Shall I Choose . . . ENGINEERING?

Shall I Choose Engineering?

By

H. S. Rogers

Dean of the School of Engineering.

With sections by Dean C. E. Newton of the School of Mines and Dr. F. E. Rowland, head of the Department of Chemical Engineering.

Oregon State
Agricultural College
Corvallis

Engineering Laboratory.

FOREWORD

THE intricacy of modern civilization, with its subdivision of labor, industry, and the professional occupations, is making it increasingly difficult for the high school boy or girl to make a wise selection of a life work. It is bringing about a greater need for clarification of the relationship between various fields of occupation in the economic structure of the country. The purpose of this pamphlet is to assist prospective students in obtaining a better understanding of what engineering is, and of what an engineer does, and to assist parents, teachers and counselors in directing students in their choice of training.

The statements that follow have been made without any intention of unduly or artificially glorifying engineering, but solely for the purpose of assisting boys in obtaining a better understanding of the requirements and the rewards in the field of engineering.

The general catalogue describing the facilities and training offered by the College, not only in engineering but in the various other fields covered by the College, will be mailed upon application to the Registrar.

For particular information concerning civil, electrical, and mechanical engineering courses communications may be addressed to Dean H. S. Rogers. Inquiries concerning chemical engineering should be addressed to Dr. F. E. Rowland, head of Chemical Engineering, and inquiries concerning mining engineering to Dean C. E. Newton, School of Mines.

The Memorial Union building in the West Quadrangle, now under construction, will be the center of campus life, bringing students in all departments into closer fellowship. It is built from voluntary gifts.

Campus Gateway on Monroe Street, showing Apperson Hall, where are located the Electrical Engineering laboratories and Radio KOAC.

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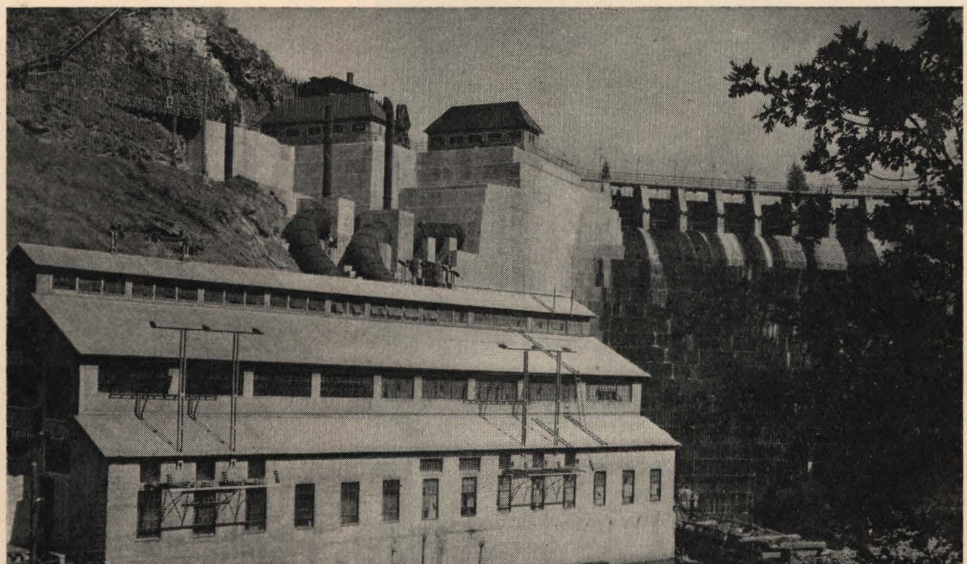
WHAT IS ENGINEERING?

A BOY who is contemplating the wise selection of a life work must find his understanding of that work immediately about him or through comparison and contrast with work he has observed. While a high school boy may find little meaning in the comprehensive and abstract definitions of engineering, the works of the professional engineer are familiar enough. Engineering deals almost exclusively with utilities which we have about us on every hand. The achievements of mechanical, electrical, civil, mining, and chemical engineers are the products and devices which we constantly utilize. Our modern conveniences, such as water supply, sewerage systems, electric lights, telephone, electric ranges, radios, automobiles, automatic refrigerators, washing machines, vacuum

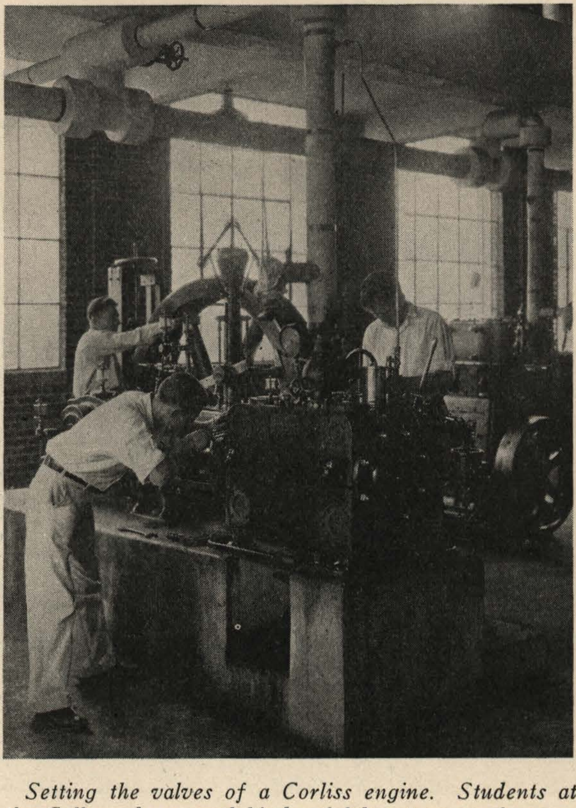


Station No. 1, California-Oregon Power Company. The electrical, mechanical, hydraulic, and civil engineer, each has his work in the planning and construction of a large hydroelectric project.

cleaners, etc., have all been made possible through engineering. The complexity and subdivision of the work of providing these utilities, however, quite generally obscure the engineer.

The review of any large construction or manufacturing project in the immediate vicinity will enable any high school boy to get some understanding of engineering. Such a review will disclose a wide and diversified field in which interesting employment and opportunity are afforded to men of widely different tastes and abilities. It will disclose that the work of engineers can be classified as a trade, a business, and a profession.

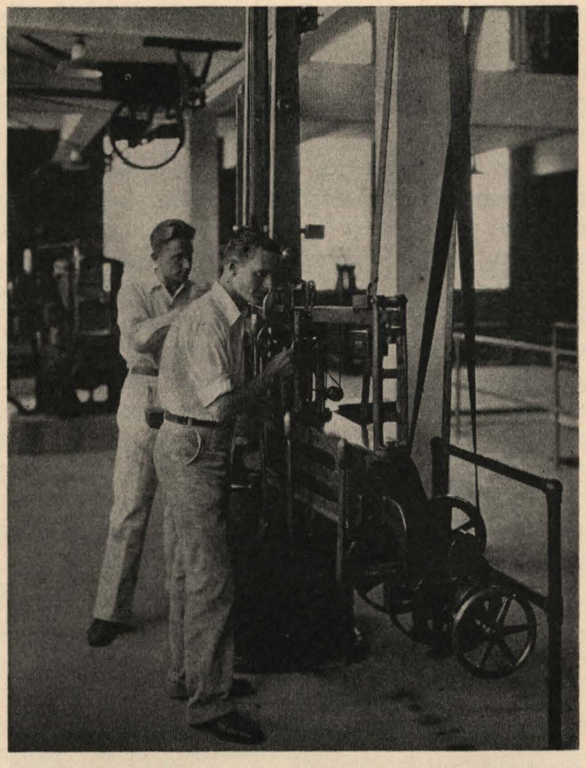
The development of a hydroelectric power plant involves a quantitative study of the power available at a particular site and the possible market for that power. It requires a survey of the ground upon which the works for the development and distribution of that power are to be made. It requires a mapping and planning upon paper of these works, very comprehensive and complete in all details. It involves the letting of contracts and the supervision of construction of work and the estimates of amounts to be paid contractors, together with the inspection and final acceptance of the completed works. The magnitude of such a project for a large power development requires the services of many men in the field of engineering. Some of these, such as survey men and certain of the detail draftsmen, will be hardly more than skilled artisans. Others in responsible charge of design and supervision will be called upon to execute works and make judgments that can be done only with a thorough knowledge and understanding of the principles and practices involved. Some of the engineers employed in such a work will be civil engineers, others will be mechanical engineers, and perhaps those having the greatest responsibility will be electrical engineers. All will be contributing their specialized services in the development of a large and important engineering pro-



Setting the valves of a Corliss engine. Students at the College do several kinds of laboratory work, some of a manual arts nature, some of an operating nature, and some of a testing nature.

ject. A review of such a project will clearly indicate the work and responsibility of all classes of engineers.

The large scale production and standardization of gasoline engines or electric motors has reduced many of the problems of the manufacturing process to a routine or trade nature. At the same time it has placed additional emphasis upon the scientific analysis underlying the design of the products and the plants and increased responsibility upon the administrators of such plants.



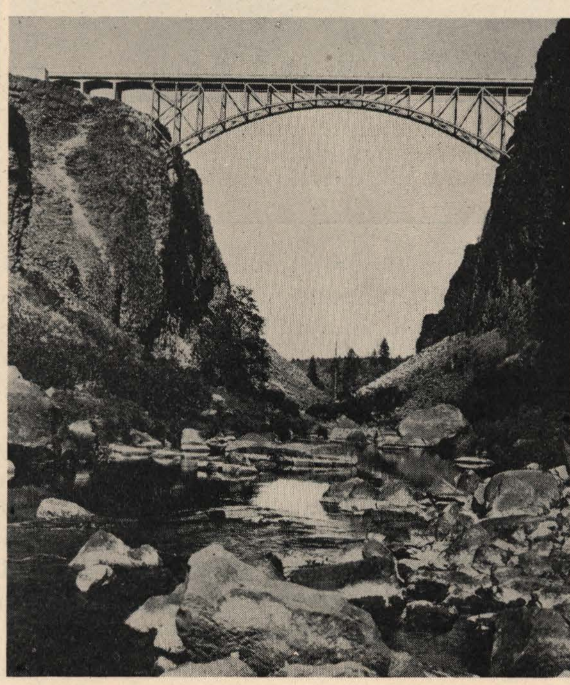
A tensile test on steel in college laboratory. The steel for all important uses must meet standard specifications of composition and physical properties.

Many of the occupations into which engineering graduates immediately find their way are of a technical nature in which they encounter others without engineering training doing the same work of estimating, drawing, designing, constructing, operating, testing, inspecting, and the like. The college graduate, however, progresses rapidly to managerial and administrative positions, or to positions of a highly specialized and highly technical nature. In the former capacity administrative ability is essential in the supervision and coordination of the routine work; while in the latter the highest type of technical knowledge and skill is essential in making developments and improvements. A successful engineer must have a knowledge of what constitutes the best practice in production and construction. He must have a knowledge of the applications of mathematical and abstract basic laws of nature to the solution of practical problems, and the best methods of making these applications. Engineering in its highest sense is not the work of all who call themselves engineers, but more particularly of those who are applying their knowledge not as a trade or as a business, but as a profession.

The highest type of engineering, therefore, may more correctly be defined as a *way of thinking* applied to the practical problems of construction and production. An example of an application of this way of thinking to many problems even outside the field of engineering is found in the thinking of Herbert Hoover, whose vigorous analysis and study of all the practical phases of government and administration make him one of the outstanding figures in the presidential cabinet. The essential characteristics of such thinking are its exact and tangible nature and its application to practical problems. It involves a knowledge of the best practice developed in particular fields, together with an ability to apply engineering principles to the solution of new problems.

Should a carpenter or builder construct a bridge without any particular knowledge of engineering, the completed structure, although it might give safe and satisfactory service, would not be a piece of engineering. If, however, the builder makes a study of the weights or loads that will come upon the bridge, determines by mathematical processes how much compression or tension will be in each of the members of the bridge, and uses members of such proportion as adequately and safely to carry these loads and yet be not too strong, the work then becomes engineering. If a man selects a pump or engine from a manufacturer's catalogue to do a particular piece of work, that is not necessarily engineering; but if he understandingly selects the best pump or engine, that becomes engineering. Furthermore, if a man, being unable to find the pump or engine to do a particular work, designs one which will do it to better advantage than those available, that is certainly engineering.

This manner of reasoning or habit of scientific thought is a common characteristic of all engineers, even though they may be occupied in varied pursuits. Many of our large electrical and mechanical manufacturing companies are administered by men whose time is chiefly absorbed with business problems, but who have in the past contributed largely to the engineering improvements and development of the products of their companies, and who are today masters of that field of engineering which applies to their particular problems of production and development.



Crooked River Highway Bridge. One of the highest bridges in the West. Designed and erected by the Bridge Department of the Oregon State Highway Commission.

