EMPLOYMENT OUTLOOK FOR

PHYSICISTS

UNITED STATES DEPARTMENT OF LABOR
James P. Mitchell, Secretary

BUREAU OF LABOR STATISTICS
Ewan Clague, Commissioner

in cooperation with VETERANS ADMINISTRATION

OCCUPATIONAL OUTLOOK SERIES

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Cover picture.—Physicist adjusting the eyepiece of an optical instrument used in observing the circular interference fringe of the green light from a newly developed mercury vapor lamp. This lamp contains mercury of atomic weight 198. Length measurements based on the interference pattern shown in the background can be made with an accuracy of 1 part in 100 million. The lamp thus enables any research organization to have an ultimate standard of length in its own laboratory.

Photographs are by courtesy of the National Bureau of Standards, and the U. S. Civil Service Commission.

LETTER OF TRANSMITTAL

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington, D. C., October 28, 1953.

The SECRETARY OF LABOR:

I have the honor to transmit herewith a report on the employment outlook for physicists. 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 physicists' essential contributions to the national defense and welfare and the shortage of personnel in this field of science, it is important that information on the profession be made available to young people who have the abilities and interests requisite for scientific work.

This study was conducted in the Bureau's Division of Manpower and Employment Statistics. The report was prepared by Norman Seltzer and Robert W. Cain, under the supervision of Helen Wood. The Bureau wishes to acknowledge the generous assistance and cooperation received in connection with the study from officials of the professional organizations of physicists, of Government agencies, and of industrial research laboratories, and from individual members of the physics profession.

EWAN CLAGUE, *Commissioner.*

Hon. JAMES P. MITCHELL,
Secretary of Labor.

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EMPLOYMENT OUTLOOK FOR PHYSICISTS

Introduction

Man's interest in physical facts and his use of the laws governing them in solving his everyday problems began in prehistoric times. In erecting a hut, our remote ancestors applied, in a rough way, some of the concepts of what physicists call "statics"—the branch of physics which relates to bodies held in equilibrium by the forces acting on them. The man who invented the first wheel, and thus was able to change his sledge into a cart, used some of the principles of "dynamics"—the branch of physics which deals with the motions of bodies and the forces producing motion.

The organization of men's scattered observations about physical facts into a systematic body of knowledge began in the early civilizations. The ancient Egyptians and Greeks and other early civilized peoples made a start in developing such a body of knowledge and understood that physical laws can often be described in mathematical terms. From this point on, advances in physics went hand in hand with advances in mathematics, until the development of analytic geometry and of calculus made it possible to describe complicated physical phenomena and their relationships by exact mathematical equations. Equally important in the history of the science was Newton's development of a comprehensive system of mechanics, the foundation of what is today known as classical physics.

Since Newton's time, the world of physics has broadened in countless directions. The most significant advances have been in electricity, since Faraday first discovered the principle on which the modern electric generator is based (1831); in electronics, since Hertz discovered radio waves (between 1885 and 1889); in theoretical physics, since Planck enunciated the quantum theory (1900); and in the concepts of the essential unity of space and time, since Einstein formulated his theory of relativity.

The advances in theoretical physics have greatly enlarged scientific knowledge, have given rise to a host of new products—from radio to the atomic bomb, and have expanded research in physics. During the past decade, physics has been growing so rapidly that there has been a persistent demand for additional personnel in the field.

As a result of the current mobilization program, the demand for physicists has been greatly intensified. Physical research is underway on problems related to air, land, naval, and atomic warfare and on many matters of importance to the civilian economy. The production of high-precision instruments, the development of intricate electronic equipment, the improvement of communications systems, and the solution of biological problems by physical methods are among the important activities of physicists which have created the prospect of a continuing need for trained personnel in this profession.

The present report is designed to give persons interested in preparing for employment in the profession an overall picture of the areas of specialization within physics, the nature of the work performed, the education and training requirements, the current employment opportunities, and the long-run employment outlook. A short section on earnings is also included.

Fields of Specialization

Present-day physics is concerned, basically, with energy in all its forms, with the structure of matter, and with the relationships between energy and matter. Its major objective is to explain natural phenomena. Because this requires a knowledge of the quantitative relationships involved, physics is, to a considerable extent, a science of measurement. In many respects, physics is the most fundamental of the natural sciences—part of the foundation of all experimental science.

As knowledge of physical phenomena has increased, physicists have tended, more and more, to specialize in different branches of the science. Most members of the profession now regard themselves as specialists in some area of physics, as indicated by a survey conducted by the National Scientific Register in early 1951.[1] Eighty-five percent of the survey physicists cited some specialty in filling out their questionnaire. The remaining 15 percent did not consider themselves specialists—in many cases because their experience had consisted wholly or mainly of teaching physics at the high school or undergraduate college level.

Physics specialties have a close interrelationship and are difficult to delimit and classify. Every specialty of the profession utilizes principles drawn from other branches of physics, and they all rest on the same fundamental principles. Furthermore, many physicists are engaged in work which cuts across the usual specialty lines. For these and other reasons, no system of classification has yet been devised which is satisfactory to all members of the profession. Following is a list of the major divisions of the science based on a classification of specialties developed by the National Scientific Register in cooperation with the American Institute of Physics: mechanics, heat, optics, acoustics, electronics, atomic and molecular phenomena, solid state physics, nuclear physics, classical theoretical physics, and quantum mechanics.[2]

The new and growing fields of electronics and nuclear physics are now the largest branches of the profession. Eighteen percent of the physicists in the National Scientific Register survey cited electronics as their field of highest competence, and 15 percent cited nuclear physics. Another sizable group (14 percent) reported specialization in optics. Not more than 7 percent checked specialties in any other major branch of physics.

A few illustrations of the types of work with which physicists in each of the major branches of the science are concerned are presented in the following paragraphs.

Mechanics.—This branch of physics treats of the action of forces on bodies, including liquids and gases as well as solids. Specialists in mechanics work on many problems important to the defense program. They may, for example, be concerned with problems encountered when jet aircraft and guided missiles move faster than the speed of sound or with the characteristics of the shock waves produced by explosions or by objects moving with supersonic speeds. Other physicists in this specialty are concerned with the development of new methods of measuring the physical properties of substances—for use in connection with automatic process controls—which are being introduced to an increasing extent in private industry. Another series of problems on which physicists in this specialty are working, in both private industry and Government, are those relating to the strength of basic materials and machine parts under stress.

Heat.—The problems studied by physicists specializing in heat—its measurement, development, transmission, and effects—are of great industrial and military importance because of the tremendous amount of fuel required by our industries and

[1] Manpower Resources in Physics, 1951. A study conducted jointly by U. S. Department of Labor, Bureau of Labor Statistics and Federal Security Agency, Office of Education. (Scientific Manpower Series No. 3, published by National Scientific Register, January 1952.)

The survey included about 6,600 members of the American Institute of Physics and its member societies—somewhat less than half of all physicists in the country at the time of the survey. The responding physicists were asked to indicate which specialty, out of a list provided in the questionnaire, they considered to be their field of highest competence or to check "Physics, general" if they considered their experience not specialized.

[2] Each of these major branches of physics was subdivided into a number of narrower specialties. The list of detailed specialties developed by the National Scientific Register in cooperation with the American Institute of Physics is given in the appendix (p. 21).

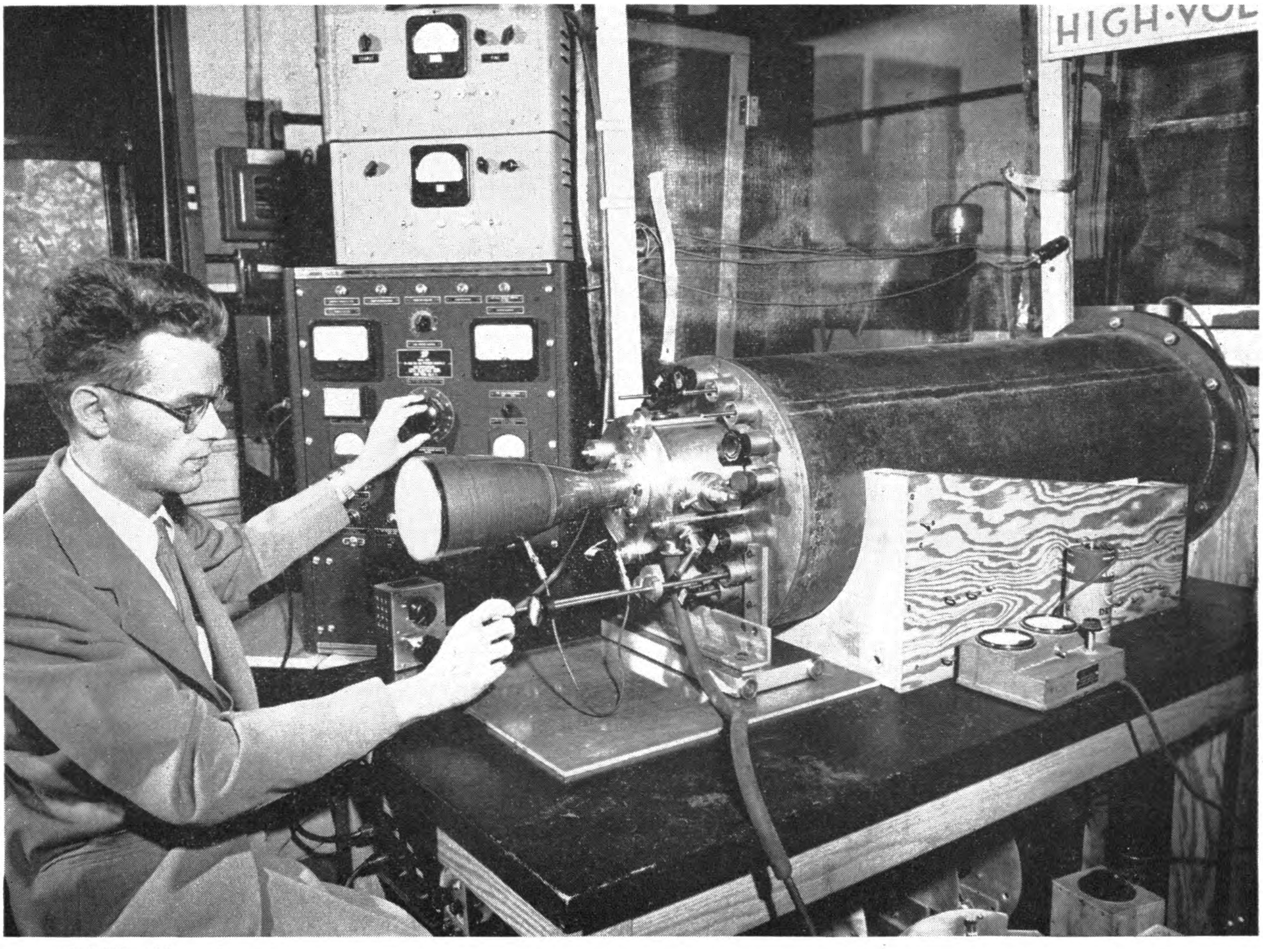
Armed Forces. Among the types of problems which these physicists study are the processes by which heat is generated in the burning of fuels and methods of reducing heat losses. Other specialists in this area are investigating the fundamental thermodynamic properties of various gaseous compounds, such as those used in jet engines. Research is also underway with regard to the properties of metals and ceramic materials at the extremely high temperatures developed in jet engines.

