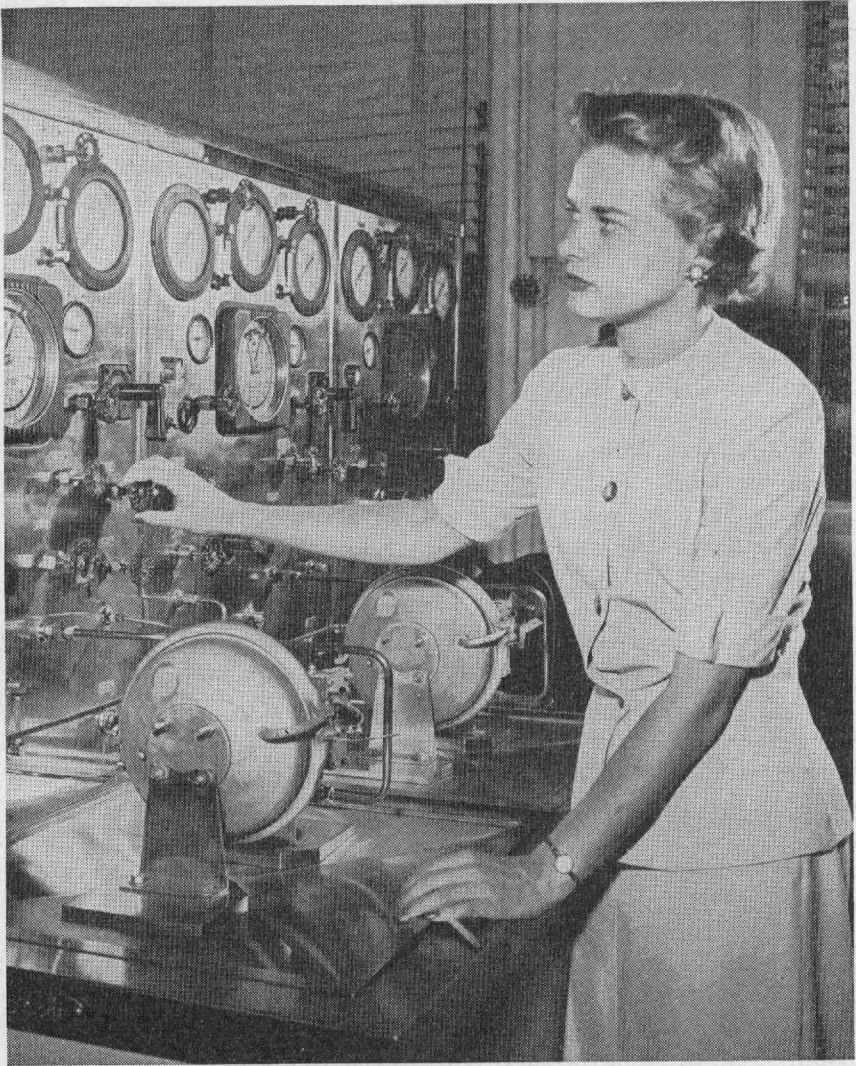
Nevertheless, the information obtained from the survey relates to women whose professional engineering status is fairly well established according to the usual standards of education: 91 percent had undergraduate training in engineering or in the related fields of science, mathematics or architecture; more than four-fifths had obtained undergraduate degrees, and over one-third had graduate training. Furthermore, according to the 1950 census the largest number of engineers, both men and women, are employed in the Northeastern States so that the geographical concentration of SWE membership is consistent with the geographical distribution of employed engineers.

At a minimum, data from the 1953 survey are useful both for consideration alongside of data from the 1950 census and for information not revealed by census data. Despite its limitations, the kind of information received from the survey is not available from any other source. It is recognized, of course, that data from the Society of Women Engineers' survey are not statistically comparable with census data on women engineers.

