ENGINEERING AS A VOCATION

ERNEST McCULLOUGH

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BY

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To

The Engineer's Wife

THIS BOOK

IS MOST RESPECTFULLY DEDICATED

BY

HER FRIEND AND SINCERE ADMIRER

AND SYMPATHIZER.

The Author

And Ruth said "Intreat me not to leave thee, or to return from following after thee; for whither thou goest I will go; and where thou lodgest I will lodge; . . ."

SPECIFICATIONS FOR A GOOD ENGINEER

"A good engineer must be of inflexible integrity, sober, truthful, accurate, resolute, discreet, of cool and sound judgment, must have command of his temper, must have courage to resist and repel attempts at intimidation, a firmness that is proof against solicitation, flattery or improper bias of any kind, must take an interest in his work, must be energetic, quick to decide, prompt to act, must be fair and impartial as a judge on the bench, must have experience in his work and dealing with men, which implies some maturity of years, must have business habits and knowledge of accounts. Men who combine these qualities are not to be picked up every day. Still, they can be found. But they are greatly in demand and when found they are worth their price; rather, they are beyond price and their value cannot be estimated by dollars."
—Chief Engineer Sterling's Report to the Mississippi Levee Commissioners.

PREFACE

THE subject matter of this work has been rearranged (with additions) from a number of addresses given before technical schools and associations of engineer assistants. It is published for the information of parents in order that they may act wisely in selecting a career for their sons. Semi-technical periodicals and daily newspapers are bureaus of information consulted frequently by ill-informed parents; and, perhaps, more than half the students now in technical schools are there because of opinions obtained as valuable advice from such sources.

The reason for the opinions expressed by writers in such publications is hard to ascertain. A careful reading of the back numbers of technical periodicals and transactions of technical societies will prove the statements in this book to be accurate, and the advocates of wholesale technical education have always had these sources from which to obtain information. The reader is to bear in mind that when the average engineer is mentioned it is the average in numbers and not in ability that is meant.

THE AUTHOR.

Chicago, Ill., June, 1911.

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"The fact that a competent engineer can make a little money go much further than it would go without his advice and aid is one which the general public is slow to comprehend. The average man congratulates himself upon the dollars he saves by dispensing with an engineer's services, and knows nothing of the dollars lost in exorbitant prices, or work poorly executed."—*From an editorial in Engineering News, July 11, 1895.*

ENGINEERING AS A VOCATION

CHAPTER I

THE ENGINEER

THE average person is puzzled over the exact meaning of the word "Engineer" after some acquaintance with the many sorts of men who so style themselves. To engineers the confusion is often humorous, but none the less occasionally mortifying. A fond mother whose son was a student in engineering at one of the leading technical schools was asked by a friend how she could contemplate having her son work in greasy clothes around an engine, "like a common laborer." The same mother was asked by another friend if she did not think it a great waste of money to educate her boy at such an expensive school "to be only a common surveyor after all."

Engineers enjoy the story of the payroll. The name was not Smith, but it does for the story. On a certain payroll appeared:

Smith, Aaron, Engineer. .$15 per week.
Smith, James, Asst. Eng. .$75 per week.

Aaron Smith was a colored man unable to read and write. His duty was to run the steam launch that carried James Smith, C. E., the principal assistant of the Chief Engineer up and down the river where he had charge of important improvements costing several millions of dollars. What's in a name?

For years professional engineers have tried to designate men like Aaron Smith as "launch tenders," men who operate stationary engines as "engine runners," and men who operate locomotives as "engine drivers." Such terms are used in some countries, but are being gradually supplanted by the word "engineer" with a qualifying word before it.

In the United States the locomotive engineer is styling himself a "traveling engineer," although that term should be applied exclusively to men employed by railways to travel and instruct locomotive engineers. By this time the public knows that a "stationary engineer" operates engines in power houses and on contractors' plants. A "hoisting engineer" runs a hoisting engine. A man in charge of an entire power plant is known as an "operating engineer." This does not always fully explain, for the operating engineer who takes a contract to look after a number of large plants in important factories or large office buildings, may be a graduate mechanical or electrical engineer, while the "operating engineer" in a sawmill may

be illiterate and his entire power plant consist of a second-hand fifty horse-power engine.

At present an "electrical engineer" may be a man who designs, or sells, or installs electrical machinery, or he may be a man in temporary charge of a five horse-power motor. Some bell hangers are called electrical engineers and so advertise themselves. In Great Britain an "engineer" may be one of the greatest men in the empire or he may be merely an employe in an engineering works, or, as we term them in the United States, machine shops or factories.

With all the confusion the public, through the medium of the press is coming to a better realization of the engineer and his work so that the professional engineer is taking rank among educated people, with the lawyer, the surgeon, the physician and the clergyman. With this better conception of the professional side of the calling there has also crept in the idea that it is a remarkably well-paid business, embracing the romance and adventure of the soldier's life with that of Aladdin, who merely rubbed an old lamp when he needed money.

The engineer only incidentally is tied to an engine, either as designer, builder or operator. A search of the dictionary for roots yields the following definitions:

> ENGINE, *French, engin; from Latin, Ingenium, a genius, an invention.*

ENGINEER, *English, engin-er; Old French, enginier; French, ingénieur.* A person of genius or ingenuity.

In the Latin-English dictionary we find:
Ingĕnĭōsus-a-um. *(ingenium) Naturally clever, talented, acute, able, ingenious.*

Students of engineering history accept the foregoing definitions as satisfactory root forms of the word "Engineer." Thus we find the engineer is "the ingenious man." This broad definition brings all characteristically energetic, able men into the category of engineers. When a man is said to have engineered a deal it is understood he obtained his own way after the exercise of considerable ingenuity. There are to-day many foolish persons who display a silly affectation in assuming the title of engineer, such as social engineers, who are persons engaged in studying social conditions; advertising engineers, who are persons engaged in handling advertising on a large scale, etc., ad nauseum. Other words, equally, if not more, effective in conveying the intended meaning might be used, for the English language is very rich. To the writer and other men in the profession there are two definitions which exactly describe the engineer, and these definitions, if properly acknowledged, would break down the artificial lines of separation between the numerous "specialties" of engineering work which are

damaging and tend to make of the school-bred engineer an automaton and an illy-paid, hardly-treated person.

In 1828, Thomas Tredgold, in England, defined civil engineering as "the art of directing the great sources of power in nature for the use and convenience of man." This definition is incorporated in the constitution of the Institution of Civil Engineers of Great Britain.

In 1885, A. M. Wellington, a prominent American engineer, for many years editor of Engineering News, said in the preface of his classic "Economic Theory of the Location of Railways," that "engineering . . . is the art of doing that well with one dollar, which any bungler can do with two after a fashion."

The second definition is really the more broad. Any man who directs the great sources of power in nature for the use and convenience of man is practising engineering. A partly educated man may do this. The fresh—often too fresh—young graduate of an engineering school may do this. The engineer, however, has been so well trained in engineering that he can do a thing well with one dollar which a bungler can do in a bungling manner with the expenditure of two dollars.

Ability+Education+Training+Experience=Engineer.