Optics.—This branch of physics is concerned with the study of light, its sources, propagation, and effects. Among the more important problems in optical physics is the search for better sources of illumination. The development of fluorescent lamps has depended to a great extent on research by physicists who have studied intensively the laws of radiation, the optical spectrum, fluorescent materials, and radiations from hot wires.

Because of the need for extremely accurate and versatile optical instruments in many types of scientific, industrial, and military work, some specialists in optics are concerned primarily with developing and designing such devices. These include, for example, high precision spectrometers used to determine the properties of optical glasses, emission spectrographs used in analysis of atmospheric dusts and gases, and such military items as rangefinders, gunsights, and bombsights. In investigations related to photography, some physicists are concerned with developing improved films and plates especially suited for astronomical and spectroscopic uses.

Acoustics.—This is the science of sound. One of the major investigations undertaken by physi-

Electronic specialist adjusting a recently developed electron-optical device, which is used in investigating extremely small electronic and magnetic fields in spaces where measurements could not previously be made.



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cists specializing in acoustics is the study of sound transmission in the subsonic and ultrasonic frequency ranges, a matter of great importance in the development of military communication equipment. The planning of auditoriums and broadcasting and television studios involves the solution by physicists of such acoustical problems as the effects on sounds of various kinds of materials and structures. Other specialists in acoustics are doing research, often in conjunction with engineers, on the reduction of noise and vibration in industrial machinery. Still others are concerned with the physiological and psychological effects of sound.

Electronics.—Research in this branch of physics has paved the way for the development of radio and television, radar, and the countless other industrial and military applications of electronics. Physicists specializing in electronics are concerned with the emission, behavior, and effects of electrons, especially in vacuum tubes. They may be engaged in developing more advanced forms of such devices as vacuum tubes, gas-filled thermionic tubes and electron-tube circuits, for use in many types of industrial and military equipment. Electronics specialists are also participating, along with physicists specializing in optics, in the development of improved electron microscopes. Some working in the field of television are engaged in research aimed at improving transmission; they employ special monitoring equipment to test the various methods suggested by their research. Specialists in this branch of physics also participated in the development of the new electronic computers, which can rapidly tabulate great masses of statistical data and solve in a short time complex mathematical problems, the solution of which would have taken years with the best electrical computing equipment previously available.

Atomic and molecular phenomena.—This branch of physics deals with the structure and behavior of molecules and atoms (but not of the nucleus of the atom, which is the special concern of nuclear physics). Some physicists doing fundamental research in this area are engaged in the study and interpretation of properties of matter in terms of properties of atoms. In this research, they use such instruments as the spectroscope, which makes it possible to measure the wave length of radiations from atomic particles. Other atomic physicists are investigating the processes by which atoms and molecules obtain or lose energy—problems of great importance in the conversion of nuclear energy for either military or industrial purposes. In the study of the behavior of free electrons and the development of methods and equipment for measurement of ionization produced by electrons, some atomic physicists work with electronics specialists who are seeking to develop new electronic devices.

Solid state physics.—Some physicists concerned with solid state theory are studying intensively the wave mechanics of the solid state, in order to better understand the motion of the electrons and nuclei in solids. Such studies have led to an understanding of the difference between electrical conductors and electrical insulators. Specialists working in this branch of physics also analyze the properties of semiconductors—substances with characteristics intermediate between conductors and nonconductors. The study of semiconductors is important in the development of such items as transistors which have some of the characteristics of vacuum tubes and which are being used in connection with various types of communication equipment. The behavior of solid materials under stress is being intensively studied, especially in view of the present widespread use of plastics. Solid state physicists working on problems of the flow properties of solid materials conduct experiments to enable them to classify solids as either elastic, viscous, or viscoelastic. This information is of importance in determining the best kinds of material to use in constructing certain types of mechanisms.

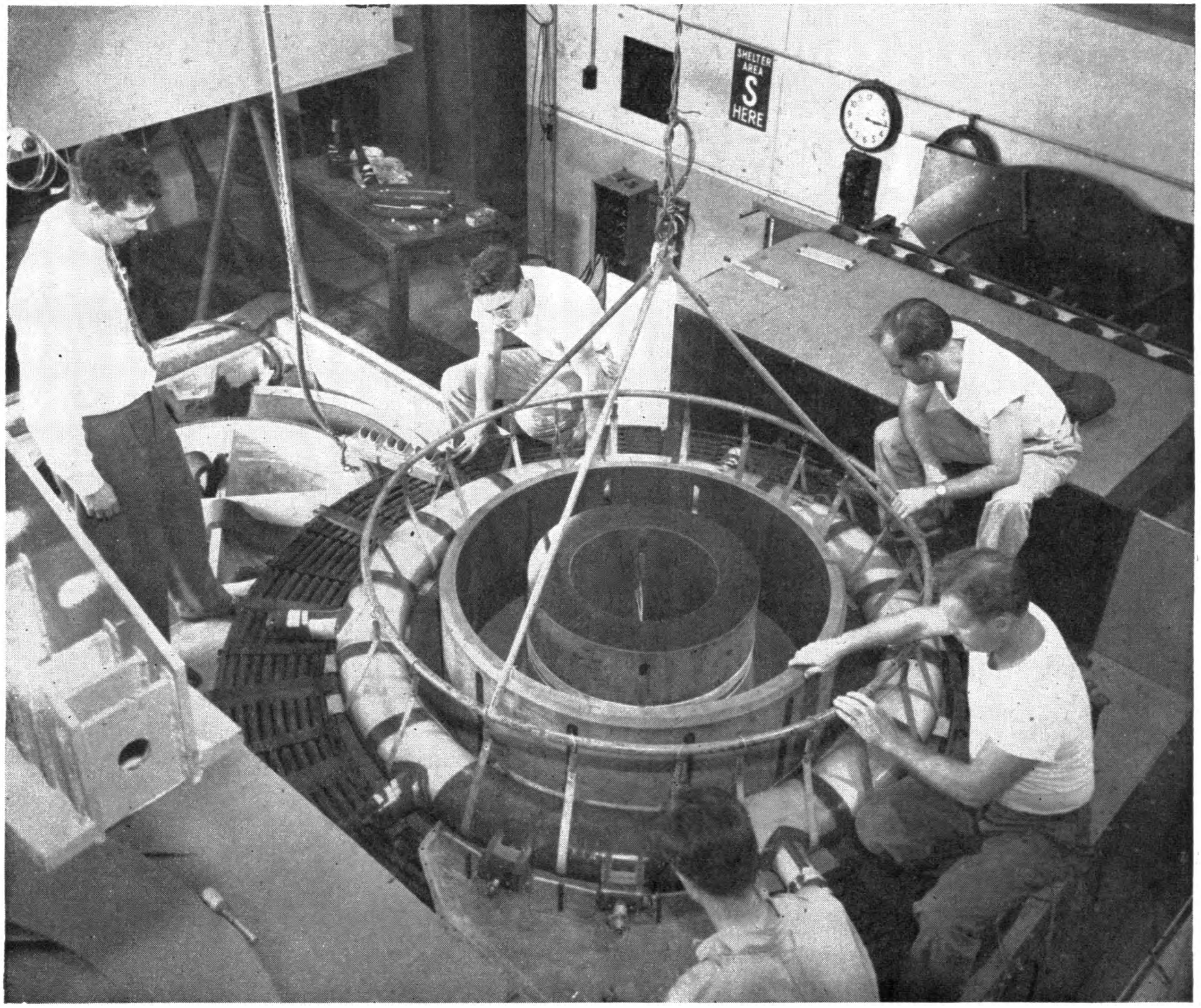
Nuclear physics.—This branch of physics is concerned with the structure and properties of the nucleus of the atom and with nuclear reactions. Much of the research carried on by nuclear physicists centers on the utilization of nuclear energy for military and industrial purposes. With the aid of special instruments such as betatrons, synchrotrons, and cyclotrons, physicists are attempting to determine the modes of disintegration of atomic nuclei. Some physicists specialize in the study of the detection and measurement of nuclear radiations and of methods of protection against radiations from radioactive materials. Still other nuclear physicists are engaged in the study and measurement of isotopes and their applications in industry and in the fields of biology and medicine.

Classical and quantum theoretical physics.—These two broad areas of physics provide the theoretical basis for all the other branches of the science. Classical theoretical physics is the logical foundation for much of the subject matter of the "old" fields of physics—acoustics, optics, mechanics and heat. It is concerned with the concepts, laws, and advanced theories based upon Newtonian mechanics. Quantum theoretical physics (or quantum mechanics) is the basis of modern physics, including electronics and atomic and molecular, solid state, and nuclear physics.

The physicist who specializes in the theoretical aspects of the science uses as his basic tools a thorough understanding of physical principles and advanced mathematical methods. He often works closely with experimental physicists to assist them in planning experiments and interpreting the results. His work is designed to clarify the significance of experimental observations already made and, even more important, to point out the directions in which further progress can be made in the understanding of natural phenomena.