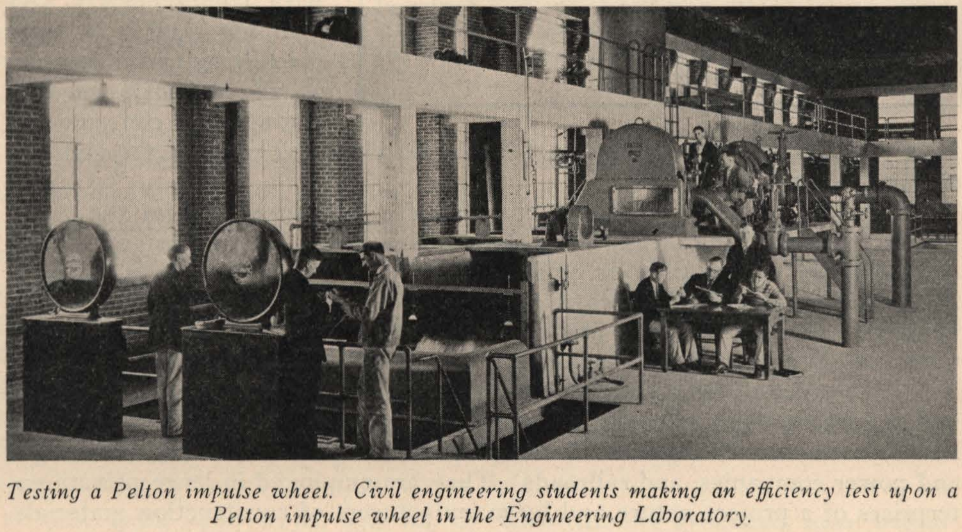
With the tremendous developments in the scale of modern construction and production there is an increasing need for administrators with engineering understanding, and with the engineering habit of thought. The training of our engineering colleges is given for the purpose of developing this habit of thought, and the elements of the training are scientific thought and a knowledge of the best in modern construction and production. The manner of thinking of the civil, electrical, mechanical, chemical, or mining engineer is identical, although the fields of application are quite dissimilar.

TECHNICAL DIVISIONS OF ENGINEERING

WHILE all engineers are engaged in the development of natural resources and in fashioning materials of earth for the benefit of mankind, their work may be divided into more or less fundamental groups. The divisions most generally made are civil, mechanical, electrical, chemical, and mining engineering. These five divisions are represented by five great national professional organizations, and each constitutes a more or less clearly defined field of interest and occupation.

In early historic times the work of the engineer was largely done in preparation for war and defense, and engineering was generally designated as military engineering. The first classification of engineering applied to the peaceful and economic pursuits of life was civil engineering in contradistinction from military engineering. Early developments in heat engines were responsible for differentiating the mechanical from the civil engineer and subsequent differentiation has been brought about by the developments in mining, in electricity, and in chemical industries.

The civil engineer is concerned primarily with the construction of static things, such as bridges, canals, highways, buildings, dams, and the like; while mechanical and electrical engineers are concerned with the production and uses of heat power or electrical power and the development of machines and engines. The mining engineer is concerned with the extraction and refinement of ores and marketing of the finished product; and the chemical en-

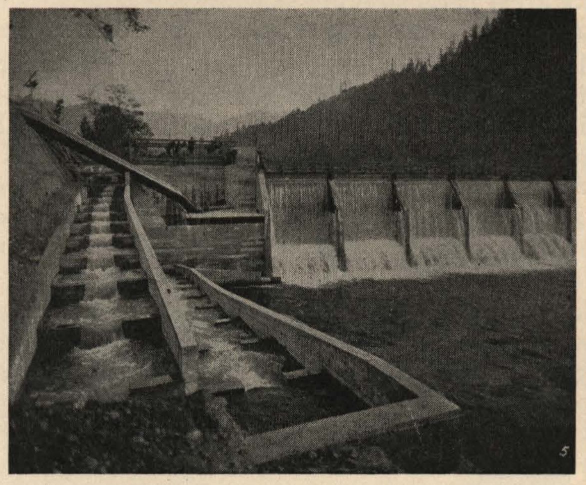


Testing a Pelton impulse wheel. Civil engineering students making an efficiency test upon a Pelton impulse wheel in the Engineering Laboratory.

gineer is concerned with the manufacture, production, and refinement of materials and chemicals.

Civil Engineering

Civil engineering is the general classification which includes work in the fields of surveying and geodesy, highways, railroads, irrigation and drainage, river and harbor improvements, structures, hydraulics, sanitation, and municipal engineering. The work done by civil engineers includes the location, design, construction, maintenance, and operation of highways, railways, pipe lines, canals; with the location, design, construction, and maintenance of river and harbor works, such as levees, sea walls, jetties, wharves, docks, piers, lighthouses; it includes the general planning, design, construction, and operation of all works for irrigating dry land, draining wet land, and protecting lands from floods; it has to do with the planning, designing, construction, and maintenance of bridges, steel and reinforced concrete buildings, dams, tunnels, viaducts, aqueducts, tall chimneys, grain elevators, storage bins, and power plants. It has to do with the supplying of pure water for domestic use, with fire prevention, with the removal and treatment of sewage, with the disposal of municipal refuse, with the paving of streets, and with comprehensive city planning; and it includes the testing and inspecting of all materials used in engineering construction. It is directly related to and a part in the development of all large and stationary works.



Savage Rapids Dam near Grants Pass.. A portion of the dam, the turbine and pump pit, and the fish ladder in the foreground. This construction was planned and supervised by civil engineers.

The work done by civil engineers includes land surveying for the establishing and relocating of lot, farm, state, and national boundaries and for the determination of the contour or shape of the earth's surface over areas or along lines of possible highways, railways, or canals. This surveying is developed in its most scientific and exact form in the work of the United States Coast and Geodetic Survey, and of the United States Geological Survey.

The graduates from civil engineering courses enter various fields of work under governmental agencies, such as federal, state, county, or city bureaus and departments. They enter the employment of public utilities, such as gas and power companies, and railroads. They are employed in large private enterprises of a project nature and by manufacturers of construction materials.

They are engaged as sales engineers by distributors of construction materials and equipment. They enter into the field of contracting as principals or employees. They engage in private practice, selling their services and special knowledge usually in connection with large private enterprises or public work. They are employed in fields of investigation, research, and teaching.

The greatest rewards are probably found in contracting and consulting engineering. The larger opportunities in manufacturing are related to construction materials and equipment and are of administrative or sales nature. Many of the rank and file and the beginners in the profession find employment in work of a detailed engineering nature rendering services to the purchasers of engineering materials as a means of promoting and developing the sales. Those working for all state, municipal, and governmental agencies are employed in various capacities related to the work of such offices and bodies as the city engineer, the county engineer, the state highway department, the state water office, the United States Bureau of Public Roads, and the United States Reclamation Service. Much of this employment is upon the civil service basis and governmental and municipal circulars fully describe the classifications found. Employment by public utilities is very similar to employment by the manufacturers of construction materials and equipment, being related to particular phases of expansion in construction and particular problems of maintenance.

A practice lesson in surveying. Surveying is fundamental to all work of a project nature.

It is obvious that the function of the civil engineer is, in brief, to determine conditions "upon the ground" and to fit projects to these conditions. The work can be divided, therefore, into two general classes, that of the office and that of the field. Engineers concerned with the work of surveying and construction are of necessity employed out-of-doors; while those doing the work of planning, designing, and drafting may be confined to desks and drafting tables. There are thus two general types of men who with proper qualifications might find themselves particularly adapted to civil engineering work. One is the man of rugged health and endurance who enjoys action; the other is the man of studious, deliberate, careful, and analytical bent. The former is found in the field and on the job. The latter is found working over plans and specifications. A third group possessing many of the abilities and accomplishments of each is coordinating the work in a supervisory manner.

The work upon which a group of representative graduates have begun shortly after graduation will give some indication of the approach to positions in the profession which is normally made by the beginner.

- Foreman on Sewer Construction, Klamath Falls.
- Inspector on Bridge Construction, Longview, Wash.
- Levelman on Surveying Party, Oregon State Highway Department.
- Transitman on Surveying Party, Southern Pacific Railway.
- Chief of Surveying Party, California Oregon Power Co.
- Chief Clerk, Engineering Department, Portland Electric Power Co.
- Inspector of Highway Construction, Oregon State Highway Department.
- Laboratory Assistant, Portland Cement Association.
- Designing Draftsman, United States Bureau of Public Roads.
- Water Master, Office of State Engineer.
- Sales Engineer, Truscon Steel Co., Portland.
- Draftsman, City Engineer's Office, Portland.
- Draftsman, Water Bureau, Portland.
- Junior Engineer, United States Geological Survey.

Mechanical Engineering

The field of mechanical engineering is not generally subdivided into classes, like civil engineering, but the occupations of mechanical engineers become highly specialized in various subdivisions of related work. Some mechanical engineers, for example, may devote their time to planning and developing machinery for paper mills, others for lumber mills, others for steel mills, and each may become especially skilled and experienced in his particular field. The professional divisions established by the American Society of Mechanical Engineers give some indication of the variety of specialization. These are as follows:

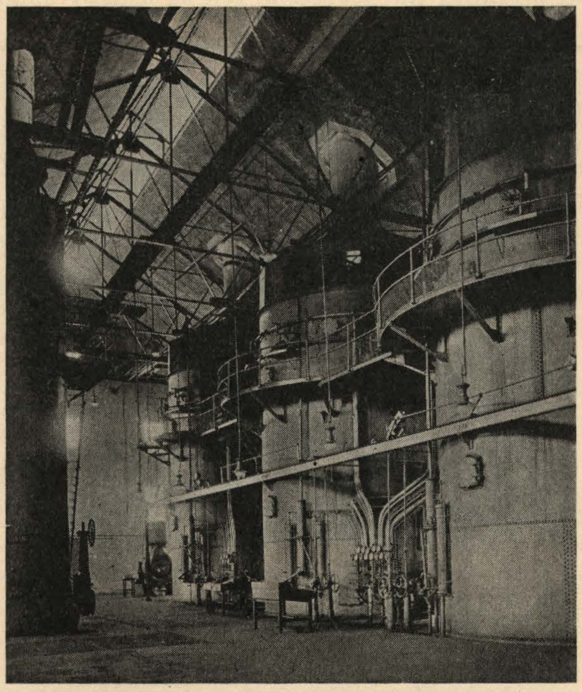
Aeronautic Division	Oil and Gas Power Division
Fuels Division	Petroleum Division
Hydraulic Division	Power Division
Machine Shop Practice Division	Printing Machinery Division
Management Division	Railroad Division
Materials Handling Division	Textile Division
National Defense Division	Wood Industries Division

In general, however, the field of mechanical engineering may be said to include the work related to steam power plants, steam and gas engines, turbines and pumps, heating, ventilating, refrigerating, and manufacturing.

Robert A. Booth Bridge over the North Umpqua on the Pacific Highway. The successful bridge engineer must possess much artistic ability. This arched bridge was designed by the State Bridge Department.

The field of mechanical engineering includes the planning and development of the plant and processes for manufacturing enterprises; the design, erection, and operation of power plants, and of all systems for heating, ventilating, and refrigeration. It includes the design and production of many machines and mechanical labor-saving devices. It includes the design and production of gas and steam engines and pumps, and many machines and systems into which these are incorporated. It includes sales engineering, consulting engineering, and industrial research.

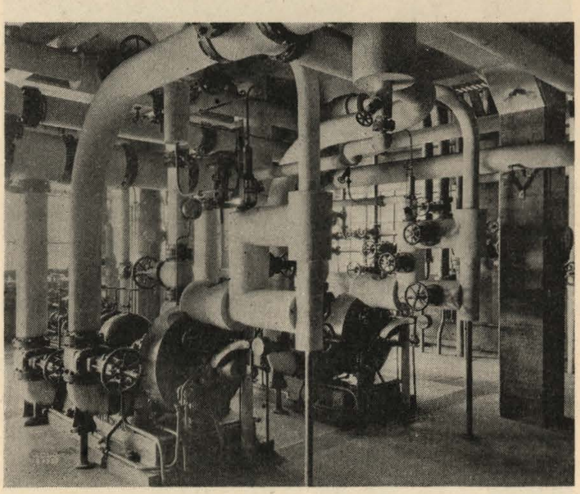
The work done by mechanical engineers in the development of steam power plants, heating, ventilating and refrigerating systems is one of planning and supervising the construction of plants economically to meet predetermined conditions. It very frequently includes the operation and continued planning of extensions and improvements of such systems, particularly if extensive.