There was some spice, perhaps unintentional, in the definition of civil engineering. To one, how-

ever, who appreciates the grim humor of strong, self-tutored men, the spice was, no doubt, intended. From the beginning of civilization men had houses built by builders who came to form a distinct order and were known after a while as architects. These men wrought for the comfort and convenience of mankind. Engineers, however, were military men whose structures were for warlike purposes. Their bridges were not erected for peaceful use and as an embellishment of the landscape were never looked on with favor. Only architects built beautiful bridges, following the plans of the engineers, whose bridges were erected so that armies might attack a province or defend a city. For many centuries engineers were employed to plan campaigns and lay out works to defend or to attack forts and cities. Many great soldiers in the past preferred the title of "Engineer" to that of "General."

Military engineers showed their ingenuity in the invention of engines and implements of war and the use of every means at hand to kill men and destroy the works of their hands. In times of peace, or when the engineer corps of an army was quartered in cities, the engineers were employed to construct water works and drainage works for large districts. This was not done primarily for the purpose of making conditions tolerable for the inhabitants, but to provide water and guard health during a possible siege, for sieges in those old days sometimes lasted for years. The engineer, the mili-

tary engineer, might have been defined as one "who practised the art of directing the great sources of power in nature for the harm and destruction of man."

Somewhat more than one hundred years ago some Englishmen engaged on construction work intended for the advancement of civilization, such as the building of roads, bridges and canals, and the erection of great buildings, learned that many Italian, French and Spanish architects and bridge builders, the latter work by this time having become a distinct specialty, were in the habit of terming themselves engineers without any qualifying designation and military engineers were making strong objection. These Englishmen concluded that since much ingenuity was required in civil as well as military construction, the term "Civil Engineer" was eminently proper and it was adopted. There being strong opposition to the use of the word engineer by civilians it was necessary to exactly define the civil engineer, the definition of Thomas Tredgold being the result; somewhat insulting to the army as well as to the naval engineer, who, at that time, had no engines to care for, but who built docks, designed ordnance, etc., and assisted the naval architect in the design and construction of war vessels.

To-day the distinction is disappearing. Military engineers have so little employment of the old sort that most of their time is spent in work of a

civil engineering nature, the internal improvements of the country. The army engineers of all armies are selected from the honor graduates of the national military academies. They constitute a body of well-trained men on whom the government may call for any duty. Their pay is the highest of all soldiers and the engineers are the ranking branch of the military service. Naval engineers are highly trained mechanical and electrical engineers. For the construction and maintenance of ship yards, docks, etc., there is a special corps of Civil Engineers of the Navy, Robert E. Peary having been a member of that honorable corps of men who have a relative rank, with uniforms and all the honors pertaining to the rank, but who have no right to the use of the title. For example when Robert E. Peary was a Commander he was borne on the Navy lists as a Commander; wore the uniform of a Commander; took rank in a procession or at a reception in accordance with his relative rank; got the pay of that rank, and yet among naval officers he was Mr. Peary, Civil Engineer, U. S. N. To-day, while retired as an Admiral he has no right to have the word Admiral engraved on his calling card, unless the act retiring him with that rank was so worded as to confer that right. But we digress while discussing the strange customs of the least democratic of all the institutions of the American government.

Shortly after the Civil Engineer appeared the

steam engine was improved to such an extent that its rapid development led to the most wonderful changes the world has ever witnessed. The power of men to achieve was multiplied a millionfold and manual labor gave way to mechanical effort, whereby comforts hitherto unknown were brought within the means of everyone. Need was had for men trained in mathematics and the physical sciences and such men were found in the ranks of the engineers, civil, naval and military. The first men to make a specialty of engine design and operation were known as Mechanical Civil Engineers, but for only a short time was the awkward title used, the word civil being dropped so that the Mechanical Engineer became an individual. The first mining men who called themselves engineers were Mining Civil Engineers, but it was a cumbersome title soon abandoned for that of Mining Engineer, or Engineer of Mines. The Electrical Engineer was an electrician when that science first came into prominence and the Electrical Engineer as such did not appear upon the scene until about seventy-five years after the Mechanical Engineer dropped the word civil from his title.

"Farther than runneth the memory of man," every nation had schools for the training of military engineers and the professors were men who wrote many books so that some of the rules of construction followed to-day date back several cen-

turies. The first school, however, to teach the new profession of civil engineering, as such, with the degree of Civil Engineer, was the Rensselaer Polytechnic Institute of Troy, N. Y., founded in 1826. It has had a most successful career and is to-day a leading school, courses in mechanical engineering and electrical engineering having been added within the last five years. Engineers have not been particularly impressed with the value of the history of their profession and all the facts are not exactly known, or are not easily accessible. It is believed that the second civil engineering school was established in France a year or two after the establishment of the Rensselaer Polytechnic Institute in Troy, although the famous Ecole des Ponts et Chausses for the training of engineers to care for the French highways, was essentially a civil engineering school, the military school of St. Cyr educating military engineers and artillerymen. Between 1830 and 1840 the University of Glasgow, Scotland, established a course in mathematics and the natural sciences for the theoretical training of young gentlemen apprenticed to civil engineers and from this school was graduated William John Macquorne Rankine. Rankine practised as a civil engineer for several years and, in 1856, upon the retirement of the great Professor Gordon, succeeded him as professor of civil engineering. Rankine was a phenomenal man who wrote many books covering the entire field of engineering,

establishing it upon a sound basis as a mathematical science. There were many great investigators and writers on engineering subjects in Europe, especially in France and Germany, whose work he made free use of, but by all of these men he was looked up to as a leader and might be said to have been the father of the civil engineer. Before his time the engineer "picked up" his education and received his theoretical and scientific knowledge as best he could while burning the midnight lamp. Rankine made it possible to study engineering with the least loss of time and wasted effort. The fourth school of civil engineering was Union College, now Union University, Schenectady, N. Y.

In Great Britain it was the custom for many years, which custom has not entirely died out, to apprentice boys to some engineer for a definite term of years, paying a fee for the privilege, the amount of the fee being governed by the degree of eminence of the engineer. The boys were supposed to receive practical instruction through helping around the office and out in the field or in the works, becoming engineers through the operation of a gradual "soaking in" process. The schools were so conducted as to give one, two, or three years' instruction for a few months each year in mathematics and science, to enable the "articled" pupil to acquire the theoretical knowledge he actually needed. Since the instruction given at the schools was wholly along theoretical

lines it was not looked upon with much favor, the British being a great people to laud practical (?) methods. Some of the old feeling against schools crops out once in a while, but the majority of the British engineering schools to-day are not very different in aims and methods from the schools of other countries.

In continental Europe young engineers received all their theoretical instruction in schools having five- and six-year courses before going into practical work. To-day a certain amount of practical work, or shop training, is insisted upon as a prerequisite to graduation, this work being sandwiched between school years. In the United States the apprentice system was never in favor and the schools in this country from the first endeavored to complete the scholastic training of the students before they went into practice. Engineers were in demand and for a great many years the schools could not turn them out fast enough, so there was lacking the intense thoroughness of the German and Frenchman and the practical training of the Briton. The differences in methods of instruction formerly common in the schools of different countries were well illustrated in a remark made by a prominent educator a few years ago to the effect that the British engineer was a technically trained mechanic, the continental European engineer a technically trained scientist and the American engineer a technically trained busi-

ness man. It was said that these differences were plainly shown in South Africa and other frontiers of civilization where the British engineer was an outside superintendent at good pay bossing laborers; the continental engineers were in the drafting office and computing desk getting much less pay and the American engineer was drawing a large salary as general manager. Actually such a view of the matter was a most unjust slur on the engineers trained in British, German and French schools. In those countries no railway was built or any great public work undertaken until it was deemed a necessity. When decided upon it could not be started until many tedious legal formalities and governmental requirements had been complied with. It was not a gamble, and, therefore, no expense was spared to make it permanent. The young men trained in the schools of such countries naturally were drilled in methods that were hardly adapted to pioneer countries where every railway and other enterprise was a gamble and the item of first cost most important. Americans have never been particularly noted for willing acquiescence in regulations of any sort that interfere with a man doing as he pleases, so, of course, American engineers were the best for newly exploited countries. In old countries the idea of having to rebuild anything is viewed with horror. In the United States, especially the United States of a couple of generations ago, the very cheapest work was

wanted as it was believed the profits would enable the work to be done over in a few years if necessary. The differences, therefore, between the engineers of the different countries were not due wholly to the training received in schools, but were due primarily to environment, heredity, custom and habit.