Related fields.—In addition to the areas of specialization which have developed within physics, a number of new disciplines have been built up in

Nuclear physicists adjusting the "doughnut" of the National Bureau of Standards' 180 million electron-volt synchroton



recent years on the borderline between physics and other sciences. Among these new areas of specialization are biophysics, geophysics, astrophysics, and chemical physics—which draw their methodology and subject matter in part from physics, and in part from biology, geology, astronomy, or chemistry. In its practical applications, physics also merges with engineering, and there is evidence of a growing demand on the part of employers, especially in private industry, for personnel with training in both disciplines.

Fields of Employment

Between 15,000 and 20,000 persons were employed as professional physicists in the United States in 1953. The largest number work for educational institutions and firms in private industry. Another large group (over 3,000 in 1951) are employed by government agencies. A few work for nonprofit foundations or are self-employed as independent consultants. Although most physicists work full-time for only one employer, many with regular teaching jobs do consulting or research work on a part-time basis for other organizations.

Private Industry

Physicists are employed in many different branches of manufacturing and in some nonmanufacturing industries. The companies employing them range in size from small laboratories with only a few technically trained persons and assistants on their staffs to giant corporations employing hundreds of physicists and thousands of other workers.

The industries which offer the most employment opportunities for physicists are indicated by a 1950 survey of industrial research laboratories conducted by the National Research Council.[3] One-fifth of the total of approximately 3,000 physicists covered by the survey were in laboratories owned and operated by the telephone and radio and television broadcasting industries (table 1). The next largest groups were in two major branches of manufacturing—the professional and scientific instruments and photographic equipment industries (13 percent) and the electrical equipment industry (12 percent). Independent consulting laboratories, which do research work on a contract basis for concerns in different industries, were also one of the major sources of employment for these physicists.

TABLE 1.—*Distribution by industry of physicists employed in industries research laboratories, 1950*

Industry	Number	Percent
Total	2,969	100.0
Mining	11	.4
Railroads	9	.3
Utilities	6	.2
Consulting laboratories	270	9.1
Trade associations	4	.1
Ordnance	112	3.8
Food products	10	.3
Textile mill products	29	1.0
Lumber and wood products	1	(1)
Furniture	1	(1)
Paper products	36	1.2
Printing and publishing	5	.2
Chemicals	216	7.3
Industrial inorganic and organic	124	4.2
Drugs and medicines	20	.7
Soaps, cleaners, textile auxiliaries	9	.3
Paints, varnishes, lacquers, and inorganic pigments	23	.8
Other chemical products	40	1.3
Petroleum and coal products	245	8.3
Rubber	82	2.8
Stone, clay, and glass	93	3.1
Primary metal industries	88	3.0
Fabricated metal products	27	.9
Machinery (not electrical)	144	4.9
Electrical equipment	344	11.6
Communications	615	20.7
Motor vehicles	66	2.2
Aircraft	124	4.2
Instruments	398	13.4
Scientific instruments	245	8.3
Photographic equipment	109	3.7
Other	44	1.5
Miscellaneous manufacturing	16	.5
Miscellaneous nonmanufacturing	17	.6

[1] Less than 0.05 percent.

Source: Research and Development Personnel in Industrial Laboratories—1950. Report of the National Academy of Sciences—National Research Council to the National Scientific Register, U. S. Office of Education, Federal Security Agency. (Scientific Manpower Series No. 1, May 1951.)

The 3,000 physicists covered by the National Research Council survey probably represented two-thirds to three-fourths of the total number employed in private industry. The survey did not cover all industrial research laboratories in the United States. Furthermore, although physicists in private industry work mainly in laboratories, some are employed in production plants and administrative offices.

[3] Research and Development Personnel in Industrial Laboratories—1950. Report of the National Academy of Sciences—National Research Council to the National Scientific Register, U. S. Office of Education, Federal Security Agency. (Scientific Manpower Series No. 1, May 1951.)

The variety of activities of physicists in private industry is indicated by data from the National Scientific Register survey already cited. About 72 percent of the physicists in manufacturing covered by this survey were engaged primarily in research and development work. Other functions performed by smaller numbers included management, design, inspection, and production (table 2).

In most companies, physicists are permanently assigned to the same type of activity. In some instances, however, the work is so organized that a physicist can follow the development of his own embryo idea to the completion of the final product. After spending some time in applied research, involving experiments supplemented by theoretical computations, he may supervise the preparation and testing of laboratory models and, later, the design and testing of working models. Thus, the scientist may have the satisfaction of seeing his research materialize in the production of a new item or the modification of an existing product.

While the work of individual physicists in private industry tends to be specialized, the specialties cover most of the branches of physics outlined in the previous section. For example, many of those in the communications and electrical equipment industries are specialists in electronics, concerned with research involving vacuum tubes for operation in all parts of the radio-frequency spectrum and for special functions. In both these industries, research regarding the application of electronics to nuclear physics is also in progress.

Solid-state physicists at the National Bureau of Standards use this specially designed apparatus in studying the internal friction of crystals.

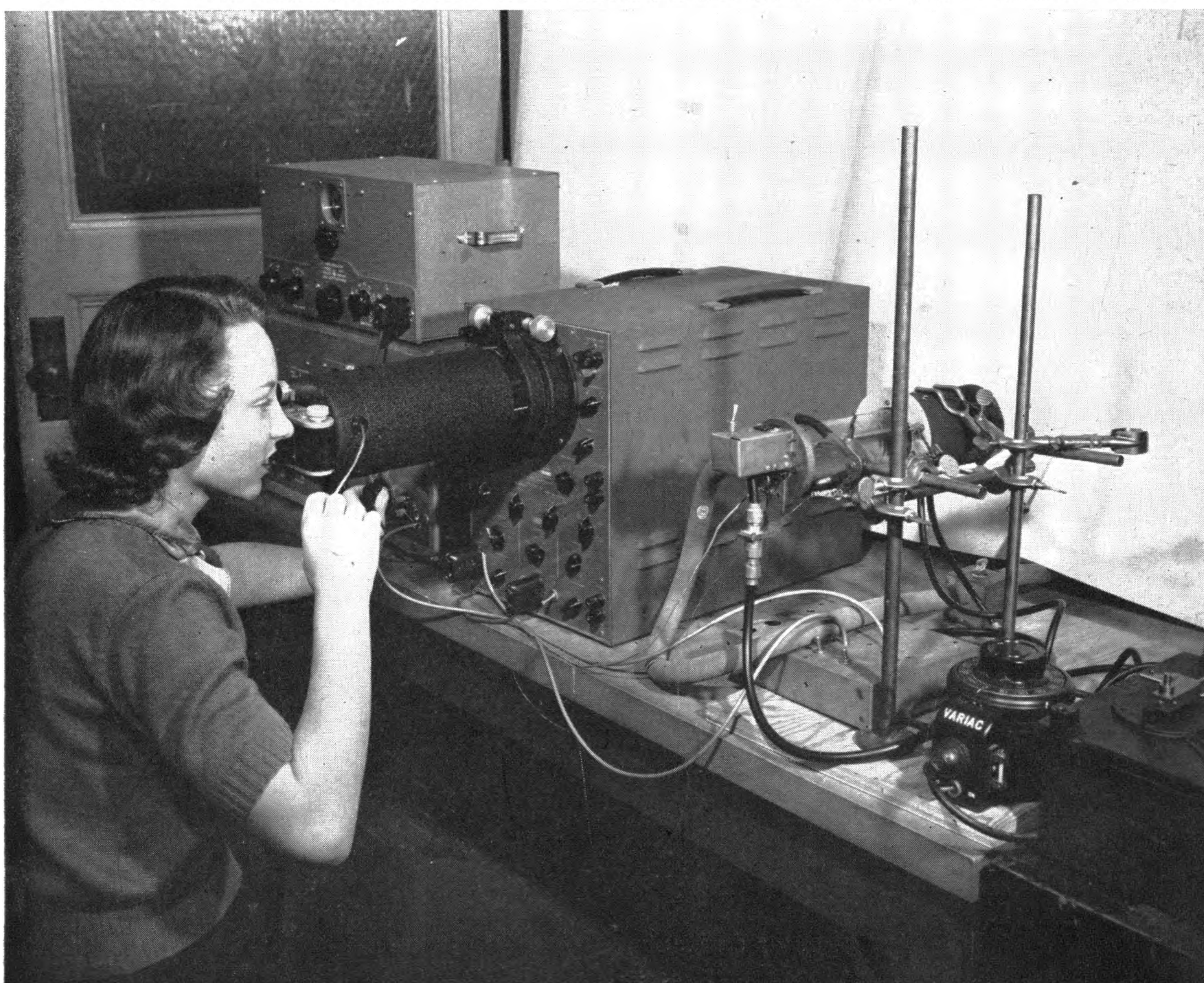


TABLE 2.—*Functions of physicists, by industry, 1951* [1]

Industry	All functions	Percent distribution								
		Research [2]	Consulting	Management	Teaching	Technical writing	Design	Inspection	Production	Technical sales
	Percent									
All industries	100.0	46.9	1.5	8.4	36.6	0.6	2.7	1.7	1.3	0.3
Manufacturing	100.0	71.6	1.3	12.1	.2	1.4	6.6	3.6	2.4	.8
Chemicals	100.0	70.4	2.1	12.0	1.4	1.4	4.9	6.4	.7	.7
Electrical machinery	100.0	73.4	1.5	13.3		.8	6.1	1.6	2.6	.7
Transportation equipment	100.0	73.5	.9	8.8	.9		6.2	6.2	3.5	
Professional, scientific equipment	100.0	54.7	2.1	18.2		1.2	13.8	4.7	2.9	2.4
Other manufacturing	100.0	79.1	.7	8.0	.2	2.3	3.4	3.9	2.1	.3
Transportation and communication	100.0	93.1	1.0	2.9			1.0	1.0	1.0	
Research and consulting services	100.0	69.8	9.8	13.2	.4		5.4	1.0	.4	
Educational institutions	100.0	18.9	.1	2.7	77.7	.1	.2	(3)	.3	
Government	100.0	70.7	3.1	16.6	2.2	.9	1.8	3.1	1.6	
Other industries, n. e. c.	100.0	40.4	3.8	23.1		3.8	3.8	7.7	11.6	5.8

[1] Covers 5,905 physicists reporting a function in the survey.
[2] Includes basic and applied research, and development.
[3] Less than 0.05 percent.

