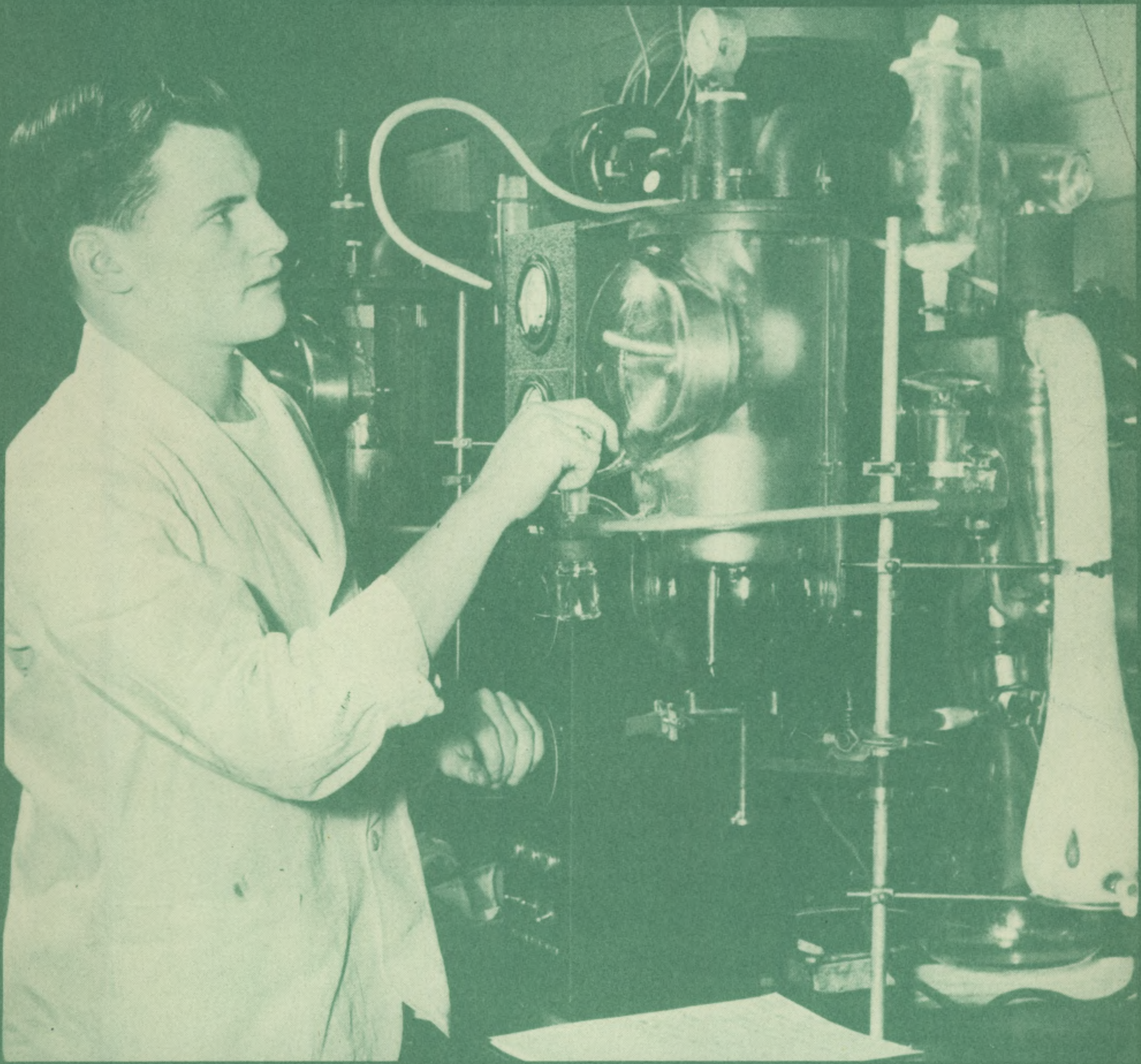
Employment Outlook for

TECHNICIANS

A Report on Draftsmen, Engineering Aids, Laboratory Technicians, and Electronic Technicians



UNITED STATES DEPARTMENT OF LABOR
Martin P. Durkin, *Secretary*

BUREAU OF LABOR STATISTICS
Ewan Clague, *Commissioner*

in cooperation with **VETERANS ADMINISTRATION**

Occupational Outlook Series

Bulletin No. 1131

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Technicians

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Cover picture—Technician operating vacuum distillation equipment.

Letter of Transmittal

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington, D. C., April 15, 1953.

The SECRETARY OF LABOR:

I have the honor to transmit herewith a report on the employment outlook for technicians. This is one of a series of reports made available through the Bureau's Occupational Outlook Service for use in the vocational counseling of young people in school, veterans, and others interested in selecting an occupation. The study was financed largely by the Veterans Administration, and the report was originally published as a Veterans Administration pamphlet for use in vocational rehabilitation and education activities.

In view of the shortage of scientific manpower and the essential contributions technicians make to the national defense and welfare, it is important that information on employment opportunities in these occupations be made available to young people possessing the necessary aptitudes for and interest in such work.

This study was conducted in the Bureau's Division of Manpower and Employment Statistics. The report was prepared by Howard Rosen under the immediate supervision of Cora E. Taylor. Sylvia K. Lawrence assisted in the library research. The Bureau wishes to acknowledge generous assistance and cooperation from the various organizations and individuals interested in the education and employment of technicians.

EWAN CLAGUE, *Commissioner.*

Hon. MARTIN P. DURKIN,
Secretary of Labor.

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Photographs are by courtesy of Rochester Institute of Technology, Capitol Radio Engineering Institute, American Association of Junior Colleges, General Foods Corporation, and U. S. Coast and Geodetic Survey.

Employment Outlook for Technicians

Introduction

Technicians who work with professional engineers and scientists are a relatively new occupational group emerging from the growing complexity of this country's industrial processes and the great expansion in industrial research and development work. The past half century has seen a tremendous increase in the application of science and engineering to industrial and military problems. This growing reliance on scientific principles and techniques has resulted in a sharp increase in the employment of engineers, chemists, and, more recently, physicists. In addition, an increasing number of workers with a combination of basic scientific knowledge and manual skill are being employed as assistants to professional personnel. These workers, often referred to as technicians, are the subject of this report.[1]

Technicians work as members of an engineering or scientific team in research and production planning, and in designing, constructing, and maintaining the materials and machines of our mass-production economy. Approximately 2 years of post-high-school training are needed usually. In addition to basic mathematics and science, they must have specialized education in some branch of engineering or other technical fields such as electricity or industrial chemistry.

Some of the main technician occupations covered by this report are those of the electronic technician, draftsman, laboratory technician, physical-science aid, and engineering aid. It was not possible to include in the present study all the many kinds of jobs held by technicians. The report is concerned only with the types of workers who work with engineers, physicists, and chemists.[2]

The current international crisis has greatly intensified America's need for engineers and scientists. These professional workers can improve their efficiency and increase their total output by having technicians perform some of the more routine tasks. Thus, technicians have an important part in strengthening America's technical and military position. Demand for their services has been rising sharply since the current defense program began and will probably continue to mount in the near future. Furthermore, the long-term outlook is for expansion in their employment.

This report describes the nature of the work performed by technicians and the fields in which they are employed. Information is given also on how one can become a technician and on future employment prospects. The concluding chapter summarizes the available data on technicians' earnings.

Nature of Work

Technicians work alongside engineers and scientists in a great variety of industries and at all stages of production—from the origin of a product on the drawing board to its sale to the customer. When a new product is being developed, draftsmen assist the engineers in translating their design ideas into production. As the time for actual production approaches, other technicians aid in working out specifications regarding needed materials and methods of manufacture. During the production process, still other technically trained workers serve as inspectors and supervisors. Furthermore, manufacturers often depend on salesmen with a technical background to sell machinery or other specialized products, especially if these are to be used in industry. Though many technical salesmen have professional engineering degrees, others with less professional training often can sell equally well.

[1] The occupations covered in this report fall within the semiprofessional classification of the Dictionary of Occupational Titles, vol. II, 2d ed. Codes assigned are in the O-4. through O-6. series.

[2] The medical field is another important area in which technicians are employed. For information on medical laboratory technicians, medical X-ray technicians, and dental hygienists, see Occupational Outlook Handbook, Bureau of Labor Statistics Bulletin No. 998, U. S. Government Printing Office, Washington 25, D. C., 1951.

Laboratory technicians assist scientists in research and development work or perform functions related to production control or testing. They may perform simple tests or do highly technical analytical work depending on their training and experience. Some technicians supervise other workers in a particular department of the laboratory.

The work of technicians, whether in research or production, varies greatly among industries and among plants in the same industry. Even within a single plant, workers classed as technicians may perform duties ranging from simple routine tasks to those of a highly technical nature. Because of wide variation in the types of work of technicians, it is difficult to give an over-all description of the nature of their work. However, the following definition, which applies particularly to the workers closely associated with professional engineers (draftsmen, tool designers, engineering aids, and assistants), seems to capture the "flavor" of the work involved in many technician occupations.[3]

> "The technician is a person who works at a job which requires applied technical knowledge and applied technical skill. His work, in this respect, is somewhat akin to that of the engineer, but usually the scope is narrower. His job also requires some manipulative skills—those necessary to handle properly the tools and instruments needed to perform the technical tasks.
>
> "In his special field, he has considerable technical knowledge of industrial processes, and in this field he knows how to apply the necessary principles of the physical sciences and of mathematics. In general, he uses instruments, in contrast with tools. His contribution is mainly through mental effort, in contrast with muscular exertion.
>
> "The job of the technician is not easy to define. On the one hand, it has many of the characteristics of engineering, on the other, many of the qualities associated with the skilled trades. Some technician jobs lean toward the engineering type, jobs which consist mainly of drafting, computations, and laboratory testing. Others border on the skilled crafts, such as those which deal with repair of mechanical or electrical equipment where much technical 'know-how' is demanded but which also require considerable manual skill. It hardly seems practical to set up clearly defined boundaries within which lie all technician jobs.
>
> "We also find great differences in the 'levels' of jobs of technician type. A job may be definitely technical in character, yet be extremely limited in scope and of a repetitive type. Certain simple inspection jobs are in this category. Yet other technician jobs may require a high quality of technical knowledge and technical skill, such as all-round tool and gage inspection, which requires the use of many types of instruments.
>
> "The kinds of technical ability found in the various technician jobs are of considerable variety. Some jobs emphasize analysis and diagnosis. Some require visualization of drawings, or a flair for creative design. Some demand a high degree of applied mathematical ability. Some require a knowledge of practices in the skilled trades, but not the ability to perform the skilled tasks. Some require extensive understanding of industrial equipment and processes. Sometimes the job involves supervisory responsibilities, and combines skill in handling people with skill in dealing with technological matters."

Although all jobs held by technicians who work with engineers and scientists have some common characteristics—notably, that they require a knowledge and practical application of mathematics and physical science—the nature of the work performed differs considerably among occupations. The kind of work done by some of the larger groups of technicians is described in the following sections.

Draftsmen

Draftsmen prepare exact detailed drawings from sketches or specifications furnished by engineers or designers. Their work involves the use of small instruments such as compasses, protractors, triangles, dividers, scales, T-squares, special drafting pencils, and lettering pens. They may have to make calculations not only with respect to the dimensions of an object but also with respect to its weight and tensile strength.

Draftsmen use their knowledge of mathematics in these calculations and in referring to engineering handbooks for information on tolerances, tensile strength, gear ratios, types of threads, sizes of bolts, metal finishes and composition, and related matters. They use descriptive geometry in portraying objects in their correct relationships, according to distance and size. In drawing plans for machine parts, a draftsman may also use his knowledge of physics and engineering.

Most of the draftsmen in an engineering team are mechanical draftsmen who specialize in the drawing of machines or parts. Others are specialists in aeronautical, marine, electrical, geological, topographical, and similar fields.

[3] Unpublished definition by Dr. Lynn A. Emerson, Director, Instructional Materials Laboratory, New York State School of Industrial and Labor Relations, Cornell University, Ithaca, N. Y.

Draftsman specialized in map making.