To-day engineers in all countries read and study papers and books written by men in other countries. Translators are busy everywhere so that each week the up-to-date engineer receives by mail a paper containing an account of everything of value to him in his own and other countries. The schools are gradually getting together and there is very little difference between first-class schools, whether they are in England, Germany, France, Belgium, Sweden, Italy, Austria, Russia, Japan, Argentine or in the United States. In all will be found the leading works of the leading instructors in all countries and Rankine's works have been translated into many languages and have formed the basis of hundreds of standard text books.

Considerable criticism of engineering schools is heard. "What is the trouble with our engineering schools?" is a cry frequently heard, but if there in any trouble it is farther back and the cry should be "What is the trouble of our engineering schools?" The answer being "The false ideals and the lack of consistency and coordination in the

public schools." It is not fair to expect the engineering schools of the United States to take that illy-digested product, the average grammar or high school graduate, with his smattering of many things, including plain sewing, and expect to get as perfect a product in the way of an educated man as the German schools turn out. Much of the criticism, however, of our engineering schools is a survival of the days when few engineers were school bred and a college education was not common. No employer cared to have in his employ a man better educated than himself, for they were autocratic, were the successful men of the days of our fathers and grandfathers. The old practical (so-called) engineer was preferred whenever an engineer was employed. A strong stream of engineering graduates has been poured out over the world within the past thirty years and numbers of them have deserted technical (professional technical) engineering to go into contracting and manufacturing. Their success has been so marked that the heads of the largest manufacturing establishments and the heads of the most progressive contracting companies are men who received engineering educations. If their training had not been as practical as it is possible to make school training, they would not have succeeded. Some men ask that the school courses be made more practical and yet are unable to explain just what they mean. Some are merely echoing an old com-

plaint and some graduates are crying from disappointment, when, perhaps, the school was not responsible. Accidents of birth have much to do with lack of success in life. No school can supply a man with common sense and intelligence if these very desirable qualities were omitted in his make-up, but education can do much to enable one to make good use of all the intelligence he may have.

The modern engineer must have a college training or something that is equivalent. The equivalent is very, very hard to obtain. Teaching is a distinct profession and the practising engineer cannot always obtain the viewpoint of the teaching engineer. The curricula of the numerous engineering schools bear a very close resemblance to each other, yet many men have taken positions as professors with the idea of revolutionizing matters. Many of these men have had the privilege of organizing new schools in old colleges and universities and have had, some of them, the opportunity to start out on new lines in entirely new institutions unhampered by traditions. With the free hand given them and the splendid opportunity offered for reform it is significant that the courses in such schools gradually bear a very strong resemblance to those in older schools. All heads of engineering schools pay great attention to old graduates and the average engineering school of to-day, with all its reputed shortcomings is really

the product of the alumnæ, much as some of them will dispute it.

There is really nothing serious the matter with our engineering schools that will not be corrected in time. The Society for the Promotion of Engineering Education is doing good work and many eminent practising engineers belong to this society, which invites helpful criticism. If anything is a fault with the training given in the schools it is that many schools have paid entirely too much attention to outside criticism and the students are narrowly trained specialists, who have been cheated in their unfortunate attempt to get a proper education. However, this does not belong in the chapter which is supposed merely to define the engineer. In a later chapter the subject of the scholastic training of the engineer will be discussed. This present chapter has defined the engineer in the words of two eminent engineers. A third definition is by some unknown and reads: "An engineer is a compound of common sense and mathematics. If he has not enough mathematics his lot in life will be hard. If he has not enough common sense God pity him."

CHAPTER II

THE WORK OF THE ENGINEER

THE old-time civil engineer, before he was known by that title, built roads and bridges and helped architects erect great buildings. During the middle ages when the wonderful cathedrals and monumental bridges of Europe were built, the greatest architects were engineers and often preferred to be called engineers. Some were able military engineers and conducted many campaigns and great sieges of history. Leonardi da Vinci was an architect, an engineer, a painter and sculptor; of commanding rank in each calling. The knowledge of the world was not so great in those days, but that one man could know practically all that was necessary in many callings.

For a long period architecture was a sleeping art for nothing new was developed and the architects grew proud and drew away from the engineers and courted the society of artists. Architects were delighted when their art was called "frozen music," little recking that things are generally dead when frozen. For centuries architects did nothing but measure and copy and try to develop schools without placing proper emphasis on the fact that architecture is "The art of build-

ing pleasingly." To build pleasingly the material must be recognized. The long spans of Grecian architraves were possible with the strong stone used by the Greeks and imitations in the weaker limestones and sandstones of other countries were but imitations after all, beautiful as some were. The greatest buildings were erected and architecture made advances only when the engineer and architect worked together or were one and the same person. With the invention of the steel-framed building, the introduction of reinforced concrete and structural tile, all due to the engineer, architecture has been reborn and the moderns, in America, at least, are developing styles which will some day eventuate in something as good as the Greek pillar and lintel, the arch of the Etruscans and Romans and the pillared vaults of the Goths. Since the engineer has joined hands with the unwilling architect there is no limit to the possibilities of realizing dreams and embodying them in lasting materials.

The old-time civil engineer also improved rivers and harbors and constructed canals. This ends the list of his achievements. He, of course, had to know how to make surveys so he could lay out his work and make estimates of cost and prepare plans. It is well known that the science of geometry arose from the necessity for recovering land lines and boundaries buried in the mud at the times of the annual rises of the Nile. The

geometers (earth measurers), land surveyors or engineers, call them what you please, were always employed to set out work and no doubt from very early times surveying was a large part of the work of practical builders, architects and contractors, later of engineers. The old-time civil engineer had to be a draftsman also, for drafting is a universal language understood alike by the trained engineer, the architect and the building mechanic. The surveyor had also to be a draftsman in order to make maps of his surveys. To be a good surveyor and draftsman implied a good knowledge of mathematics. The student in a modern American high school receives more instruction in mathematics than the best engineer of two hundred years ago. The old-time engineer then was a man of ingenuity and common sense with little mathematics. The engineer of to-day must have fully as much ingenuity and common sense as the engineer of olden time, together with much more mathematics.