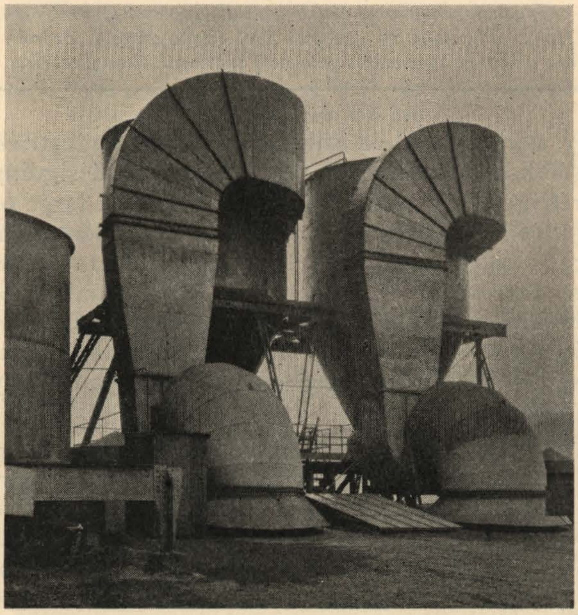
Generator house of the Portland Gas and Coke Company. The field of gas and fuel engineering is becoming a highly specialized phase of mechanical engineering.

Mechanical engineers may work for public utilities or private industries. Many mechanical engineers establish themselves in private practice, designing the heating, ventilating, and refrigeration systems for buildings of a large or public character. Others, employed as agents for mechanical equipment companies, render a similar service as sales engineers selling the products manufactured by the companies they represent. In recent years large numbers of mechanical engineers have gone into this field of sales engineering using their engineering knowledge in selling equipment. Many from the sales and manufacturing departments have risen to positions of large executive responsibility in industry.

The mechanical engineer is quite generally employed by private enterprises or occupied in the field of consulting engineering. The largest opportunities from the financial standpoint are probably found in administrative positions where in addition to general business acumen and experience, technical knowledge and training are particularly desirable. The field of industrial research offers, however, tremendous opportunities for men of creative imagination in the development and improvement of modern machines and processes. Those who today are contributing most in this field are men of broad technical training and experience. A review of inventions offered to the United States Government for carrying on the World War shows that those of outstanding value were produced by men of thorough scientific training and experience. While the mechanical engineer may not necessarily be an inventor, the successful one is usually endowed with ingenuity and creative instincts and adapts the designs of engines and machinery to the solution of his particular problems.



Lincoln Station, Northwestern Electric Company. The selection and arrangement of Boiler Feed pumps and piping is a part of the work of developing a steam power plant.



"Cinder Cones," Lincoln Station, Northwestern Electric Company, for removing cinders from stack gases. The mechanical engineer has many problems related to removing the nuisances of cinders and smoke.

The developments in correlated fields, generally classified under mechanical engineering, which have been brought about and fostered by science and research have been so numerous and so extensive that it is hardly possible to classify them clearly under one general heading. In recent years the developments in aeronautical and fuel and gas engineering have aroused public interest in these subdivisions. The electrification of industry has in many instances brought the mechanical and electrical engineer so close together that it has been necessary to train some men in both fields.

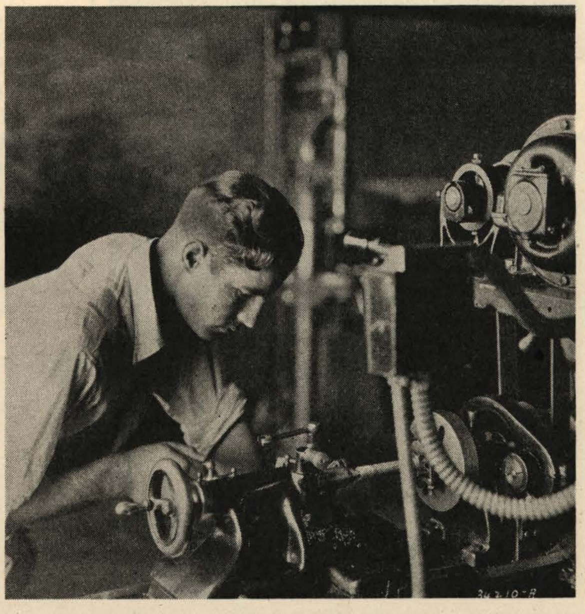
Many of the recent developments in the mechanical field are directly related to the electrical field. Steam turbines of exceptional capacity have been developed for the electrical generation of power. High steam pressures and superheating have also followed the demands of large-capacity electrical power plants. The large electric companies by intense scientific study have developed the field of mechanical engineering parallel with electrical engineering.

The recent graduates of mechanical engineering courses enter the profession in a variety of pursuits as indicated below.

Apprentice in Factory Management, General Electric Co., Schenectady, N. Y.
Sales Manager, Union Steel Products Co., Portland.
Junior Engineer, United States Navy Yard, Brooklyn, N. Y.
Testing Gas Appliances, Portland Gas & Coke Co., Portland.
Draftsman, Willamette Iron & Steel Co., Portland.
Research Engineer, Bell Telephone Laboratories, New York.
Instructor in Mechanical Engineering, Harvard.
Research Scholarship, Oregon State Agricultural College.
Master Mechanic, Portland Gas & Coke Co.
In Charge of Technical Control Work, Crown Willamette Paper Co.
Production Engineer, Indian Territory Illumination Co., Bartlesville, Okla.
Manager, C. J. Cook Co., Contractors, Portland.
Estimator, Allis Chalmers Co., Milwaukee, Wis.
Chief Draftsman, Northwestern Electric Co., Portland.
Economic Engineer, Pacific Telephone & Telegraph Co., San Francisco, Calif.

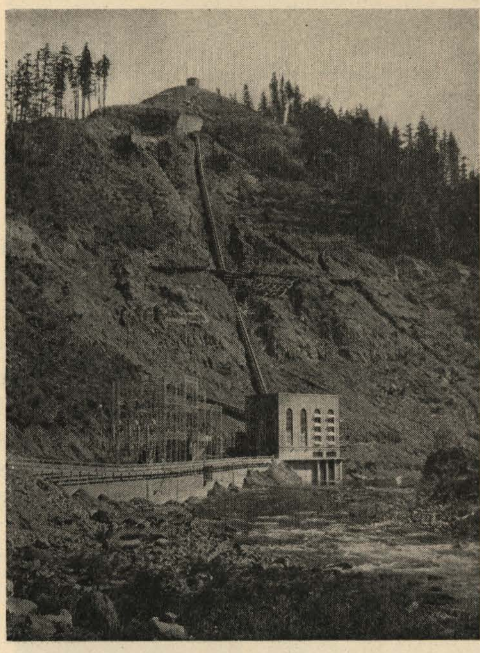
Electrical Engineering

The field of electrical engineering includes the development, design, manufacture and sale of all electrical machines and appliances. It includes the planning, construction, and operation of systems for the generation and transmission of electrical power, and of electric railway systems. It includes the planning and construction for all systems of electrical communication, as for example, the telegraph, telephone, and radio systems. It includes the development, maintenance, and operation of electrical illumination, of electrical hoists, conveyors, and other forms of electrically driven machinery. It includes the planning and development of many specialized applications of electricity to manufacturing and material processes, such as smelting, welding, and the electro-chemical industry. It includes the design, installation, and operation of many types of automatic and remote signaling and control.

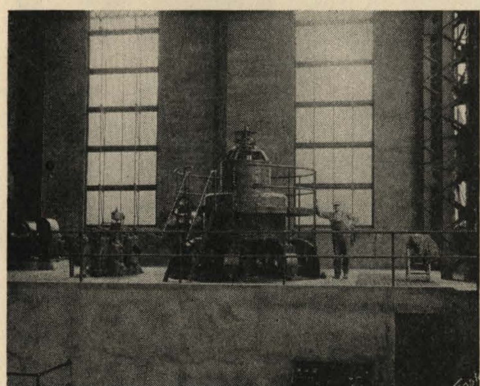


Operating a lathe. The object of machine shop work in college is not to produce machinists but to familiarize students with manufacturing processes and production methods.

Most of the products in the electrical engineering field are developed and placed upon the market by the large manufacturing industries, and many of the electrical engineering graduates find occupations with the companies in designing, planning, testing, experimenting, or in administrative and sales positions. Others find employment with the public utilities in field or office capacity upon projects for furnishing light and power, railway service, or telephone and telegraph service. Some find occupation as consulting engineers in an advisory capacity upon projects of great magnitude. Others enter the field of equipping smaller plants and distributing electrical appliances, and use their knowledge of engineering as a means of making sales.



Oak Grove Plant of Portland Electric Power Company. The planning of such a generating station involves many problems of electrical engineering and construction.



Interior of the Oak Grove Station, Portland Electric Power Company. Many electrical engineers obtain experience in the operating field as an element of a preparation for larger responsibilities.

In common with other engineers, the graduates usually spend a period of apprenticeship in work of a more or less routine nature with the large manufacturing and power companies, and make advancement in accordance with their technical preparation and business ability.

Recent graduates are now engaged as follows:

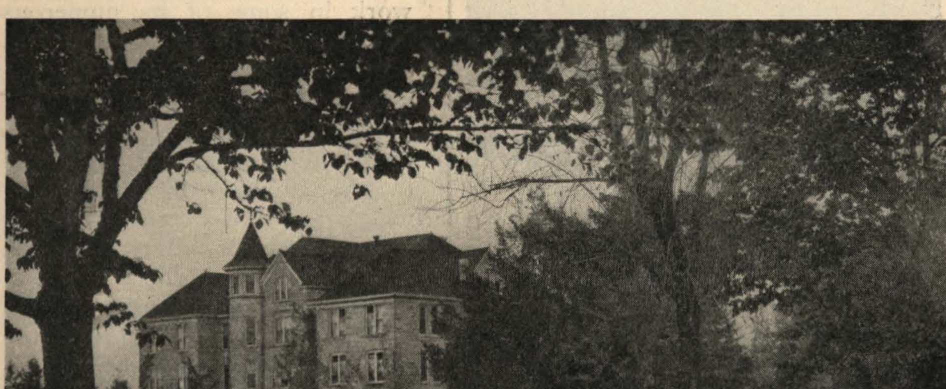
- Charge Industrial Training for Southern California, Los Angeles, California.
- District Meter Inspector, Pacific Power & Light Co., Lewiston, Idaho.
- Assistant Sales Manager, North Coast Power Company, Hillsboro, Oregon.
- First Assistant Electrical Engineer, Dredge Clackamas, Port of Portland.
- Research Engineer, Bell Telephone Laboratories, New York.
- Electrician, Crown Willamette Paper Company.
- Installer, Tester, Western Electric Co., Portland.
- Test Inspector, Foreman, Western Electric Co., Los Angeles.
- Student Engineer, Curtis Lighting, Inc.
- Draftsman, Mountain States Power Company.
- Signal Maintainer, Great Northern Railway, Whitefish, Mont.
- Teaching Fellow, Iowa State College.
- Student Test Course, General Electric Co., Schenectady, N. Y.

Chemical Engineering—By Dr. Floyd E. Rowland.

The recent phenomenal development of the chemical industry is daily demonstrating the need and field for the chemical engineer. The field is primarily that of industrial chemistry, in which the work includes investigating, testing, operating, and developing. Practically every industry today is based on chemical reaction. Some of the largest of these industries are agriculture, iron and steel, gas, tar, coke, acids, alkalies, fertilizers, dyes and explosives.

Chemical Engineering Laboratory. The chemical engineer delves deeply into the action and composition of organic and inorganic substances.

Oregon has natural chemical resources which will in time provide the raw material for some of her greatest industries. The deposit of sodium carbonate in Summer Lake alone will produce, it is estimated, $100,000,000 for the State. Our saw mills are having increasing difficulty in disposing of their waste. They need the help of the chemical engineer. Oregon, Washington, and California hold 45 per cent of all the water power in the United States. The time will



Science Hall, housing Chemistry and Chemical Engineering.

come when this power will be developed and gigantic electrochemical industries will be brought into existence employing engineers in every field.

The chemical engineer bridges the gap between the science of chemistry and its application to commercial processes by the use of machinery and equipment. He must have a certain amount of mechanical ingenuity and a desire to produce practical results.

For example, a few of our graduates have been employed by the following companies:

Industrial Chemists:

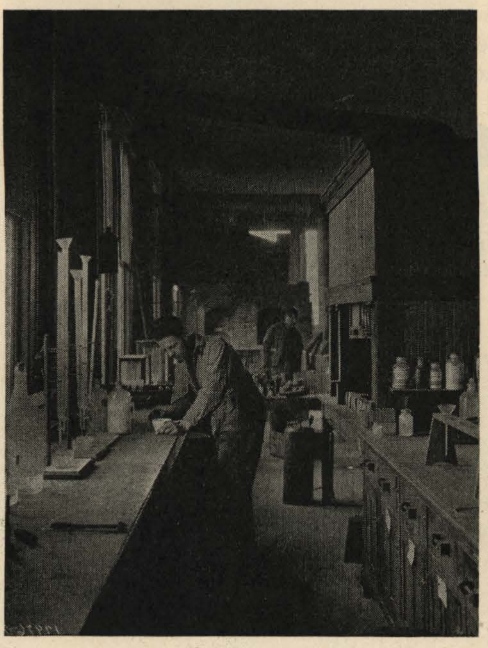
- Sherwin Williams Paint Company, Chicago.
- Portland Gas and Coke Company, Portland.
- State Board of Health, Connecticut.
- National Gas Association, Cleveland, Ohio.
- Pittsburg Tin Plate Company, Pittsburg.
- American Chemical and Potash Co., Trona, Calif.