Some Comparisons and Contrasts

The median age of women classified as engineers in the 1950 census was 31 years. This is 5 years lower than the median age for all women workers in 1950. Only one other group of women at a comparable professional level, namely chemists, showed a lower median age. Men engineers in 1950 showed a median age 7 years above that for women. Young as the women engineers shown in the census count were, those in the survey were even younger: employed women engineers in the survey showed a median age of 29 years. Thus, women engineers apparently are a remarkably young group. This is not surprising, in view of the fact that the sizable increases in the enrollment of women in engineering colleges took place only 10 years ago, that is, during the period of World War II.

Correlated with the lower median age for women than men engineers is the fact that a greater proportion of women engineers than men were single. According to census estimates, approximately one-third of women engineers were single, while only a little more than one-tenth of men engineers were single. As in the case of age,



**Figure 5.—Automobile Manufacturers Employ Women Engineers.
Mechanical Engineer Tests Automobile Motor in Research Department.**

the SWE survey underscores this characteristic, showing that, among the survey respondents, about one-half were single.

It is interesting to note that the relative youthfulness of women engineers reported in the SWE survey is reflected in the ages of their children. Of the women with children, three out of four had children under 6 years of age. These women, together with single women still in school, were the ones working at part-time jobs. Of course, the

predominance of single women and married women without children in the survey is consistent with the fact that 9 out of 10 of the women were employed at full-time jobs.

The great majority of women engineers in the SWE group apparently had little trouble finding a job after having received their degrees. Four out of five got their first engineering jobs almost immediately after attaining their degrees, but some of those who received degrees prior to World War II did not succeed in finding engineering jobs until during or after the war. Of course, starting salaries were progressively higher for those obtaining their first engineering jobs in the period of the war and again after World War II than for those who obtained engineering jobs prior to 1941.

At the time of the survey (early 1953) about half of the women engineers who reported salaries in their present jobs were earning \$5,000 or more per year. Less than one out of five was earning under \$4,000 per year, and almost all of these women were part-time workers or had been employed in their jobs less than 2 years. By contrast, almost half of the women engineers who were earning \$6,000 or more per year had been employed at least 5 years.

Unfortunately, only a very limited amount of information is available on salaries for similarly selected groups of women in other professions. However, nearly comparable data for women chemists and psychologists indicate that the median salary of women engineers in the survey—\$5,306 per year—is as high or higher than median salaries for these two groups.

In Summary

The woman professional engineer of today is more likely than the average working woman to be single, a finding that might be expected, in view of the fact that she is likely to be about 5 years younger. She probably has acquired at least an undergraduate degree in engineering, science, mathematics, or architecture and has had little difficulty in finding an engineering job after graduation. If she works full time at her job and has had at least 5 years of experience, she probably earns more than \$5,000 per year.

Specialization Trends: Men and Women

Broad indications of the occupational shifts and developments in the various special engineering fields may be obtained on the basis of census data for 1940 and 1950. As previously observed, the data refer to engineering personnel of unverified professional status, and of the 6,475 women workers counted in 1950, probably not more than 3,600 could be roughly estimated as professional. (See page 15.) The accompanying table shows only the distribution of engineering

personnel by sex, and the percentages for 1940 and 1950. Probably two-fifths or more of the women shown in the 1950 distributions were engineering aides, draftsmen, and engineering technicians. The distributions are nevertheless of interest in showing the proportions of women to men and the fields which reflected shifts in numbers and proportion during the decade.

Table 2.—Technical Engineers by Field of Engineering and Sex: 1950 and 1940

(Employed persons)