Hero of Alexandria is styled the first engineer of recorded history. He invented a fountain and a steam engine, besides many other things of service to mankind, although his steam engine remained a toy and the principle has only lately been applied in the turbine engine, which is regarded by many as the coming engine. His writings consisted of fourteen books treating on the whole of practical surveying and construction work as they were

understood in those early days, but all the books did not survive the numerous wars and raids of the intervening years. A book in the days of the ancients was generally about as full as a thin pamphlet or a chapter in a modern book. The author of fourteen books hardly wrote as much as the author of a ten-chapter treatise on the design of a plate girder to-day. Be this as it may, Hero is reputed to be the author of fourteen books which for some centuries were a veritable cyclopedia of engineering and of these books we have only his surveying in full, with parts of three or four other books. His treatise on surveying contains many of the problems taught to-day and his methods of solution are unchanged, except as changes have been made by the introduction of algebra and trigonometry, two subjects of which the ancients knew nothing. Hero was not regarded highly by his brother mathematicians in Alexandria because he believed in "practical, applied" mathematics and wrote books for the purpose of educating the common herd. He profaned a most noble science when he disclosed the grave secrets of the mathematicians and made a science of what was a philosophy. It is said that to-day the first toast at the annual banquet of a certain mathematical society is "Here's to pure mathematics. Cursed be he who attempts to find use for it."

Let us see how modern this wonderful profession of engineering is. All knowledge of stress

and strain was empiric up to a very late date. In 1678, Robert Hooke published his famous law of stress and deformation in materials, namely, "As the extension, so is the resistance," which he claimed to have discovered eighteen years previously and kept secret for the purpose of obtaining some patents. It is still termed Hooke's Law, but is now known to be true only within the elastic limit of any material. From that date until 1857, when Saint-Venant gave a complete analysis of the strength and elasticity of beams, engineers followed many strange hypotheses, which they dignified by styling them theories, and tried to preserve many individual secrets. Self-tutored mechanics to-day bring forth startling ideas, startling at least to modern engineers, because so many of them read reprints of books written fifty and sixty years ago. The self-tutored man should never buy a book without examining the copyright page for the date. If the copyright was obtained prior to 1895 he should not purchase the book.

When the first man wanted to cross a river without swimming and found a fallen tree spanning from bank to bank, the first bridge existed. It may have been many centuries before the human race developed to a point where it was possible to fell trees and build bridges. The bridges as late as Roman times were built of horizontal beams and girders resting on piles, with no attempt at intelligent trussing. That is, of course, wooden

bridges were so built, for stone and brick arch bridges are very ancient. In the course of time it was discovered that the triangle was the ideal form of framework and the truss was developed. Bridge building became the work of a craft, like the building of cathedrals, and men went all over Europe erecting bridges, yet no real principles underlay their work, which consisted in a cut-and-try method of design. The art of building truss bridges developed through correction of errors of judgment, but methods for computing the strength of suspension bridges were known fairly well about 1780. When railways commenced to supplant navigable canals and bridges were required to carry something more than light wagons many strange patents were obtained for trusses combining the principles of the truss, the arch and the chain.

In the summer of 1846 a Yankee school teacher, Squire Whipple, sat on the bank of a stream fishing and idly watching some carpenters repairing a wooden highway bridge close by. The school teacher learned that the foreman was a noted bridge builder, so he stopped fishing to converse with him. It was with considerable surprise that he learned there was no certain method then known for calculating stresses in bridge trusses. Upon his return home Whipple made a model of the bridge with small pieces of wood, joined at the angles with pins, having strings for counterbraces.

By rolling balls in grooves along the top chord he discovered how the frame work deflected and thus learned how to design a bridge to carry a predetermined load. He wrote a "Practical Treatise on Bridge Building," which was printed in Utica, N. Y., in 1847. In 1851, Haupt, in America, and Bow, in England, produced books on bridge design, the forerunners of a literature which justifies one in saying with the old Hebrew "Of the making of books there is no end."

Tramways were first built in England about two hundred and fifty years ago for the purpose of transporting coal from collieries to the sea. They were first made of two lines of flat stones to afford a track for the wagons. Civil engineers, or rather surveyors, were employed to secure proper curves and grades. Longitudinal timbers enabled heavier loads to be drawn and when iron rails were placed on the timbers, thus further reducing resistance and wear and permitting still heavier loads to be drawn, the tramways became railways. The first rails were channeled, or grooved, and it was a stroke of real genius when some man used a plain rail and put the flange on the wheel. It effected great economy and was very simple, but then the really great things in this world are very simple in their inception. In 1821 the Stockton and Darlington Railway was incorporated in England, this road being operated by steam locomotives in 1825.

The success of the steam locomotive caused a

boom in railway building and the demand for civil engineers was so great that for many years it was almost impossible to find enough to go around. At the same time the need for skilled designers of engines and machinery led the mechanical engineers to form a distinct body as distinguished from civil engineers. The old distinction between civil and military engineers was lost forever and to-day we have engineers. The old qualifying terms remain but the lines, for a time so distinct, are each day becoming fainter. The real distinction now exists as between engineers who design and build stable structures and those who design, build and sell engines and machines.

By common consent the man who is to-day known as a civil engineer is one who deals with statics, and the man who is known as a mechanical engineer is one who deals with kinetics, the electrical engineer being a cross between a physicist and a mechanical engineer, having a marked strain of conceit common to youth; the electrical engineer being comparatively an infant, but very husky. Mechanics is that part of the science of dynamics which treats of the laws governing the interaction between forces and solid matter. Statics is a branch of mechanics treating of the action of forces upon bodies at rest, or in a state of static equilibrium; that is, of balanced forces. Kinetics is a branch of mechanics treating of the action of unbalanced forces and the movement of solid

bodies. Statics, therefore, applies to bridges and all stationary frames, as well as embankments, retaining walls, river and canal improvements, etc. Kinetics deals with engines and machines.

In hydraulics the engineer has been employed from time immemorial. At first his employment on harbor work was in the government service, connected with the navy, but later he was employed as a civil engineer to design and build harbors for vessels of commerce. Centuries of dock and wharf building developed rules and styles which have not been much changed by the advance in scientific instruction of engineers in the past century. Navigable canals were for a time the great training schools for engineers, but they are everywhere giving way to railways, except where interested agitation keeps alive public interest in old-fashioned things. A few canals are kept up at enormous expense to satisfy artificially created public demands, supposedly to act as a deterrant upon railway rates. Sentiment, however, rather than common sense business principles, keeps the small navigable canal in existence. The present day hydraulic engineer finds his chief employment in the design, construction and operation of water works for towns and cities; canals, reservoirs and dams for irrigation; canals and ditches for land drainage; the improvement and regulation of rivers.

The first writer of note on public water supplies

was Sextus Julius Frontinus, water commissioner in Rome during the reigns of Nerva and Trajan. He possessed a shrewd knowledge of the flow of fluids, but hardly more than that which any observing man may pick up by working around a water works system to-day. In 1628 Castelli published a small pamphlet on the flow of fluids, followed in 1643 by a pamphlet giving more important discoveries. In 1828 Fourneyron invented the turbine and from that time to this important discoveries on the flow of water have been announced at intervals. The past twenty-five years have seen the knowledge respecting the flow of water placed on nearly as satisfactory a basis as a knowledge of the stresses in structures, although for fifty years prior enough was known to enable engineers to carry out great hydraulic works with reasonable certainty and economy.