Draftsmen usually begin their careers as copyists or tracers. At this level, their work is routine and requires relatively little knowledge and skill. With additional experience and training, workers may advance to detailers, junior draftsmen, senior draftsmen, and chief draftsmen.

Engineering Aids

Engineering aids assist engineers in production planning and research. In general they work under the supervision of an engineer and perform specialized functions requiring less cultural and theoretical training than is provided by a professional engineering course. Their work usually requires a knowledge of some specialized field—for example, electrical, mechanical, or some other branch of engineering, or an industry such as petroleum, ship construction, or aircraft manufacturing.

The aid may assist the engineer in production planning by designing and analyzing layouts. When production begins, he may make tests, record data, make computations, work on production methods, or check materials. He may also act as the liaison or contact man between the engineering department and the drafting department, tool room, and production department.

In the field of research, engineering aids perform tests with regard to such matters as stress, strain, motion, and impact. They may set up, calibrate, and operate instruments such as revolution counters or torsion meters. They may also test and calibrate electrical control devices employing vacuum-tube circuits. And they may make calculations with respect to weight, centers of gravity, and a variety of other problems.

Many of the jobs performed by engineering aids require them to make rough drawings. Two of their basic tools are slide rules, used in making quick mathematical calculations, and micrometers, used in making exact measurements.

Entry jobs for engineering aids often require only the performance of routine tasks under close supervision. With additional experience, the aids, because of their technical background, may be given more responsible jobs which require greater use of judgment. In the more advanced jobs, they will usually be expected to make the fullest utilization of their educational preparation by performing highly technical work with a minimum of supervision.

Laboratory Technicians and Physical-Science Aids

These workers assist chemists, physicists, and engineers in laboratories. Much of their work involves conducting routine tests and recording the

Testing gelatin in a food products laboratory.

results—often in the form of reports, charts, or graphs—for interpretation by the professional workers.

Laboratory technicians and physical-science aids must be familiar with a wide range of testing equipment and apparatus such as dilatometers, temperature control instruments, interferometers, analytical balances, burettes, pipettes, centrifuges, and furnaces. Technicians who assist physicists may prepare samples for testing—performing tasks like marking, measuring, drying, and weighing materials or items. Some of the more common tests are: liquid limit, plastic limit, shrinkage limit, expansion and contraction, tensile strength, and compression strength. Those technicians who work with chemists may do both qualitative and quantitative chemical analyses. Some of the common analyses are: analysis of steel for carbon phosphorous and sulphur content, analysis of oil for viscosity and flash point, and mineral analysis of water for amount of silicia, iron, and calcium present.

Laboratory technicians and physical-science aids may, like the engineering aids, begin their work in routine jobs and advance to positions of greater responsibility after they have acquired additional experience and demonstrated their ability to work without close supervision.

Electronic Technicians

The electronic technicians considered within the scope of this report have a background of electronic theory, physical science, and mathematics which enables them to perform jobs above the routine operating, maintenance, and repair level. Their work usually requires them to make practical application of their theoretical knowledge. The practical part of their job may call for the use of such basic tools as pliers, screw drivers, wrenches, soldering irons, and metal punches, whereas the theoretical part of their job may call for the use, understanding, and interpretation of results obtained from instruments such as oscilloscopes, signal generators, ohmmeters, ammeters, voltmeters, multitesters, and Q-meters. Their work often calls for a combination of manual skills in handling simple tools and a knowledge of complex testing equipment. They must be able to read and interpret layout and other diagrams, use mathematical formulas for circuit work, and wire intricate electronic units.

The electronic technicians working in laboratories construct, test, install, modify, operate, and under certain conditions, design experimental electronic apparatus. They may be called upon to offer ideas and suggestions, devise practical solutions to problems of design, select suitable materials and methods of construction, evaluate the operating characteristics of the equipment, and in other ways contribute to the research and development process.

In industry, electronic technicians may perform "trouble-shooting" functions or do the more complicated types of testing and inspection work. An important function of electronic technicians associated with production is the building of testing equipment. They apply their technical knowledge principally to communications equipment. Some of the devices with which electronic technicians work are in radio, television, facsimile, and telephony operations. The more specialized applications in the field include radar, sonar, radio navigational equipment, and radiosonde.

Related Technician Occupations

In addition to the occupations described above, a wide range of related jobs are open to persons trained as technicians. For example, persons trained as electronic technicians can often qualify also as broadcasting engineers and technicians in the radio and television industry, or as inspectors, draftsmen, or estimators in the electric light and power or telephone and telegraph industries.[4] Technicians can move not only from one industry to another, but into many different jobs within the same industry. A list of related jobs into which technicians with the same basic training may move is given in appendix C (p. 24).

The wide range of jobs open to technicians is illustrated by the following list of occupations, requiring vocational-technical training, found on the payrolls of four industries.[5]

Air transportation: engineering assistant, flight engineer, instrument technician, and technical assistant.

[4] Further information on many related occupations and industries may be found in the Occupational Outlook publications listed at the end of this bulletin.

[5] Vocational Technical Training for Industrial Occupations, Vocational Division Bulletin No. 228, U. S. Office of Education, Federal Security Agency, Washington, D. C., U. S. Government Printing Office, 1944.

Aircraft manufacturing: time study analyst, tool designer, engineering draftsman, engineering technician, laboratory technician, and junior aerodynamics engineer.[6]

Automobile manufacturing: chemical analyst, die designer, dynamometer technician, experimental technician, chemical laboratory assistant, physics laboratory assistant, metallurgical technician, and production supervisor.

Communications equipment manufacturing: detailer draftsman, engineering assistant, instrument maker, material specification writer, production supervisor, and test maintenance man.

Some of the job titles listed above, as well as many others used by employers in referring to technicians, do not accurately describe the duties performed nor the requirements for a job. Furthermore, job titles overlap and differ greatly among companies. Trained technicians doing the same type of work may be given titles as engineering aid, junior engineer, physical-science aid, or laboratory assistant.[7]

Where Employed

Private Industry

Technicians are employed in a wide range of industries, in both large and small companies. In general, large companies employing many engineers and scientists are the greatest source of employment for technicians. Technicians, however, are used also by smaller establishments, when the technology of the industry makes it advantageous to employ them.

The variety of industries in which technicians find jobs is indicated by a study of selected establishments in the following 22 industries:[8]

- Air transportation
- Aircraft manufacturing
- Automobile manufacturing
- Building construction
- Communications equipment manufacturing
- Electric power production and distribution
- Electrical equipment manufacturing
- Hydroelectric development
- Industrial chemistry
- Industrial electronics
- Iron and steel production
- Lumbering and wood processing
- Machine tool manufacturing
- Metal mining
- Metal products manufacturing
- Oil refining
- Petroleum and butadiene production
- Pulp and paper manufacturing
- Rail transportation
- Shipbuilding
- Telegraph and telephone communications service
- Textile and garment manufacturing

All these industries were found to employ technicians. Altogether, several hundred different job titles referring to positions requiring vocational-technical training were listed on the payrolls of the companies surveyed.

Widespread employment of technicians is also indicated by studies made in New York, California, Texas, and Louisiana. According to a 1945–46 survey in New York City and up-State New York, an estimated total of about 25,000 technicians were employed in the metal products manufacturing industries, 10,000 in printing, 6,000 in electric light and power, and 5,000 in the chemical manufacturing industries.[9] Other industries employing more than a thousand technicians at the time of the New York survey were optical goods manufacturing; subway and water transportation; construction; and steel, paper, and aircraft manufacturing. A 1950 California study indicated that aircraft manufacturers and utility companies employed many of these workers.[10] Similarly, a 1951 survey in the Dallas-Fort Worth area disclosed many technicians employed by five companies engaged in the manufacture of airplanes, airplane engines, aircraft parts, and guided missiles.[11] In Louisiana, a significant number of technicians were employed in each of the following eight manufacturing industries, according to a 1950 study.[12]

[6] This payroll designation, like all others in the list, referred to a job not requiring 4-year college training.

[7] In an effort to standardize the terminology used in referring to persons performing technician-type jobs, the Technical Institute Division of the American Society for Engineering Education recently adopted a resolution to advocate use of the title "engineering technician."

[8] See footnote 5.

[9] Beach, C. Kenneth and Associates, Technical Occupations in the State of New York, The University of the State of New York, the State Education Department, Albany, March 30, 1946, pt. IV, p. 6, and pt. V, p. 6.

[10] Rodes, Harold P., A Report on a Preliminary Survey of the Needs of California Industries and Governmental Agencies for Personnel with Training of Technical Institute Type (mimeographed), University of California, Los Angeles, 1950.

[11] Regional Defense Manpower Administration, Report of Training Need Survey and Costs—Engineering and Subprofessional, Dallas-Fort Worth area, September 1951.

[12] Hampton, Thomas Edgar, A Study of Technical Occupations in Louisiana Industry, Department of Commerce and Industry, State of Louisiana, 1950.

Chemical and allied products	Printing, publishing, and allied products
Petroleum and coal products	Ship- and boatbuilding and repair
Sawmills and planing mills	Rice cleaning and polishing
Paper and allied products	Malt liquors

The two industries employing the largest numbers of technicians were those producing chemical and allied products and petroleum and coal products.

The fact that companies manufacturing aircraft engines depend on technicians to assist their engineers and scientists is also indicated by data received in the early part of 1952. Technicians constituted 3.6 percent of the 65,851 employees of the 6 reporting companies. Professional personnel consisting mainly of physicists, mathematicians, engineers, and chemists, represented about the same proportion (3.8 percent) of the total number of workers.

The use of technicians in chemical production varies considerably with the type of plant or product. However, in 102 industrial chemical plants manufacturing a variety of products 3.6 percent of all the employees were draftsmen and laboratory assistants, according to a 1951 survey (table 1). In these plants there were, on the average, 10 laboratory assistants for every 28 professional workers.

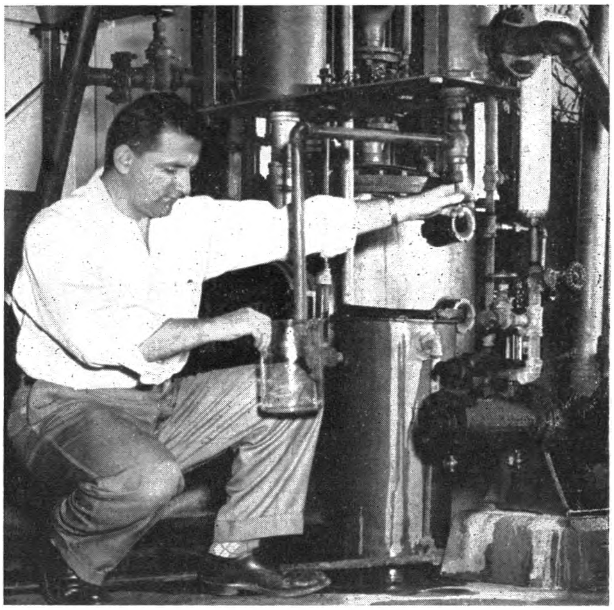
TABLE 1.—*Employment of selected occupational groups in 102 industrial chemical plants in 6 regions, October 1951*[1]

Occupational group	Number	Percent
All employees	79,751	100.0
Professional employees	[2] 6,209	7.8
Laboratory assistants	[3] 2,242	2.8
Draftsmen	676	.8
All other employees	70,624	88.6

[1] Data for the following regions: Southwest, Border States, New England, Southeast, Pacific, and Middle Atlantic.
[2] Includes 65 women chemists.
[3] Includes 463 women.

SOURCE: Unpublished data of U. S. Department of Labor, Bureau of Labor Statistics.

Although technicians are to be found in many different departments of factories, a large number are employed in laboratories. In 1950, more than 40,000 technicians were in the Nation's industrial research laboratories (see chart). These technicians carried on research and testing activities, thus enabling the professional scientists to devote more of their time to work requiring greater



Operating a vacuum evaporator in an industrial chemistry laboratory.

scientific training. For every 17 professional workers an average of 10 technicians were employed in the industrial laboratories.

