chapter 1

What Is Engineering?

THE activity that we call Engineering began as an art and a craft thousands of years before man had adequate devices for the keeping of records. From pictures and ruins of those times we can see that there must have been men who were skilled in planning and building, and who were recognized and respected because of their special skill and ability. They planned and directed the building of huge projects such as the Egyptian pyramids, the irrigation canals of Mesopotamia, and the temples of the Mayans in Central America.

These men were not known in their time as engineers; that word was to come later. In ancient Egypt they were called "superintendents"; Archimedes was a "wise man" of Carthage; Vitruvius, a Roman of the first century before Christ, was called "architect," this word coming from the Greek and meaning chief builder.

Also during this period, another group of men was carrying on similar activities in the armies. They built fortresses for defense and implements for offense, and canals, roads, bridges, breakwaters. In most instances these projects were built for military purposes. Probably Cyrus had such men about 500 B.C. when he diverted the Euphrates River and took Babylon; doubtless, Julius Caesar had such expert help when he bridged the Rhine; and Louis XIV had the advice of Vauban during the latter half of the seventeenth century.

Derivation of Engineer. Men who performed those kinds of tasks were called "engineers" in Italy and France seven or eight hundred years ago because they were *ingenious* and conceived things out of their heads. Much later came the development of machines called engines, and men who operate them are called engineers, also. This double use of the word has caused misunderstanding and confusion for those who are interested in the profession of Engineering. Probably the words engine and engineer sprang from a common root. But engineer in the professional sense did not grow out of engine. Engineer derived from engine would mean one who operates an engine. Recently the word engineman has been used to designate an engine operator. The form of the word for engineer in some of the European languages means "ingenious designer." Clearly, those who first took the name engineer to describe their work were designers and creators, not machine or engine operators.

During the seventeenth and eighteenth centuries there were increasing developments in science. As information became available the abler architects and craftsmen began to apply the principles to their daily work. They used mathematics as a tool in their practical calculations and to push farther into the unknown. They began to understand and use the laws of chemistry and physics. And out of their theoretical and experimental investigations there gradually evolved a substantial body of principles. Henceforth, engineering was a triad of art, craft, and science, with science holding the increasingly dominant role.

It is a matter of interest to know when the work of these builders began to have public recognition. Usually names follow practices. Their work came to be known as military engineering and civil engineering, the former relating to operations of war, the latter to works for civilian use and called civil to distinguish them from military. We know that John Smeaton, an Englishman, was the first man to call himself a "civil engineer." That was in 1761. He was the designer and builder of the great Eddystone lighthouse. His report on that structure contained the phrase, "my profession of a civil engineer." There have been many developments and many kinds of engineering since the days of John Smeaton. We will discuss these later.

Definition of Engineering. At this point we are ready to define engineering and to see how it measures up to the requirements of a profession. Most definitions have their source in that famous contribution to engineering terminology which was made by Thomas Tredgold in the early 1800's for the charter of the Institution of Civil Engineering in Great Britain. He called engineering "the art of directing the great sources of power in nature for the use and convenience of man."

Many definitions of engineering have been written, as the field has grown since the days of Tredgold. In the main, these later definitions emphasize science and materials and give increasing attention to the place of engineering in the management and human relationship fields. For example, "Engineering is the art of applying the laws of the natural sciences, including mechanics and thermodynamics, to the utilization of the materials and forces of nature in producing facilities for the benefit of mankind, and the art of organizing the human effort required in connection therewith."[1]

Also, the responsibilities of the engineer include "the entire range of technical and executive direction involved in the production of fuels and industrial materials, the planning and erection of structures, the design and fabrication of industrial products, the planning and operation of utility services, the ordering of industrial plants and processes, the sale of technical products and their adaptation to special uses, and the administration of technical enterprises, both private and public."[2]

Time and Engineering March On. In 1955 the Committee on Evaluation of Engineering Education of the American Society for Engineering Education, in discussing the objectives of engineering education and the pattern that it should take in the future, stated, "The pattern . . . must, of necessity, be based upon the obligations of the engineering profession to Society and upon the importance of the development of the student as an individual. The obligations of an engineer as a servant of society involve the continual maintenance and improvement of man's material environment, within economic bounds, and the substitution of labor-saving devices for human effort.