Hydraulic engineers were formerly employed in large numbers on the design and construction of power plants operated by water wheels. After the introduction of the steam engine the water wheel declined in importance and many mills replaced their hydraulic plant with steam plants. To-day the hydraulic engineer is again in demand to design and erect water power installations in which the wheel picks up the power from falling water and carries it to huge electric generators, to be converted into electricity which is easily transmitted for long distances. The term

"Hydraulic Engineer" is now borne by three classes of engineers:

Hydraulic civil engineers are skilled in the survey, planning, designing and construction of canals, dams and power houses; also in the design, construction and operation of water works for municipalities, irrigation and drainage projects.

Hydraulic mechanical engineers are skilled in the design and construction of all kinds of hydraulic machinery, including hydraulic presses, water wheels, turbines, etc.

Hydraulic electrical engineers are skilled in the design, installation and operation of hydro-electric plants.

The sanitary engineer is an important man to-day and his value to the community is increasing. He may be employed to design and construct systems for the sewering of municipalities and the purification of sewage, and he may be employed to design and construct water works systems and plants to purify water. The tendency, however, is marked to limit the sanitary engineer to the design and construction of plants to purify sewage and domestic water supplies.

The municipal engineer is charged with the planning and construction of water works, sewerage systems and street improvements within the corporate limits of municipalities. For the purification of sewage or water he calls in the consulting sanitary engineer and for the bringing of the

water to the city limits he calls in the hydraulic civil engineer. If large pumping stations are required he employs the hydraulic mechanical engineer. For the ordinary work required in the average town and city the local municipal engineer is usually competent, if his training has been broad and of the approved kind. One defect in many cities is the employment of imperfectly trained men of limited experience because they work for low pay. The position of the average town and city engineer is not enviable, for his office is the prey of politics.

On a railway the civil engineer surveys the routes, makes estimates of cost and constructs the lines. He designs all buildings and terminal yards and on many roads designs all the bridges, while on other roads he merely prepares specifications for the design of bridges and supervises their erection. Maintenance-of-way engineers have charge of the upkeep of the railway, look after repairs and in general have charge of all renewals and reconstruction. The engineering department is almost wholly connected with the surveying and construction of new lines, the maintenance-of-way department being separate. Some old railways have no chief engineer, the maintenance-of-way department doing all the civil engineering work, for these roads make no important extensions. The mechanical engineer on a railway has charge of the purchase and repair of rolling stock and all

machinery; and machines required in the repair of machinery. The mechanical engineer also prepares specifications for such equipment as the railway may have made to order or purchases under contract.

Bridge engineering is practically a distinct profession, for many companies are engaged exclusively in the design and erection of bridges for railways and highways.

Structural engineering is also a distinct profession for few important buildings are erected to-day without steel or reinforced concrete framework and floor systems.

Numbers of men trained as engineers go into surveying work, but not so many that it is right to say "A civil engineer is nothing but a surveyor," as so many illy-informed or mendacious mechanical and electrical engineers remark to parents who make inquiries with reference to selecting careers for their sons. Some surveyors work for the government and are employed in making accurate surveys for the purpose of marking national boundaries, determining the size and shape of the earth, topographical surveys as a basis for the development of sections of a country, etc. Some engineers go into private practice and specialize on surveys for determining land lines, settling property disputes, setting grades for ditches, for drainage or irrigation, etc. Others work all their lives for railways and other corporations, running instru-

ments, making maps and doing work of a similar nature in the development work upon which all such corporations are engaged. This latter class does not receive steady employment, the unfortunate wanderers never knowing how long a job will last and not receiving very high pay.

The United States Government is doing a great deal of work in connection with irrigation development and within a very few years the drainage question has assumed wonderful importance. A number of young graduates enter government employ each year in the irrigation and drainage departments. Numbers of companies are engaged in private irrigation and land drainage enterprises, but the employment is uncertain and the pay poor.

The demand for improved highways has led to the formation of an important department. The Bureau of Road Inquiry conducts investigations and gives free information on the subject, besides giving young engineering graduates special training in highway work, in order to prepare them to enter the employ of states in which highway improvement is a live issue. The pay for the rank and file is low, but state highway commissioners generally receive high salaries, which means a mingling of politics and efficiency, generally to the impairment of the latter.

Members of the Engineer Corps of the United States Army are educated at West Point, the man standing at the head of the graduating class being

sent for a post-graduate course to an advanced engineering school. Civil engineers in the United States Navy, in charge of navy yards, etc., are selected after severe competitive examinations from graduates of good civil engineering schools. Naval engineers and naval architects are graduates of Annapolis who stand at, or near, the head of the graduating class and are then sent to special schools for more instruction.

The greatest opportunities for engineering graduates to-day lie in the field of contracting and general construction work and the best training for this employment is to be had in the civil engineering and mining engineering courses.

The four great divisions of engineering, military and naval engineers being ranked merely as engineers, are:

Civil Engineering,
Mining Engineering,
Mechanical Engineering,
Electrical Engineering.

Each is divided into numerous specialties, but the young man who takes a specialty in one of the above branches makes a mistake, unless he is preparing himself to fit into a certain position already provided.

Every engineer ends by specializing to a greater or less extent. This is unavoidable in the conduct of the work of the world, but the fundamentals are

the same in all branches and for every specialty in each branch. For the average graduate several years must elapse before a permanent line of work is entered upon. Frequently this is not along the line of the specialty selected while at school. It is an axiom with experienced engineers that the specialty selects the man by a process of chance, rather than the man the specialty.

Knowing this it seems the height of absurdity for schools, as many do, to require a student upon the completion of his freshman year to make a selection for the following three years' work from a bewildering list of specialties, when he has not really made up his mind as to why he chose the hard engineering course instead of the easy courses in which memory, rather than reasoning ability, enables one to secure high marks and make the honorary fraternities.

The writer does not decry any desire on the part of ambitious young men to pursue some special subject after adequate preparation, provided this is done in the same way that a man collects stamps, becomes a high-grade amateur photographer, or pursues any other hobby. A specialty, after adequate preparation, selected in such manner is a splendid thing and if the student finally makes it pay well he is to be congratulated. A specialty selected after a supposedly due consideration of the question, "Which specialty do you think pays best?" is frequently, in fact, gen-

erally disappointing. Proper consideration must be paid to other inclinations than the desire to earn money.

The following clipping from *The Chicago Tribune* shows the point of view of practically all newspaper writers on the subject of the profession of the engineer. This was taken from a page containing advertisements of schools, some technical schools being represented, but, of course, this fact cannot be supposed to have influenced the writer of the article clipped:

FUTURE DEMANDS TRAINED ENGINEERS

The field for the labors of the engineer—constructive or electrical—are practically unlimited. The student graduating from the accredited technical school is assured of good positions months before he graduates. Indeed, it is a true embarrassment of riches when, as is repeated yearly with the graduating classes of every technical school, the youthful engineer has to choose between several enticing and profitable offers of employment before he has ceased to breathe schoolroom air.

Only one among the multiplied advantages of engineering as a profession compared with the older professions of medicine and the law, is that the young engineer is entirely and comfortably self-supporting from the beginning—earning a good salary from the start. The technical school trained engineer holds the world in his hand. Employers are waiting for him. Opportunities for ultimately becoming independent or his own employer, are legion.