Source: Manpower Resources in Physics, 1951. A study conducted jointly by U. S. Department of Labor, Bureau of Labor Statistics and Federal Security Agency, Office of Education. (Scientific Manpower Series No. 3, published by National Scientific Register, January 1952.)

Firms manufacturing microphones, loudspeakers, sound recorders, and sound absorbers—for use in radio and television receivers, phonographs, and public address systems—utilize physicists to investigate acoustical problems and aid in the development and design of equipment. The optical goods industry, with products ranging from such simple items as eyeglasses to highly complicated microscopes, and the photographic equipment industry both employ large numbers of physicists to investigate complicated problems with respect to light, spectroscopy, and colorimetry. The many physical problems involved in chemical research have led to increasing utilization of physicists in the chemicals industries. For example, physicists work with chemists and chemical engineers in applied research regarding the action of resins in the manufacture of wet-strength paper or the protection of woolens against shrinkage.

Educational Institutions

Education is the second major field of employment for physicists. About one-third of all physicists in the country are employed by educational institutions, mainly colleges and universities.

Although most physicists on college and university staffs are employed primarily as teachers, some are engaged solely in research, on projects either set up independently by the college or contracted for by industry or government. Many do both teaching and research.

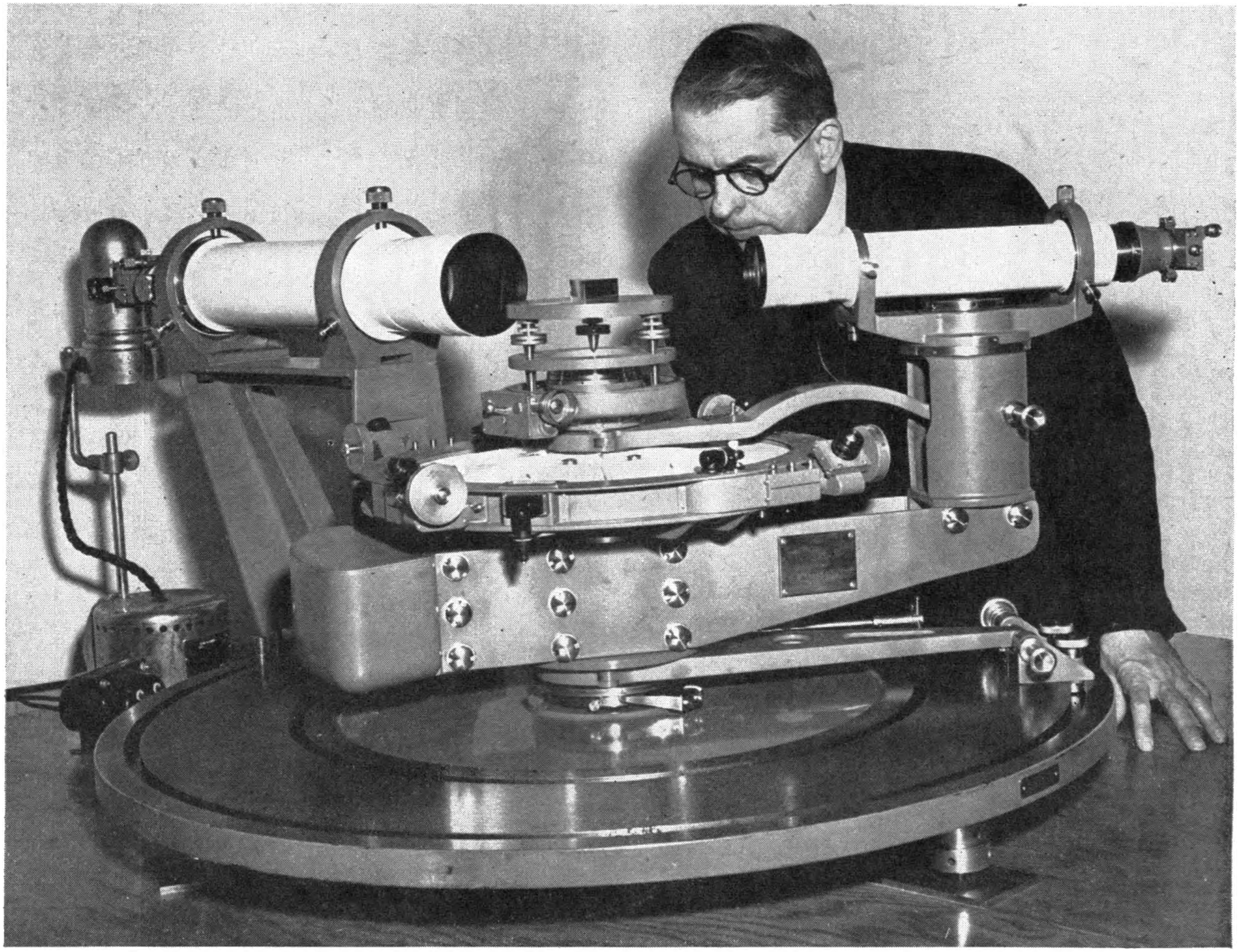
In large universities, instructors or assistants, who may be graduate students studying for advanced degrees, usually teach the elementary courses in physics. These junior faculty members also have such duties as conducting laboratory sessions and aiding faculty members of higher rank on research projects.

Generally, the teachers assigned to advanced courses have reached the rank of assistant, associate, or full professor. In addition to teaching, professors often conduct research projects in their fields of specialization and supervise instructors and assistants. Those who have reached the top rank often have administrative responsibilities. Many college faculty members also engage in outside activities, such as consulting and writing for technical journals.

Relatively few professional physicists are employed as science teachers in secondary schools.

Government

Most physicists working for government agencies are in the Federal service, although a few work for State governments. According to a survey by the United States Civil Service Commission, there were about 3,000 Federal employees in physicist positions as of June 30, 1951. In addition, many persons with training in physics were in related jobs, such as physical science administrator or electronic scientist. The Department of Defense (including the Departments of the Army, Navy, and Air Force) employed more than three-fourths of the persons in physicist positions. The agencies employing the next largest numbers were the Department of Commerce (mainly its National



A high-precision spectrometer used by specialists in optics to determine the refractive index of transparent materials.

Bureau of Standards), the Department of the Interior, and the Atomic Energy Commission.

In Federal agencies, as elsewhere, physicists carry on a wide variety of activities. The Department of Defense conducts research on extremely complex physical problems, including those of supersonic and high-altitude flight, the physics of the ocean, the detection of submarines and protection against torpedoes, and the physics of explosions and explosives, both chemical and nuclear. This research work is carried out in the various laboratories of the Departments of the Army, Navy, and Air Force, including the Naval Research Laboratory, the Navy Electronics Laboratory, the Ballistics Laboratories at Aberdeen Proving Ground, and the Wright-Patterson Air Force Laboratories.

The Atomic Energy Commission carries on most of the work in nuclear physics. It maintains seven major centers of research, which are administered either by universities or large companies. Although the AEC does not itself employ many physicists, these centers utilize a large number. Each laboratory has its own research and development program and offers extensive opportunities for pioneering work in physics.

The National Bureau of Standards of the U. S. Department of Commerce, in addition to carrying on a varied scientific program which is concerned with many branches of physics and their applications, develops and maintains the standards of measurement for the whole country. Another agency which has in recent years found need for physicists in some parts of its research programs is the Bureau of Agricultural and Industrial Chemistry of the Department of Agriculture.

Training Requirements

Persons interested in careers as physicists need at least a bachelor's degree with a major in physics and should, if possible, obtain graduate training. Doctoral degrees are required for many positions. Of the physicists included in the National Scientific Register survey, 45 percent held Ph. D. degrees and an additional 27 percent held master's degrees. However, the proportion of scientists with graduate training was probably somewhat higher among the physics society members in this survey than among all physicists in the country.[4]

Graduate training is of special importance for college teaching positions. Colleges and universities employed close to 60 percent of the Ph. D.'s in the National Scientific Register survey and nearly half of the holders of masters degrees, but fewer than a fifth of the scientists without graduate degrees. Private industry was the largest field of employment for physicists without advanced training, employing 52 percent of those with only bachelor's degrees and 67 percent of those who had not completed college. The proportion of the bachelors who were in Government employment was also relatively high (24 percent), but only 1 out of 10 Ph. D.'s and 1 out of 6 masters worked for the Government.

A starting position in a college or university may be obtained immediately after completion of graduate work or, in many instances, while the young physicist is still taking advanced training. A 1951 study indicated that, out of a total of 4,971 graduate students in physics, 1,118 were teaching assistants and 1,180 were research assistants.[5] An increasing number of institutions, especially those with outstanding graduate schools, will offer permanent faculty appointments only to individuals whose training includes several years or more of advanced study and research.

[4] The mailing list used in this survey was the membership list of the American Institute of Physics and its five founder societies. The fact that the AIP has drawn its membership to a considerable extent from college faculty members partly accounts for the relatively large proportion of Ph. D.'s in the survey.

[5] National Research Council, National Survey of Graduate Students in the Natural Sciences—November 1, 1951, mimeographed.

To qualify for a beginning position as Junior Scientist in the Federal Government, an applicant must have completed a 4-year course leading to a bachelor's degree or have an equivalent combination of education and experience. In either case, his college education must include at least 24 semester hours in physics. For positions of higher grade, there are progressive requirements with respect to experience, for which graduate work may be substituted in part.

The amount of training required for positions in private industry varies from one company to another, depending on the industry and type of activity in which the physicist will be engaged and also on company policy. Many companies prefer to hire only Ph. D.'s, since they recognize that the physical problems encountered in their operations are so complex as to require persons who have demonstrated their scientific ability by completing the most advanced graduate work. Others are willing to hire physicists either with or without graduate training if they believe them to have capacity for growth and future attainment. Some firms actively seek new graduates with only bachelor's degrees, desiring to train them in their own programs. However, in the great majority of companies, new entrants with Ph. D.'s are likely to have greater opportunity to do advanced research than those with less academic preparation. Also, in deciding the level of position for which an employee can qualify, most companies regard graduate training as equivalent to a certain amount of work experience.

Well over 500 institutions of higher education offer an undergraduate major in physics. However, relatively few offer graduate training. Approximately 150 schools give training leading to the master's degree in physics and only about 75 have Ph. D. programs.