"The first objective, the technical goal of engineering education, is preparation for the performance of the functions of analysis and creative design, or of the functions of construction, production, or operation where a full knowledge of the analysis and design of the structure, machine, or process is essential. It also involves mastery of the fundamental scientific principles associated with any branch of engineering . . .

"The second objective, the broad social goal of engineering education, includes the development of leadership, the inculcation of a deep sense of professional ethics and the general education of the individual. These broad objectives include an understanding

[1] Preliminary draft of report on Civil Engineering Curricula by Committee on Education, A.S.C.E., T. R. Agg, Ames, Iowa, July 17, 1940.

[2] Report on Aims and Scope of Engineering Curricula, *Journal of Engineering Education,* Vol. 30, March, 1940, p. 558.

of the evolution of society and of the impact of technology on it; an acquaintance with and appreciation of the heritage of other cultural fields; and the development of both a personal philosophy which will insure satisfaction in the pursuit of a productive life and a sense of moral and ethical values consistent with the career of a professional engineer."

In discussing the attainment of these objectives by the elimination of material now in the curricula and the addition of new curricula, the committee recommended, "Other areas due for close scrutiny, with a view toward possible elimination or reduction in time, are those courses having a high vocational or skill content and those primarily attempting to convey engineering art or practice. Some attention to engineering art and practice is necessary, but their high purpose is to illuminate the engineering science, analysis, or design, rather than to teach the art as engineering methodology.

"A review of the evolution of engineering curricula over many years shows a trend toward increasing emphasis on the science underlying engineering at the expenses of the study of engineering art for its own usefulness."[3]

CHARACTERISTICS OF A PROFESSION

In the foregoing paragraphs we have given a good deal of attention to the objectives of engineering education, because objectives or goals are of first importance in determining what will be the outcome of the educational process. We have used the word "profession" several times. It has both a broad and a narrow or restricted meaning and use. In its general use it means the occupation or calling to which a man devotes himself. When used in that sense, a man's work could be termed his profession—excepting, perhaps, trades, commercial and agricultural pursuits, and the like.

We are interested here in the restricted meaning of profession. It is necessary that we see the implications of the attitudes and points of view, expressed and implied, in the following definition if we are to have a real understanding of "engineering" and the work of the engineer. Many years ago the late William E. Wickenden composed this good definition of a profession:

> In its higher senses, a profession is an occupation which:
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> 1. Renders a specialized service, based upon advanced specialized knowledge and skill, and dealing with its problems primarily on an intellectual plane rather than on a physical or a manual-labor plane;
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> 2. Involves a confidential relationship, between a practitioner and a client or employer;

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[3] Report on Evaluation of Engineering Education, American Society for Engineering Education, June 15, 1955, p. 19.

3. Is charged with a substantial degree of public obligation, by virtue of its possession of specialized knowledge;
4. Enjoys a common heritage of knowledge, skill, and status to the cumulative store of which professional men are bound to contribute through their individual and collective efforts;
5. Performs its service to a substantial degree in the general public interest, receiving its compensation through limited fees rather than through direct profit from improvements in goods, services, or knowledge which it accomplishes;
6. Is bound by a distinctive ethical code, in its relationships with clients, colleagues, and the public.[4]

The description or definition of a "professional man" is given from another point of view in the section of the Taft-Hartley Act of the 80th Congress, which deals with collective bargaining. According to this act, a "professional employee" means any employee engaged in work (1) predominantly intellectual and varied in character as opposed to routine mental, manual, mechanical or physical work; (2) involving the consistent exercise of discretion and judgment in its performance; (3) of such a character that the output produced or the result accomplished cannot be standardized in relation to a given period of time; (4) requiring knowledge of an advanced type in a field of science or learning customarily acquired by a prolonged course of specialized intellectual instruction and study in an institution of higher learning . . . as distinguished from a general academic education, or from an apprenticeship, or from training in the performance of routine mental, manual, or physical processes.[5]

GROUPS THAT MAKE THE ENGINEERING FRATERNITY

Although Engineering is a profession, as we have defined it in the preceding paragraphs, the activities of those who call themselves Engineers are so numerous and so varied that we find it difficult to classify all of them in one reasonably homogeneous group. This fact is the root of many discussions on which courses should be included in an engineering curriculum. Some people would include many courses in various areas, such as administration, management, construction, selling, because many graduates of engineering colleges find careers in those fields.