Research Chemists:

- National Research Fellow, California Institute of Technology.
- Guggenheim Fellowship, Munich, Germany.
- Research Chemist Iron and Steel, Purdue.
- Instructor, Oregon State Agricultural College.

Mining Engineering—By DEAN C. E. NEWTON.

The brain of the mining engineer directs the complicated work of mining. As the present age is primarily a metal and mineral using age, the ambition of any boy may well be satisfied by the work that is offered in the field of mining.



A corner of the Mines Laboratory. Students operating the furnaces.

The field is so extensive that the average mining engineer has no difficulty in finding congenial work in some of its numerous branches. The broad education of the well-trained mining engineer, in fact, fits him for any of the allied branches of mining, because all branches are employed in the industry for producing metals and non-metals.

Because his calling takes him throughout the world, the professional mining engineer has opportunities for travel and profitable investment and develops associations and acquaintances with mining men of world-wide reputation. Names of prominent engineers and industrial operators of today, such as Herbert Hoover and Andrew W. Mellon, are included in the list of members of this profession.

American mining engineers unquestionably take the lead in all parts of the world.

In preparing to be a mining engineer one should acquire a thorough grounding in the natural sciences supplemented by a broad outline of study. A good undergraduate course in mining covers at least four years of intensive study, preceded by a good high school education. The best education is not beyond the reach of any boy who insists upon having it, unless he is handicapped by ill health or other causes. In all schools of mines there are students who earn a part or all of their expenses.

Mining events stand out prominently among the romances of history, such as the silver mines of the Spanish conquerors, the gold days of '49 in California, the discovery of diamonds and gold in South Africa in the '90s, the Alaska placers in 1900, and other more recent sensations. Great as were these soldier-of-fortune findings, they are dwarfed by the yield of the mines of the present day. Iron, copper, lead, zinc, tin, mercury, aluminum, coal, petroleum, and many others, although far less alluring, are more essential to industry.

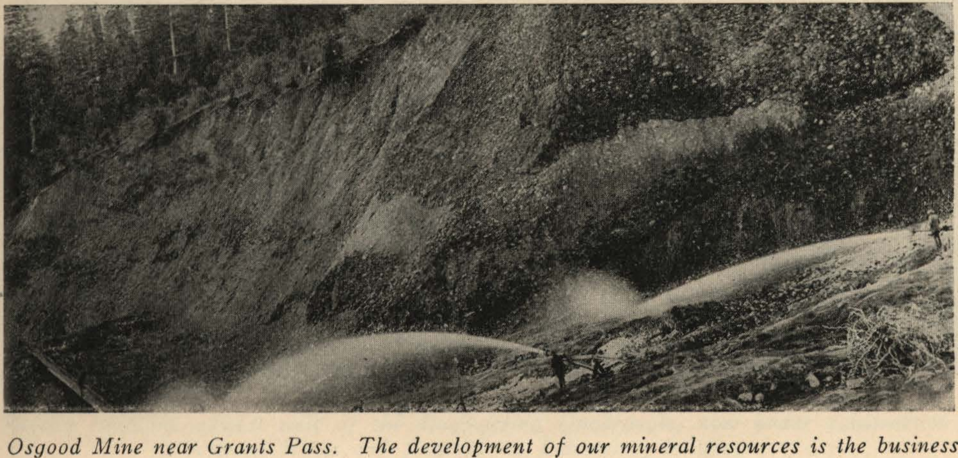
The mining and metallurgical industries of the world are impressive for their size and importance. The field of the mining engineer is constantly broadening and continually calling for trained men.

The work of the School of Mines offers training in three major divisions, Geology, Mining, and Metallurgy.

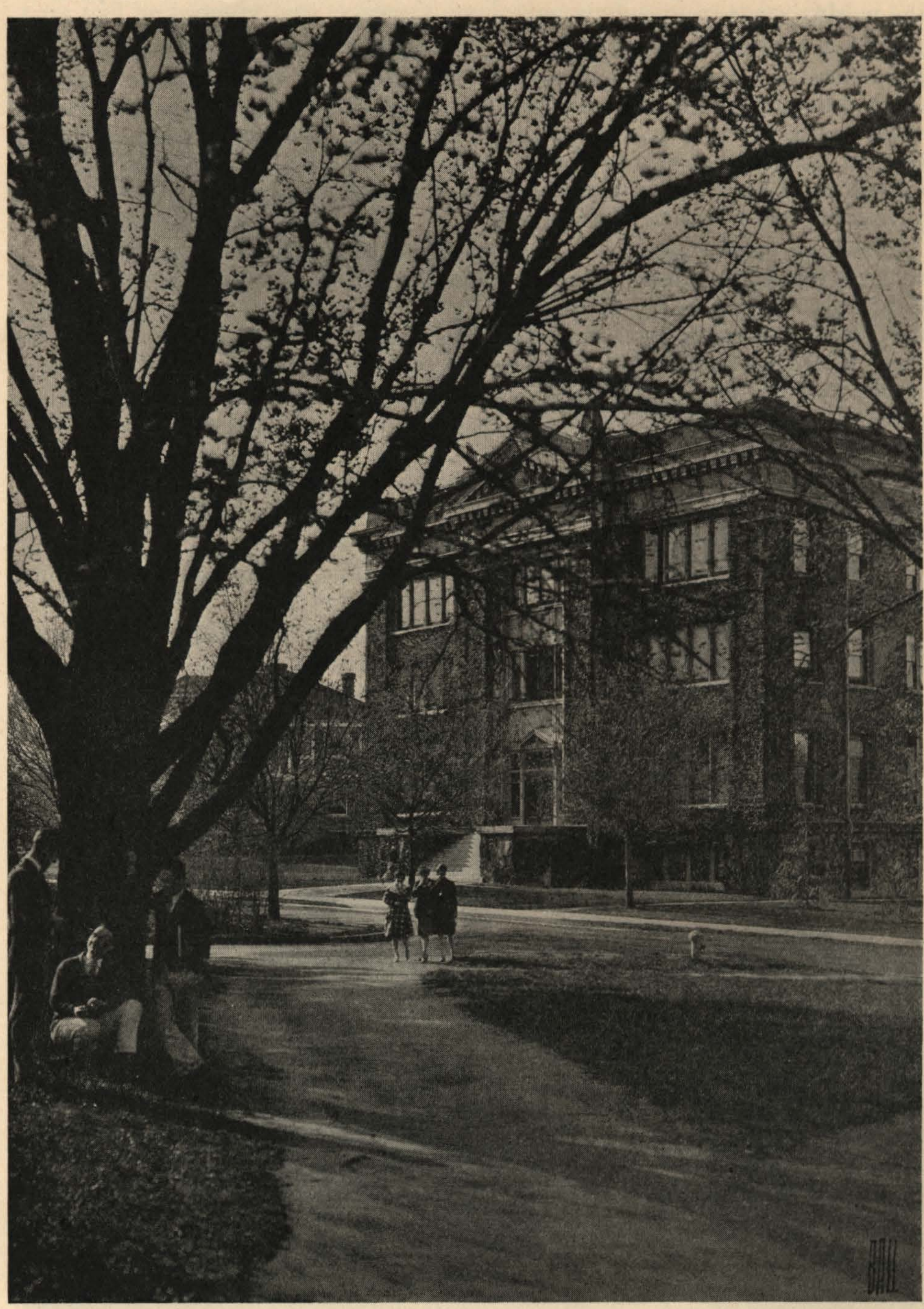
Geology is the study of the science of the earth. It includes the study of minerals, rocks, changes in the form of the earth's surface, occurrence of ore deposits, volcanoes, earthquakes, and life on the earth as revealed by fossils in the rocks.

Mining is an art founded upon scientific principles. It includes the study of methods used to discover and extract ores and natural mineral substances which are economically useful. The mineral wealth of the world is won by mining.

Metallurgy is the art of extracting metals from the ores produced by mining, refining them, and adapting them to use. It includes all phases of work-



Osgood Mine near Grants Pass. The development of our mineral resources is the business of the mining engineer.



The Mines Building.

ing the metals as raw materials, of production and preparation up to the point of fabrication or manufacture of the fully prepared material.

The most dominant characteristic of the mining engineering profession is the vast preponderance of the commercial over the technical in the daily work of the engineer. A mining engineer is not only the technician who makes reports and blue-prints, but he also gives advice on finance, and constructs and manages the work which he advises.

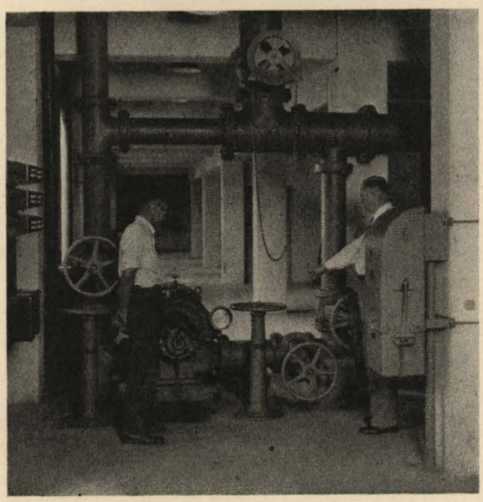
The School of Mines offers to the students the opportunity of training for the right start in the work of mining engineering, which is a profession that uses mineral—the nation's greatest asset—for the advancement and comfort of humanity.

The graduates of mining engineering courses find outlets in a variety of pursuits. The records of employment of some recent graduates follow.

District Manager, Oil Company, South America.
Junior Mining Engineer, Simon Silver-Lead Mines, Inc., Mina, Nevada.
Manager of Mine, Lower Bridge, Ore.
Junior Mining Engineer, Bethlehem Steel Company, Cornwall, Penn.
Superintendent North Hubbard Mine, Julian, Cal.
Examining Engineer, Llallagua, Bolivia.
Mining Engineer, Bunker Hill and Sullivan Mining Co., Kellogg, Ida.
Fellowship, University of Utah.
Fellowship, University of California.
Graduate Student, University of Washington.

Physics Building, newest unit of the Engineering Quadrangle, now under construction between Mines and Engineering Laboratory buildings.

OCCUPATIONS of graduate engineers are not differentiated entirely upon the basis of the technical divisions, but may be as sharply differentiated upon types of work. A patent classification in the things with which a man works may be made by technical divisions, but striking similarity will be found in the conditions and manner in which men work in the occupational divisions. Engineers in all technical branches are engaged in similar types of work, such as:



The pumps of the Hydraulic Laboratory. Although the principal object of laboratory tests is a scientific explanation of performance, the procedure necessary for their execution gives students practical training in operation and maintenance of machinery.

Consulting engineering
Designing, estimating, and drafting
Testing and inspecting
Operation and maintenance
Construction and installation
Research and teaching
Administration and management
Sales
Clerical, manual, and miscellaneous.

These basic occupations are more exactly descriptive of the nature of the work done by engineering graduates than the broad classifications of the technical divisions. It is taste and aptitude for certain of the basic occupations which should draw young men into the field of engineering. In general, some students select a training in civil engineering because the field of construction grasps the imagination, others a training in mechanical engineering because of a liking for machines and engines, and some a training in electrical engineering because of an interest in electrical appliances. The field of mining with its explorations and underground operations grasps the interest of some. The chemical industries with their laboratory work and method appeal to others. Much work in each field, however, is very similar to that in the other fields.

The design of machinery is much the same whether it be put to electrical, mechanical or mining purposes. It involves many of the same principles of science and mathematics; it requires the same skill in drafting-board layout; and the designers work under similar conditions with similar tools.

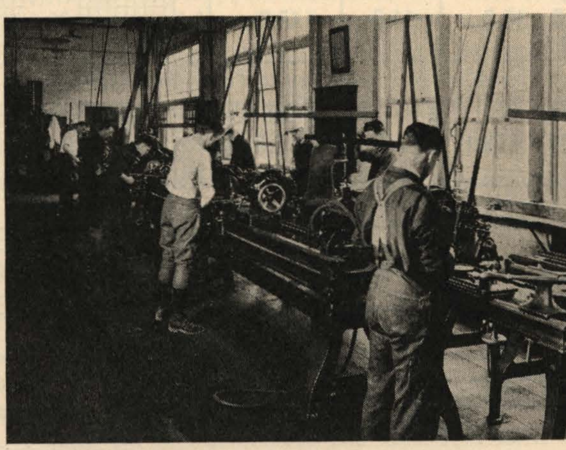
Testing and inspecting as related to materials produced at the plant or delivered on the job are very similar in all fields regardless of the application to which the materials may be put. The testing of machinery, whether it be electrical or mechanical, is also very similar.