Engineering field	1950			1940		
	Total	Men	Women	Total	Men	Women
NUMBER						
Total.....	525, 256	518, 781	6, 475	275, 325	274, 595	730
Chemical.....	32, 522	31, 893	629	12, 620	12, 581	39
Civil.....	123, 318	121, 386	1, 932	85, 875	85, 684	191
Electrical.....	106, 515	105, 278	1, 237	61, 367	61, 203	164
Industrial.....	40, 200	39, 750	450	11, 683	11, 609	74
Metallurgical, metallurgists, and mining.....	22, 105	21, 755	350	11, 063	10, 989	74
Other engineers.....	200, 596	198, 719	1, 877	92, 717	92, 529	188
Aeronautical.....	17, 635	17, 304	331	(¹)	(¹)	(¹)
Mechanical.....	110, 164	109, 588	576	(¹)	(¹)	(¹)
Not elsewhere classified..	72, 797	71, 827	970	(¹)	(¹)	(¹)
PERCENT DISTRIBUTION						
Total.....	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0
Chemical.....	6. 2	6. 1	9. 7	4. 6	4. 6	5. 3
Civil.....	23. 5	23. 4	29. 8	31. 2	31. 2	26. 2
Electrical.....	20. 3	20. 3	19. 1	22. 3	22. 3	22. 5
Industrial.....	7. 7	7. 7	6. 9	4. 2	4. 2	10. 1
Metallurgical, metallurgists, and mining.....	4. 2	4. 2	5. 4	4. 0	4. 0	10. 1
Other engineers.....	38. 2	38. 3	29. 0	33. 7	33. 7	25. 8
Aeronautical.....	3. 3	3. 3	5. 1	(¹)	(¹)	(¹)
Mechanical.....	21. 0	21. 1	8. 9	(¹)	(¹)	(¹)
Not elsewhere classified..	13. 9	13. 8	15. 0	(¹)	(¹)	(¹)

¹ Comparable detail not available for 1940.

Source: U. S. Department of Commerce, Bureau of the Census. 1950 Census of Population.

Civil engineering, in 1940 and again in 1950 according to the decennial census reports, led the field in employing the largest numbers of engineering personnel, both men and women. There were, however, some shifts in the relative importance of these and other specializations. Chemical engineering and the group ("other engineers") which includes aeronautical and mechanical fields showed increases in the number and proportion of workers, both men and women, between 1940 and 1950, whereas the proportion of men and women, engaged in electrical engineering showed some decrease. Although these changes were proportionately small, they are nevertheless of interest as indicative of trends.

It can be seen that civil engineering alone (which is the largest single specialization) increased in importance for women and decreased in importance for men. A tenfold increase of women in civil engineering—which showed less proportionate growth during the decade than any other field—provokes some speculation because traditionally women have been considered less suited to this field than all others, except mining.

One explanation of the sizable increase of women in civil engineering in 1950 may lie in the fact that almost half of all civil engineers work for government agencies (Federal and other). Salaries for highly skilled technical personnel in government agencies have not kept pace with salaries in industry. It is possible that a number of men engineers moved from government agencies into higher paying industrial jobs during the decade 1940-1950, and that women found their way into positions vacated by men. To what extent the increase of women in civil engineering represents an influx of women engineers with professional status is, of course, not known. Possibly many of the women who entered this field in the period 1940 to 1950 were draftsmen or engineering aides.

IV. INFORMATION FOR PROSPECTIVE WOMEN ENGINEERS

Early Indications of Aptitude

There is no sure way for a young woman to tell whether she would make a good engineer or, for that matter, a good doctor or lawyer. Persons with experience in the engineering field believe, however, that there are certain clues to aptitude for engineering which may be helpful to students considering the career.

A child may reveal engineering aptitude at a very early age by interest in mechanical processes, such as building automobile or airplane models, tinkering with radios, trying to find out *how* and, especially, *why* mechanical things work the way they do and attempt-

ing to make them operate better. Reading books and magazines on scientific subjects, keeping up on new developments in science, visiting places where mechanical things are built or repaired are also significant indicators of engineering aptitude. In school work, the potential engineer usually shows interest and ability in mathematics and science courses.

Some of the criteria used by recognized colleges of engineering for testing the qualifications of college entrants who wish to study engineering are as follows: (1) an aptitude for, and preparation in, mathematics; (2) an ability to visualize; (3) a knowledge of mechanical movements and physical principles; and (4) a preference for scientific or mechanical work.

Available on request at almost any State employment service office is the General Aptitude Test Battery. This is of great assistance to young women who wish to obtain an evaluation of their skills and potential capacities for various kinds of work, including engineering. The results of the GATB, as interpreted by the employment service counselor, may be used both by the engineering candidate and her school advisers. The GATB is given without charge, as a public service.