There does exist just the demand mentioned in the article, but there also exists a demand in

the business world for stenographers, clerks, bookkeepers, and all classes of employes at entering pay. When the supply is large many employers have no hesitancy in dismissing older employes to make room for the younger men. This active demand will continue just as long as the supply is continuous of fresh young men, who work at low pay "to gain experience," hence the demand is largely artificial and fostered by the readiness with which it is supplied. A large employer of engineering graduates told the writer that 90 per cent. of his work was of such a nature that it could be acceptably done by young men, with little or no experience, provided with a good technical education. Consequently he did not pay very high salaries, wages he termed it, for there was a constant supply of just the sort of men he wanted, and at the first signs of dissatisfaction with pay he let men go. This fact is known by many engineers to satisfactorily explain the standing advertisements of large companies for draftsmen and designers.

The following advertisement was clipped from another page of *The Chicago Tribune:*

> SITUATION WANTED—Massachusetts Institute of Technology civil engineering graduate, 1911, age 26, having had several years' business experience as a bookkeeper and timekeeper for a contracting firm, desires a position where he can make use of his training and experience; salary no object. Address N 206, Tribune.

CHAPTER III

THE EDUCATION OF THE ENGINEER

An engineering course comprises:

Eight years grammar school,
Four years high school,
Four, five or six years technical school.

The standard course in technical schools has been four years in length, but within the past ten years many American colleges and universities have established five- and six-year courses. Some have done this in order to give the students more purely cultural studies and some have added to the courses many things that seem to be essential nowadays to the education of the engineer along professional lines.

In all colleges and universities offering a selection of courses for different degrees the engineering courses are avoided by lazy students and "the engineers" are looked upon as being the hardest worked students; their courses the most difficult. If a man cannot undertake such a training as is above outlined he had better go into a business where the training is not so severe and expensive, for an engineering education costs from two thousand dollars up to any amount the student

may be able to secure from his parents or guardians. By giving up the idea of studying engineering the man not perfectly adapted to the work will help the profession by enabling thousands of illy-paid, highly educated men to get better pay and steadier employment, besides giving them more zest in the doing of their work.

While the regular method above outlined is the very best, there exist splendid opportunities for the men who missed their chance earlier in life. For such men good courses of instruction are given by some reputable correspondence schools, evening classes in the Y. M. C. A., evening classes, in high-grade technical schools, and in a few private schools giving individual instruction. Young fellows who can afford the time to go to college and study engineering in the proper manner have no place in these schools intended solely for men who missed early chances and now want instruction in special subjects. The man who works by day and studies in odd moments cannot possibly cover properly the broad and comprehensive schedule of studies provided by specialists in engineering teaching for young fellows whose sole object, when under their instruction, is to prepare for their life work.

The man studying under the severe handicaps incident to earning a living is apt to be hypercritical and has neither the patience, nor the time, to take up any study from which he sees no hope

of immediate financial return. Night schools, therefore, arrange courses of study to meet the needs of these strictly utilitarian pupils. The young man going to a regular resident engineering school makes a mistake in taking up a specialty. The man who later in life endeavors to study the things he feels he sorely needs, is of necessity the most narrow of specialists. Occasionally men take up one subject after another in special schools, gradually getting the equivalent of a fairly complete engineering education. The percentage, however, is small and the result of the widely advertised special courses in engineering subjects has been to crowd the ranks with partly trained men who keep down pay and lower the dignity of the calling. It is sometimes a serious question whether it is wise to give the few who are worthy a chance, when in the giving of it so many are injured.

There is a third way by which a man may obtain a fair engineering education, and that is by self-tutoring. The self-tutored man is one who endeavors to educate himself from books, without the assistance of teachers or correspondence schools. All honor to the man who succeeds in this stupendous undertaking which many start upon and few accomplish. It was the way in which 90 per cent. of the engineers were educated more than fifty years ago and a large percentage of engineers now living, who are past middle age,

were self-tutored. That many achieved great success was due rather to the fact that the country needed them and they were instinctive engineers, than that they were "practically educated." With the advent of the well-trained college graduate the self-tutored men are not so highly thought of as was once the case. Prior to the civil war there was considerable activity in railway building, and the engineering schools of the country were so few that it was hard to hold the graduates of West Point and Annapolis in the service of the army and navy, their education being so good along the lines of applied science. General McClellan, a graduate of West Point was chief engineer and manager of a railway when the war broke out. After the war ended the whole country, especially the west, experienced such a boom and there was so much railway building that the schools were again unable to supply enough engineers, so boys with the most elementary training were placed at drafting boards and bright young fellows were given a few lessons in handling surveying instruments, the result being that the country in dull times was crowded with "engineers," many of whom were hardly more than automatons, doing all the routine work connected with railway surveying and building in a mechanical manner. One panic period lasting three or four years sufficed to enable the engineering schools, enormously increased in numbers from the half dozen existing in the late 60's,

to catch up and more than supply the legitimate existing demand, a condition of affairs that still exists.

Much of the work done in engineering offices is of a nature which does not demand the full training required by an engineer. Much of this work is drafting of a kind that merely requires a fair knowledge of standard methods of construction and the man who has worked around an office long enough "to soak it in," manages to eke out a fair living and is employed pretty constantly at pay which is about that of an average clerk. There are others who do nothing but make tracings, and obviously they do not require any more education than is given in grammar schools. Their pay is not high. Others are employed as blue printers, filing clerks, statisticians, timekeepers, rodmen, chainmen, etc. Nearly all enter upon the work with the idea of "learning it practically," the result being an imitation of the old-time British engineer, a technically trained mechanic. It is only an imitation, for in the case of the British boy a high premium was paid for the privilege of getting him into an office and some pains were taken to see that he managed to get the rudiments of an engineering education for the credit of the office, if for no other reason. The present-day boys and young men in American offices are not taken in as pupils. They are employed to do certain definite work that calls for no particular education and is

never more highly paid than is the work of a common laborer, frequently not so highly paid as the work of a union laborer.

It is this class of assistants that supports the correspondence schools, the evening classes, the private "practical" schools. A pitifully small number do amount to something after a while and from the very nature of engineering work a large percentage of engineers to the end of time will be men who have not received an education in resident technical schools. Some men prove by statistics based on records of men applying for membership in the national engineering societies, that very few men engaged in engineering work to-day are self-tutored. Their deductions are false, for, in the first place, the successful self-tutored men have to be urged to apply for membership in such societies, having a feeling that a prejudice exists against engineers who are non-graduates. In the second place a man has only to canvass the offices of engineers and make inquiries to discover that a large percentage of the engineers and their assistants to be found to-day are non-graduates. Many are high school graduates and many have had only one or two years in resident schools, while a great many have simply grown up in the business, starting in as office boys. The writer made a canvass of one hundred engineering offices and sixty architects' offices and the drafting offices

of forty manufacturing establishments to determine these facts. The percentages were as follows:

	Graduates. %	Non-graduates. %
Engineers' offices	80	20
Architects' offices	22	78
Manufacturing plants	18	82

In engineers' offices the permanent positions are few and when an engineer has to increase his force he must have men already trained. This accounts for the high percentage of graduates in the offices of engineers in private practice. With architects the conditions of employment for draftsmen are better than with engineers in private practice. In manufacturing establishments there are many permanent positions for low-grade draftsmen. If this canvass had been made in the works and offices of the great electrical companies the percentages would probably have been ninety-five graduates to five non-graduates, but conditions of pay not improved. In manufacturing lines much of the work has been standardized and the drafting consists in tracing and making slight alterations in existing drawings to adapt them to other uses. There is very little high-class designing, empirical methods developed by many years of practice in a particular specialty being used. In electricity there is greater need of well-trained men than in mechanical work, for electrical practice has not yet been fully standardized.