The operation and maintenance of large utilities and plants are similar except in minor details. The operation of a steam electric plant for production of power is not dissimilar from the operation of a lumber mill. The operation of a lumber mill is not dissimilar from the operation of a steel mill.

Many phases of construction and installation in all branches of engineering are very similar. The mechanical engineer in charge of the construction of a large power plant works under conditions and in a manner in no way dissimilar from that of the civil engineer in charge of construction of a bridge or building. In fact, the two may be associated in either the power plant or building construction, one supervising the plant proper and the other supervising the installation of machinery.

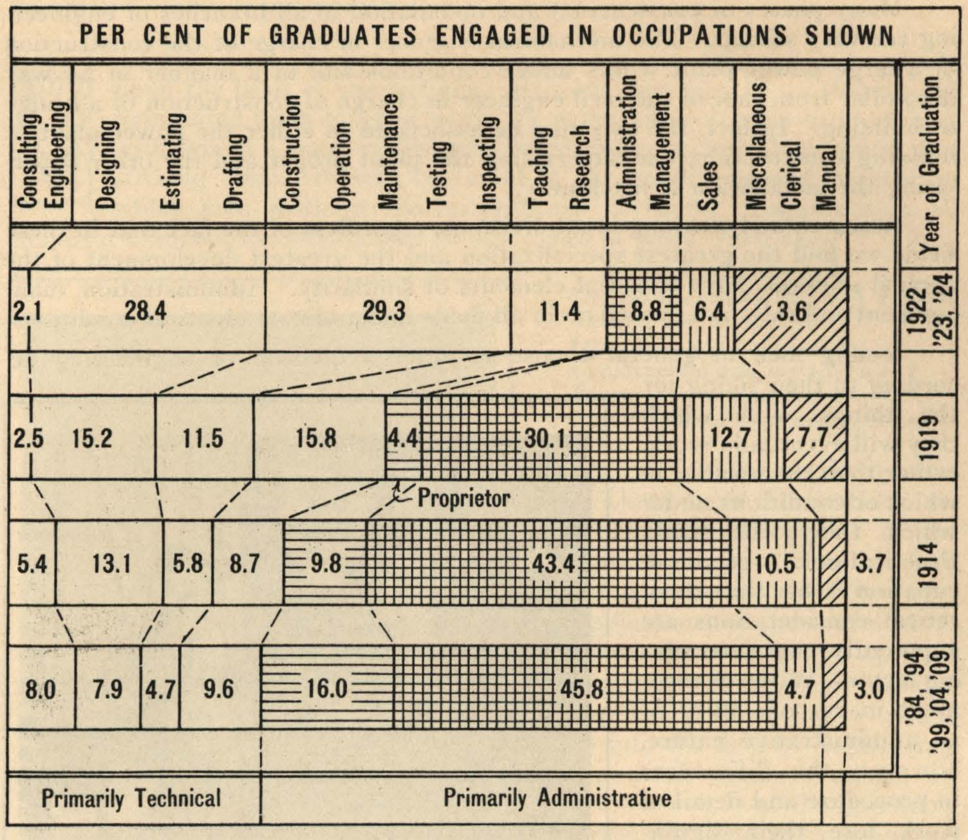
Research and teaching in all divisions, regardless of the fact that in these fields we find the greatest specialization and the greatest development of the applied sciences, have essential elements of similarity. Administration, management and sales are carried on in all fields under almost identical conditions.

Young men in general choose to enter a division of engineering according to their liking for the things with which they will eventually work, rather than the manner in which or conditions under which they will work. Practical details of an occupation rather than theoretical considerations are apparently the determining factors. With advancement in responsibility of an administrative nature, however, the differences in procedure and detail of work lose their significance. The number of men required for the routine technical positions is, of course, much greater than that required for the positions of administrative responsibility. After years of experience, therefore, many men who begin their engineering experience in the technical phases advance into administrative work in which success is dependent not only upon technical knowledge, but also upon business ability and capacity to deal effectively with employees and the public and upon habits of personal efficiency.



Machine shop practice. A liking for machinery frequently draws young men into the field of mechanical engineering.

Foundry practice. The foundry is operated upon a production basis. Many practical castings are made.

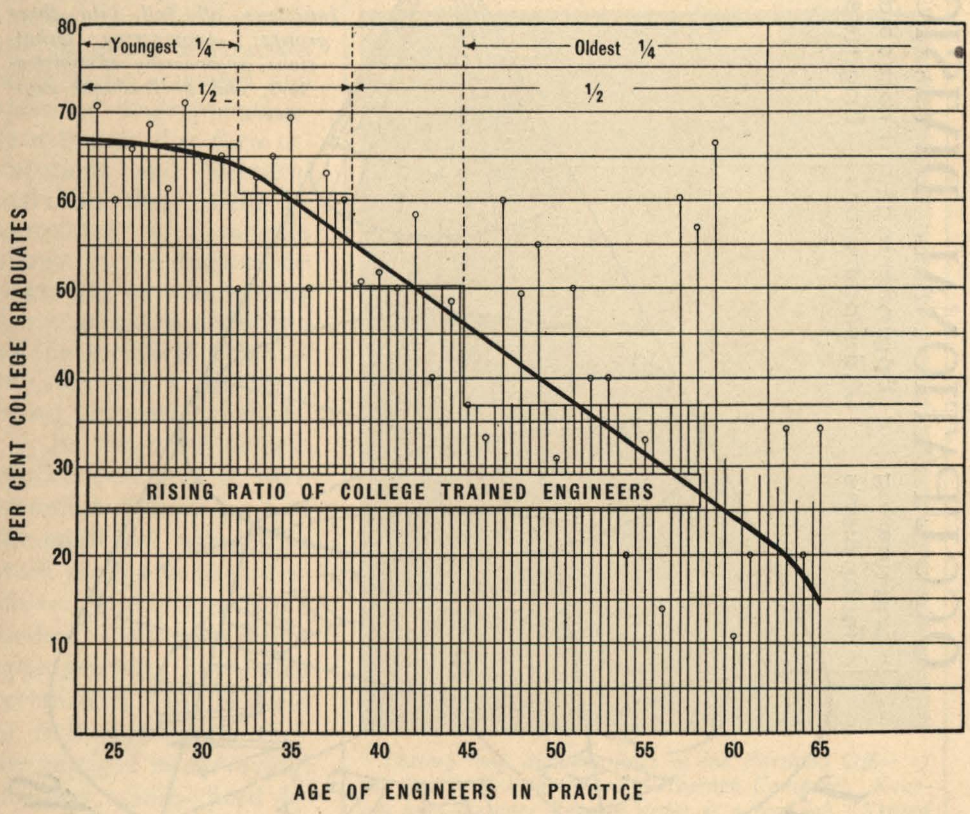


With experience and advancement in the fields of engineering many who begin with routine technical work pass into responsibilities of administration. The progressive trend of engineering graduates toward administrative duties is illustrated in the chart, based upon data compiled in 1925.

A diagram of this progressive trend toward managerial duties after graduation and entrance into active engineering work is shown above. This diagram was prepared from statistics gathered in 1925 from some 8800 graduates of engineering colleges in America by the Society for the Promotion of Engineering Education. The diagram presents very clearly the fact that with experience and advancement in the fields of engineering many of those who begin with routine work of a technical nature pass into responsibilities of administration.

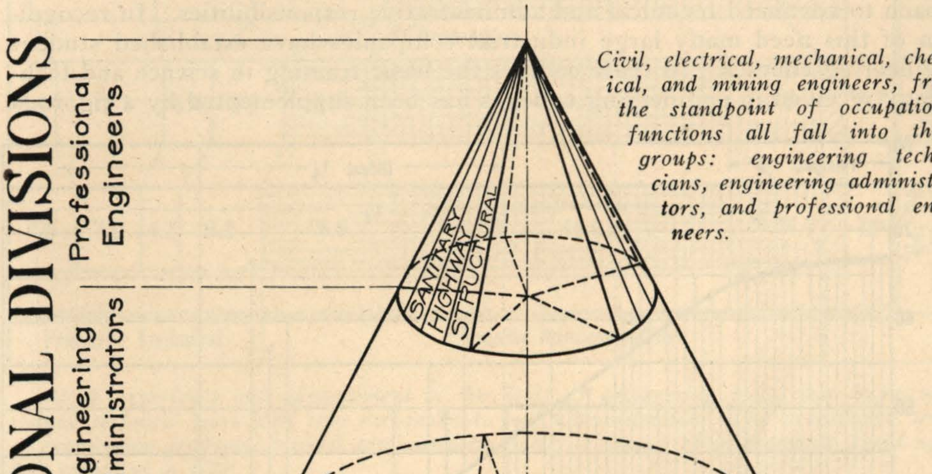
It does not necessarily follow, however, that all technical work is of a routine nature. Much of it relates to continuing projects, and work can be standardized and reduced to routine. For example, it is possible to design steel roof-trusses, gas engines, and electrical generators which will meet a large variety of applications and which can be standardized and distributed like many other commodities. Much of the work related to the application of engineering in structural, mechanical, and electrical design, estimating, and drafting, as well as that related to the details of construction, operation, maintenance, testing, and inspection, has been standardized.

In past years many young men have found their way into this routine work without a college education. At the present time, however, there is a very marked and increasing ratio in the employment of college-trained men for these positions. This increasing ratio of college-trained men as found in engineering work performed by men of different ages is shown in the diagram below, which has been taken from figures compiled and presented by the Society for the Promotion of Engineering Education. It is certainly to be anticipated that in time there will be a rising ratio of college-trained engineers among engineers of more advanced age. This organization of work within industry has followed the logical development of administration and has been led by those engineers who were early established in the various fields of production and public works. It has brought about a normal vertical stratification of engineers. It makes it essential that the college graduate should approach his practical experience with the appreciation that he must serve a sort of apprenticeship, or pass through a vocational experience in his approach to advanced technical and administrative responsibilities. In recognition of this need many large industrial companies have established student engineering courses. In these courses the basic training in science and technology received in engineering colleges has been supplemented by a rigorous



Though in the past many young men without a college education have served as engineering technicians, the tendency is for many of these positions to go to college-trained men. The rising ratio of college-trained engineers found in engineering practice is illustrated in the chart.

Learning the principles of surveying. Field survey men might properly be classified as engineering technicians.



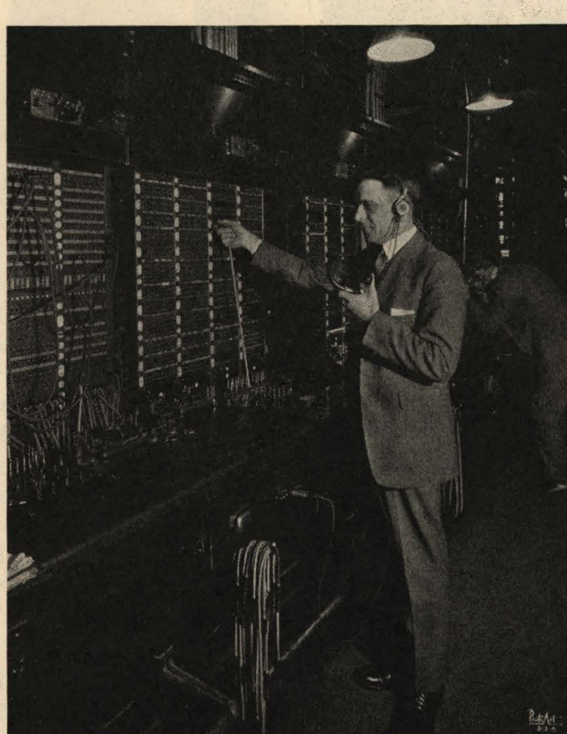
Civil, electrical, mechanical, chemical, and mining engineers, from the standpoint of occupational functions all fall into three groups: engineering technicians, engineering administrators, and professional engineers.

training in problems of a primarily practical nature. It should not be understood that all primarily technical positions have been or can be reduced to a routine nature.