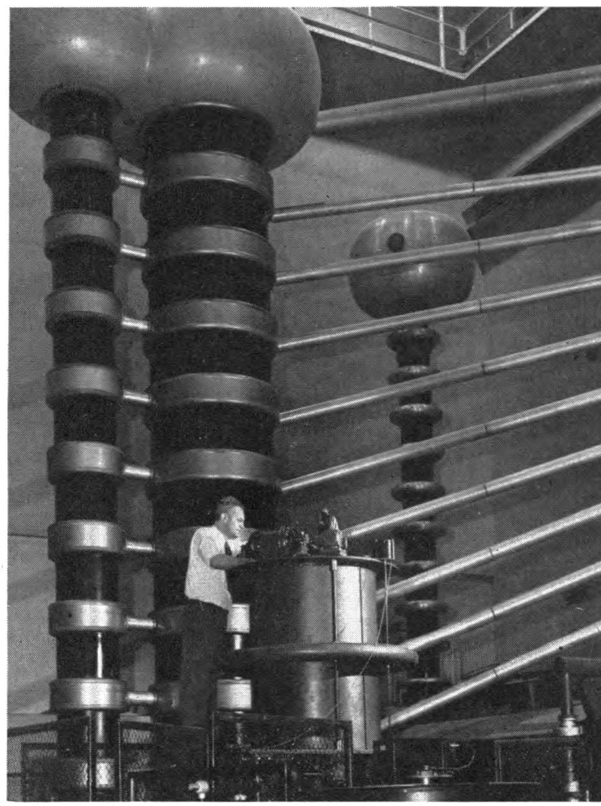
Most students taking undergraduate majors in physics do so in a department of physics of a college or university. However, a physics major is offered also as part of the general engineering curriculum in many engineering schools. In addition, about 50 engineering schools have set up an engineering physics or industrial physics curriculum leading to a bachelor's degree, and the number offering this training in "applied physics in an engineering atmosphere" is increasing. The approaches of applied physics are like those of pure physics, but the subject matter is chosen primarily on the basis of practical usefulness rather than of conceptual or analytical significance. A few schools are developing graduate as well as undergraduate programs in applied physics. Many industrial firms are interested in obtaining personnel with this synthesis of physics and engineering training.

A few schools have set up undergraduate programs in electronics, designed to prepare students to go directly into work in electronics at the completion of their undergraduate training. Manufacturers of electronics equipment report that persons with such training can be employed in jobs similar to those held by electrical or electronic engineers.

Course requirements for a bachelor's degree in physics differ considerably among the hundreds of institutions granting such degrees. A typical program meeting the credit requirements for entrance to most graduate schools would require that between one-fourth and one-third of the total semester hours of undergraduate work be in physics courses. At least another fourth of the semester hours would be in such subjects as mathematics (including calculus) and chemistry. Courses in French or German should be taken for competence in reading foreign technical papers.

The undergraduate student first receives training in general physics, designed to give him a well-rounded background in the fundamentals of the science. These general courses usually cover the basic principles of mechanics, heat, sound, light, electricity, and magnetism. Later, advanced courses are taken which provide further training in the above subjects as well as an introduction to the more recently developed areas of the science, such as electronics and atomic and nuclear physics.

For admission to graduate school, an applicant must meet requirements with respect to undergraduate training in physics and related subjects, must have maintained a high scholastic standing as an undergraduate, and must provide other evidence of his intellectual attainment, scientific "bent," and capacity for study and research. In most graduate schools, a minimum of 1 year's study, with at least half the work in physics, is required for a master's degree. Examples of the subjects of graduate courses, many of which include extensive laboratory work, are atomic structure, X-ray and crystal structure, thermodynamics, nuclear physics, cosmic rays, and theoretical physics. Some institutions require a thesis for a master's degree; others give a comprehensive examination covering all branches of physics. In a few institutions, candidates for the M. S. degree have to prepare a thesis and also pass a comprehensive examination.



Physicist making adjustments on high-voltage X-ray generating equipment, the largest of its kind in the world. This installation at the National Bureau of Standards is used in X-ray research, development and testing.

It takes at least 3 years of graduate study and usually longer to earn a Ph. D. degree in physics. Every candidate must be able to read two foreign languages, generally French and German. He must have a wide and thorough knowledge of many branches of physics and related sciences and demonstrate this by passing comprehensive examinations. He must also prepare a dissertation which shows his ability to do exhaustive, independent research of an original nature.

The current emphasis on nuclear physics is reflected in the large proportion of graduate students specializing in this branch of the science. The National Scientific Register survey included 1,300 graduate students of physics, about one-fourth of the total number in the country in early 1951. One out of every 4 of these graduate students cited nuclear physics as his first specialty, despite the fact that a substantial proportion (36 percent) had not advanced far enough in their studies to specialize in any one branch of physics. Electronics, which was the students' second most frequent field of specialization, was cited by only 9 percent. The following figures show the proportion of students specializing in each of the major branches of physics.[6]

Field of highest competence	*Percent*
Total	100.0
Physics, general	36.4
Nuclear physics	23.4
Electronics	9.1
Quantum theory	8.8
Solid state	4.6
Optics	4.4
Atomic and molecular physics	4.0
Classical theory	3.6
Mechanics and heat	2.5
Acoustics	2.1
Other physics specialties	1.1

[6] Manpower Resources in Physics, op. cit., page 25.

Employment Outlook

A shortage of physicists, especially of those with advanced training, existed in mid-1953, primarily because of the defense program. Resources of trained personnel in this expanding profession were insufficient to meet the demand even before the current defense program began. In all probability, the demand for physicists with graduate training or professional experience will remain at a high level for sometime, and there will continue to be an active demand for those with only undergraduate training. However, it should be noted that employment opportunities in this profession depend to a great extent on the level of expenditures for research and development, primarily those made by the Federal Government and private industry.

The shortage of personnel will probably be much more acute in some branches of physics than in others and some areas of employment, including atomic energy programs and other work directly connected with defense activities, will offer more opportunities than others.

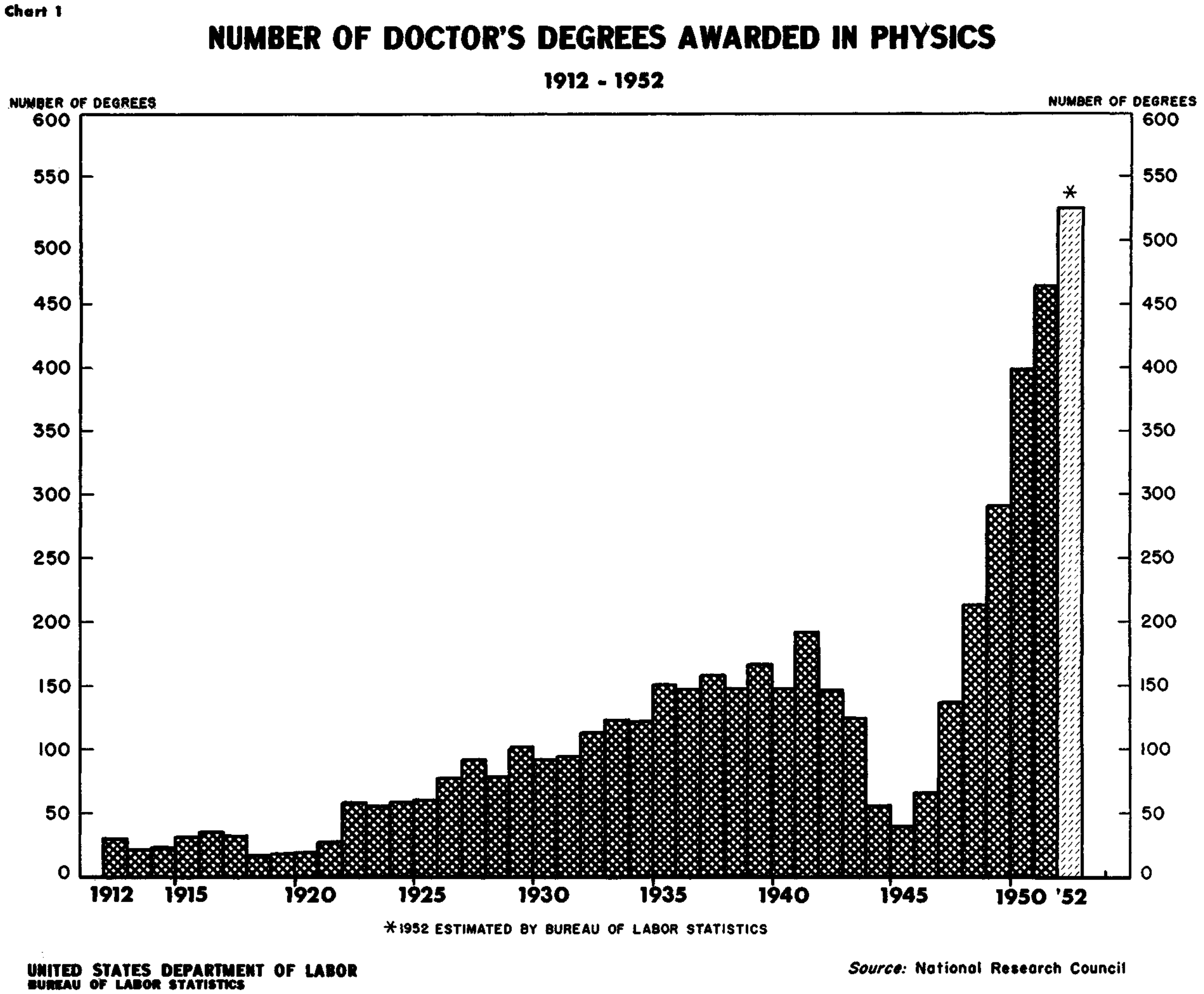
Past Growth of the Profession

Before World War II, physics was a small though rapidly growing science. Physicists were employed largely in colleges and universities, although during the 1930's expanding industrial laboratories began to employ an increasing number. The war gave tremendous impetus to research in physics and to the employment of physicists, much like the stimulus which World War I gave to the development of chemistry. It led to a great growth in nuclear physics, electronics, and other "new" fields of the science. Since this recent expansion in the profession has been mostly in the realm of applied physics, it has meant a change in the pattern of employment—the growth of employment opportunities for physicists in laboratories operated by private industry and Government agencies.