Actually, the practice of those who call themselves engineers may include, in varying amounts, some aspects of a trade, a business, and a profession. Included among these engineers are men whose abilities, education, and training extend from that of the

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[4] *A Professional Guide for Junior Engineers,* William E. Wickenden, p. 32, Engineers' Council for Professional Development, New York, 1949.
[5] Taft-Hartley Act, Section 2 (12), 80th Congress.

most advanced scientific and technical type to that of the practical "school of experience" type. Because of this broad and heterogeneous mixture of abilities we might, with some justification, designate this group the "engineering fraternity," expecting that those with the aptitude, interest, industry, and personality will rise to meet the requirements of a profession.

Engineering enterprises require the services of three groups: skilled artisans, technicians, and professional engineers. There are no strict boundary lines—legal, technical, educational, or traditional—that mark off each group. They merge into one another, and many men are continuously in the process, by education and experience, of raising themselves from a lower to a higher level. Each of the groups does have certain essential and distinguishing traits which we shall now discuss in some detail, beginning with the artisan or craftsman.

Skilled Artisans or Craftsmen

This group contains nearly 30 per cent of the entire population of gainful workers in the United States. It is larger than any of the other groups, such as unskilled manual laborers, semiskilled factory operators, skilled clerical workers, and the professions. Because of the large numbers involved and the length of time devoted to training and experience, either through formal schooling or apprenticeship, this group, known as the *skilled trades,* has a great deal of economic and educational importance.

Skilled Trades are manual occupations for which more than two years of special training are ordinarily prerequisite. This training may be gained through course work in trade and vocational schools, technical high schools, or apprenticeship. Examples of skilled trades are patternmaker, sheet-metal worker, machinist, toolmaker, blacksmith, molder, electrician, carpenter, mason, painter, compositer, pressman, weaver, watchmaker, and many others. Several of these have subgroups, each of which is more or less a specialty.

For example, there are many kinds of machinists. Using the strict meaning of the word, machinists are people who machine metal, that is, cut metal. Some machinists make machines, others erect them or operate them. Detailed classification would include under the general heading of machinist such workers as: operators of punch presses, drill presses, shapers, broachers, boring mills, and grinders; millwrights, who erect machinery; and tool and diemakers, known as the aristocrats among machinists.

Inasmuch as these skilled artisans and craftsmen are so numerous and are so intimately and indispensably linked with the details of manufacturing processes, it follows that the way of the skilled trades is a good route to success and positions of responsibility. Many of our captains of industry and their principal subordinates have come up through the ranks of craftsmen. All large industries are keenly alive to the importance of having an alert and efficient group of skilled workmen. Some companies maintain well-organized and competently supervised apprentice training courses; others cooperate with public and semipublic groups that are carrying on vocational education programs.

Traits of Successful Craftsmen. There is a widespread general belief that *manual dexterity* is the only prerequisite for success in a trade. Probably the common classification of manual occupations—unskilled, semiskilled, and skilled—which seems to place the emphasis on degrees of manual skill, has fostered that belief. Actually, the success of a skilled craftsman is also dependent upon his *technical knowledge* and the *sound judgment* which he exercises when he makes decisions. Comprehensive and extensive groups of intelligence tests show that successful skilled craftsmen rank *above the general average in intelligence* and that the best of these are near the professions at the top of the intelligence rating scale.

This observation on the significance of better-than-average intelligence should be noted by those who think that learning a trade offers a successful way out for men who make unsatisfactory scholastic records in the engineering college. Their lack of ability to master academic subjects may include lack of mechanical aptitude also. Each case should be examined. The answer should be based upon a comparison between the individual's aptitudes and interests and the requirements of the craft considered.

We shall enumerate, in the order of their importance, the traits possessed by successful skilled craftsmen: (1) better-than-average intelligence, as measured by a standard intelligence test; (2) definite interest in learning the trade and progressing in it; (3) ability to acquire manual expertness in the required skills. The extent of this ability may be ascertained by standardized and established tests or by work in the shop under actual operating conditions. There should be concrete evidence of one's ability to acquire trade knowledge and exercise practical judgment as well as to become proficient in the use of the working tools of the trade chosen. No one will find pleasure in a trade that is hard for him to learn, nor will he get far in the apprenticeship if he is clumsy and dull.