The majority of men, however, who are trying to secure an engineering education by night study will never succeed, for their trouble is temperamental. They went into practical work instead of going to a technical school, because they imagined four years was too long a time to spend in study and thought there was some royal road to learning. Some, in fact many, believed there was no necessity for all the studies the technical student must take. The desire to begin earning money led them to neglect the preliminary school training. Later in life they take up night study, but the impatient spirit still stirs within them and prevents rapid or great progress. Such men are generally pretentious to a degree and are a positive detriment to the profession.

A man succeeds in the present day because of one or all of three things, as compared with his competitors. They are:

Superior intelligence,
Greater energy,
Superior preparation.

The superior intelligence must be proven and it takes many years generally for a young chap to prove he has ordinary intelligence. The possession of greater energy must be proven and this takes years of hustle in competition with seasoned veterans in the battle for existence. Adequate preparation along lines which a century of experi-

ence in training engineers has shown to be good, is the finest backing that intelligence and energy can have. It is a mistake to permit a young fellow to go into a profession like engineering without the best technical training it is possible to secure. Sometimes the man who has a good training can make a small amount of energy and a mediocre brain carry him through life splendidly.

What sort of an education does an engineer require?

In the first place he should be an excellent draftsman. Drafting is a universal language by means of which the designer conveys instructions to the workman. The graduate is employed for the first few years after graduation in minor positions in which drafting is his principal occupation. If he is not a good draftsman he seldom has an opportunity to get a foothold in his chosen work.

The engineer is lost without a sound knowledge of mathematics. The amount used in routine work is not great and there is a class of "rule of thumb" and "pocket-book" engineers, which decries the great stress laid upon a sound knowledge of mathematics by the men who head the engineering schools. It is a puzzling thing that the actual amount of mathematics required in daily work is so small, yet the men who have received the broadest training in mathematics are the most reliable, and, in late life, are the most successful engineers.

The first few years out of school are spent in

detail work and it is the young fellow, generally, who is intrusted with most of the research work requiring a knowledge of mathematics; work of a nature to seriously tax the patience of an older man. With the passing of years the work of the engineer becomes more executive and his knowledge of mathematics less sure. The fact that few eminent engineers can pass a satisfactory examination in elementary mathematics and would flunk badly in the higher branches is no argument against the value of a thorough training in mathematics. It may be that the reason the men achieve marked success who acquire an understanding knowledge of mathematics is that they are instinctive engineers and so took the mathematical instruction intelligently as a necessary part of the preparation for their life work.

Mathematics enable a man to investigate scientifically many things which might otherwise wait years for experimental proof. The rapid growth in the use of reinforced concrete as a structural material is an evidence of this. The invention of reinforced concrete was not due to an engineer. A gardener used wire netting embedded in concrete in the construction of some large jars and an engineer saw the possibilities in such material. He possessed a sound knowledge of mathematics and mechanics and developed some theoretical formulas to explain the action of the internal stresses and to arrive at the correct

amount of steel required to reinforce concrete. Other engineers and mathematicians also worked at the problem and a number of hypotheses were worked out, differing slightly in detail, but practically all giving nearly like results. In Europe the material had a wider use than in the United States, which is naturally a backward country in taking up new ideas, and in which besides, certain patents gave a monopoly to a few concerns. When the patents expired the material came into common use and so many uneducated and half-educated men went into the business with empirical and rule of thumb methods of design that many accidents happened. A number of experiments were made from which simple formulas were derived, and it was discovered that the formulas and methods of the mathematicians of Europe were to all intents and purposes safe and their reasoning in the main correct. The presence of thousands of half-educated, self-styled engineers in this country was responsible for many disasters, the public having great confidence in the "practical" man and being fearful of the "theoretical" man. The writer has observed this strange sentiment for many years and has discovered that to be a practical man it is merely necessary for a man to style himself "practical" and rail at men who have spent good money to acquire an education. The public makes no investigation into the qualifications of the self-styled

"practical" man, taking his word that he is practical and that the trained man is a fool, and "theoretical." Because the word theoretical is used in an awesome manner it is thought to mean something dreadful. Barnum once made a statement that the people like to be humbugged.

Theory is a plain statement of a law that has been proven. Hypothesis is an idea advanced as a theory. The man who takes a thorough engineering course studies the theories underlying his work and thereby obtains a practical understanding of it. In engineering schools a large part of the instruction consists in a study of the work done by engineers and contractors in many parts of the world and during all the centuries. When a young fellow who has conscientiously pursued his engineering studies graduates, it does not take him long to acquire a first-hand practical knowledge of his work and to this he adds a knowledge of what other men have done. It is plain to see, therefore, that the theoretically trained man is the practical man.

The man who has no school training in the underlying theory of his work and merely learns by seeing, without doing much, if any, reading, or without doing any reading under proper guidance, has only his own experience to guide him. He is practical to the extent that he has "picked up knowledge" by doing. Not being a student he knows little of what other men have done, except

men situated like himself whom he occasionally meets. Sometimes an idea strikes him and he produces an hypothesis, dignifies it by the term of "theory" and starts on a wild goose chase, frequently finding men of means to advance money to push his wild ideas. The man who follows true theory is the practical man, for he follows what others before him proved to be true. The man who works by hypothesis will distort facts to attempt to prove himself right and is really the theoretical man in the sense that the average individual understands the meaning of theory. The "theoretical" man is not the educated man and the "practical" man is not the uneducated man.

Anything which will enable a man to think soundly and act with intelligence has a place in the curriculum of an engineering school. Mathematics is, therefore, entitled to first place when it is taught as a tool and not as an end.

In school a grade of 70 will carry a boy through and 90 gives him extremely creditable standing. In business a grade of 100, or perfect, is necessary to hold a position. Intelligence, plus a grade of 100, is absolutely necessary for advancement. The well-known "Gentleman's grade of C," of the old-time classical course is an inferior grade in the engineering course. A careful study of the biographies of successful engineers, appearing frequently in technical papers, will show that a surprisingly large number won prizes and had excellent stand-

ing in many, if not all, of their studies while in school. Their careful, conscientious work at school enabled them to secure satisfactory positions upon graduation. When men were laid off in dull seasons these well-trained workers were retained. They were not all "greasy grinds," in spite of their high standing, for many won enviable records on the athletic field. The engineering student must not forget that his training is for service and if he does not acquire industrious habits in school he will hardly change in character and acquire them later in life. The standards of schools existing merely for culture must not be permitted to dominate the schools intended for utilitarian training.

Many young chaps fail in offices not only because they are poor draftsmen, but because their training in mechanics has not been thorough. The training in mathematics is for the purpose of enabling mechanics to be properly studied and the two are essential. A common complaint against engineering graduates is that they are often able to chase "the elusive x through the mazes of a cubic equation" and yet cannot perform an ordinary problem in arithmetic. The time in school has been spent on the study of principles and laws with insufficient time for an application of the principles. The writer does not wonder at this very much, however, as he is well acquainted with a number of instructors in mathematics. Their

interest does not lie in teaching, but in the study of this, their favorite science. Each student is put through a course of instruction without any idea on the part of the instructor that he is to regard it as a tool, but merely because it is a part of the prescribed course of instruction. There are a few professors and instructors who rail bitterly at life because they must teach to earn a living. They think college is a fine place were it not for the students and their idea of happiness is to sit and study all day and night. The head of the institution may require certain text books to be used, but an examination of the books will reveal the word "omit" written on every page where practical examples are given, and at the beginning of every chapter filled with applications of the theory taught. It is not an uncommon thing to find a 300-page text book used and only a part of it given to the students when there are plenty of abridged works on the market which the teacher could use, supplementing the book with personal instruction were he not too lazy. Instead of using large books and giving a "skim" course, it would be better to give a short course from a small book and give it thoroughly. The writer believes that tutorial methods should be used to some extent in engineering schools, so that the instructors in mathematics, graphics and mechanics could be changed every semester and thus the teachers of mathematics would learn to know what their students require.