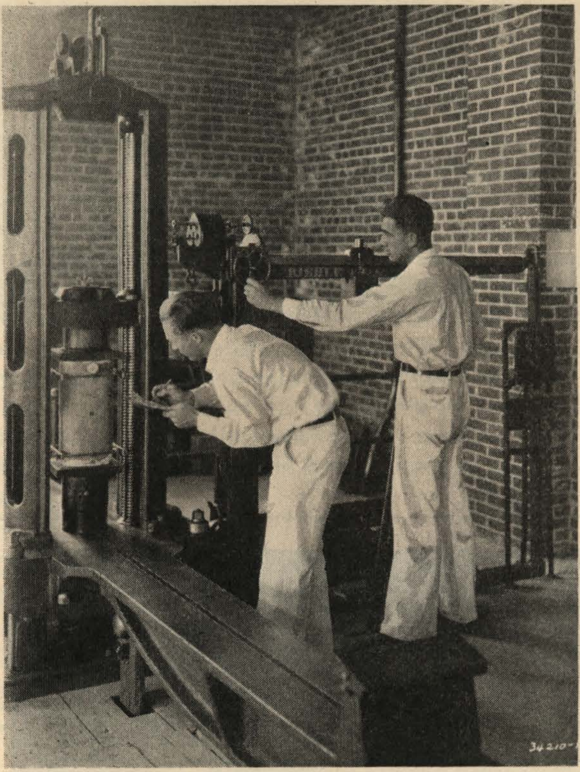
All unusual developments and unprecedented designs have been developed by men who are thorough masters of technical knowledge and who have the ability of applying it to practical problems. The distinction between the routine worker in the technical field and the advanced or responsible worker lies essentially in the understanding which each has of the principles of engineering. The successful routine worker has acquired great skill and facility in the application of standard methods to the solution of standard problems. The advanced consulting, designing, or research engineer has developed an outstanding ability in the application of fundamental principles of science to the solution of new problems. This ability, while usually of a more or less general nature, is more often applied to particular fields of engineering.

Engineering cannot be described in simple terms as a profession comparable to the profession of law or medicine. It is essentially a composite and blending of a trade, a business, and a profession, and men of similar functional or occupational capacity will be found in each of the technical divisions. If the engineers of America were to be arranged and classified diagrammatically with regard to their occupations and technical activities they could be correlated in a manner shown in the diagram on page 26, in which they are segregated according to the technical fields of the occupation and three broad occupational fields.

In the more or less routine positions of each technical division we find the engineers engaged in work similar in nature to the very highly specialized trades. These men might appropriately be called technicians. In the field of civil engineering they are engaged in surveying, drawing, standardized design, inspection, cost keeping, testing and operating. In the field of me-



Testing long distance lines in the Portland Office of the Pacific Telephone and Telegraph Company. Keeping long distance lines in order is a real job. Skilled testboardmen are constantly making tests of various kinds. H. C. Barton, chief testboardman at Portland, is shown here making a test of a long distance line.



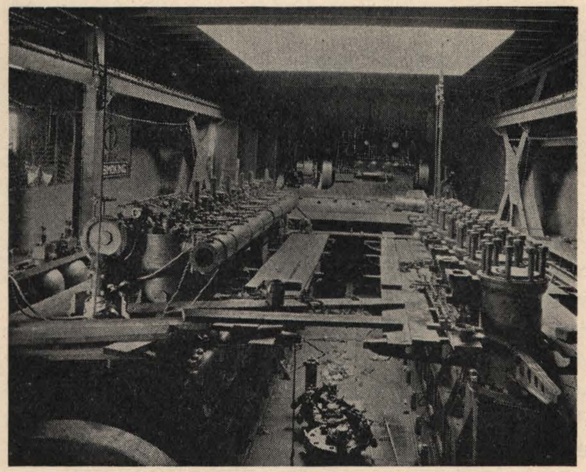
Students testing strength of concrete. The concrete used in all important work is designed and tested to obtain maximum strength.

chanical and electrical engineering they are engaged in drawing, designing of a more or less standardized nature, testing, inspecting, and operating. In mining engineering we find mine surveyors, foremen, operators, and assistants in this class. In chemical engineering we find laboratory workers and assistants. These technicians are executing the standardized tests used in the control of industrial processes.

Immediately above this group are found the engineering administrators. These cannot be so easily differentiated into the various technical divisions. We may, for example, find the chief engineer of a steel plant who is a civil engineer supervising and directing technicians of several classifications. This man may in turn, through changes in the organization, give way to a mechanical engineer who will carry on the same type of work, and who, like the former, because of the similarity of principles and procedure in the allied technical fields, will be able effectively to direct and supervise the work of all technicians. Those who make the largest success in administrative work usually have, however, a thorough understanding of the duties of technicians and have advanced to responsibility from routine technical positions.

Above the administrative group, at least in their mastery of engineering principles and practice and in their position in the profession, is found the true group of professional engineers. These men are doing work primarily of a technical nature which, however, is to be distinguished from that of engineering technicians by its ingenious, inventive, pioneering research, or constructive nature and which calls for the highest type of engineering skill, knowledge, and ability. In this classification we find the technical divisions more minutely subdivided. Civil engineering, for example, is subdivided into highways, railways, sanitary, hydraulic, structural, irrigation, and others.

The structural engineer, for example, who designs and supervises the new bridges over the Willamette River in the City of Portland would not undertake the work of the hydraulic engineer who has planned the new Bear Creek Dam and other works for increasing the water supply of the same city. While each is engaged in professional engineering work, one is independently applying his special knowledge and ability in directing and advising communities or corporations upon particular bridge problems; the other is directly employed by the City of Portland to carry the full responsibility of the engineering features of the water supply system.



800-horse-power Diesel eight-cylinder engines being erected in the dredge Clackamas for the Port of Portland.

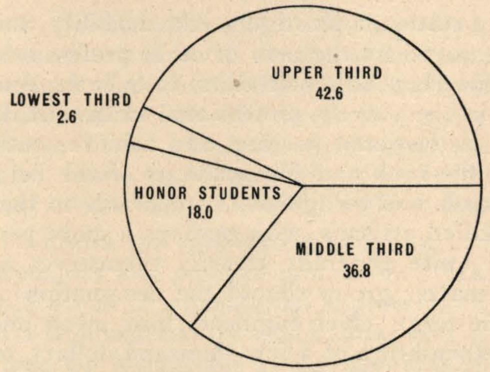
In this division, therefore, we find the consulting engineers of all technical fields, the directors of the technical divisions of governmental, state, or municipal engineering corps, and engineers engaged in what industries call a staff capacity giving special service and solving special research problems for the administrators of large industries and utilities. In the mechanical engineering division we find here specialization in heating and ventilating, in refrigeration, in power plant design, in gas engines, and other branches. In electrical engineering we find specialization in telephone engineering, telegraph, radio, electric railways, power development, and the like. In mining engineering and other fields we find similar specialization.

The men of this last group enjoy a station, a prestige, a responsibility, and a remuneration comparable to that enjoyed by the men of other professions. Those occupying positions as engineering administrators frequently find financial returns greater than those in the strictly professional class, but do not, however, enjoy the prestige of professional position and achievements. The engineering technicians occupy the rank and file positions of the field, shop, and office, and receive the rewards and recognition comparable to that received by highly specialized and skilled artisans, with perhaps a more permanent status of employment. All quite generally classify themselves as engineers, but only to those of the master group should the designation of professional engineers be given. The term "chief engineer" may mean one who supervizes a few men and the expenditure of a few thousand dollars, or one who directs thousands of men and the expenditure of millions. A "consulting engineer" may be one doing land surveying or one who advises and directs the largest public works. As a result, much confusion exists in the minds of those contemplating a career in engineering. A more exact classification would be of material benefit to public understanding. Such a classification should give consideration to the occupational divisions.

ESSENTIAL CHARACTERISTICS FOR ENGINEERING SUCCESS

A FEW years ago, under the direction of the Carnegie Foundation, about seven thousand questionnaires were distributed to engineers, engineering educators, and employers of engineers asking them to designate the qualities which enabled men to be successful in the engineering field. The unanimity of opinion presented in the replies was very striking. A composite expression of this indicated that success of engineers was determined, first of all, by their character and leadership, which were evaluated at 75 percent, and finally by their knowledge of engineering science and of engineering practice, which were evaluated respectively at 15 percent and 10 percent. It does not follow, however, that any one possessing character and leadership might succeed in engineering. Any building is 75 percent structure; the equipment placed in it determines whether it becomes a shop, a factory, a library, a hospital, or a laboratory. And so, in the field of engineering, the knowledge of engineering science and engineering practice is the determining element of success.

The qualities sought by employers of engineers, listed in order of their relative importance and indicated by a very comprehensive study made by the Society for the Promotion of Engineering Education, are character, leadership, special training, physical qualities, and scholastic record. After character and leadership, special training is placed in a position of importance. It is this special training that the engineering colleges endeavor to give. The results of good college training should show themselves in a mastery of fundamental principles of science, in methods of thinking and expression, and in habits of work. The effective habits and characteristics of special importance in engineering success are those of initiative, originality, concentration, diligence, dependability, integrity, accuracy, thoroughness, orderliness, and neatness. Obviously, many of these characteristics are essential for success in other fields. All successful men possess them to some extent.

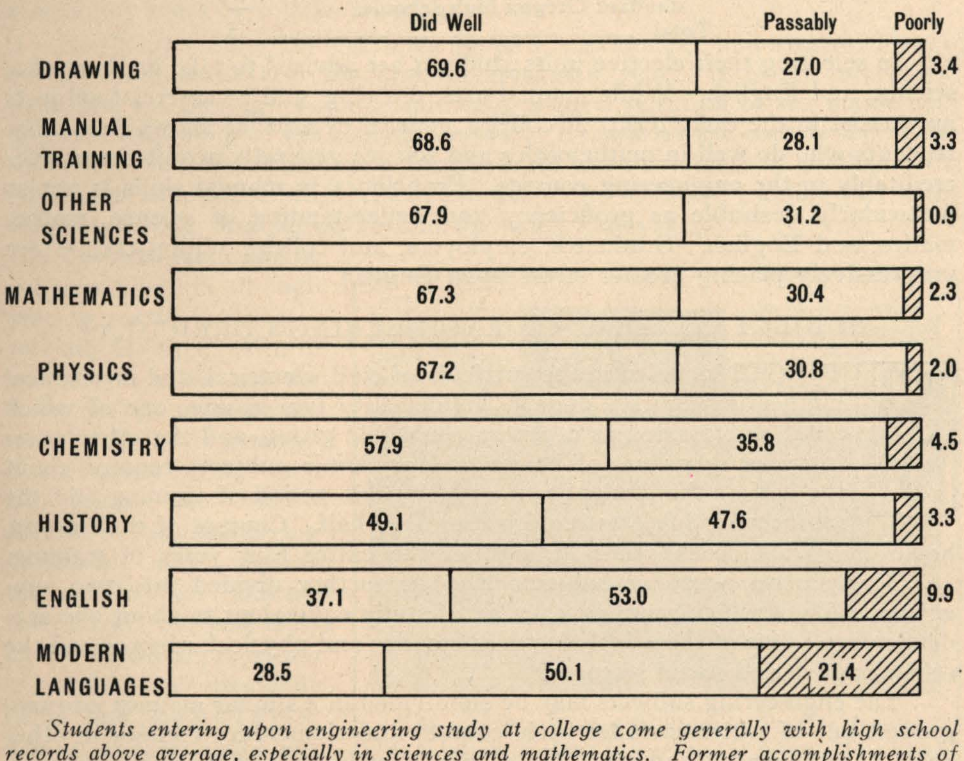


Six out of every ten engineering students made superior scholarship records in high school, according to a nation-wide survey, while practically all made at least average records. The distribution of honor and superior students is illustrated in the diagram.

A certain group of abilities and likes, however, are essential for success in engineering. Chief of these, perhaps, is a taste for and ability in mathematics, physics, and other sciences, together with an interest in manual arts, construction, and drawing. Most engineering students do well in drawing, manual training, mathematics, physics, and other sciences in their high school work. Ability in these subjects, coupled with a liking for machinery or construction, constitutes probably one of the best indexes of possible success in engineering. The fact that a student does well in drawing and manual training, while not essential to his college success, is probably a significant index of his interests.

Studies carried on by the Society for the Promotion of Engineering Education covering every section of the country and involving 4079 students of the class entering engineering institutions in the fall of 1924 indicated, as shown in the diagram, that engineering students did well in the above-mentioned subjects. Practically all engineering students came from the middle group or above in high school standing. While in the past it has been possible to enter the field of engineering and make some advancement without a college education, the inventions, discoveries, and developments in the field of engineering and science make it almost imperative for one who aspires to success and responsibility to prepare himself by a college education.

Work in the Wood Shops. The instruction given at the College is planned to develop managers of cabinet and pattern shops or teachers of manual arts.



Students entering upon engineering study at college come generally with high school records above average, especially in sciences and mathematics. Former accomplishments of engineering students in their high school courses, according to a nation-wide study, are indicated in the diagram. Figures indicate percent of students.

HIGH SCHOOL PREPARATION FOR ENGINEERING COURSES

IN order to be admitted to Oregon State Agricultural College a student must be of good moral character and must present evidence of preparation sufficient to pursue profitably the curriculum for which he desires to register. When a student can not present such evidence he must take the regular entrance examinations of the College, held at the beginning of each term. Graduates of Oregon high schools standardized by the State Department of Education are admitted on presentation of the required entrance units, certified by the principal or superintendent on the regulation form for this purpose. The specific requirements for entrance to the School of Engineering at the College include:

	Units
English	3
Elementary Algebra	1
Higher Algebra	½
Plane Geometry	1
Other Subjects (Specified)	5
English — Foreign Languages	
Mathematics — Laboratory Sciences	
History (including Civics)	
Economics	
Other Subjects (Elective)	4½
Subjects credited toward graduation by standard Oregon high schools.	—
Total	15

In selecting their elective units students are advised to take mathematics, science, and English. While manual arts, drawing, and commercial subjects may assist in the early terms at college, general experience shows that those students who do well in mathematics and science generally acquit themselves creditably in the engineering courses. Proficiency in manual skills is not so particularly desirable as proficiency and understanding of science, mathematics, and English. Graduates, employers, and college administrators are progressively placing greater stress upon English.