High-School Preparation

Students interested in an engineering career should consult the high-school counselor as early as possible regarding college-entrance requirements and the proper selection of the high-school curriculum. Mathematics and science courses are a "must," and it is frequently recommended that the full sequence in mathematics be followed. Courses in solid geometry and technical drawing are important for development of the ability to visualize, and courses in physics provide a beginning knowledge of mechanical movements and physical principles.

Colleges differ somewhat in their specific entrance requirements, but the following list of high-school courses is illustrative of the requirements for admission to a degree-granting engineering college:

	<i>Units</i>
English.....	3
History or social studies.....	1
Algebra.....	1½
Plane geometry.....	1
Solid geometry.....	½
Science (with laboratory work).....	1
Additional work in any of the above subjects.....	3
Other high-school subjects.....	4
Total.....	15

An extra unit of science (preferably physics or chemistry) and an extra $\frac{1}{2}$ unit of algebra, plus $\frac{1}{2}$ unit of trigonometry are strongly recommended for the engineering student, but are not always required.

Since engineering is a field in which women are likely to find themselves "spot-lighted," both in training and on the job, it is important that the prospective woman engineer secure the kind of preparation which will not place her at a disadvantage in relation to men candidates.

Engineering Training

In years past, many engineers gained their engineering knowledge by self-study and on-the-job experience (sometimes through an apprenticeship-type agreement with a practicing engineer) or were able to enter the engineering field through training in a technical institute or in related sciences, such as chemistry, physics, or mathematics. Today, the number entering the profession without completing engineering college training has been steadily growing smaller. Gradually the educational level of the entire profession has been rising, and the emphasis in recent years has been largely on the 4-year undergraduate curriculum in accredited institutions granting engineering degrees. (See appendix 1, "Occupational Information for the Student.") Thus, for women especially, the selection of an accredited school of engineering is of great importance. Persons trained at such schools generally have the best employment opportunities. A list of institutions offering accredited curricula in one or more engineering specialties in 1953 may be found in the appendix, and current lists may be obtained from the Engineers' Council for Professional Development, 25-33 West 39th Street, New York 18, New York.

There seems to be some concern among leaders in the profession about the lack of nontechnical and general knowledge on the part of large numbers of engineers. As a result, the present trend is toward including in the college curricula more nonengineering courses, such as business administration, psychology, economics, English, social and political sciences, and literature.

Because some educators feel that the addition of a wider range of courses to the full program of technical and specialized engineering subjects causes overcrowding of the undergraduate's schedule, as this requires the student to complete 5 or 6 years' work in 4, some colleges have moved toward the adoption of a 5-year engineering course for the bachelor's degree. In view of the variations in engineering training, even among institutions of the same type, the prospective engineering student should consult with interested authorities, as to the particular curriculum most suited to her needs. In this respect, the

Society of Women Engineers, 4 Washington Square North, New York 3, New York, through its Professional Guidance and Education Committee, may be of assistance.

Fields of Specialization for Women

Despite the employment barriers commonly encountered in the past by women engineers, there remains a relatively wide choice of employment for the college-trained engineer. There are individual firms in almost every kind of industry which seem willing to hire qualified engineers, regardless of sex. However, opinions vary as to whether the newly graduated woman engineer will find the greatest opportunity for success and personal satisfaction in a specialization where men have always predominated, or in specializations that can be related to women's interests.

Some experienced women engineers feel that women will do best if they specialize in engineering related to such consumer products as household appliances and equipment, textiles, clothing, and food; that is, in fields where they have a natural advantage. On the other hand, others, among them Katharine Stinson, President of the Society of Women Engineers, and herself an aeronautical engineer, feel that the woman engineer should pursue the specialty in which she has the greatest interest, whether this be building bridges, aircraft design, or highway construction. It is up to the individual woman to make the choice in accordance with her own talent, vitality, needs, and interests.