Federal Government

The Federal Government is an important employer of technicians in times of both peace and emergency. Most Government technicians of the types covered in this report are in jobs classified in the following categories or series: engineering aid, engineering drafting, surveying and cartography, physical-science aid, and electronic technician. The jobs in each of these categories are classified according to grade level. The lower grade jobs may be entered by persons without post-high-school education.[13] Furthermore, some of the highest grade jobs are primarily administrative rather than technical.[14] On the other hand, some occupations in the Government which are not included in table 2 are open to persons with training and experience as technicians; such occupations are chiefly classified with various mechanics groups and are not easily identified.

[13] See appendix E for Civil Service requirements for some technician occupations. Further information on job qualifications and procedures in applying for Government positions may be obtained from the U. S. Civil Service Commission, Washington 25, D. C., and from State and local governments.
[14] For the distribution of Federal Government employees by grade level, see table 6, p. 20.

TABLE 2.—*Distribution of personnel in selected technician occupations in Federal Government, by agency, June 30, 1951*

Agency	Total, selected occupations		Percent distribution of workers in jobs classified in—				
	Number	Percent	Engineering aid series [1]	Surveying and cartography series [2]	Engineering drafting series [3]	Physical-science aid series [4]	Electronic technician series [5]
Total	28,436	100.0	100.0	100.0	100.0	100.0	100.0
Army	8,793	31.0	32.3	36.1	33.9	24.0	17.5
Navy	6,417	22.6	16.8	9.6	38.3	23.4	26.9
Interior	4,727	16.6	26.0	18.2	8.4	13.1	.4
Commerce	3,092	10.9	5.0	16.3	3.4	10.0	45.3
Air Force	1,813	6.4	4.1	14.6	8.6	1.7	2.3
Agriculture	1,534	5.4	8.7	3.4	1.5	7.1	2.6
Tennessee Valley Authority	623	2.2	3.7	1.4	1.5	1.5	----------
Federal Security Agency	213	.7	1.0	.1	.1	2.9	.3
State	180	.6	.5	.1	.1	----------	4.0
Treasury	109	.4	(6)	----------	.5	2.2	----------
Veterans Administration	69	.2	.2	----------	.4	.5	.1
Atomic Energy Commission	48	.2	.2	----------	.3	.2	.1
Justice	40	.1	.1	----------	(6)	.8	.1
General Services Administration	36	.1	.1	----------	.3	.2	----------
All other agencies	742	2.6	1.3	.2	2.7	12.4	.4

[1] Includes engineering aid and student-aid trainee.
[2] Includes cartographer, cartographic aid, and student-aid trainee.
[3] Includes draftsman (patent) and engineering draftsman.
[4] Includes scientific aid (cotton), scientific aid (nautical), student-aid trainee, computer, and physical-science aid.
[5] Includes electronic technician and laboratory electronic mechanic.
[6] Less than 0.05 percent.

SOURCE: Bureau of Labor Statistics and Civil Service Commission, BLS Bulletin No. 1117, Federal White-Collar Workers, Their Occupations and Salaries, June 1951, in process.

As of June 30, 1951, the Federal Government had 28,436 employees in the 5 selected technician groups (table 2). About 17,000 or 60 percent of these technicians were working in the Department of Defense—in the Army, Navy, and Air Force.

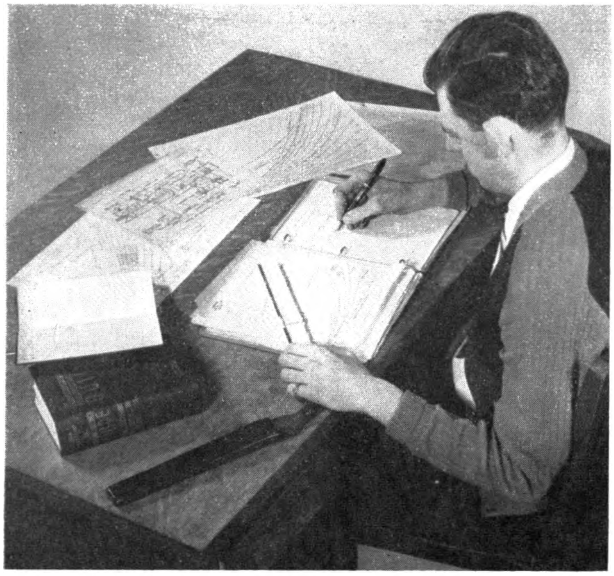
The Department of the Interior was the largest employer of technicians among the civilian agencies, with the Departments of Commerce and Agriculture ranking next.

The Department of the Army employed more than 32 percent of the workers in jobs classed in the engineering aid series, and the Department of the Interior was the second largest employer of these workers. More than 50 percent of the persons in surveying and cartography jobs[15] were working for the Departments of the Army and the Interior. The Department of the Navy was the largest employer of workers in engineering drafting jobs; the Army and Navy together employed over 72 percent of these workers. The Departments of Commerce, the Interior, Army, and Navy had more than 70 percent of the physical-science aids on their payrolls. Of the electronic technician group, 45 percent were employed chiefly in the Department of Commerce, where large numbers are needed by the Civil Aeronautics Administration and the National Bureau of Standards. The research laboratories and other units of the Department of the Navy employed over one-fourth of the electronic technicians.

How To Become a Technician

Not all persons who work as technicians are specifically trained for their occupations. Engineering college dropouts, graduates and dropouts of liberal arts colleges, and other persons who have received some post-high-school education often take technical positions. Some workers qualify as technicians through experience only. Young men and women who wish to prepare specifically for careers as technicians can, however, obtain formal education for this work from at least eight sources; namely, technical institutes, junior colleges, extension divisions of universities, colleges offering 2-year special programs, technical high schools, training programs operated by industry and business, correspondence schools, and vocational-technical training given by trade schools, primarily in their evening classes.

[15] For a detailed description of the field of cartography in the Federal Government, see Cartographic Work in the Federal Civil Service, Pamphlet No. 40, U. S. Civil Service Commission, Washington, D. C., February 1950.



Technicians need a good basic knowledge of mathematics and science.

The type of education given prospective technicians is often described as "vocational-technical," i. e., vocational in objective and technical in content. The education is designed to enable the technician to become productive immediately upon entering industry; it is expected that only a minimum of on-the-job training will be necessary to make him useful to his employer. Schools preparing students for technician jobs give courses in applied science, applied mathematics, and applied engineering, with subject-matter related to the practical problems students will face on the job (for examples of curricula, see appendix B). Students are also taught basic skills in the use of instruments, machinery, and tools. This training, however, is designed to familiarize the student with equipment rather than to develop manual skill. In contrast to the skilled craftsman whose job depends primarily upon his manipulative ability, a technician often uses instruments and machinery merely as an aid in applying his scientific knowledge to a particular problem.

A brief discussion of some of the types of educational institutions and other sources where young people can obtain training as technicians follows.

Technical Institutes

These schools offer 1, 2, or 3 years of training above the high-school level, 2 years being the most usual training period.

The programs of technical institutes are specifically designed to give prospective technicians a vocational-technical background. A student is prepared for some specific job or cluster of related jobs. In general the student receives less theoretical and general education than is provided by 4-year engineering and academic colleges.

Some schools offer cooperative programs, under which a student spends part of his time in school and part in employment related to the occupation for which he is preparing himself. It may take more than 2 years to complete the course at the technical institute with a cooperative program, but this type of program gives students valuable experience in industrial situations, which often outweighs the disadvantage of a longer training period. In addition, students participating in cooperative plans are able to pay for at least a part of their educational expenses from income derived from their work.

Most technical institutes conduct both day and evening sessions. Evening classes are of particular importance to students who, for financial reasons, must have full-time jobs. Often, employed workers can up-grade themselves to higher level technician jobs or obtain sufficient training to shift from one field of work to a technician's job by attending evening classes. Almost half of all the students attending technical institutes in 1951 were enrolled in evening and special courses.

Some technical institutes offer associate degrees which signify that the student has completed at least 2 years of college-level work. However, if a prospective student desires eventually to obtain a degree from a 4-year college, he should investigate in advance whether his technical institute credits are transferable to the college of his choice. Although some colleges will give full credit for work taken at technical institutes, others will give either partial or no credit.

The amount of general education offered at technical institutes varies greatly. Some schools offer intensive training for technical occupations but almost no general education, whereas other schools require their students to devote as much as 25 percent of their time to such courses as English and history, and 75 percent to specific courses in their vocational field. In selecting a school, the advantages and disadvantages of both types of curricula must be considered by the prospective student in the light of his future needs as a citizen and a worker.

The direct method of teaching used in many technical institutes does not emphasize homework and "book study" as much as academic colleges. In many cases, the emphasis is on teaching job techniques rather than theory. To familiarize the students with instruments and equipment found in industry, considerable laboratory work is required. However, manual skills are not stressed as much as in vocational schools which prepare students for skilled jobs.

Technical institutes offering similar programs are operated under a variety of types of control which may be categorized as State and municipal, privately endowed, extension divisions of colleges and universities, proprietary, and YMCA schools. Altogether, there were about 64 technical institutes with a total of more than 46,000 students in 1951–52.[16]

Eleven 2-year institutes in New York, a leading State in the education of technicians, offer a wide choice of curricula under the auspices of the State University. There is no tuition charge to residents of New York State. The schools are strategically located throughout the State, for the convenience of both students and industry. A close working relationship exists between the schools and local advisory groups who examine the curricula and make suggestions affecting the preparation of students for technical occupations. In October 1951, 7,333 students were enrolled in the 11 New York State technical institutes; about 3,150 of these students were preparing for work as technicians of the types covered in this report. This latter figure included students enrolled for technical study in chemistry, electricity, industrial instrumentation, metallurgy, aircraft instruments, construction, and many other occupational fields open to the technician. The New York State institutes, like many other schools, prepare students for "job clusters." This type of preparation enables graduates to qualify for a wide range of jobs (appendix C). All graduates of these institutes are awarded the associate in applied science degree.

[16] Smith, Leo F., "Annual Survey of Technical Institutes, 1951–52," Technical Education News, vol. XL, No. 4, June 1952.

[17] A list of junior colleges offering technician training is available from the American Association of Junior Colleges, 1785 Massachusetts Avenue, NW., Washington 6, D. C.

Junior Colleges

Some of the approximately 500 junior or "community" colleges in the country also prepare students for technician occupations in industry and Government.[17] These schools usually offer 2 years of post-high-school education. It is common practice to award the degree of associate in arts upon completion of the 2-year program.

Not all junior colleges are equipped to give technical training of the type described in this report, nor do most of them consider this their primary purpose. Many of them do not have the shop and laboratory facilities required for thorough technical training. Furthermore, in contrast with the technical institutes which concentrate upon terminal education (after which the student is not ordinarily expected to take advanced work elsewhere), junior colleges also give academic courses equivalent to those offered in the freshman and sophomore years of 4-year colleges, so that students can begin with the junior year in such colleges.

Junior college courses in technical fields are usually planned around the employment needs of the industries in the community where the college is located. The training programs for prospective technicians therefore vary and may be highly specialized. In some cases, the courses are designed to meet the specifications of one or two industries or even of a single plant. For example, in California, where the junior college movement has made great progress, several of the colleges in the southern part of the State offer technical training for jobs in the aircraft industry (appendix B).

Many junior colleges are important adult education centers and offer extensive part-time courses at night. Through appropriate courses at junior colleges, as at technical institutes, workers may prepare themselves for higher grade jobs. Adult and special students accounted for more than half the total enrollment in junior colleges in 1950–51.[18]

Training in Industry

Some large corporations conduct training programs for technicians. This type of training is primarily technical and rarely includes any general studies. Instruction is given either through formal classes or through training on the job.

[18] American Association of Junior Colleges, Junior College Directory, 19

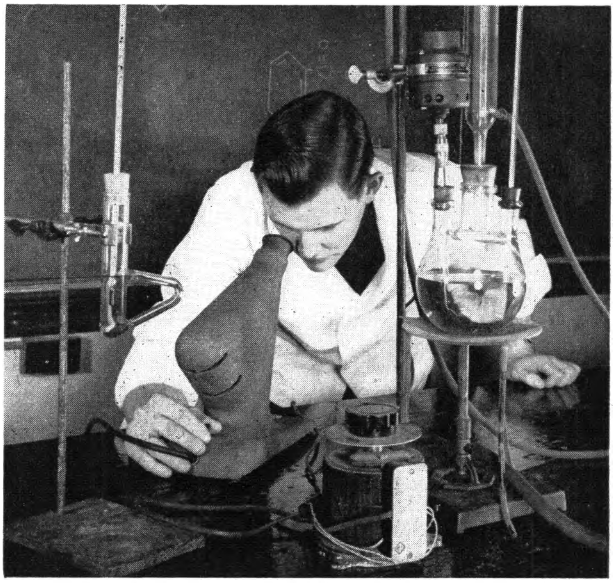
Workers who receive their training on the job only do not usually get as much theory as those who receive classroom instruction.