SUBJECT CONTENT OF ENGINEERING CURRICULA

SUBJECTS included in the curricula of civil, electrical, and mechanical engineering courses may be divided into two groups, one of which could be classified as a general academic group, and the other as an engineering group. The general academic subjects require about one-half of the student's time during his period of training and the engineering subjects require the other half. Courses of each group, however, parallel each other throughout the entire four years of training.

The general academic subjects may be further divided into two subgroups, each of which requires a period of study equivalent to about one academic year. One of these includes mathematics and physical sciences and the other English and social sciences.

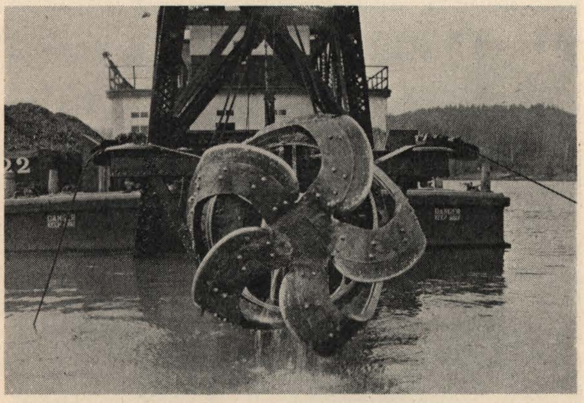
The engineering subjects may be subdivided in a similar manner into two groups, one of which includes basic courses and elementary courses in other fields of engineering and the other of which includes engineering courses in the curriculum chosen. An approximate division of the time in training for civil, mechanical, and electrical students is given in the following table.

General Academic Group			
Physical Science (chemistry, physics, geology)	0.37 yr.		
Mathematics (algebra, analytical geometry, calculus)	0.52 yr.	0.89 yr.	
Economics, Social Science	0.18 yr.		
English	0.22 yr.		
Free Electives	0.40 yr.		
Military, Physical Training	0.29 yr.	1.09 yr.	1.98 yr.
Engineering Group			
Major (elected by student)		1.11 yr.	
Other Branches (civil, mechanical, or electrical)	0.28 yr.		
Basic Principles (mechanics, hydraulics)	0.34 yr.		
Drawing, Shop	0.29 yr.	0.91 yr.	2.02 yr.
Total			4.00 yr.

The general academic group is similar for all the groups of engineering. The basic group of technical subjects is also quite similar in all fields. The difference in the several curricula, therefore, is primarily and approximately made in one year's work upon courses given in the technical division of the student's choice. This year's work is not, however, concentrated at any one time in any of the curricula, but is distributed largely throughout the junior and senior years of college training.

At Oregon State the curricula in civil, mechanical, and electrical engineering are identical in the first, or freshman year. It is not necessary, therefore, for the high school student to make a selection of his major field until the beginning of the sophomore year. Even after the completion of the sophomore year the student may change from one curriculum to another without a great amount of inconvenience in his period of future training and without lengthening that period beyond the usual four years.

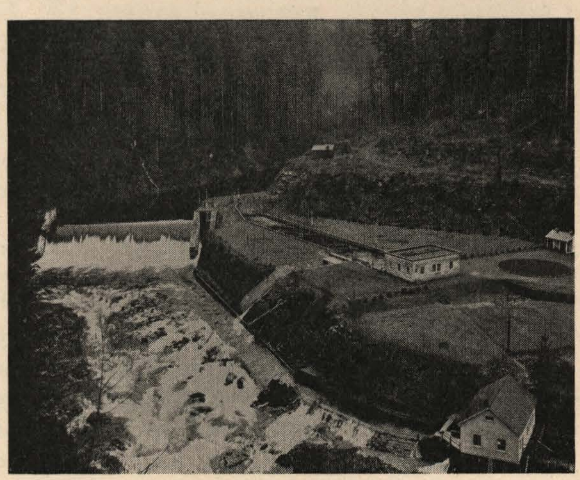
The general academic subjects found in all engineering curricula are given both for their cultural and liberal value and for their use as professional tools. It is quite generally recognized that men who attain the highest success in the engineering profession must possess the ability to express themselves well and must have a broad appreciation of social and economic fields and problems. These general academic subjects and the elementary subjects of an engi-



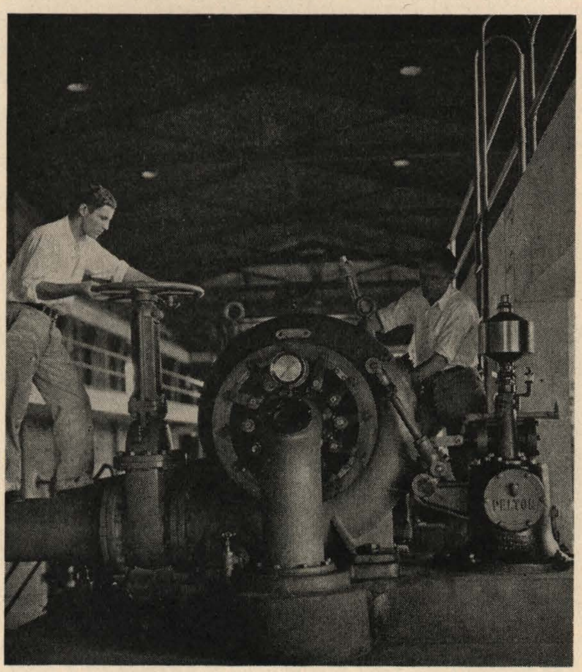
Cutter on the Dredge Willamette, Port of Portland. The work of the Port of Portland is directed by a chief engineer and manager whose duties are largely administrative.

neering nature are particularly similar in the curricula of civil, electrical, and mechanical engineering.

The civil engineering major specializes in the applications of the principles of mechanics to solids and liquids and in the properties of materials. In other words, it deals primarily with flowing water and static structures, and with the materials of which these structures are made. The mechanical engineering curriculum, while it includes the basic principles of mechanics, specializes more particularly upon the generation, transmission, application, and conservation of heat power. The mechanical engineer deals primarily with machines, engines, and power plants. The electrical engineering curriculum is differentiated from mechanical by the special stress laid upon the generation, transmission, application, and conservation of electrical power and by the study of the application and performance of electrical machinery. The mechanical and electrical engineering curricula, are, however, more similar than any other two.



Bull Run Headworks, Portland Water Supply. These works were designed and constructed under the direction of the chief engineer of the Bureau of Water Works.



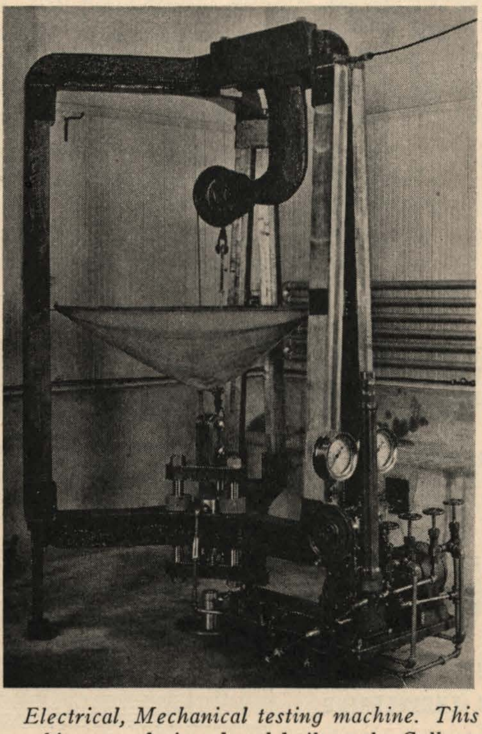
Preparing for a turbine test. The tests performed in the laboratory are comprehensive and practical.

The curricula in chemical and mining engineering differ considerably from those in civil, electrical, and mechanical engineering. They include, like the other three, a group of general academic courses which require about two college years for their completion. The remaining two years, however, are more particularly devoted to subjects in the field of the student's choice. The subjects in the curriculum in mining engineering may be classified under three headings: (1) geology, (2) metallurgy, and (3) mining machinery, methods, and management. The curriculum in chemical engineering provides in a similar manner for two years of specialized training in three general groups: (1) inorganic, (2) organic, and (3) industrial chemistry. While the engineering curricula differ in the fields of specific training and specific purpose, they are all administered with the same general objectives and purposes, the developing of certain habits of thought and work.

ENGINEERING TRAINING IN HABITS OF THOUGHT AND WORK

THERE are two general classes of higher education—one that can be adapted to the individual tastes and abilities, and the other to which the individual must adapt himself. The former is frequently called collegiate or academic and the latter professional or vocational. One may take the collegiate type of training and with a proper selection of major courses and electives quite satisfactorily adapt it to his particular tastes and abilities. The professional training, however, is a training in which he who succeeds must adjust himself to the requirements and standards of the profession. It is necessary, therefore, that one who desires to succeed in a profession should be potentially adapted to it.

The purpose of technical education in the engineering profession is not so much to impart technical knowledge to the student as it is to furnish a training which will enable him to think clearly and accurately, to understand and investigate the conditions which surround a problem, to determine the fundamental principles upon which its successful solution depends, to design the structures, machines, and works needed for its successful solution, and to supervise the activities necessary for a successful and economic conclusion. To provide such a training, coaching is required (1) in the mastery of those fundamental principles and sciences upon which the practice of engineering depends, (2) in the application of scientific methods,



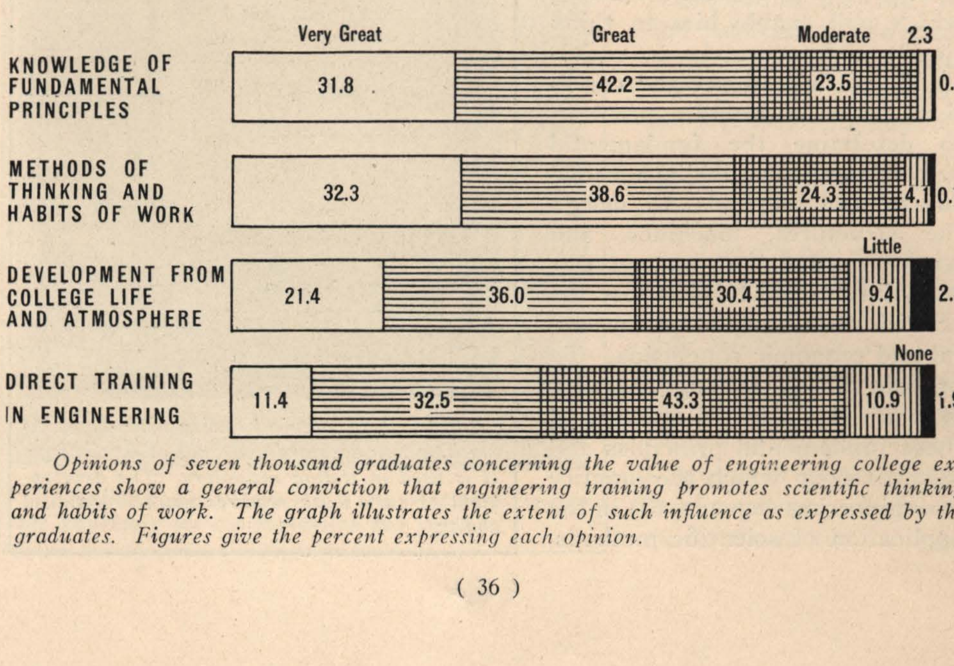
Electrical, Mechanical testing machine. This machine was designed and built at the College. It is used in testing insulators. The development of such work requires marked technical ability.

Forge Shop. Forge shop work is one of the subjects of the engineering group.

calculations, and processes, and (3) in a knowledge of standard practices and current processes found in the fields of engineering. These things are provided in a well-organized curriculum.

Training is also essential in engineering habits of thinking and expression. It is perhaps impossible to present clearly to the high school boy what habits of scientific thinking and expression are, just as it is impossible to explain some difficult game, such as chess; a true understanding of such a game can be obtained only by playing. That engineering training develops the scientific attitude is, however, quite generally agreed.