The growth which has taken place in the profession is indicated by several types of data. The number of doctoral degrees awarded yearly in physics has risen steadily since the early 1900's, except for interruptions during the two World Wars (chart 1). The rise was from 30 doctorates awarded in 1912 to 148 in 1940, 399 in 1950, and an estimated 525 in 1952. Though the numbers of doctorates granted yearly in other sciences have risen also, the gain in most of these fields has not been as rapid as that in physics. Between 1940 and 1950, for example, the increase in doctorates awarded was 158 percent in physics, compared with only 124 percent in all physical sciences (physics, chemistry, geology, etc.) and only 88 percent in all natural sciences taken together.

Figures on the membership of a professional society over a period of years give a rough indica-

Chart 1



tion of the trend of employment in the profession. As chart 2 shows, most of the leading organizations of physicists have had a steady rise in membership, particularly in the last 5 years. It should be borne in mind in interpreting this chart that many physicists belong to more than one society, and that there are still a considerable number who are not affiliated with any professional organization.

Another indication of the rapid growth of physics in recent years is the increase in the number of physicists in industrial laboratories (table 3). Between 1938 and 1950, employment of physicists in such laboratories increased faster than that of any other professional group for which information is available, with the exception of engineers.

In the Federal Government, employment of physicists nearly doubled between 1937 and 1951, owing in part to the defense program initiated after the outbreak of hostilities in Korea.

Prospective Demand for Physicists

Expenditures for research and development work have been mainly responsible for the expansion in employment of physicists and will have a great influence on future employment trends in the profession. The Nation spent $3.75 billion for research and development in all fields of science and engineering during 1952.[7] This compared

[7] All figures on spending for research and development refer to operating expenditures only. They exclude capital expenditures for both plant and equipment.

TABLE 3.—*Numbers of engineers and scientists employed by industrial research laboratories in selected years, 1938–50*

Occupation	1950	1946	1940	1938	Percent change 1938–50
Total professional personnel	70,577	54,009	34,809	23,236	+203.7
Chemists	23,159	20,783	11,755	7,328	+216.0
Physicists	2,969	2,660	1,423	797	+272.5
Metallurgists	2,673	2,364	2,003	968	+176.1
Engineers	35,601	20,637	12,711	6,633	+436.1
Biologists	1,670	1,659	944	557	+199.8
Other professional scientists	4,505	5,906	5,972	6,953	−35.2
Number of reporting organizations [1]	2,795	(2)	2,264	1,769	+58.0

[1] The increase in the number of organizations was due not only to better coverage of the Nation's research and development laboratories but also to the increase in the total number of laboratories in the country.
[2] Not available.

Source: National Research Council.

with an expenditure of only $900 million in 1941.

Three-fifths of the research and development funds expended during 1952 (over $2 billion) came from the Federal Government. Private industry contributed close to two-fifths of the total sum; colleges, universities, and other nonprofit institutions and organizations, only about 2 percent. The substantial increase since 1941 in the expenditures from each of these sources are shown in table 4. Expenditures by the Federal Government have risen more than those from other sources—by over one-third between 1950 and 1952 and sixfold from 1941 to 1952.

It is obviously impossible to predict with any exactness the future level of research and development activity, which will depend in large measure on the nature of the defense program and on the appropriations made available by Congress. Nevertheless, in view of the long period of defense mobilization which appears to lie ahead, it is probable that expenditures for this purpose will remain high for sometime. In a period of partial mobilization such as the present, there is inevitably great emphasis on continued, rapid technological advances. Physicists have been and will be called on to play a great part in this work. It is probable that expenditures for research in physics have increased at an even more rapid rate than total expenditures for research and development. In all likelihood, they will continue to do so.

Private Industry.—More physicists were employed in private industry in 1952 and early 1953 than at any previous time, and the number is expected to increase further over the long run.

Approximately two-thirds of the total national expenditure for research and development during 1952 was for work performed in laboratories and other facilities owned or operated by private industry. Although much of this private research work was financed by the Federal Government, more than half was supported by industry itself. As already indicated, federally financed programs are likely to stay at a high level for some time. Those supported from private funds are also likely to remain large and may expand over the long run.

Up to the present time, industrial research personnel have been concentrated in a relatively small number of large research organizations. According to a recent survey made by the Research and Development Board of the U. S. Department of Defense and analyzed by the Bureau of Labor

TABLE 4.—*Research and development expenditures in the United States, 1941–52*

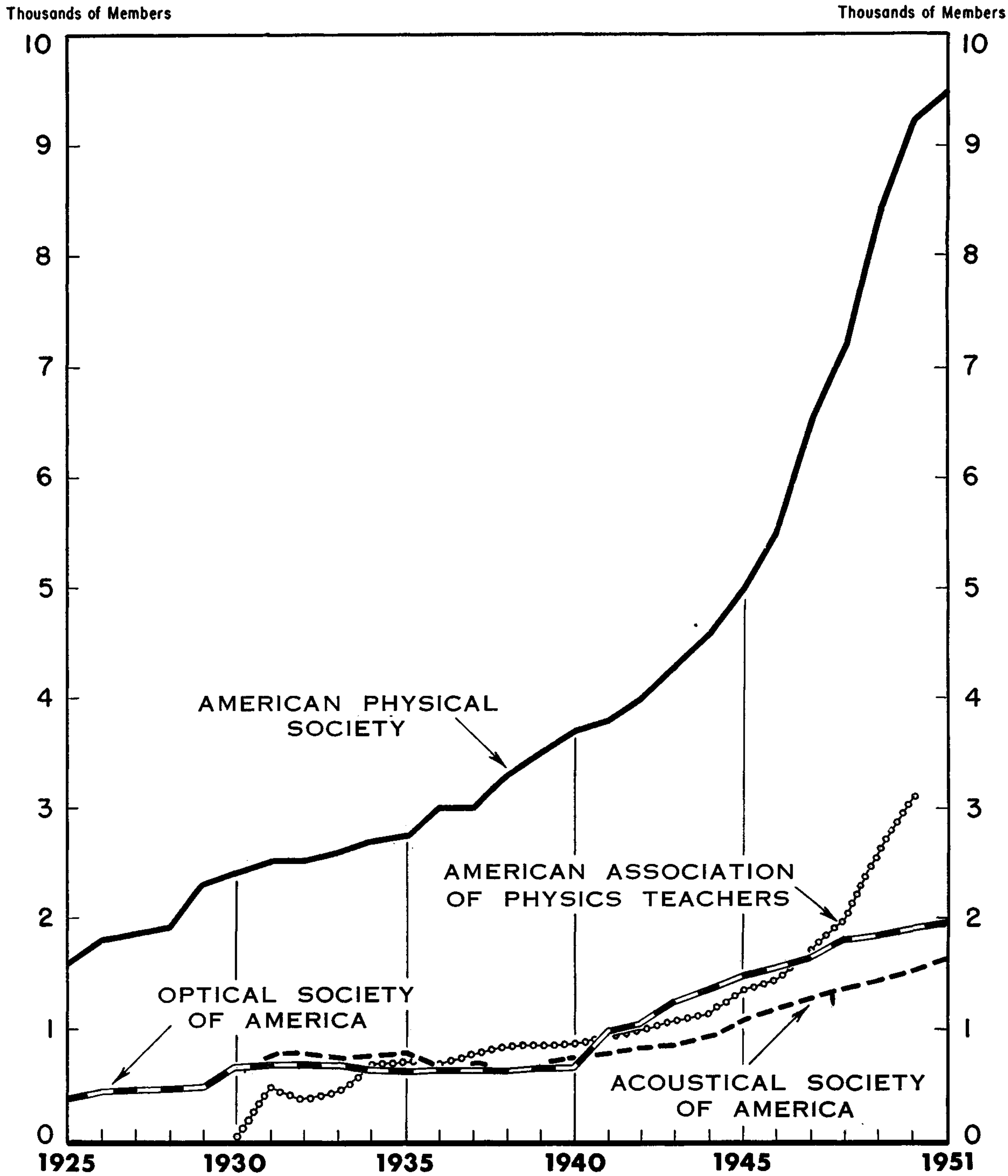
[*In millions*]

Year	Amount expended by—				Cost of research performed by—			
	All sources	Government	Private industry	Educational and other nonprofit institutions	All sources	Government	Private industry	Educational and other nonprofit institutions
1941	$900	$370	$510	$20	$900	$200	$660	$40
1942	1,070	490	560	20	1,070	240	780	50
1943	1,210	780	410	20	1,210	300	850	60
1944	1,380	940	420	20	1,380	390	910	80
1945	1,520	1,070	430	20	1,520	430	990	100
1946	1,780	910	840	30	1,780	470	1,190	120
1947	2,260	1,160	1,050	50	2,260	520	1,570	170
1948	2,610	1,390	1,150	70	2,610	570	1,820	220
1949	2,610	1,550	990	70	2,610	550	1,790	270
1950	2,870	1,610	1,180	80	2,870	570	1,980	320
1951	3,360	1,980	1,300	80	3,360	700	2,300	360
1952	3,750	2,240	1,430	80	3,750	800	2,530	420

Source: U. S. Department of Defense, Research and Development Board.

Chart 2

GROWTH IN MEMBERSHIP OF PROFESSIONAL SOCIETIES IN FIELD OF PHYSICS



UNITED STATES DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS

Sources: The Societies and the World Almanac

Statistics, nearly 40 percent of all engineers and scientists employed in industrial research and development at the beginning of 1952 worked for companies (only 44 out of the 1,953 in the survey) which had at least 25,000 employees.[8] There are thousands of industrial concerns which have not as yet established formal research and development programs, but more and more companies are setting up such programs or using the services of scientific consulting firms.

Furthermore, many companies currently engaged in research and development are increasing their expenditures for this activity. A National Industrial Conference Board survey of 107 firms showed an increase in research spending during 1951 and 1952. The results of the survey also suggested that the upward trend would continue in 1953. Nearly two-thirds of the firms cooperating in the survey stated that their research and development expenditures in 1953 would equal or exceed the amount spent in 1952.[9]

Over the long run, industry's expenditures for research and development will probably have a continuing upward trend. Forward-looking companies are aware of the contribution that research can make to their growth and to their success in keeping abreast of the advances made by their competitors. Because of continually advancing technology and the changing demands of consumers, newly developed products often become obsolete within a few years. Furthermore, the increasing complexity of industrial technology is creating an increasing need for physicists (as for engineers and other scientists) in production and other nonresearch activities. It thus appears that employment of physicists in private industry will grow at least as fast as total expenditures for and employment in research and development work.