Other employers who do not have training programs but are aware of the need for technically trained workers often encourage their employees to attend classes in local schools. Employers sometimes ask the schools to arrange special educational programs which will expand the technical background of their employees. Some large corporations reimburse their employees for tuition after they have completed the course satisfactorily. The workers are usually expected to take courses directly related to their work assignment, and are often allowed to attend classes on the employers' time.

Other Training

Training for some occupations in the technician category may be obtained through a formal apprenticeship lasting more than 2 years. Occupations of which this is true include those of tool and die designer and draftsman. Supplementary education in mathematics and science may be necessary in some cases. Persons interested in apprentice training can obtain further information from the local office of their State Employment Service, directly from employers, or from the local labor union concerned with the occupation they wish to learn (appendix A). High-school graduates are given preference for openings. During normal times, the age of apprentices at the start of training is generally from 17 to 22 years. However, World War II veterans who were older have been admitted for training.

Although most of the jobs considered in this report require post-high-school education or the equivalent in experience, a few technical high schools offer programs which qualify their graduates for entry jobs as technicians. These high schools have high admission requirements and offer more thorough and advanced courses in mathematics, science, drawing, and laboratory work than either an academic high school or a vocational school. Some schools have evening programs which may be organized as formal technical programs to prepare technicians or which may merely consist of selected subjects for a particular area of work. These programs, like other evening courses, appeal especially to employed persons who wish to improve their job status by acquiring a technical background. Other technical high schools give an additional year of schooling above the regular fourth year. This extra year is at the vocational-technical level and is offered to students who are interested in becoming technicians.



Laboratory technicians must be familiar with a variety of equipment.

Correspondence schools and home study courses constitute additional sources of preparation for technicians. Persons who wish to learn more about their jobs or who wish to advance to a better job in the same field derive the most benefit from such courses. But those who do not have considerable theoretical background in mathematics and science and do not understand their practical application may find these courses of limited value in preparing for technician positions. Success in such courses depends greatly on the ability of the student to study by himself without the benefit of an instructor or of laboratory equipment. Furthermore, the quality and extent of the courses offered by correspondence schools vary greatly.

Entrance Requirements

The entrance requirements of most schools specializing in education for technician jobs are not as rigid or standardized as those of 4-year colleges. A study of the entrance requirements

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of 20 technical institutes indicated that all these schools preferred high-school graduates.[19] Eight of them, however, would admit students who could show the "equivalent" of a full high-school course, and another eight schools would admit persons without a high-school diploma if they satisfied age requirements, could pass special examinations, or could demonstrate that they were "adult, mature individuals."

A study of the entrance requirements of 88 junior colleges, not affiliated with 4-year colleges, showed that more than 93 percent preferred their applicants to be high-school graduates. Seventy-one schools, however, would admit nongraduates if they could meet one of the following requirements: Be over 18 years of age, pass entrance examinations, or indicate that they would "profit by training offered."

An examination of the entrance requirements of thirty-five 4-year colleges with technical institute or junior college divisions indicated that the majority preferred their applicants be high-school graduates. However, more than half the schools would admit applicants without high-school diplomas if the applicants were above specified ages, could demonstrate their ability to perform work above the high-school level, or were veterans.

The flexible entrance requirements of many of the schools offering education to prospective technicians make possible a career in the technical field for many persons who could not gain admission to regular 4-year colleges. At the same time, young people should realize that the technical and scientific courses in many of these schools are of college level. For all the occupations considered in this report, basic training in mathematics and science is essential, and students who expect to prepare for the technician field should, therefore, obtain a good background in these subjects in high school.

[19] References to admission requirements and length of training are based upon an examination by the Bureau of Labor Statistics in February 1952 of 143 catalogues of educational institutions offering post-high-school vocational technical programs of less than 4 years. The schools included 88 junior colleges, 20 technical institutes, and 35 degree-granting institutions having 2-year programs which prepared students for immediate employment as semiprofessional workers. Curricula were examined which would primarily apply to the preparation of technicians who could assist engineers, chemists, and physicists in industry and government. Such courses as those in medical and health service, agriculture, photography, homemaking fields, skilled trades, and maintenance and repair work were excluded from this study. The 143 institutions whose catalogues were reviewed offered training in 291 vocational-technical subject fields.

Selection of School

Although most schools in the field of vocational-technical education try to give their students good technical preparation, other institutions seem to have been created primarily for the personal profit of the proprietors. Through misleading advertisements and misrepresentation, dishonest technical, vocational, and correspondence schools have fooled students into believing that the educational background necessary to qualify for the job of a technician could be gained through shortcut methods.

The abuses found in the area of technical and vocational training have been examined by agencies of the Federal Government and Congress. A congressional committee investigating all educational training under the GI bill for veterans of World War II concluded: "There was a rapid uncontrolled expansion of private profit schools during the first several years of the veterans' training programs. Many of these schools were without educational background and experience and offered training of doubtful quality."[20]

A student seeking a technical education should use more than ordinary care in selecting a school. (See appendix A for sources of information on schools.) If possible, information should be secured about State accreditation, professional recognition, the length of time the school has been in operation, instructional facilities, faculty qualifications, and the success of the school's graduates. Above all, a student should realize that there is no quick and easy method of acquiring the background in mathematics, chemistry, and other physical sciences which will enable him to qualify as a technician.

Employment Experience of Technician Graduates

As has already been indicated, technicians obtain their education from widely differing sources. This naturally raises a question as to the types of jobs in which the various students find employment. A wide range of jobs are available, according to the follow-up studies of their graduates made by some of the training institutions.

[20] U. S. Congress, House of Representatives, House Select Committee to Investigate Educational, Training, and Loan Guaranty Programs Under GI Bill, 82d Cong., H. Rept. No. 1375, U. S. Government Printing Office, Washington, D. C., 1952, p. 3.

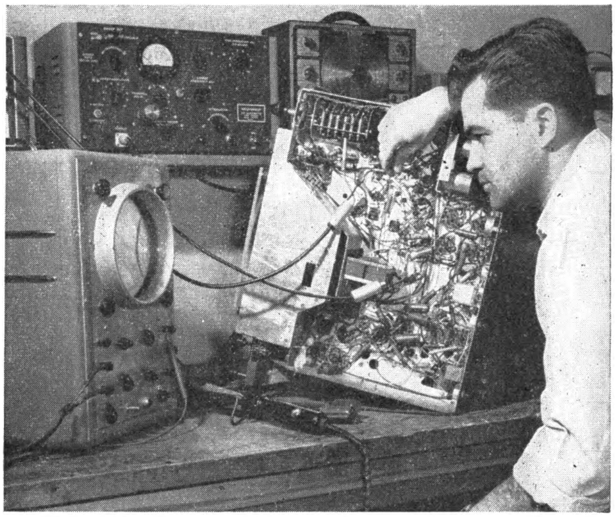
The short- and long-term studies made by a privately endowed technical institute provide information concerning the opportunities for employment and advancement of its graduates.[21] A survey of the mechanical department graduates, including only those who were out of school 5 or more years, showed that only 2½ percent of the graduates were employed in fields unrelated to those for which they had been trained. The following list of jobs serves as an example of the types of employment found by the graduates of the mechanical department. They were working as draftsman, tool designer, machine designer, instrument maker, tool and die maker, production planner, inspector, mechanical engineer, engineering salesman, and foreman.

Those persons who graduated from the electrical department between 1925 and 1947 were working as technical salesman, administrator, engineer, circuit engineer, technician, power plant and substation operator, electrician, and inspector and tester.

Some of the graduates of the chemistry department from 1927–48 were employed as apprentice draftsman, processing assistant, assistant foreman, tester, laboratory technician and assistant, junior chemist, and chemist.

Placement surveys by the New York State technical institutes showed that their recent graduates have taken jobs in industry as architectural draftsman, construction estimator and layout man, research assistant, control chemist, instrument mechanic and tester, laboratory technician, sales engineer, purchasing agent, junior engineering aid, and technical assistant to metallurgists.[22] The same surveys also indicate that an extremely high percentage of the graduates are employed in the specific fields for which they were prepared. Because the New York State schools have been in existence only a short time, it is impossible to know how far their graduates will advance eventually.

Another technical institute offering courses in all technical branches of radio and television communication examined the job placements of its advanced technology graduates for the school year 1949–50. Of the graduates available for placement, more than 98 percent were employed. The following is a partial list of the jobs obtained by the graduates of the advanced course. The titles were given by the employers.[23]



Electronic technician checking vertical sweep voltage generator in television receiver.

Position	*Total employed*
Junior engineer	13
Laboratory technician	55
Instructor	14
Transmitter engineer (radio)	19
Television technician (production)	36
Television final tester (production)	11

An eastern junior college studied the work careers of its graduates and reported that they secured jobs specifically related to their education, such as field service engineer, draftsman (design), junior engineer, designer, shop superintendent, and production manager.[24] The school's survey revealed that, within 5 years after graduation, 64 percent of the graduates held technical-professional, supervisory, or executive positions related to their education; and 82 percent of those who graduated 10 or more years earlier were holding such positions.

These studies of the types of jobs obtained by those who have technical training indicate a wide range of occupational opportunity for technicians. Graduates of vocational-technical educational programs have a good chance to obtain employment in the occupations of their choice.

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[21] Unpublished reports, Rochester Institute of Technology, Rochester, N. Y.

[22] State University of New York, Long Island Agricultural and Technical Institute, Report on Placement and Progress of Graduates, Industrial-Technical Division, Farmingdale, N. Y., 1951; Buffalo Technical Institute, Technical Careers in Eight Fields, Buffalo, N. Y., 1951.

[23] RCA Institutes Inc., Report on Job Placement of Graduates for School Year 1949–1950, New York, N. Y., p. 6.

[24] New Haven YMCA Junior College, Our Graduates and What They Do—A Follow-Up Study, New Haven, Conn., March 1947.

Employment Prospects

The short-run outlook is good for well-trained technicians, and employment of technicians will probably tend to rise over the long run. Use of technicians has increased sharply since the outbreak of hostilities in Korea, as it did during World War II. In both these periods, a great expansion occurred in research and development activity and in types of production which employ the largest number of engineers. This has led to an acute shortage of engineers and scientists and, therefore, to an increased demand for technicians who can handle the more routine tasks thus enabling the professional personnel to concentrate on more advanced aspects of the work. Because a continued shortage of engineers and scientists is expected during the next several years, the demand for technicians will probably remain high, and the prospect is that not enough well-trained people will be available to meet this need. The general advance of scientific knowledge and of its practical application to industry should further expand the employment of technicians over the long run.

Past Trends

Employment of technicians has increased markedly over the past four decades.

Among the technicians allied with engineers and scientists, draftsmen were the first group to become established as a separate occupation, and they still outnumber every other group of technicians. The number of draftsmen in the country rose from 12,000 in 1910 to 88,000 in 1940. In addition, the 1940 Census included 67,000 laboratory technicians and assistants and 8,000 technicians of other types, but in both these groups there were large numbers of workers (for example, medical technicians) not covered by this report. Before 1940, these occupations were not considered important enough to be reported separately by the Census.