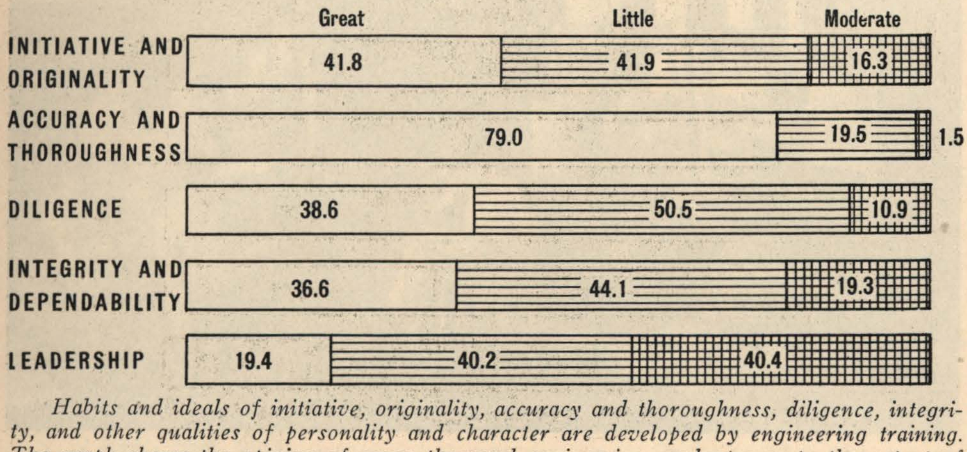
A summary of opinions of approximately 7000 graduates of engineering schools made by the Society for the Promotion of Engineering Education indicates the value of training as shown in the diagrams. That training in scientific methods of thinking and habits of work and in knowledge of fundamental principles of engineering sciences is quite generally accompanied by the development of habits of dependability, integrity, accuracy, thoroughness, orderliness, and neatness was also indicated by the same group of graduates. This expression of opinion may certainly be taken as conclusive evidence of the results of engineering training. All good engineering courses are organized and administered for the development of these powers and habits, and all good engineering students show marked progress in developing them.



Opinions of seven thousand graduates concerning the value of engineering college experiences show a general conviction that engineering training promotes scientific thinking and habits of work. The graph illustrates the extent of such influence as expressed by the graduates. Figures give the percent expressing each opinion.

NO life work should be undertaken solely for the anticipated financial success. Any work which is to give continued satisfaction and pleasure to the individual must possess a challenge of interest and must be reasonably within the individual's ability. "All work is hard unless you care for it and are interested in it. Interest is to work what oil is to machinery. A machine operating without oil will grind itself to pieces and in the meantime uses more power and produces less, as well as shortens its life. The human body, like the machine, has only a certain period to serve and live." It is quite certain, however, that interest cannot be maintained in a work which does not bring sufficient rewards for a reasonably dignified, useful, and comfortable life. It is also quite certain that the college graduate cannot maintain his interest in a work which will not enable him to rear his children under conditions giving them the fullest advantage of an American heritage.

The rewards in engineering seem sufficient to supply this life and opportunity for those occupied in the field. They are satisfactorily comparable to those of the other professions. It is not infrequently the case that men in one profession are compared with those in another by single illustrations. This is not a satisfactory basis from which to draw conclusions concerning any profession as a field of life work. Such comparisons can be made only by group studies. The earnings of engineering graduates as determined by the Society for the Promotion of Engineering Education are indicated in the accompanying diagram on page 40 and table on page 38. "The earnings of recent graduates seem to increase steadily and satisfactorily, their progress being approximately $300 per year in annual salary. * * * The progress of older graduates seems fair, though the rate of increase of earlier years is not maintained. There do not seem to be the extreme variations between earnings of graduates of different institutions. Certainly none greater than would be expected due to varying economic conditions of varying parts of the country."



Habits and ideals of initiative, originality, accuracy and thoroughness, diligence, integrity, and other qualities of personality and character are developed by engineering training. The graph shows the opinion of seven thousand engineering graduates as to the extent of influence of engineering training. Figures give the percent expressing each opinion.

These figures indicate that one may select engineering for his life work without being unusually or unduly concerned with the financial worries incident to the maintaining of a home and rearing of a family and may, furthermore, reasonably anticipate fair rewards for unusual ability and efforts. In preparing the diagram on page 40, the extreme earnings of those in the maximum 10 percent have been omitted. Such earnings have been above $17,500 and $30,000 a year, twenty and thirty years, respectively, after graduation. The data were supplied by approximately one-half of those canvassed. Earnings of graduates of institutions from which a large number of replies was received and those of institutions from which a small number was received were generally similar.

EARNINGS OF ENGINEERING GRADUATES

Class of		Years after graduation 0	1	2	3	5	10	15	20	30
1924	Number reporting	1191	....	....	....	....	....	....	....	....
	Median annual earnings	$1476	....	....	....	....	....	....	....	....
1923	Number reporting	1331	1218	....	....	....	....	....	....	....
	Median annual earnings	$1440	$1800	....	....	....	....	....	....	....
1922	Number reporting	1149	1082	1023	....	....	....	....	....	....
	Median annual earnings	$1320	$1800	$2100	....	....	....	....	....	....
1919	Number reporting	319	319	304	274	309	....	....	....	....
	Median annual earnings	$1300	$1800	$2000	$2200	$2860	....	....	....	....
1914	Number reporting	496	475	458	436	444	498	....	....	....
	Median annual earnings	$ 800	$1000	$1200	$1600	$2400	$4000	....	....	....
1909	Number reporting	459	418	414	404	416	422	430	....	....
	Median annual earnings	$ 720	$ 900	$1200	$1366	$1800	$3000	$5000	....	....
1904	Number reporting	243	223	221	212	202	226	216	238	....
	Median annual earnings	$ 720	$ 900	$1200	$1300	$1530	$2500	$4000	$5500	....
1899	Number reporting	156	126	125	123	125	130	129	147	....
	Median annual earnings	$ 600	$ 800	$1075	$1380	$1600	$2700	$4000	$6000	....
1894	Number reporting	119	97	96	92	109	102	103	100	116
	Median annual earnings	$ 600	$ 900	$1000	$1200	$1500	$2400	$3600	$5000	$7500

Electrical laboratory test. Tests of a scientific nature are made for the purpose of observing and explaining the performance of electrical machinery.

ENGINEERING BIBLIOGRAPHY OF VOCATIONAL INTEREST

HIGH school students who are particularly earnest in their selection of a life work and high school instructors who are seeking to be of maximum service in vocational guidance will find much information and helpful material in the following writings upon engineering. Many other works of a vocational nature have been written and are available. Those selected here seem, however, to cover the field in a thorough and comprehensive manner.

The Engineer.—John Hays Hammond
A description of engineering and engineering education. 1921. 195 pp. Chas. Scribner's Sons, New York.

Engineering As A Career.—Newell & Drayer
A group of addresses given by engineering leaders and supplemented by a vocational discussion. 1916. 214 pp. D. Van Nostrand Company, New York.

Engineering As A Vocation.—Ernest McCullough
A group of addresses given by the author before technical schools. A description of the engineer, his work, and his education. 1912. 200 pp. U. P. C. Book Co., Inc., New York.

Engineering As A Profession.—A. P. M. Fleming & R. W. Bailey
A description of engineering education and opportunities. 1924. 288 pp. John Long, London.

The Young Man and Civil Engineering.—G. F. Swain
A description of the field of civil engineering, qualifications for success, education and opportunity. 1922. 200 pp. The MacMillan Company, New York.

Engineering Education.—Ray Palmer Baker
A group of essays by eminent engineers, C. P. Steinmetz, R. A. Millikan, Isham Randolph, and others. 1919. 185 pp. John Wiley & Sons, New York.

The Adventures Of A Civil Engineer.—C. O. Burge
An interesting story of fifty years' experience. 1909. 320 pp. Alston Rivers, Ltd., London.

The Romance Of Modern Engineering.—A. Williams
Descriptions of a group of projects of a varied nature. 1921. 357 pp. Seeley & Company, London.

Engineering Of Today.—Thomas W. Corbin
A story of the modern achievements in applied science written in a popular style. 1911. 365 pp. Seeley & Company, London.

On The Battlefront Of Engineering.—A. Russell Bond
Fiction dealing with large engineering developments. 1916. 331 pp. The Century Company, New York.

Tackling Tech.—Lawrence W. Connant
Advice to students of technical schools. 1922. 197 pp. The Ronald Press Company, New York.

Addresses To Engineering Students.—J. A. L. Waddell & J. L. Harrington
A group of addresses given by the authors before students of technical schools. 1912. 563 pp. Waddell & Harrington, Kansas City.

The Engineer In War.—P. S. Bond
A description of the part played by men of technical training under conditions of war. 1916. 175 pp. McGraw-Hill Book Company, New York.

Lives Of Engineers.—Samuel Smiles
Five volumes of biographies of early engineers. 1924. Charles Scribner's Sons, New York.

C. P. Steinmetz, A Biography.—John W. Hammond
An authentic history. 1924. 489 pp. The Century Co., New York.

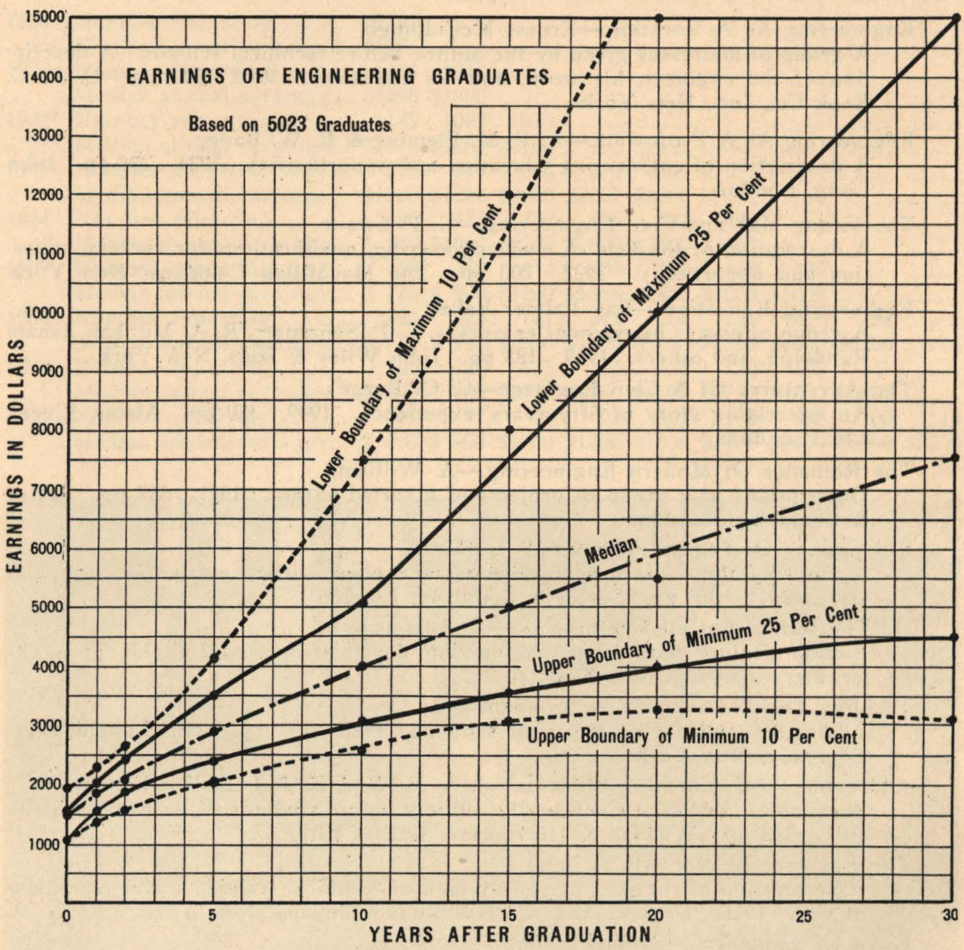
The Life Of George Westinghouse.—H. G. Prout
Authentic account of life and work. 1921. 350 pp. American Society of Mechanical Engineers, New York.

Bulletins and Reports of the Society for the Promotion of Engineering Education. Obtainable from the Lancaster Press, Lancaster, Pa.

No. 1. Engineering Students at the Time of Entrance to College. 20 cents.
No. 2. Admission and Eliminations of Engineering Students. 20 cents.
No. 3. Engineering Graduates and Non-Graduate Former Students. 20 cents.
No. 8. A Study of a Group of Electrical Engineering Graduates. 15 cents.
No. 9. A Summary of Opinions Concerning Engineering Curricula. 40 cents.
No. 10. A Study of Engineering Curricula. 40 cents.
No. 12. A Study of the Cooperative Method of Engineering Education. 30 cents.

Opportunities for Engineers in U. S. Civil Service. Washington Government Printing Office.

Student Expenses at Oregon State. (State Grange report.) Copies obtainable from The Registrar, Oregon State Agricultural College, Corvallis.



Curves showing increasing earnings of engineering graduates. The earnings of engineering graduates compare favorably with those in other professions. The curves in the diagram, based upon data collected by the Society for the Promotion of Engineering Education, show the minimum and maximum earnings of more than five thousand engineers.

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