For positions in industrial research laboratories, physicists with graduate training or equivalent experience will be in greatest demand. However, opportunities for physicists without advanced degrees are likely to expand also. Those with only bachelor's degrees have been found to be valuable in positions involving mainly design, inspection, or production work and as assistants to more experienced scientists. In addition, as pointed out previously, some firms are finding that new physics graduates, particularly those who have taken courses in applied physics, can handle various types of engineering work.

Educational institutions.—In the next few years, employment of physicists in educational institutions is expected to remain near the 1952–53 level. Nevertheless, colleges and universities will have a considerable number of openings for physicists each year, to replace those who die, retire, transfer to other civilian jobs, or enter the Armed Forces.

College enrollments will, for a number of years, remain below the postwar peak reached in 1949–50, when enrollment of veterans was highest. The total number of students dropped about 15 percent between the fall of 1949 and the fall of 1951 and then rose slightly in 1952, mainly as a result of a 15 percent gain in first-year students. During the next few years, the college-age population will increase slowly. However, college enrollments will be greatly influenced also by selective-service regulations, the amount of aid given to veterans, and other Government policies affecting college attendance of young men.

University laboratories are among the foremost centers of basic research and, in recent years, have undertaken an increasing amount of applied research and development work as well. Much of their work is done on contract with Government agencies and private industry; colleges and universities themselves financed only about one-fifth of their 1952 research and development effort (table 4). A substantial part of all Government-sponsored university research is in physics and related specialties.[10] In all probability, research in this science in university laboratories will continue to receive substantial support from Government agencies and private industry, and will continue to employ sizable numbers of physicists.

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[8] U. S. Department of Labor, Bureau of Labor Statistics, Bulletin No. 1148, *Scientific Research and Development in American Industry—A Study of Manpower and Costs.*

[9] National Industrial Conference Board, *The Conference Board Business Record,* February 1953. Pp. 82–87.

[10] "Research in physics, not including electronics, accounts for nearly 20 percent of all Government-sponsored research in the engineering and physical sciences in American colleges and universities. . . . Electronics, much of which represents the work of physics faculty members, accounts for another 10 percent of the total." Mattill, John I., "College and University Research in Physics." In *Physics Today,* September 1952 (pp. 14–18).

In the late 1950's, college enrollments will rise rapidly, as the large numbers of children born during World War II begin to reach college age. Enrollments in science courses are expected to increase at least as rapidly as total enrollments. By 1960, the number of physics majors will probably surpass the 1950 peak. In view of this expected rise in enrollments and the likelihood that colleges and universities will continue to play an important part in the Nation's research activities, these institutions should offer expanding employment opportunities for physicists over the long run.

Government.—Employment of physicists in the Federal Government is expected to remain relatively high for a number of years.

Government laboratories carry on a variety of scientific activities, important to the national defense and the general health and welfare, in which physicists have a key role (see p. 9).

Two outstanding examples are the aeronautical research and atomic energy programs. The Federal program of aeronautical research and development, which has been greatly accelerated since mid-1950, involves the solution of complex problems in applied science. This, in turn, depends on advances in basic physics. Among the branches of the science in which advances are needed are solid state physics, heat, and acoustics. Rapid engineering progress results from the resolution of engineering problems into their component physical subproblems, which are attacked by the methods of the physicists. Another contribution of physicists to aeronautical research is the development of new tools of measurement to accomplish tasks in applied research which otherwise could not be successfully carried out.

The atomic energy program was initiated in large measure by physicists, and its future progress will be closely related to advances in physics. However, the number of physicists employed directly by the Atomic Energy Commission is small. The physicists on the Commission's payroll are engaged mainly in administering the manifold research activities carried out by the industrial concerns and universities holding contracts with the Atomic Energy Commission. During 1951–52, the total cost of the Atomic Energy Commission's research program in physics was $17½ million.

Prospective Supply of Physicists

Even before the outbreak of hostilities in Korea, additional personnel were needed in physics. Since that time the shortage of trained physicists has been greatly intensified.

Employers have had most difficulty in recruiting scientists with advanced degrees, considerable experience, or a combination of both. In addition, companies seeking recent graduates with bachelor's degrees for entry jobs in physics have met keen competition from other employers, including companies seeking such graduates for engineering and related jobs. Specialties in which the shortage of personnel has been particularly acute include nuclear physics, electronics, solid state physics, and certain branches of mechanics.

The current shortage of physics personnel has developed in the face of record graduations during the late 1940's and early 1950's. The number of bachelor's degrees awarded in physics set new records after the war, reaching a peak of 3,414 in 1949–50, when most veterans graduated (table 5). Since then graduations have decreased, reflecting the drop in enrollments (see p. 18), and will continue to decrease for another few years. After the middle of the decade, graduations will begin to rise again. By the early 1960's, the number of bachelor's degrees awarded yearly should again reach the peak levels of 1949 and 1950.

The numbers of students awarded graduate degrees reflect, a few years later (allowing for the time required for graduate study), the changes in the numbers receiving bachelor's degrees. Thus, the master's degrees granted in physics continued to increase until 1951, declined between 1951 and 1952, and will probably decrease further for several years. The number of physics doctorates continued to rise through 1952 and may remain at peak levels for a year or two longer. Thereafter, they are expected to decline.

These conclusions regarding future trends in graduations do not allow for several factors which may affect college attendance in this partial mobilization period. The decrease in graduations expected in the next few years may be aggravated by withdrawals of students for military service, although up to mid-1953, selective-service policies had allowed the deferment of all qualified graduate students and many undergraduates. Defer-

TABLE 5.—*Earned degrees in physics conferred by institutions of higher education, by type of degree, 1947–48 to 1951–52*

Year	Bachelor's degree			Master's degree			Doctor's degree		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
1947–48	2, 126	1, 962	164	706	663	43	198	192	6
1948–49	2, 828	2, 645	183	841	798	43	266	259	7
1949–50	3, 414	3, 287	127	922	888	34	358	353	5
1950–51	2, 788	2, 671	117	973	934	39	443	435	8
1951–52	2, 247	2, 141	106	886	851	35	485	476	9

[1] The questionnaires used in obtaining these figures are in most cases filled out by an official such as the registrar, rather than by the departments involved. Also, the definition of a major in a specific field varies by school. These factors probably result in underenumeration of degrees in certain fields and in understatement of the number of schools granting such degrees; some overenumeration in certain other fields is also known to exist. Other surveys of training in physics made on a different basis have yielded different figures on schools awarding degrees and total numbers of degrees. (See M. W. White, "Enrollments and Degrees Awarded to Physics Majors," *American Journal of Physics*, January 1951.)

Source: Annual surveys of earned degrees conferred by institutions of higher education made by United States Office of Education.

ment of undergraduate students is allowed under two standards: class standing and grade achieved in the selective-service qualification test. Information from a 10-percent sample survey of all students tested in the spring and summer of 1951 indicated that the proportion of students qualifying for deferment under these two standards was greatest in scientific and technical fields. Also, many fellowships and scholarships will be provided by the National Science Foundation, other Government agencies, private organizations, and schools themselves. Thus, it is expected that, in the near future, science enrollments will hold up better than total college enrollments.

In conclusion, the supply-and-demand situation may be summed up as follows. The demand for trained physicists will probably continue at a high level for an indefinite period. Furthermore, the supply of qualified personnel was insufficient in mid-1953 to meet the need, and decreasing numbers of new graduates are expected in the next several years. Toward the end of the decade, the number of bachelor's degrees awarded will be rising sharply again, but the new upturn in numbers of graduate degrees will probably lag several years behind that in bachelor's degrees. The outlook for physicists with graduate degrees or experience is therefore excellent. In most fields of specialization, there will be many opportunities for those with only undergraduate training for a number of years at least.

Earnings

The median professional income of physicists included in the National Scientific Register survey was about $6,100 a year in early 1951.[11] Three-fourths of these scientists earned over $4,600, and one-fourth made over $8,000. These figures represent total professional income, including consulting fees, royalties, and other supplementary professional earnings, as well as salaries.

During the 2 years since that survey was conducted, earnings have had a general upward trend in the United States. On the other hand, the men surveyed probably had a somewhat higher average income than all physicists in the country. The proportion of physicists with doctorates was much higher among the surveyed scientists than among all members of the profession, and Ph.D.'s tend to have higher incomes than persons with less academic training, as shown by the following figures for physicists at different levels of education from the same survey:

Highest degree held	*Median income*
Ph.D	$7, 100
Master's degree	5, 300
Bachelor's degree	5, 100