A further sharp increase in employment of technicians has taken place since 1940. One reason for this conclusion is the rise in the number of employed professional engineers (from 245,000 in 1940 to more than 400,000 in 1952). Employment of chemists, the largest group of natural scientists, likewise increased greatly (from 55,000 in 1940 to nearly 100,000 in 1952). It is probable that the number of technicians working with these engineers and scientists also has increased rapidly, although no nationwide statistics are yet available on the number in the field since 1940 nor on the average number of technicians employed per engineer or scientist.[25]

The best evidence of the increasing use of technicians during the last decade is from the National Research Council's Directories of Industrial Research Laboratories. (See chart.) These studies show a greater relative growth from 1940 to 1950 in employment of technical workers than of professional personnel or in the total staff of industrial research laboratories. Over the decade, the number of technical workers in these laboratories increased by nearly 150 percent (from 16,400 to 40,800), whereas professional personnel increased only 93 percent (from 36,550 to 70,570) and the total number of laboratory workers rose by 136 percent (from 70,000 to 165,000). One technical worker was employed for every 2.2 professional workers in 1940, but the ratio was 1 to 1.7 by 1950. Most of the rise in employment of technicians occurred during the World War II period, from 1940 to 1946. In the last 4 years of the decade, employment of technicians increased by only 18 percent (compared with an increase of 111 percent from 1940 to 1946) and professional personnel increased 30 percent (compared with a 49-percent increase over the earlier period).

Outlook

The need for engineers, scientists, and other persons with technical knowledge and specialized skills is great as a result of defense activities and

[25] Several studies have been made by different organizations of the relative numbers of technicians, engineers, and scientists employed in certain industries. These studies indicate an extremely wide variation in the ratio of technicians to engineers and scientists, due in part to the lack of uniform definitions of technical and other related jobs. The ratio was found to vary from 20 technicians for each engineer to 1.7 per engineer in different industries. It also differed considerably among plants in the same industry. The studies examined include the following:

Wickenden, W. E. and Spahr, R. H., A Study of Technical Institutes, Society for the Promotion of Engineering Education, Lancaster, Pa., The Lancaster Press, 1931.

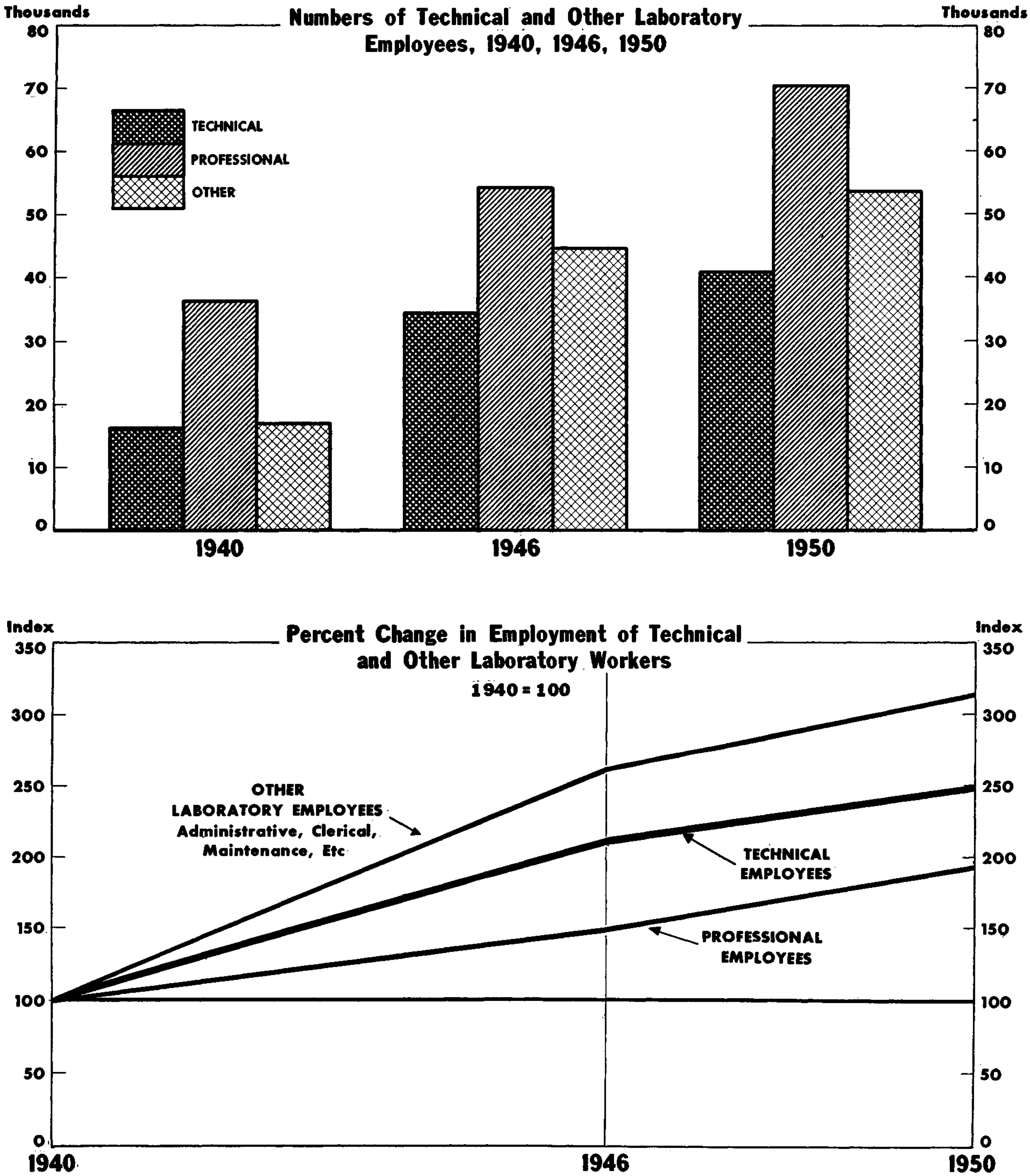
Federal Security Agency, U. S. Office of Education, Vocational-Technical Training for Industrial Occupations, Report of the Consulting Committee on Vocational-Technical Training Appointed by the U. S. Commissioner of Education, U. S. Government Printing Office, Washington, D. C., 1944 (Vocational Division Bulletin No. 228).

Anthony, Robert N., Selected Operating Data for Industrial Research Laboratories, Harvard Business School, Division of Research, Boston, Mass., 1951.

Hampton, Thomas Edgar, A Survey of Technical Occupations in Louisiana Industry, Department of Commerce and Industry, State of Louisiana, 1950.

Beach, C. Kenneth and Associates, Technical Occupations in the State of New York, State Education Department, Albany, N. Y., 1946.

EMPLOYMENT OF TECHNICIANS IN INDUSTRIAL LABORATORIES IS RISING RAPIDLY



UNITED STATES DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS

Source: National Research Council, National Academy of Sciences, Industrial Research Laboratories of the United States.

the generally high level of production in late 1952. The heavy demand for such personnel has created shortages of technicians in some fields and is expected to bring increasing employment opportunities for all technicians as long as the mobilization program continues.

An indication of the shortage of certain types of technicians is the inclusion of three types—electronic technicians, tool and die designers, and design engineer draftsmen—in the List of Critical Occupations issued by the United States Department of Labor. (See appendix D.) Workers in occupations on the List may receive special consideration in connection with military deferments if they are employed in essential industries or activities.

The current shortage of experienced mechanical draftsmen is evidenced by numerous listings in the "help wanted" sections of newspapers, especially those in large industrial cities. The United States Employment Service of the Department of Labor also lists draftsmen among the occupations in short supply in some localities. The demand for draftsmen began to increase shortly after the outbreak of hostilities in Korea. From July 1950 to March 1952, the number of draftsman jobs for which an effort was made to recruit workers outside the local labor market rose from about 150 to more than 3,000. This latter figure by no means represents the total number of openings for draftsmen because not all employers report their job needs to the United States Employment Service and its

Making precision measurements on a crankshaft in a quality control laboratory.

affiliated State employment services. The figures do, however, indicate a continually rising demand for draftsmen.

In addition to recruiting experienced draftsmen, some employers are instituting their own programs to train urgently needed draftsmen for their engineering departments. The aircraft and electronics industries are making special efforts to secure draftsmen. At least one large aircraft company has been advertising for student draftsmen whom it will pay while they are learning.[26] Although some companies will hire inexperienced draftsmen, the greatest demand is for mechanical draftsmen who have had experience in particular industries. Women are in demand for many types of drafting jobs, employment experience during World War II showed women to be well suited to drafting work in many industries.[27]

Current announcements by the United States Civil Service Commission of job opportunities emphasize the Federal Government's need for additional technicians. In May 1952, the Commission listed engineering aid, engineering draftsman, junior scientist, tool designer, electronic equipment repairer, and electronic mechanic among the personnel for whom there was urgent need in specified localities.[28]

The demand for technicians will probably be great as long as the defense program continues. Because shortages of engineers, chemists, physicists, and other scientific personnel are expected to continue for some years,[29] the need for technicians to work with them will probably rise further. The current shortage of scientists and engineers has given renewed impetus to the trend, notable during World War II, toward greater use of technicians. In some cases scientific jobs are being "diluted" and "broken-down" so that technicians may be used for some specialized activity. If the shortage of scientific personnel continues, alert management will probably employ additional technicians in order to make more efficient use of their professional employees.

The need for better utilization of fully trained professional personnel is receiving recognition from many sources, and, to this end, the employment of greater numbers of technicians is recommended. In line with this trend a writer has noted: "It seems to me that we have been giving thousands and thousands of young men a 4-year training in the fundamentals of engineering at considerable expense to them, and then putting a great many of them in jobs that could be done as well by people with a fraction of their training." [30] It has also been suggested that we could expand our research programs if we adopted the European method of research which employs many more assistants as aids to the professionals.[31]

It is expected that the greatest demand for technicians in the next few years will be in the defense-related industries. The electronics industry, for example, will need more technicians to aid in the manufacture and servicing of electronic equipment important in military operations. Employment in aircraft manufacturing, where draftsmen and many other technicians are already reported to be in short supply, is still expanding. Current production schedules call for a continued increase in defense output through the middle of 1953 and for a very high level of production for several years thereafter. Other industries important in defense-connected research and production, such as the machine tool, industrial chemicals, and petroleum industries, are therefore expected to need additional technicians.

The announcement in April 1952, by the Federal Communications Commission, that 2,053 new television stations would be allowed to open will further intensify shortages of trained electronic technicians, because sizable numbers will be needed to maintain and service the additional stations when they are established.

The supply of well-trained or experienced technicians available in the near future will probably not be sufficient to meet the above-described demands. Because of the wide variety of sources from which industrial technicians may be recruited, it is impossible to estimate the supply of workers

[26] Business Week, Feb. 9, 1952, pp. 46–48.

[27] For information concerning opportunities for women in scientific and related occupations, see The Outlook for Women in Science, Bulletin No. 223, vols. 1–8, U. S. Department of Labor, Women's Bureau, 1948–49. (Available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.)

[28] See Civil Service Commission, Federal Job Opportunities Throughout the United States, Announcement No. 2280, May 1952. Information on job openings in the Government may be obtained from State and local governments and from the U. S. Civil Service Commission, Washington 25, D. C. Announcements of Federal job openings are often posted in local post offices.

[29] See Occupational Outlook Handbook, Bulletin No. 998, Bureau of Labor Statistics, U. S. Department of Labor, 1951, pp. 79–83. Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price $3.

[30] Mitchell, Don C., "Engineering Manpower for Industry," The Journal of Engineering Education, vol. 42, No. 3, (November 1951), p. 134.

[31] Morris, H. E., "Problems in Utilizing Technical Personnel," Journal of College Placement, vol. 12, No. 3, (March 1952), p. 34.

available at any time or likely to become available in the future. However, placement officers of technical institutes and junior colleges report that they have many more calls for their graduates than can be filled. Also, there probably will be fewer new entrants from other sources than in times when the general employment situation is less favorable.

Employment of technicians is likely to continue to expand over the long run. Some of the factors which are expected to affect favorably the long-term employment for technicians are the general advance of scientific knowledge and its practical application in industrial operations, and the increasing use of technically trained personnel in sales jobs, supervisory jobs, and other types of work. Further, it is probable that high levels of expenditures for research and development will persist over the long run. More and more companies are establishing research programs and existing programs are being expanded to meet the strong competition in developing new products and processes. Furthermore, in view of the long period of defense mobilization which appears to lie ahead of us, it is probable that expenditures for this purpose will continue at a high level. The demand for research personnel therefore will be high. If the trend toward greater use of technical workers continues (see chart), employment prospects for technicians in laboratories will be good. In addition to new positions created by growth in the field, many employment opportunities for technicians will occur each year because of deaths, retirements, or transfer of experienced workers.