Sources of Information

The woman engineer who is seeking a job will do well to consult with engineering and placement officials at her university. Many firms today go directly to the universities to recruit engineering talent, and interviews with prospective graduates are arranged and supervised by college authorities. Engineering societies, including the Society of Women Engineers, can also be of help; their members are in daily contact with developments in the engineering field. Engineers interested in Federal employment should contact the nearest office of the U. S. Civil Service Commission.

For some kinds of engineering work a person must be a "registered engineer," and registration laws have been adopted by all States. The various States differ in requirements for registration, but in general, the purpose of such laws is to insure that engineering work which involves the safeguarding of life, health, or property shall be done by qualified engineers. Detailed information on registration laws and addresses of boards of examiners may be obtained from the National Society of Professional Engineers, 1121 Fifteenth Street, NW., Washington, D. C.

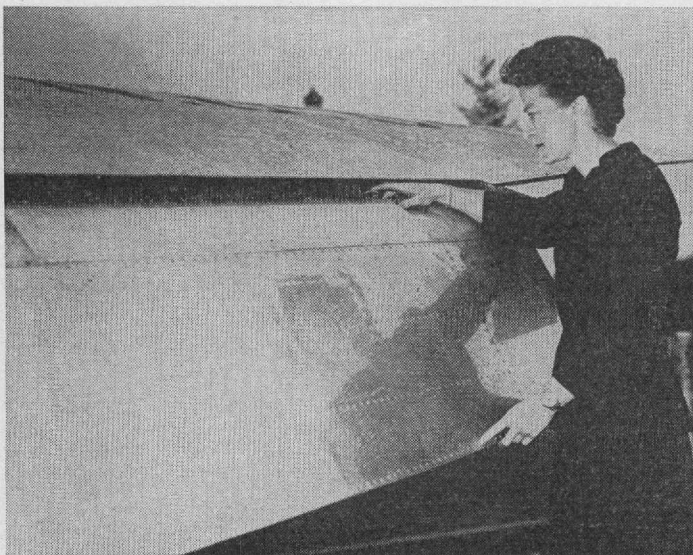


Figure 6.—Women Engineers Are Successfully Employed in Aircraft Manufacturing and Aeronautical Control.

Aeronautical Engineer Examines Fittings Between Flap and Aileron to Determine Whether They Meet Specifications.

Although there are more than 60 national engineering organizations in the United States, and most of them accept women as members, only one organization, the Society of Women Engineers, devotes itself exclusively to the interests of women engineers. The Society of Women Engineers was incorporated in the District of Columbia on February 13, 1952. Its objectives are stated as follows:

To inform the public of the availability of qualified women for engineering positions; to foster a favorable attitude in industry toward women engineers; and to contribute to their professional advancement.

To encourage young women with suitable aptitudes and interests to enter the engineering profession, and to guide them in their educational programs.

To encourage membership in other technical and professional engineering societies, participation in their activities, and adherence to their code of ethics.

Membership information and applications may be obtained on request from the Society.

The major branches of engineering are represented by the following national organizations:

- American Society of Civil Engineers
- American Institute of Mining and Metallurgical Engineers
- American Society of Mechanical Engineers
- American Institute of Electrical Engineers
- American Institute of Chemical Engineers

All of these organizations are represented in the Engineers Joint Council whose purpose is to correlate the professional aims and objectives of these organizations and to act jointly for them in representing the engineering profession as a whole on matters of national interest which affect professional engineers. Inquiries may be directed to the Council at 33 West 39th Street, New York, New York.

APPENDIX

1. Occupational Information for the Student

Problems of Job Definition

The term ENGINEER applies to two different kinds of occupations, one of which is professional, and the other, highly skilled but requiring mainly the operation of machines and equipment.