Engineering Technicians

Engineering technicians occupy the area and perform functions between the artisans and the professionally prepared engineer.

Some of their jobs are quite elementary and routine; others require a high order of detailed technical ability. Most engineering graduates serve a short training or "experience-gaining" assignment to such tasks. Here they learn the important methods of their company and at the same time are under observation by the responsible officials. This is the beginning of the young man's climb toward a position where he can rate as an engineer. Some graduates never rise above the level of routine performers and, although engineering graduates, do not become engineers.

Work of the engineering technician includes surveying, drafting, inspecting, testing, laboratory analysis, time keeping, cost keeping, time and motion study, servicing and selling, and others. Obviously, these jobs are so closely related to the important work of industry that it would be difficult to draw a line separating technicians from engineers. There is a wide common band or twilight zone in which both technicians and young men headed for engineering are employed. Some stay in this area by choice; others, because of aptitude, interests, or limiting factors, find it necessary to remain. This need not be taken as a sign of failure. Many important jobs are found in this area and there must be men to do the work.

There is a large number of such positions. Our present system of technical education in the United States does not make sufficient provision for the selection and training of men to fill them. There are several schools, generally designated Technical Institutes, that offer terminal programs about two years in length for the training of technicians. Recently, the Engineers' Council for Professional Development recognized the importance of these schools and set up machinery for their evaluation and accreditation as technical institutes.

Many technicians come from the ranks of the four-year engineering college graduates or from the group that did not complete requirements for the B. S. degree. Others move out of the ranks of craftsman and trade school or technical high school graduates. Some receive specific training through organized programs maintained by companies that have a need for people with specific skills. For the majority of these technician positions the pay is below that of a craftsman, and subtantially above that of a common laborer.

Need for Technicians. If the estimates of employers who need technicians are correct there is a large annual unfilled demand for such men. The solution offered in several industrial centers is short, practical, and intensive courses of study lasting about two years that are designed to prepare men for immediate assimilation into an industrial organization. This plan has two advantages. For the employer it provides men with specific training who can work effectively from the start; for the employee it provides a short, intensive, not-too-expensive training which is leading toward a definite job.

There are disadvantages, too, but they can be minimized or eliminated. At the present time many young men are entering curriculums leading to the B. S. in Engineering who should follow a shorter, more practical program. This desire to earn the B. S. in Engineering is natural because of the eternal ambition of young people to get ahead, and because few are willing to admit that their abilities do not warrant the investment in a regular four-year engineering curriculum. Therein lies one of the knotty problems of our American educational program. Sufficient progress has been made with prognostic tests to warrant the hope that we shall soon be able to offer sound educational advice to young men on the likelihood of success in various college curriculums, as well as to offer alternate suggestions in case the outlook for success in college seems doubtful. We must also develop a technique which will enable us to persuade them to follow the advice. Everyone cannot "become president."

The Professional Engineer

Now we face the question, When and how does an engineering graduate become a professional engineer? Certainly not upon graduation from the engineering college. Probably not after any specified number of years of experience. During this experience-gaining period he has advanced beyond the engineering technician. He has shown considerable ability in the application of the fundamental principles of science and engineering to the solution of problems. These problems may be highly technical, requiring research or ingenious and complex analyses and designs; then again, they may call for demonstrated, creative ability in technical fields, or in administration, management, organization, or economy. Probably a ruling requirement will be that the engineering graduate has demonstrated the ability to have responsible charge of an engineering project of some importance.

As we have noted earlier, men with degrees in engineering, and who rate themselves engineers, are engaged in a variety of activities that call for varying amounts of engineering ability. Because of this confusion and because there is increasing need for a standard mark for those who are engineers, there is a growing movement to have all engineers become registered professional engineers.

Engineering Registration, or the licensing of an individual to practice professional engineering, is a legal requirement of each of the states and territories of the United States and of many foreign countries. The legal basis for this registration or licensing of individuals to practice engineering rests upon the fact that the practice of engineering, in cases such as the design and construction of structures, waterworks, heating and ventilating systems, electrical systems, and boilers affects the life, health, property, and public welfare of the citizens. Therefore, the state seeks to safeguard the life, health, and property, and to promote the general welfare by restricting the practice of professional engineering to those who are able to satisfy the requirements of the state's board of engineering examiners.