The number of job openings available to technicians over the long run, however, will reflect the general economic situation. If international conditions should improve and the defense program should be cut, the demand for technicians would be reduced. Furthermore, technicians face special competitive problems when jobs become scarce, because they are in occupations which can be filled by persons with a wide variety of backgrounds. In the past, during periods of considerable unemployment, the most serious contenders for technician jobs have been the professional workers. In such periods, employers are more selective because they can hire highly trained employees at the salaries of lesser trained workers. The possibility of greater flexibility and broader background from the 4-year college graduate may influence the employer's preference. The technician, then, would be well advised to consider taking additional courses of a general nature, as well as specialized courses in his field, to better prepare himself to meet competition.

Earnings

Private Industry

Information on the earnings of some types of technicians, including draftsmen, is available from a number of surveys in different industries and localities, though no nationwide studies have been made of technicians' pay.

Draftsmen.—The job of tracer is the usual entrance position in the draftsman category. In 12 cities covered by Bureau surveys in 1951–52, tracers had average straight-time weekly earnings ranging from $47.00 in the Newark-Jersey City area to $63.50 in Detroit (table 3).

Junior draftsmen, the group at the next higher level of skill, tend to earn considerably more than tracers in the same city. In the Newark-Jersey City area, for example, their average straight-time weekly pay was $63.00; in Detroit, it was $72.50. Altogether, information on earnings of junior draftsmen was collected in 26 cities, many more than were covered by the data for tracers. In these cities, the range in average earnings for workers in junior positions was from $48.00 in Richmond to $72.50 in Detroit. The higher earnings received by more highly skilled workers who are classed as draftsmen and chief draftsmen, are shown in table 3.

Laboratory assistants in the industrial chemicals industry.—Male laboratory assistants in this industry had average straight-time hourly earnings of $1.77 in late 1951 (or $70.80 for the 40-hour workweek customary in industry), according to a survey of 244 plants.[32] The much smaller number

[32] U. S. Department of Labor, Bureau of Labor Statistics, Wage Structure-Industrial Chemicals, Series 2, No. 87, October–November 1951. Available upon request as long as supply lasts.

TABLE 3.—*Average straight-time weekly earnings for male draftsmen in selected metropolitan areas, June 1951–January 1952*

Region and area	Tracers	Junior drafts-men	Drafts-men	Chief drafts-men
New England:				
Worcester, Mass		$58.50	$73.50	$116.00
Providence, R. I		58.00	72.00	84.50
Bridgeport, Conn		62.50	83.50	112.50
Hartford, Conn	$48.50	58.50	77.50	97.00
Middle Atlantic:				
Buffalo, N. Y		66.50	86.50	104.50
Rochester, N. Y		69.50	81.50	103.50
Newark–Jersey City, N. J	47.00	63.00	85.50	113.00
Philadelphia, Pa.–Camden, N. J	48.50	68.00	86.50	113.50
Pittsburgh, Pa	61.00	71.50	90.50	139.50
East North Central:				
Cleveland, Ohio		68.50	84.50	105.00
Dayton, Ohio		67.50	89.00	109.50
Indianapolis, Ind	56.00	64.00	85.00	101.00
Detroit, Mich	63.50	72.50	98.50	129.00
West North Central:				
Minneapolis-St. Paul, Minn		54.00	72.50	92.50
Kansas City, Mo	56.50	65.50	74.00	90.00
St. Louis, Mo	49.50	58.50	78.50	103.00
South Atlantic:				
Baltimore, Md	48.00	49.50	76.50	109.50
Richmond, Va		48.00	75.50	
East South Central:				
Memphis, Tenn		60.00	65.50	95.00
West South Central:				
New Orleans, La			74.50	
Oklahoma City, Okla		62.50	76.00	
Dallas, Tex		49.50	72.50	90.50
Houston, Tex	52.00	56.00	80.50	97.00
Mountain:				
Salt Lake City, Utah		65.00	78.00	
Pacific:				
Seattle, Wash	62.50	70.50	82.50	98.50
Portland, Oreg		60.00	78.00	102.50
Los Angeles, Calif	57.50	68.00	92.50	123.50

SOURCE: U. S. Department of Labor, Bureau of Labor Statistics, Community Wage Surveys.

of women laboratory assistants had average earnings of $1.58. Average earnings for men varied from $1.48 in New England to $1.87 in the Southwest. Laboratory assistants in large plants (more than 500 workers) earned 28 cents more an hour, on the average, than workers in smaller establishments.

Broadcasting engineers and technicians.—Radio and television broadcasting stations represent one of the employment fields for men trained as electronic technicians. In this field, the highest paid men are those employed by the networks and their key stations. Their average full-time earnings were more than $120 a week in October 1950, according to a study made by the Bureau in cooperation with the Federal Communications Commission (table 4). In other stations with 15 or more employees, the studio engineers and technicians with first-class radio-telephone licenses were the best paid group; their average pay was $88 a week. Studio engineers without such licenses averaged $79.50 a week in the stations not operated by networks; and transmitter engineers and technicians with first-class licenses had average earnings of $74 a week in independent stations.

TABLE 4.—*Average weekly hours and earnings of selected full-time employees in radio and television stations with 15 or more employees, October 1950*

Occupation and employer	Number of employees	Average weekly hours	Average weekly earnings
Studio engineers and technicians:			
With first-class radio-telephone licenses	3,218	42.5	$95.50
In network stations [1]	729	44.0	121.00
In independent stations	2,489	42.0	88.00
Without first-class radio-telephone licenses	1,378	43.5	100.00
In network stations [1]	624	44.5	124.50
In independent stations	754	43.0	79.50
Transmitter engineers and technicians:			
With first-class radio-telephone licenses	3,404	42.0	77.50
In network stations [1]	231	41.5	122.00
In independent stations	3,173	42.0	74.00
Without first-class radio-telephone licenses	41	41.0	67.00
In network stations [1]	6	(2)	(2)
In independent stations	35	41.0	62.50

[1] Includes networks and their owned and operated stations.
[2] Insufficient data to warrant presentation.

SOURCE: U. S. Department of Labor, Bureau of Labor Statistics in cooperation with Federal Communications Commission, Average Hours, Earnings, and Employment, Radio and TV Broadcasting Industry, October 1950, table 4, p. 4.

Engineers in stations with fewer than 15 employees are known to have lower earnings, though recent figures are not available on their pay. In examining the earnings figures in table 4, prospective technicians should realize that inexperienced men ordinarily must first attain experience in small stations before they can qualify for employment in the larger ones.

Technical institute and junior college graduates.—Further information on technicians' pay is available from studies of the earnings records of graduates of several technical institutes and the technical divisions of junior colleges.

Nearly two-thirds of the reporting 1950 graduates of the Long Island Agricultural and Technical Institute were making $50 or more a week within 6 months after graduation, according to a survey conducted by the Institute as of December 1, 1950.[33] One out of every four members of this graduating class reported a weekly wage of $60 or more. Among the reporting graduates of the class of 1948, the large majority (71 percent) were making $60 or more a week at the time of the survey (table 5).

[33] State University of New York, Long Island Agricultural and Technical Institute, Report on Placement and Progress of Graduates, Industrial-Technical Division, Farmingdale, N. Y., 1951.

TABLE 5.—*Percent distribution of 501 technical institute graduates, by weekly salary, December 1950*

Weekly salary	Percent of graduates in—		
	Class of 1948	Class of 1949	Class of 1950
$30–$39	1	2	4
40–49	5	16	32
50–59	23	40	40
60–69	36	24	19
70 and over	35	18	5
Total	100	100	100
Number reporting [1]	167	149	185

[1] Seventy-five percent of the class of 1948, 88 percent of those who graduated in 1949, and 90 percent of the graduates of 1950 reported their wage group as of December 1, 1950.

SOURCE: State University of New York, Long Island Agricultural and Technical Institute, Report on Placement and Progress of Graduates, Industrial-Technical Division, Farmingdale, N. Y., 1951.

Graduates of the 1949–50 class in advanced technology at the RCA Institutes of New York City had an average weekly salary of approximately $59 as of September 30, 1950.[34] About 70 percent of these graduates were in the following six occupations which are included among or closely related to those covered by this study: junior engineer, laboratory technician, transmitter engineer (radio), TV technician (production), TV final tester (production), and instructor. These graduates had approximately the same average weekly salary as all members of their class.

The increase in earnings enjoyed by many technicians as they gain experience, as indicated in other follow-up studies (see table 5), is also suggested by a 1947 survey by the New Haven YMCA Junior College.[35] The median annual salary of graduates who had specialized in mechanical and electrical technology and who had been out of college more than 10 years was $4,830. This figure was nearly two-thirds higher than the median salary figure for graduates in electrical technology from 5 through 9 years after graduation, and about one-third higher than that for graduates in mechanical technology at this earlier period in their careers.

[34] RCA Institutes, Inc., Report on Job Placement of Graduates for School Year 1949–50, New York, N. Y., October 31, 1950.

Federal Government

The Federal Government classifies technician jobs, as it does other positions, according to the kind of work performed and in grades based on the qualifications required and the difficulty and responsibility of the work. In general, technicians with 2 years of appropriate post-high-school training or experience can begin in jobs classified in grades 3 or 4 and may progress through grade 7 (appendix E). A few, who advance to supervisory positions, may attain higher grades.

Scheduled gross annual salary rates for grades 3 through 7, which have been in effect since July 1951, follow:

Grade	*Salary range*
GS–3	$2,950 to $3,430
GS–4	3,175 to 3,655
GS–5	3,410 to 4,160
GS–6	3,795 to 4,545
GS–7	4,205 to 4,955

[35] New Haven YMCA Junior College, Our Graduates and What They Do—A Follow-Up Study, New Haven, Conn., March 1947.

TABLE 6.—*Percent distribution by grade, and average annual salary of Federal Government employees in selected technician occupations, June 30, 1951*

Occupational group	Total all grades		Grade										Average annual salary
	Number	Percent	1	2	3	4	5	6	7	8	9	10–13	
Total	[1] 27,813	100.0	1.9	8.0	12.5	18.7	19.3	15.8	16.5	0.7	5.0	1.6	
Engineering aid [2]	10,812	100.0	1.7	9.7	14.2	24.1	19.1	15.4	14.6	.2	.7	.3	$3,315
Surveying and cartography [3]	4,434	100.0	3.9	9.3	16.9	14.1	19.8	9.4	11.4	2.7	8.9	3.6	3,489
Engineering drafting [4]	6,750	100.0	1.9	7.0	8.8	13.6	22.4	22.7	18.7	.6	3.8	.5	3,509
Physical-science aid [5]	3,061	100.0	1.3	9.0	18.5	31.8	22.8	8.0	7.7	.2	.4	.3	3,198
Electronic technician [6]	2,756	100.0	.1	.4	1.1	2.7	7.7	19.0	36.3	.9	24.3	7.5	4,255

[1] Excludes 623 employees for whom grade is not given.
[2] Includes engineering aids and student-aid trainees.
[3] Includes cartographic aids, student-aid trainees, and some professional cartographers in grades 9 and above.
[4] Includes draftsmen (patent) and engineering draftsmen.
[5] Includes scientific aids (cotton), scientific aids, (nautical), student-aid trainees, computers, and physical-science aids.
[6] Includes electronic technicians and laboratory electronic mechanics.

SOURCE: Bureau of Labor Statistics and Civil Service Commission, BLS Bulletin No. 1117, Federal White-Collar Workers, Their Occupations and Salaries, June 1951, in process.

Employees generally start at the minimum rates. Those who perform their jobs satisfactorily are given annual increases of $80 in the lower grades and $125 in grades 5 through 7, up to the indicated maximum rates. Employees with many years of service receive additional "longevity" increases.