Distinction is made between these two uses of the word ENGINEER in the Department of Labor's *Dictionary of Occupational Titles* by the following definitions:

(1) "ENGINEER (any industry) **engineman**. A general term used to designate workers who operate various machines and equipment for the production of power or to convert power from one form to another. **May be designated according to type of machines and equipment operated, as POWERHOUSE ENGINEER I; REFRIGERATING ENGINEER; STATIONARY ENGINEER.**"

(2) "ENGINEER (professional & kindred). A general term used to designate persons who meet the educational, experience or legal qualifications established by engineering schools or licensing authorities for the fields of professional engineering. **Classifications are made according to the field of engineering specialization as CHEMICAL ENGINEER; CIVIL ENGINEER; ELECTRICAL ENGINEER; INDUSTRIAL ENGINEER; MECHANICAL ENGINEER.**"

In practice, the distinction is usually made easily between the operator of equipment and the professionally trained person. The operator is essentially a very highly skilled mechanic. The professionally trained engineer is expected to understand the principles governing development of operation and design.

If, however, the operator becomes a supervisor of other operators and adds increasingly more theory to his practical knowledge, the distinction between him and a professional engineer becomes narrow and may disappear. In fact, many professional engineers began their careers with a minimum amount of theoretical training and sometimes with little or no college training; they added to their knowledge of basic sciences and scientific principles through self-teaching while obtaining practical engineering experience on the job. The proportion of professional engineers trained in this way was large in earlier years.

It is still possible today for many kinds of professional engineers to achieve career recognition without a course of engineering study in advance of employment, but it is more difficult because of the increase in theoretical knowledge and the complexity of technical processes. It is not uncommon for a college graduate in mathematics or basic science specialization to enter engineering as a result of applying these skills on the job.

A distinction may also be made very easily between a skilled mechanic and a professional engineer who spends full time on theoretical concepts such as working with mathematics, the principles of physics, or the development of production formulas. This kind of engineer usually has no need to use applied mechanical skill, no direct contact with the product on which the work is done, and perhaps even a limited practical interest. Another kind of difficulty arises, however, in distinguishing between the professional engineer assigned to theoretical problems, and the worker classified as subprofessional engineer, or *engineering aide* or draftsman who may be doing almost the same kind of work. In most cases, the levels of skill, proficiency and responsibility are clearly differentiated, but there are borderline cases.

Assistants or Engineering Aides

In the course of time, a growing number of specializations have developed in professional engineering, both at the top level and the assistant, or aide, level. The general pattern among engineering occupations, particularly in industries characterized by large-scale manufacturing, where a multiplicity of detailed specifications is required for a single product, is to assign a professional engineer and a crew of aides and technicians to a narrow division of the total production process. Each of the assistants works on a large volume of repetitive detail of design or blueprints and does a small part of the overall job.

A second group of assistants may be established at a lower skill level, if jobs at the direct assistant level lend themselves to breakdown. These jobs may be classified as *scientific aides* or *technicians* and often involve a great variety of job duties in connection with a manufacturing or laboratory process.

Sometimes difficulties of job evaluation and classification arise between the direct engineering assistants or aides and the technicians, particularly in new fields or those undergoing change and expansion, such as electronics, chemical processes (a wide range), ceramics and others. It should be kept in mind, in this connection, that job titles in themselves are not descriptive. Moreover, jobs change as workers themselves develop new skills in them, often somewhat in advance of standards and methods which have been established to classify and evaluate the work.

Broad Fields of Engineering

The 1950 Census lists eight broad divisions of engineering:

Chemical	Metallurgical and metallurgists
Civil	Mining
Electrical	Aeronautical
Industrial	Mechanical

Each of these may include subdivisions. For example, petroleum engineering may be considered as a part of chemical engineering when it involves the processing of petroleum, and as part of mining if it involves the extraction of the crude oil. Ceramic engineering is generally classified as belonging to the chemical field, but if it continues to expand, it may become a division in itself. Similarly, electronics is properly a part of the electrical field, but has expanded to the point where it is often treated separately.

Engineering terms present difficulties for the nontechnical observer because of the complex organization of industry. For instance, the division of aeronautical engineering, strictly speaking, involves the design and function of aircraft. The aircraft manufacturing industry, however, employs a range of engineering experts who work in all of the eight broad divisions. To classify an engineer, then, it is necessary to know the specialization or, better, the exact job assignment.