The engineering registration laws of many states follow the pattern of the Model Law for the Registration of Professional Engineers and Land Surveyors.[6] This model law represents more than a quarter of a century of work by the principal engineering societies of the United States.

It defines a professional engineer as "a person, who, by reason of his specialized knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design, acquired by professional education and practical experience is qualified to practice engineering as hereinafter defined, as attested by his legal registration as a Professional Engineer."

This model law defines Practice of Engineering as "any professional service or creative work requiring engineering education, training, and experience and the application of special knowledge of the mathematical, physical, and engineering sciences to such professional services or creative work as consultation, investigation, evaluation, planning, design, and supervision of construction for the purpose of assuring compliance with specifications and design, in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works, or projects."

General Requirements for Registration. All states have standards of qualification which they consider "minimum evidence satisfactory to the Board that the applicant is qualified for registration as a Professional Engineer. . . ." These requirements are oftentimes set up to cover three types of applicants, as follows: (1) those who qualify on graduation plus experience, (2) those on experience plus examination, and (3) those engineers of long-established practice. The specification of the model law on those who qualify by graduation plus experience will illustrate the nature of the require-

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[6] The Model Laws for the Registration of Professional Engineers and Land Surveyors, National Council State Boards of Engineering Examiners, Charleston, S. C.

ment. It is: "Graduation in an approved engineering curriculum of four years or more from a school or college approved by the Board as of satisfactory standing; and a specific record of an additional four years or more of experience in engineering work of a character satisfactory to the Board, and indicating that the applicant is competent to practice engineering (in counting years of experience, the Board at its discretion may give credit, not in excess of one year, for satisfactory graduate study in engineering), provided that in a case where the evidence presented in the application does not appear to the Board conclusive nor warranting the issuing of a certificate of registration, the applicant may be required to present further evidence for the consideration of the Board, and may also be required to pass an oral or written examination, or both, as the Board may determine. . . ."

Examinations. The standard pattern of written examinations is two eight-hour examinations. The first day's questions cover the fundamentals, which is usually an examination over the principles in the courses of the engineering curriculum. The second day's questions cover the work of the applicant's field of practice and are designed to prove his competence to practice, as defined by the law.

The final rating of the applicant is usually made by giving weight to his examinations and experience. The following from rules of the Iowa Board are illustrative: "The final rating of an applicant shall be determined by the following: Personality, having to do with character, evidence of a general engineering interest and executive ability equals 10 per cent of total rating. Experience (nature and extent) equals 15 per cent of total rating. Written examination in fundamentals equals 35 per cent of total rating. (Oral examination in fundamentals equals 30 per cent, and 20 per cent on engineering experience, personality, character and executive ability when oral examination is taken.) Examination in principles of good practice, consisting of a certain number of questions in writing, depending on the branch of engineering taken equals 40 per cent of total rating with written fundamental examination and 50 per cent of total rating when oral fundamental examination is given. The candidate must make a grade of at least 60 per cent on this portion of the examination. A final rating of 70 per cent shall be considered a passing grade."[7]

As mentioned in an earlier paragraph, many engineers who are competent and qualified have not chosen to become registered professional engineers. In 1955 there were approximately 200,000 registered professional engineers in the United States which is, prob-

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[7] 1954 Report, Iowa Board of Engineering Examiners.

ably, less than 50 per cent of those who are qualified for registration. There is no compulsion to become registered on those who are not designing and building works for public or private interests not their own (or are employers of corporations so engaged). Federal and state employees and practically all of the engineers who work for industrial corporations are not required by law to seek registration. However, the trend toward registration, whether called for by law or not, as the mark of a professional engineer is growing, and the time is near when every man who calls himself an engineer will be a registered professional engineer.

Many state boards of engineering examiners provide for a grade designated Engineer in Training. Under this designation an engineering student may take the fundamentals portion of the registration examination during the final quarter or semester of his senior year in college, deferring the final portion of the examination until he has acquired the necessary qualifying experience. It is hoped that many seniors may be persuaded to take this Engineer in Training examination, and that they will follow with completion of the requirements for registration. If this happens, the number of registered professional engineers will show a marked increase and the professional status of engineering will be strengthened.