Table 6 shows the distribution of Federal employees by grade, for the occupational groups most closely related to those covered in this report. Although the table shows employees in grades 1 through 13 for these occupations, the lower grades (1 and 2) and the grades above 7 generally are considered to apply to job levels outside the scope of this report. More than 80 percent of all the workers in the five selected occupational groups were classified in grades 3 through 7. The salary rates in effect on June 30, 1951 (the date of the survey on which table 6 is based) were about 10 percent lower than the rates given above, which became effective July 8, 1951.[36]

The largest percentage (24.1) of all engineering aids were in grade 4 as of June 1951 and were earning between $2,875 and $3,355 a year, depending mainly on length of service. In the surveying and cartography group, the greatest concentration of workers (about 20 percent) was in grade 5, where annual salaries ranged from $3,100 to $3,850. About 22 percent of the engineering drafting group were classified in grade 5 and a similar proportion in grade 6. More than 31 percent of the physical-science aids were classified in grade 4. Employees in the electronic technician group, composed of laboratory electronic mechanics and electronic technicians, had the highest grade level; over one-half were in grades 6 and 7 (beginning salaries $3,450 and $3,825) and nearly a quarter in grade 9 (beginning salary, $4,600).

The average salary for all Federal white-collar employees in the United States as of June 30, 1951, was $3,700. This was higher than the average salary in any of the technician groups studied, with the exception of the electronic technicians. However, average salaries for the various occupational groups reflect differences in entrance salaries, as well as differences in length of service of individual employees.

Although it is impossible, from the data available, to trace the advancement in Federal employment of technicians, it is obvious that some persons in these classifications are able to advance to the higher grades (above grade 5) usually filled by professional and administrative personnel.

[36] The change in rates provided for a minimum increase of $300 and a maximum of $800.

Appendix A

Sources of Information on Training Opportunities

1. The State Department of Education at each State Capitol has information about approved technical institutes, junior colleges, and other educational institutions offering post-high-school training for specific technical occupations.

2. The American Association of Junior Colleges, 1785 Massachusetts Avenue, NW., Washington, 6, D. C.

A junior college directory is available from the association (price, $1) and in many libraries. The association will furnish a free list of its member-schools which offer training for technicians.

3. Bureau of Apprenticeship, United States Department of Labor, Washington 25, D. C.

To obtain information regarding apprenticeship opportunities in technician occupations, inquiries should be addressed to the Washington Office of the Bureau of Apprenticeship, or to one of the regional offices of the Bureau or to State apprenticeship agencies.

4. Engineers' Council for Professional Development, 29 West 39th Street, New York 18, N. Y.

This is the national accrediting agency for technical institute programs. A current list of schools and their approved programs is available (price, 50 cents).

5. National Council of Technical Schools, 910 17th Street, NW., Washington, D. C.

6. National Home Study Council, 1420 New York Avenue, NW., Washington, D. C.

This organization publishes "Home Study Blue Book and Directory of Accredited Private Home Study Schools and Courses—1952."

7. Technical Education News (published periodically), McGraw Hill Book Co., Inc., 330 West 42d Street, New York 18, N. Y.

This publication, available in many libraries, provides information on various technical schools and new information in the field of technical education. The May or June issue includes technical institute enrollment data and a list of schools.

Appendix B

Examples of Curricula Offered by Schools Training Technicians [37]

Aircraft Construction and Manufacturing Curriculum
San Diego Junior College, San Diego, Calif., 1951–52

FIRST YEAR

First semester	*Second semester*
Aircraft Construction and Manufacturing, including technical related subjects [38]	Aircraft Construction and Manufacturing, including technical related subjects [38]
Psychology	Industrial Science
Mathematics	Mathematics
Physical Education	English
	Physical Education

SECOND YEAR

Third semester	*Fourth semester*
Aircraft Construction and Manufacturing, including technical related subjects [38]	Aircraft Construction and Manufacturing, including technical related subjects [38]
Industrial Science	Industrial Science
English	Political Science
Health Education	Industrial Organization
Physical Education	Physical Education

[37] Students enrolling in a particular curriculum must take all of the listed courses, except where otherwise indicated.

[38] Technical related subjects required of aircraft construction and manufacturing majors are: mechanical drafting, industrial mathematics, materials and processes, welding and machine shop.

Industrial Electronics Curriculum
Wentworth Institute, Boston, Mass., 1950–52

FIRST YEAR

Mathematics	Electrical Circuits
Mechanical Drawing	Electron Tubes and Circuits
Applied Physics	Shop Techniques

SECOND YEAR

Mathematics	Electron Tubes and Circuits
Electrical Machinery	Special Tubes and Circuits
Electrical Machinery Laboratory	Testing and Measurements
Wiring Practice and Laboratory	Systems
English Composition	Shop Techniques

Mechanical Curriculum (Cooperative Program)[39]

With Majors in General Mechanical, Instrument Making, Tool Engineering, and Screw Machine Technology
Rochester Institute of Technology, Rochester, N. Y., 1952–53

FIRST YEAR

First semester	*Second semester*
Algebra and Trigonometry	Analytic Geometry and Differential Calculus
Physics	Applied Mechanics
Engineering Drawing	Engineering Drawing
Psychology of Human Relations	Psychology of Human Relations
English Communications	English Communications
Machine Shop	Machine Shop
Screw Machine Shop (For Screw Machine Technology students only—Scheduled in place of Machine Shop)	Screw Machine Shop (For Screw Machine Technology students only—Scheduled in place of Machine Shop)

SECOND YEAR

Integral Calculus	Effective Speaking
Strength of Materials	Cooperative Employment
Engineering Drawing	Power and Heating Equipment (General Mechanical Major)
Electricity	Tool Making (Tool Engineering Major)
Economics	Instrument Making (Instrument Making Major)
	Screw Machine Operation and Set-Up (Screw Machine Technology Major)

THIRD YEAR

Social Problems	Power and Heating Equipment (General Mechanical Major)
Current Events	Tool Design (Tool Engineering Major)
Metallurgy	Manufacturing Analysis (Tool Engineering Major)
Production and Quality Control	Tool Design (Instrument Making Major)
Cooperative Employment	Instrument Making (Instrument Making Major)
Machine Design (General Mechanical Major)	
Screw Machine Cam and Tool Design (Screw Machine Technology Major)	
Screw Machine Estimating and Processing (Screw Machine Technology Major)	
Screw Machine Research and Technical Problems (Screw Machine Technology Major)	

[39] Cooperative program requiring 3 years' attendance for completion. Work on co operative jobs begins after completion of first years' program. The second and third-year programs are not organized on a semester basis.

Chemical Technology Curriculum
Institute of Applied Arts and Sciences, State University of New York, Brooklyn, N. Y., 1952

FIRST YEAR

First semester	*Second semester*
General Chemistry	Organic Chemistry
Basic Communication Methods	Qualitative Analysis
Sociology	Chemical Mathematics
Technical Mathematics	Writing and Thinking Techniques
	Psychology of Human Relations
	Applied Physics

SECOND YEAR

Third semester	*Fourth semester*
Organic Chemistry	Instrumental Analysis
Quantitative Analysis	Industrial Chemistry
Effective Speaking	Industrial Analysis
Industrial Electricity	Applied Communication Procedures
Industrial Relations	American Government

Appendix C

Job-Cluster and Promotion Sequence

Technical institutes aim to prepare their students for any of the basic positions in a particular field rather than for one specific type of job. The purpose of a job-cluster chart, such as the one given below, is to show a technical institute graduate how his training enables him to apply for a wide area of related jobs. The chart and the example of a promotion sequence indicate how one can go up the employment ladder with additional experience.

Some technical institutes advise their students that they probably will find their first jobs at the "entry or training" level. It is believed that most of the graduates will probably advance to the "intermediate" jobs. The "terminal" positions represent the highest level of responsibility for technicians, because they are jobs to which graduates may advance only if they have demonstrated their personal ability and acquired greater experience. The positions classified as "basic" in the job-cluster chart are those closest to the field of training. The "supplementary" and "related" jobs illustrate some of the other types of work for which the training institutions consider their graduates qualified.

Job-Cluster Chart for Graduates of Mechanical Technology Curriculum[40]

BASIC	SUPPLEMENTARY	RELATED
1. *Entry or Training:*		
Stock clerk	Meter testman	
Assistant inspector	Meter adjuster	
Machine tool operator	Power test assistant	
Tracer	Toolroom assistant	
Tool crib attendant	Time study observer	
Maintenance man	Parts inspector	
Time study assistant	Tool draftsman	
Laboratory assistant		
Foundry worker		
Heat treater		
Patternmaker		
Tool grinder		

See footnote on page 25.

Job-Cluster Chart for Graduates of Mechanical Technology Curriculum[40]—Continued

BASIC	SUPPLEMENTARY	RELATED
2. *Intermediate:*		
Checker or inspector	Technical correspondent	
Layout man	Order clerk	
Detailer	Assistant foreman	
Process technician	Draftsman	
Time study man	Steamfitter	
Toolmaker	Job setter	
Assembler	Cost analyzer	
Draftsman	Instrument maker	
Powerplant operator		
Foreman		
Test engineer		
Toolroom foreman		
Operation planner		
Cost estimator		
Tool estimator		
Expediter		
3. *Terminal:*		
Machine designer	Chief of standards	Chief engineer
Tool designer	Chief draftsman	Catalog and instruction book illustrator
Powerplant supervisor	Technical supervisor	Calculator
Production supervisor	Foreman of experimentation	Chief of stockroom
Field engineer	Chief of testing	Technical salesman
Process engineer	Chief of inspection	Product engineer
Consultant on power work	Chief of maintenance	Serviceman
Building equipment supervisor	Chief of installation	Superintendent of buildings
Consultant on air-conditioning	Designer of powerplant equipment	Demonstrator
	Refrigeration plant supervisor	Maintenance supervisor and comparable positions

[40] Adapted from New York State Institutes of Applied Arts and Sciences, New York State Agriculture and Technical Institutes, "Technical Careers and You," Albany, N. Y. Further information on some of these occupations may be found in the Occupational Outlook Handbook, Bureau of Labor Statistics Bulletin No. 998, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 1951.

Probable Promotion Sequence in Radio and Electronics Field[41]

Training Level Jobs:	Intermediate Level Jobs:	Upper Level Jobs:
Laboratory Assistant	Assistant Laboratory Engineer	Radio or Electronic Engineer
Assistant Draftsman	Draftsman	Radio or Electronic Laboratory Engineer
Tester or Inspector	Foreman of Radio and Electronic Manufacturing Department	Supervisor of Radio or Electronic Manufacturing Department
Assemblyman	Tester or Inspector	
Machine Operator	Final Assemblyman	

[41] Adapted from, If You Are Considering a Career in the Electrical Field, Vocational Guidance Series, Pamphlet No. 7, Rochester, N. Y., Rochester Institute of Technology, 1948.

Appendix D

Technical Occupations Listed as Critical

Criteria for Inclusion on List of Critical Occupations [42]

(1) Under the foreseeable mobilization program an over-all shortage of workers in the occupation exists or is developing which will significantly interfere with effective functioning of essential industries and activities;[43]

(2) A minimum accelerated training time of 2 years (or the equivalent in work experience) is necessary to the satisfactory performance of all the major tasks found in the occupation;

(3) The occupation is indispensable to the functioning of the industries or activities in which it occurs.

Definitions of Technical Occupations Appearing on List of Critical Occupations

Electronic Technician.—Fabricates, installs, maintains, and repairs intricate electronic apparatus and equipment used in communication, detection, measurement, and control systems, such as: aid-to-navigation systems, including radar and sonar; proximity fuses; guided missiles; fire-sighting and control systems; electronic computers; complex X-ray equipment; and electronic instrument and control devices, including those for special application in meteorological, geophysical, medical, and industrial-process fields. Constructs and modifies complex electronic assemblies and components, following engineering drawings, sketches, or verbal instructions and using a comprehensive knowledge of complex and varied test, assembly, and repair procedures to insure proper diagnosis, adjustment, and operation of such equipment. Tests, calibrates, adjusts, and repairs complex electronic equipment, replacing and interchanging component parts with precision machinist's and electrician's tools and electronic testing and auxiliary equipment. This title excludes those concerned with service and repair of radio and television broadcasting equipment and receivers, public-address systems, diathermy devices, electric organs, and similar equipment.

[42] Release of May 7, 1951, Defense Manpower Administration, U. S. Department of Labor.