Job Combinations

In addition to all the specializations that have developed in the broad fields of engineering, there are many combinations of professional engineering and other skills. Among the most commonly found combinations are those which utilize the engineer's basic training and experience in sales or purchasing, in technical writing, and in careers involving principally the administrative or management function. The sales or purchasing engineer is employed when the merchandising situation requires a high degree of technical training, particularly in the marketing of machinery, chemical substances, or industrial equipment. Publishers of engineering journals prefer to employ editors and writers who are engineers. And the industrial engineer often reaches the career peak in the management of large or complex operations.

Occupational References

A fuller treatment of occupational definitions of, and training for, engineering may be found in these Department of Labor publications: "The Dictionary of Occupational Titles" of the United States Employment Service; Bulletin 968, "The Employment Outlook for Engineers" and Bulletin 1131, "The Employment Outlook for Technicians," both published by the Bureau of Labor Statistics.

2. Institutions Offering Undergraduate Engineering Curricula Accredited by the Engineers' Council for Professional Development

(Official Accrediting Agency for Engineering Colleges)

October 1953

Alabama

Alabama Polytechnic Institute, Auburn
University of Alabama, University

Alaska

University of Alaska, College

Arizona

University of Arizona, Tucson

Arkansas

University of Arkansas, Fayetteville

California

California Institute of Technology, Pasadena ¹
Stanford University, Stanford University
U. S. Naval Post Graduate School, Monterey
University of California, Berkeley
University of California, Los Angeles
University of Santa Clara, Santa Clara ¹
University of Southern California, Los Angeles

Colorado

Colorado Agricultural and Mechanical College, Fort Collins
Colorado School of Mines, Golden ¹
University of Colorado, Boulder
University of Denver, Denver

Connecticut

U. S. Coast Guard Academy, New London ¹
University of Connecticut, Storrs
Yale University, New Haven ²

Delaware

University of Delaware, Newark

District of Columbia

Catholic University of America, Washington ¹
George Washington University, Washington
Howard University, Washington

Florida

University of Florida, Gainesville

Georgia

Georgia Institute of Technology, Atlanta

Hawaii

University of Hawaii, Honolulu

^{1,2}, see p. 36.

Idaho

University of Idaho, Moscow

Illinois

Bradley University, Peoria
Illinois Institute of Technology, Chicago
Northwestern University, Evanston
University of Illinois, Urbana

Indiana

Purdue University, Lafayette
Rose Polytechnic Institute, Terre Haute ¹
University of Notre Dame, Notre Dame ¹

Iowa

Iowa State College of Agriculture and Mechanic Arts, Ames
State University of Iowa, Iowa City

Kansas

Kansas State College of Agriculture and Applied Science, Manhattan
Municipal University of Wichita, Wichita
University of Kansas, Lawrence

Kentucky

University of Kentucky, Lexington
University of Louisville, Louisville

Louisiana

Louisiana Polytechnic Institute, Ruston
Louisiana State University and Agricultural and Mechanical College, Baton Rouge
Tulane University of Louisiana, New Orleans ³

Maine

University of Maine, Orono

Maryland

Johns Hopkins University, Baltimore ¹
University of Maryland, College Park

Massachusetts

Harvard University, Cambridge ²
Lowell Technological Institute, Lowell
Massachusetts Institute of Technology, Cambridge
Northeastern University, Boston
Tufts College, Medford ³
University of Massachusetts, Amherst
Worcester Polytechnic Institute, Worcester ¹

Michigan

Michigan College of Mining and Technology, Houghton
Michigan State College, East Lansing
University of Detroit, Detroit
University of Michigan, Ann Arbor
Wayne University, Detroit

^{1, 2, 3}, see p. 36.