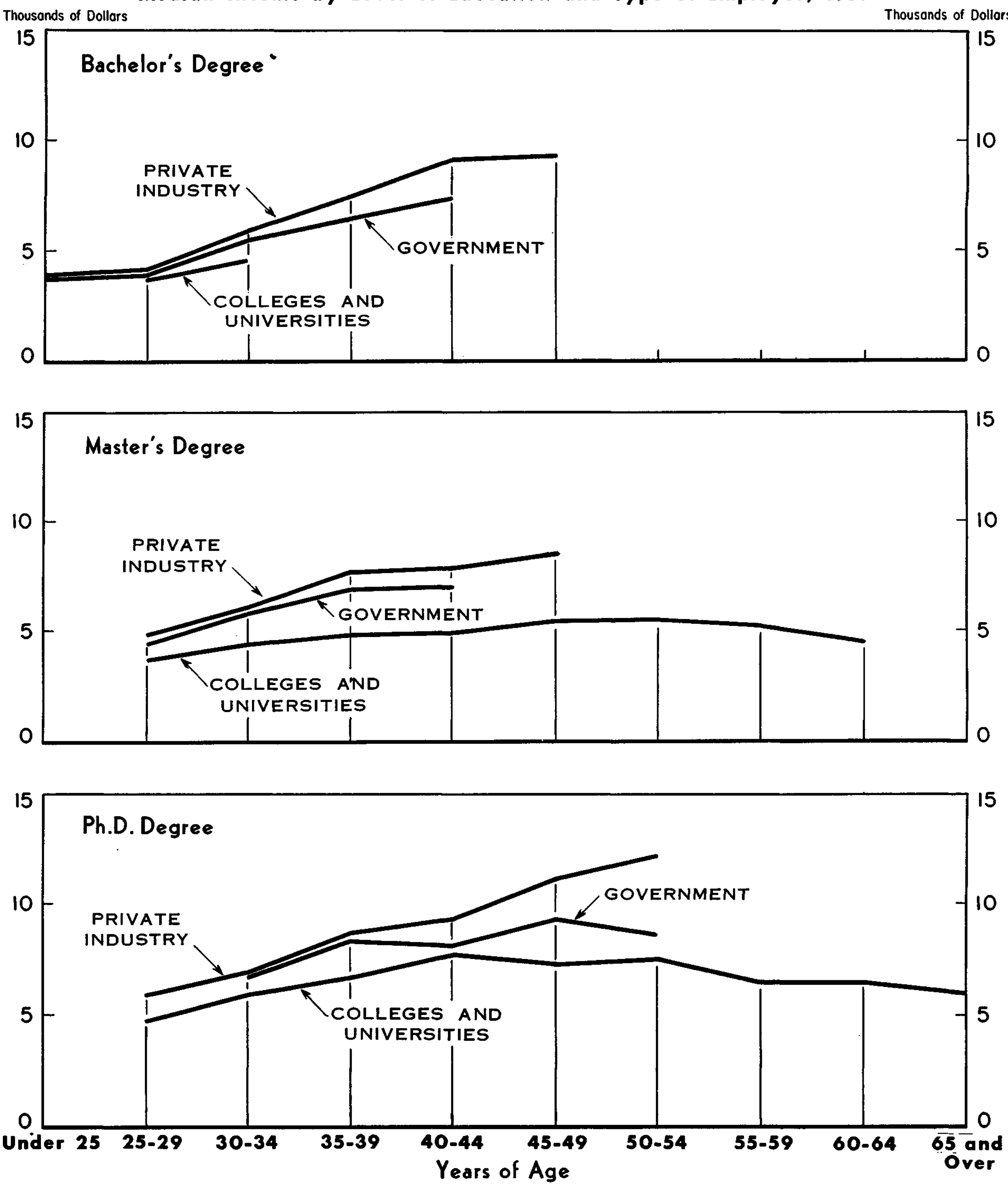
The median income figure of $7,100 for Ph. D.'s is believed to be fairly representative of the 1951 income level of all physicists with doctorates, since most such physicists were included in the study. Similarly, the income figure for men with master's degrees can be regarded as generally indicative of

[11] Manpower Resources in Physics, *op. cit.*, p. 18.

Chart 3

PH. D., M. S., AND B. S. PHYSICISTS ALL HAVE HIGHER INCOMES IN PRIVATE INDUSTRY THAN IN OTHER TYPES OF EMPLOYMENT

Median Income by Level of Education and Type of Employer, 1951



UNITED STATES DEPARTMENT OF LABOR
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Source: Manpower Resources in Physics, page 46 the income level of such scientists at the time of the survey. However, the relatively small group of bachelors in the survey probably had higher average earnings than all members of the profession with only B. S. degrees, because the mailing list used in sending out questionnaires was the membership list of the American Institute of Physics and men in comparatively low-paid junior positions less often join professional societies than those receiving higher salaries.

In physics, as in other professions, earnings tend to increase with age and experience. The physicists under 25 years of age in the NSR survey had a median yearly professional income of only $3,700. Each succeeding age group had higher median earnings, up to a peak of $8,000 a year for physicists between 45 and 50. In the still older age groups, earnings dropped—to a median of $6,300 a year for the scientists aged 65 or over.

Physicists in private industry are likely to earn more than those employed in Government agencies or as members of college and university faculties. The physicists in the survey who were working in private industry, either as salaried employees or as self-employed consultants, had a median annual income of $7,000, compared with one of $6,300 for the Government employees and $5,600 for those in educational institutions.

Starting salaries were about the same in each of the three major fields of employment (chart 3). The young physicists under 25 years of age had a median income of $3,600 in both education and Government, and of $3,900 in private industry. The differences in average income among scientists in different types of employment were much greater in the older age groups, however. For physicists aged 50–54 years, for example, the survey showed a median income of $11,700 in private industry, compared with $8,100 in Government and $6,700 in colleges and universities. Many scientists in private business can eventually command incomes beyond the rosiest expectations of those on college faculties or in Government service, where ceilings on salaries are lower and more rigid than in private industry.

Salaries in the Federal civil service are fixed by law. Positions are graded according to the amount of skill and responsibility involved in the work, and minimum and maximum salaries are specified for each grade. A new employee usually starts at the minimum salary for his grade and receives increases at regular intervals, up to the specified maximum salary, provided that his work is satisfactory.

New graduates with the bachelor's degree appointed to professional positions usually begin at a yearly salary of $3,410; those with a master's degree (or a baccalaureate and 1 year of qualifying experience), at $4,205; and those with a doctor's degree (or an equivalent combination of education and experience), at $5,060. Table 6 shows the number of physicists employed by Federal agencies in mid-1951 in each grade of position, with the salary range for the grade.

TABLE 6.—*Distribution of physicists employed by the Federal Government by salary range and grade, June 30, 1951* [1]

Salary range and grade	Number	Percent distribution
Total, all grades	[2] 3,058	100.0
$3,410 to $4,160 (GS-5)	708	23.1
$4,205 to $4,955 (GS-7)	601	19.7
$5,060 to $5,810 (GS-9)	455	14.9
$5,940 to $6,940 (GS-11)	447	14.6
$7,040 to $8,040 (GS-12)	385	12.6
$8,360 to $9,360 (GS-13)	277	9.1
$9,600 to $10,600 (GS-14)	134	4.4
$10,800 to $11,800 (GS-15)	47	1.5
$12,000 to $12,800 (GS-16)	3	.1
$13,000 to $13,800 (GS-17)	1	(3)

1 Although the distribution of physicists is of June 30, 1951, the salary range shown actually went into effect the following month—July 1951.
2 Excludes 9 physicists employed at grades 6, 8, and 10.
3 Less than 0.05 percent.

Source: U. S. Department of Labor, Bureau of Labor Statistics, Federal White-Collar Workers, Their Occupations and Salaries, June 1951, Bulletin No. 1117. In cooperation with the United States Civil Service Commission.

Appendix

List of Physics Specializations [1]

Physics (general) [2]

Theoretical physics (classical)
- Electromagnetism
- Analytical mechanics (including elasticity, etc.)
- Fluid dynamics
- Statistics (including random processes, information theory)
- Other

Theoretical physics (quantum)
- Nuclear
- Atomic
- Solids
- Field
- Other

Mechanics and heat
- Aerodynamics (including supersonics)
- Hydrodynamics
- Terminal ballistics, explosions, shock waves
- Interior ballistics, jets, rockets, etc.
- Flight of missiles
- High pressure phenomena
- Rheology
- Cryogenics
- High temperature phenomena
- Heat radiation and transmission
- Other

Optics
- Physical optics
- Optical instruments (including instrument design)
- Physiological and psychological optics
- Photography
- Photometry
- Spectroscopy
- Colorimetry
- Photoelectric phenomena
- Other

Acoustics
- Architectural acoustics
- Noise and vibrations
- Audio communications acoustics
- Physiological and psychological acoustics
- Underwater sound
- Ultrasonics
- Acoustical instruments
- Other

Electronics
- Microwaves
- Circuits
- Physical electronics
- Communication
- Telemetering
- Antennae and transmission lines
- Propagation of radio waves
- Fluorescent materials
- Electron dynamics
- Tubes
- Other

Atomic and molecular phenomena
- Spectrographics
- Isotopes (measurement and separation)
- X-rays
- Other

Solid state
- Physics of metals
- Semiconductors
- Crystals
- Dielectrics (including fluids)
- Magnetism
- Piezo electricity
- Instrumentation
- Other

Nuclear physics
- Particle accelerators
- Instrumentation
- Reactors
- Particle interactions
- Nuclear reactions
- Neutron physics
- Radioactivity
- Nuclear structure, properties
- Cosmic rays—high energy processes
- Other

Other specialties
- Instrumental measurement and control
- Servo-mechanisms
- Health physics
- Astrophysics
- Other

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[1] Developed by the National Scientific Register.

[2] Only those physicists whose experience is not specialized are classified in this category.

Where To Get Additional Information

Additional information on the physics profession may be obtained from:

American Institute of Physics
57 East 55th Street
New York 22, N. Y.

This organization serves as a clearinghouse for the profession and also maintains a placement service for its members. A booklet, *Physics As A Career*, containing information on the profession and the opportunities it offers, has been published by the Institute and may be obtained from its headquarters in New York. In addition, the Institute publishes a monthly journal, *Physics Today*, which often contains articles of interest to persons considering a career in physics. This publication is available in many libraries or may be obtained from the Institute.

The member societies of the American Institute of Physics and the names of the technical journals published by them and by the Institute are:

Acoustical Society	—The Journal of the Acoustical Society of America
American Association of Physics Teachers	—American Journal of Physics
American Physical Society	—Reviews of Modern Physics —Physical Review
Optical Society of America	—Journal of the Optical Society of America
Society of Rheology	—No publication
American Institute of Physics	—Journal of Applied Physics —Physics Today —The Journal of Chemical Physics —The Review of Scientific Instruments

Announcements of examinations for physics positions with the Federal Government are available from the United States Civil Service Commission, Washington 25, D. C., or its 12 regional offices, and are posted in all first- and second-class post offices. The Civil Service Commission has also recently published a bulletin entitled *The Physicist in the Federal Service* (Pamphlet No. 43). This bulletin describes the work of physicists in Federal agencies and gives information on requirements for positions, as well as general information about the Federal Civil Service system. It may be obtained upon request from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 30 cents.

Occupational Outlook Publications of the Bureau of Labor Statistics*

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

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

Occupational Outlook Handbook

Employment Information on Major Occupations for Use in Guidance.
Bulletin No. 998 (1951 Revised Edition). Illus. $3.

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