[43] For List of Essential Activities, see release of April 8, 1951, U. S. Department of Commerce.

Engineer Draftsman, Design (General Definition).—Makes design drawings of machines, products, processes, instruments, or structures, to assist in developing experimental ideas evolved by Design Engineers. Prepares working plans and detail drawings, working from rough or detail sketches and specifications and employing his knowledge of engineering methods and practice to solve fabrication or construction problems. Designs lesser parts and assemblies or limited structures in harmony with over-all engineering plans and designs. Verifies dimensions of parts and materials, and relationship of one part to another as well as of the various parts to the whole structure, using an extensive knowledge of the various machines, products, or processes peculiar to the specialized activity in which the work occurs.

Tool and Die Designer.—Plans, sketches, and makes detailed drawings of tools, dies, jigs, fixtures, and gages. Determines type and kind of tool or die required. This definition includes only: Die Designer and Tool Designer, defined as follows: *Die Designer* [44] (Die Designer, 0–48.42, D. O. T. p. 385). Makes drawings of dies necessary to form a complete stamping, forging, or other part. Decides on the number of sets of dies (each set representing a stage of development of the part to be made) necessary to change the metal blank into the finished piece, basing his decisions on a blueprint of the finished part and on his knowledge of dies and machines, and of their possibilities and limitations. Compares blueprints with wooden patterns of dies to determine if corrections, changes, or improvements should be made in patterns. This title includes only those related titles with the same Dictionary of Occupational Titles Code number (0–48–42). *Tool Designer* [44] (Tool Designer, 0–48.41, D. O. T. p. 1391). Designs special tools and fixtures, such as boring bars and milling-machine tools. (Frequently is a Machinist, using types of machines for which he is designing tools.) This title includes only those related titles with the same Dictionary of Occupational Titles code number (0–48.41).

[44] Code numbers are from the Dictionary of Occupational Titles (D. O. T.), 2d ed., U. S. Department of Labor, 1949. The expression "related title" refers specifically to the uncoded titles listed in vol. II, D. O. T., which appear in capital letters, under a coded job title. Corresponding definitions for such titles appear in vol. I of the D. O. T.

Appendix E

Federal Civil Service Requirements for Selected Technical Occupations [45]

Engineering Aid, GS–1, 2, 3, 4, 5, 6, 7 [46]

Experience in engineering as specified below is required:

Grade	Total experience (years)	Specialized experience (months)
GS–1*	None	None
GS–2*	1	None
GS–3	2	3
GS–4	3	6
GS–5	4	9
GS–6	4½	12
GS–7	5	12

*A written test required for GS–1 and 2.

The specialized experience, which may be included in the total experience required for GS–3 and above, must have been in the specialized branch of engineering in which eligibility is assigned, and must have been at a level of difficulty and responsibility equivalent to that of the next lower grade in this series.

Substitution.—For any grade, experience in the physical sciences (chemistry, physics, metallurgy, geology, mathematics) may be substituted to the extent of 1 year for the general, but not for the specialized experience.

The successful completion of a full 4-year or senior high-school curriculum which included six half-year courses in any combination of mathematics, (algebra, geometry, trigonometry, etc.) chemistry, physics, or drafting may be substituted for 1 year of the total experience required for GS–2 and GS–3 or for 6 months of the total experience required for GS–4. High-school duty may not be substituted for any experience required for GS–5, 6, or 7 nor for any part of the specialized engineering experience required for GS–3 and above.

Pertinent resident study successfully completed in a school or institution above high-school level, which included one or more courses in drafting, mathematics, applied engineering sciences, or in engineering, may be substituted for the required experience up to a maximum of 4 years. The amount of experience for which this type of education may be substituted will be determined by the type of institution attended, the content of the courses, and the applicability of such study to the duties of the position.

Education may not be substituted for the specialized experience required for GS–6 or 7.

Pertinent specialized training or experience acquired while serving in the Armed Forces of the United States will be accepted on the same basis as civilian training or experience and will be evaluated according to the actual time spent in training and the subject matter of the courses completed.

[45] U. S. Civil Service Commission, Civil Service Handbook X-118, Qualification Standards Governing Noncompetitive Actions and Agency Recruiting, Government Printing Office, Washington, D. C.

[46] As of April 1951. For more complete and later information, see announcements of the Civil Service Commission in local first- or second-class post offices.

Physical-Science Aid, GS-1, 2 [47]

For GS–1, no experience is required. For GS–2, applicants must have had 1 year of experience in the physical sciences or engineering.

A written test is required for both GS–1 and GS–2.

Substitution.—The successful completion of a full 4-year or senior high-school curriculum which has included six half-year courses in any combination of mathematics, physics, chemistry, or drafting may be substituted for the 1 year of experience required for the GS–2 grade.

Pertinent resident study completed in schools above high-school level may be substituted for the required experience. Such study will receive appropriate credit in accordance with the length and content of the course.

Pertinent training acquired while serving in the Armed Forces of the United States will be accepted on the same basis as civilian training and will be evaluated according to the actual time spent in training and the subject matter of the courses completed.

Physical-Science Aid, GS–3, 4, 5, 6, 7 [48]

The experience specified below is required:

Grade	Total experience (years)	Specialized experience (months)
GS–3	2	3
GS–4	3	6
GS–5	4	9
GS–6	4½	12
GS–7	5	12

The total experience must have been in one or more of the physical sciences; for example, physics, chemistry, mathematics, geology, and metallurgy. The specialized experience must have been in a specific branch of physical science and must have been at a level of difficulty and responsibility equivalent to that of the next lower grade in this series.

Experience gained in such positions as meteorological aid, observer in meteorology, cotton textile technologist, inspector, laboratory mechanic, medical technician, scientific aid in the biological sciences, or statistical clerk will not be considered qualifying experience in full in this examination. If, however, the exact nature of the duties in any of the above positions is such that it affords the applicant opportunity to acquire knowledge of the principles and concepts of a physical science pertinent to the duties of the position, partial or full credit may be given toward meeting the general nonspecialized experience requirements for any grade.

[47] As of April 1951.

[48] As of April 1951.

Substitution.—One year of engineering experience may be substituted for only 1 year of the required experience, but not for any part of the specialized experience.

The successful completion of a full 4-year or senior high-school curriculum which included six half-year courses in any combination of mathematics, physics, chemistry, or drafting, may be substituted for 1 year of the experience for GS–3 and for 6 months of the experience for GS–4. High-school study may not be substituted for any part of the experience required for GS–5, 6, or 7, nor for any part of the specialized experience required for any grade.

Pertinent undergraduate or graduate study in physical sciences or mathematics completed in an accredited college or university may be substituted year for year for the required experience, provided that such education may not be substituted for the specialized experience required for GS–6 or 7. Pertinent study completed in other resident schools above high-school level will receive appropriate credit in accordance with the courses shown in the application.

Pertinent training acquired while serving in the Armed Forces of the United States will be accepted on the same basis as civilian training and will be evaluated according to the actual time spent in training and the subject matter of the courses completed.

Computer, GS–1, 2, 3, 4, 5, 6, 7

Applicants must have had experience in mathematics as follows:

Grade	*Total experience (years)*
GS–1	None
GS–2	1
GS–3	2
GS–4	3
GS–5	4
GS–6	4½
GS–7	5

A written test is required.

For GS–3, 6 months specialized experience, for GS–4 and 5, 9 months; and for GS–6 and 7, 12 months; or the experience must have been equivalent in difficulty and responsibility to work of the next lower grade in this series.

Substitution.—The successful completion of a full 4-year or senior high-school course which included 2-year units of mathematics (algebra, geometry, or trigonometry) may be substituted for 1 year of the experience required for GS–2, 3, and 4. High-school study may not be substituted for any part of the experience required for GS–5, 6, and 7. Full-time study successfully completed in a resident school above high-school level may be substituted year for year for the required experience up to a maximum of 4 years, provided that each year of such study has included or been supplemented by six semester hours in college mathematics in such courses as algebra, trigonometry, analytic geometry, and calculus. Graduate study with major work in mathematics may be substituted year for year for the required experience. Pertinent resident study on a part-time basis successfully completed in an institution above high-school level will receive appropriate credit in accordance with the courses shown in an application.

Pertinent training acquired while serving in the Armed Forces of the United States will be accepted on the same basis as civilian training and will be evaluated according to the actual time spent in training and the courses completed.

Engineering Draftsman, GS–1, 2, 3, 4, 5, 6, 7, 9, 11[49]

Drafting samples: The applicant must submit one or more samples to show his knowledge of the techniques used and his proficiency in the branch of drafting for which he is applying. All samples must be originals in ink.

Applicants must have had experience in engineering drafting as follows:

Grade	*Total experience (years)*	*Specialized experience (months)*
GS–1	¼	None
GS–2	1	None
GS–3	2	None
GS–4	3	3
GS–5	4	6
GS–6	4½	9
GS–7	5	12

The specialized experience must have been in one of the following: aeronautical, architectural, civil, electrical, heating and ventilating, mechanical, patent, ship, structural, or general engineering drafting. It must have been comparable in difficulty and responsibility to work usually performed in the next lower grade in this series. The specialized experience shown by the applicant will determine for which option he is qualified. No specialized experience is required for grades GS–1, 2, or 3. Specialized experience exceeding the required amount may be substituted for general experience. For eligibility under more than one option, the applicant must show the required specialized experience for each option, because the same period may not be used as specialized experience in more than one option.

Substitution.—For eligibility in grade GS–6 and above, education may not be substituted for any of the specialized drafting experience.

Pertinent resident study may be substituted as follows:

A—For GS–1 Grade Only.—The successful completion of a half-year high-school course in mathematics, drafting, mechanical drawing, or art, will satisfy the requirement for GS–1.

B—High-School Education.—The successful completion of a full 4-year or senior high-school curriculum which included four half-year courses, two of them in drafting, and the others in mathematics and/or art, will satisfy the GS–2 requirement in full, and will be acceptable for 1 year of the "total" time required for the GS–3 grade and

[49] As of January 1952.

all higher grades, regardless of whether experience or further education is offered to meet the remainder of the requirement. No part of the required "specialized" time may be satisfied by high-school education.

C—Above High-School Level.—Resident study successfully completed in a school or institution above high-school level (not to exceed 4 years of education) may be given credit as follows:

(a) For a curriculum leading to a bachelor's degree with a major in architecture, engineering, forestry, geology, landscape architecture, mathematics, or physics, and *provided* at least 1 year of college-level mathematics *and* 1 year of college-level drafting are included, credit will be given as follows:

> One year of such education qualifies for the GS–3 grade or may be substituted for 2 years of experience.
>
> Two and one-half years of such education qualifies for the GS–4 grade or may be substituted for 3 years of experience.
>
> Four years of such education qualifies for the GS–5 grade or may be substituted for 4 years of experience.[50]

(b) For a curriculum leading to a bachelor's degree in fields other than those listed in (a) immediately above, and which included at least six semester hours in one or more of the following subjects per credited year of study, all of which involved drawing with instruments using pencil or ink, accurate measurements and careful lettering, either freehand or by use of mechanical lettering guides; art design, drafting, or illustrating, credit will be given as follows:

> Two years of such education qualifies for the GS–3 grade or may be substituted for 2 years of experience.
>
> Four years of such education qualifies for the GS–4 grade or may be substituted for 3 years of experience.

(c) For pertinent study which included at least one 1-year course in college-level drafting at a college or university, a technical institute, or a school specializing in drafting, credit will be given at the rate of one full-time academic year of education for 1 year of experience, not to exceed 2 years of experience for such training. If appropriate high-school credit also is shown, this will correspond to the GS–4 level. To permit such maximum credit, it must be evident that the education was pertinent and progressively difficult, and that the specialization was appropriate for the field of engineering drafting being considered.

Credit for education permitted as above specified may be applied also as a part of the total experience needed for the higher grades, but may not be used in lieu of "specialized" experience in grades above the upper limits indicated in the respective paragraphs above.

Pertinent specialized training or experience acquired while serving in the Armed Forces of the United States will be accepted on the same basis as civilian training or experience and will be evaluated according to the actual time spent in training and the subject matter of the courses completed.

[50] Full-time academic years, comprising 2 semesters, 3 quarters, or the equivalent.

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