Minnesota

University of Minnesota, Minneapolis

Mississippi

Mississippi State College, State College
University of Mississippi, University

Missouri

Missouri School of Mines and Metallurgy, Rolla
Saint Louis University, St. Louis
University of Missouri, Columbia
Washington University, St. Louis

Montana

Montana School of Mines, Butte
Montana State College, Bozeman

Nebraska

University of Nebraska, Lincoln

Nevada

University of Nevada, Reno

New Hampshire

Dartmouth College, Hanover ¹
University of New Hampshire, Durham

New Jersey

Newark College of Engineering, Newark
Princeton University, Princeton ¹
Rutgers University, New Brunswick ³
Stevens Institute of Technology, Hoboken ¹

New Mexico

New Mexico College of Agriculture and Mechanic Arts, State College
University of New Mexico, Albuquerque

New York

Alfred University (New York State College of Ceramics), Alfred
Clarkson College of Technology, Potsdam ¹
College of the City of New York, New York
Columbia University, New York
Cooper Union, New York
Cornell University, Ithaca
Manhattan College, New York ¹
New York University, New York
Polytechnic Institute of Brooklyn, Brooklyn ¹
Pratt Institute, Brooklyn
Rensselaer Polytechnic Institute, Troy
Syracuse University, Syracuse
Union College and University, Schenectady ¹
University of Rochester, Rochester
Webb Institute of Naval Architecture, New York ¹

^{1, 3}, see p. 36.

North Carolina

Duke University, Durham ³
North Carolina State College, Raleigh

North Dakota

North Dakota Agricultural College, Fargo
University of North Dakota, Grand Forks

Ohio

Case Institute of Technology, Cleveland ¹
Fenn College, Cleveland
Ohio State University, Columbus
Ohio University, Athens
University of Akron, Akron
University of Cincinnati, Cincinnati
University of Dayton, Dayton
University of Toledo, Toledo

Oklahoma

Oklahoma Agricultural and Mechanical College, Stillwater
University of Oklahoma, Norman
University of Tulsa, Tulsa

Oregon

Oregon State College, Corvallis

Pennsylvania

Bucknell University, Lewisburg
Carnegie Institute of Technology, Pittsburgh
Drexel Institute of Technology, Philadelphia
Lafayette College, Easton ¹
Lehigh University, Bethlehem ¹
Pennsylvania State College, State College
Swarthmore College, Swarthmore
University of Pennsylvania, Philadelphia ¹
University of Pittsburgh, Pittsburgh
Villanova College, Villanova ¹

Rhode Island

Brown University, Providence ³
University of Rhode Island, Kingston

South Carolina

The Citadel, Charleston ¹
Clemson Agricultural College, Clemson ¹
University of South Carolina, Columbia

South Dakota

South Dakota School of Mines and Technology, Rapid City
South Dakota State College of Agriculture and Mechanic Arts, Brookings

Tennessee

University of Tennessee, Knoxville
Vanderbilt University, Nashville

^{1, 3}, see p. 36.

Texas

Agricultural and Mechanical College of Texas, College Station ¹
 Rice Institute, Houston
 Southern Methodist University, Dallas
 Texas College of Arts and Industries, Kingsville
 Texas Technological College, Lubbock
 Texas Western College, El Paso
 University of Texas, Austin
 University of Houston, Houston

Utah

University of Utah, Salt Lake City
 Utah State Agricultural College, Logan

Vermont

Norwich University, Northfield ¹
 University of Vermont and State Agricultural College, Burlington

Virginia

University of Virginia, Charlottesville ³
 Virginia Military Institute, Lexington ¹
 Virginia Polytechnic Institute, Blacksburg

Washington

State College of Washington, Pullman
 University of Washington, Seattle

West Virginia

West Virginia University, Morgantown

Wisconsin

Marquette University, Milwaukee
 University of Wisconsin, Madison

Wyoming

University of Wyoming, Laramie

¹ All male school, or women not accepted in engineering.

² Women admitted to graduate schools only.

³ Separate colleges for men and women.

Note: Where not otherwise indicated, institutions are coeducational and, presumably, women are accepted in all departments, including engineering. Since this list is subject to change annually, prospective students are advised to write directly to the dean or director of the institution for current information.

Source: U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

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