THE ENGINEERING SOCIETIES

Engineers who are engaged in related activities have found it desirable and advantageous to band together to form organizations commonly designated "societies." Here they are able, through technical meetings, research, and various types of publications, to keep informed about developments in their fields. Also, through the efforts of the societies, they have maintained contacts with legislatures and public agencies, with the public press, and with other organizations.

These societies are international, national, statewide, and local in their activities. One of their significant characteristics is that they operate independently of one another, with only loose bonds of cooperation. Four of these, known as the Founder Societies, were established before 1900. They have headquarters and offices at 29-33 West 39th Street, New York City, in a large building which they own jointly. This building was becoming too small in 1955, and there was discussion about a new one. The four founder societies are American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, and American Institute of Electrical Engineers.

There have been numerous attempts to "unify" the engineering profession. One of these is represented by the National Society of Professional Engineers. Since its establishment in 1934, this society has tried to reach a position in membership and prestige where it can speak with authority for the entire engineering profession. Its principal emphasis is upon the professional, social, and economic status of engineers with little attention to technical matters.

Acting on this unification idea from another angle is the Engineers' Council for Professional Development (ECPD) which is "a conference organized to enhance the professional status of the engineer through the cooperative efforts of the following national organizations, concerned with the professional, technical, educational, and legislative phases of engineers' lives: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, The Engineering Institute of Canada, American Society for Engineering Education, American Institute of Chemical Engineers, National Council of State Boards of Engineering Examiners."

The ECPD does many useful things for the engineering profession in areas such as student guidance, accrediting engineering curriculums, professional education, training and recognition, engineering ethics, and the dissemination of information about them.

However, it does not have the organic structure that enables and qualifies it to speak for all engineers. So, we have an organization named Engineers Joint Council (EJC), a federation of several national engineering societies, that is trying to bring all engineers into one federated group. Constituent societies of this federation in 1955 were: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Waterworks Association, American Institute of Electrical Engineers, Society of Naval Architects and Marine Engineers, American Society for Engineering Education, American Institute of Electrical Engineers.

The parent of these technical societies is the Institution of Civil Engineers founded in 1818 in England. The American Society of Civil Engineers was founded in 1852.

The development of the steam engine and other mechanical devices brought together a large number of men with a common interest in things mechanical. Quite naturally, this group separated from the parent group of civil engineers to form a distinct profession, Mechanical Engineering. In England, the Institution of

Mechanical Engineers was founded in 1847, and George Stephenson, the locomotive builder, was its first president. The American Society of Mechanical Engineers was founded in 1880.

Men interested in mining engineering decided to set up their own profession in the eighties also. So we find the Institution of Mining Engineers founded in England in 1889 and the American Institute of Mining Engineers in 1871. The latter is now known as the American Institute of Mining and Metallurgical Engineers.

The next group to form a society was the Electrical Engineers. The Institution of Electrical Engineers was founded in England in 1883 and the American Institute of Electrical Engineers in 1884.

A long period elapsed before another division occurred. In 1908 men interested in chemical manufacturing and related problems, which were different from the purely chemical aspects, called themselves Chemical Engineers and founded the American Institute of Chemical Engineers.

Men interested in the application of power to the farm called themselves Agricultural Engineers and founded the American Society of Agricultural Engineers in 1916.

Many other engineering societies have been formed. Some of these will be mentioned later in connection with the degree-granting departments. In general, the numerous technical societies (there are about 300) represent very special technical fields. Examples of these societies are: American Railway Engineering Association, American Society of Heating and Ventilating Engineers, American Society of Safety Engineers, American Society for Testing Materials, American Concrete Institute, Institute of Radio Engineers, Illuminating Engineering Society, Society of American Military Engineers, Society of Automotive Engineers, and others. Also, there are many state, city, and local engineering societies and clubs, whose field of operation seems to be a combination of the technical, economic, and legislative. Besides these, there are many kinds of engineers who operate as a division of the parent society. In this group are highway engineers, structural engineers, sanitary engineers, transmission engineers, electronic engineers, communication engineers, and others. These numerous specialties will be pointed out in later discussions of the degree-granting departments.