If an instructor in mathematics were required to teach his poorly instructed class the following semester in mechanics he would improve as a teacher of mathematics. This lack of coordination is marked in small colleges where there is an engineering course newly established and the professor of engineering must rely upon the other older established departments to train his students in the fundamentals. It is also a fault in some large schools.

Physics, of which mechanics is a branch, is a most important subject and chemistry is becoming daily of more importance as a part of the knowledge an engineer must possess. The engineer deals with materials and a proper study cannot be made of materials without thorough grounding in physics and chemistry.

Every engineer must know how to lay out work and make surveys through strange countries. This requires a knowledge of surveying and exploratory surveying presupposes a knowledge of astronomy, which is, therefore, a part of the curriculum of all engineering schools. Sometimes it is taught as astronomy and sometimes it is a part of the course in surveying, enough of astronomy being given to determine latitude, longitude and time.

A knowledge of geology is necessary to enable the engineer to extract metals and ores from the earth, form his excavations and embankments

properly, construct dams and reservoirs and put in stable foundations.

All engineering studies such as the design of structures, the flow of water, sanitation, etc., are based upon mathematics, physics and chemistry, and the mathematical, physical and chemical sciences. Thoroughly grounded in these the student can study by himself, if need be, the higher subjects comprised in practical work.

The men who have the most to do with the framing of courses of study for engineering schools are safe guides for the young men who seek information as to electives. The individual professors are wretched advisers, for each professor is a slave to his own course and magnifies its importance. For instance, nothing more useless to an intending engineer can be imagined as an elective than the offered graduate courses in higher mathematics; the prescribed courses are amply sufficient. If the head of the mathematical department, however, is consulted he will generally advise mathematics. The professor of chemistry will sing the praises of advanced chemistry when the principal reason for the study of chemistry by an engineer is the acquisition of information. The professor of mechanics will advise technical mechanics and then more technical mechanics. These men all mean well, but they have deliberately chosen to withdraw themselves from the outside world and immure themselves in walls to deal forever with

immature minds and teach narrow special subjects. They are not qualified to advise the young man who is going out into the world to guard a home against the attack of the wolf. Neither can the professor of bridge design, of structural design, of sanitary engineering, of hydraulic engineering be counted a safe adviser, for each will unduly magnify his specialty. The entire course is arranged to give each of the subjects a proper representation and if there is any time left for electives the young man should take them in the humanities, literature, political economy, sociology, etc.

The engineer changes the very face of nature. He makes millions of blades of grass grow where none grew before. He builds railroads which people the deserts. He erects factories and equips them. Thousands of people are employed through him and his employment. History, sociology, economics and philanthropy are studies with which he should be familiar. He deals with materials and for four years his studies are arranged to give him a proper knowledge of materials. His largest dealings are with men and until a very late period nothing was taught him about mankind.

The study of English is most important. Engineers must make reports on the feasibility of projects involving the expenditure of vast sums. The men who have the money to invest are usually of a class that cannot tolerate poor English and who

also like to have men in their employ who can act, speak and write like gentlemen. The ability to write a readable report is a valuable asset. It is becoming necessary nowadays for engineers to study the laws of business and the law of contract so that litigation may be avoided. The average lawyer is sadly lacking in the ability to write intelligible English and in earlier days when every engineer assumed it to be part of the work of a lawyer to prepare all legal papers, there was much litigation over contracts. To-day few contracts and specifications are seen by lawyers and the ability to properly express his meaning, together with the marked lessening of litigation over construction work, has strengthened the engineer with his employers. The work of the engineer often takes him to foreign lands. There are also numerous international conventions. In every country there are many technical societies holding frequent meetings to describe and discuss work in progress and publishing bulletins containing reports of these meetings and discussions. Science has no national boundaries and all men of science, pure and applied, are brothers. The modern engineer, therefore, should possess a reading knowledge, at least, of French and German, while a knowledge of Italian and Spanish will wonderfully increase his power for research.

The training of engineers is so broad at the best schools and the overlapping of the various

branches is so marked, that it is not uncommon to see graduated civil engineers employed on work considered the proper employment for mechanical or electrical engineers, while the latter are often put on work of a strictly civil engineering character. The mining engineer receives such a diversified training that he is to be found everywhere doing all kinds of work.

In every school where various branches of engineering are taught it is usual to have the courses identical for the freshman and the first half of the sophomore year. In the second half of the sophomore year there is a slight difference and a final separation in the junior year. However, a number of studies are the same even in the third and fourth years, but the hours are different, some branches taking a three-hour course while others take only one or two hours.

Each school varies the standard curriculum slightly according to local influences. The majority of graduates find employment near the school and the curriculum naturally reflects to some extent the industry of most importance in that section of the country. Some of the older schools have a large number of the alumnæ employed in a certain line of work, and as the alumnæ are always loyal to their alma mater and give her graduates the preference when assistants are required, it is natural that the school will lay stress on the line of work in which the greatest number of graduates find

employment. Here is a slight hint as to the selection of a school. A very old school with an honorable name is a splendid place-finder for graduates likely to do it credit. The newer schools find it somewhat more difficult to place graduates. A disadvantage often found in old schools is intense conservatism and an overabundant supply of "inbred" instructors. Frequently a new school is good because all the teaching staff has been selected for proved ability and a desire to start a new school thoroughly abreast of the times, unhampered by traditions. This is excellent if the departments of mathematics, physics and chemistry in the older part of the institution will arrange courses of value to engineers and not consider the "culture" requirements of budding theologues, lawyers and physicians as sufficient for technical men.

The man who tries to start a school to satisfy critics in the ranks of practical engineers is foredoomed to failure. The wisest men recognize that no school can turn out engineers, but that all schools should turn out young fellows trained to be good engineering assistants and having enough education to be ready for advancement when it comes. The chief criticism against the schools is that the boys are not well enough drilled in practice, lack of time preventing more than the instilling of principles. It is a serious criticism, but unjust, for all men are not endowed with the brains

to be good engineers. All the young chaps who study engineering are not entitled to be termed "ingenious," for many are one degree removed from extreme simplicity. Because of the very large number of engineering school graduates there is quite a respectable sprinkling of those who lack ordinary intelligence in practical affairs; enough of them to bring undeserved reproach upon the schools.

The best reply possible to some severe critics is to remind them that they are themselves graduates of the schools they criticise. Many of them who met with trials after graduation may have been mistaken in taking up engineering and stuck to the work simply because they did not like to feel their time had been wasted, and, as the years rolled by, they gradually developed into engineers. The training, after all, was their salvation. This, of course, is merely a personal opinion formed after studying some men who would like to try their hands at revising engineering curricula. They are the sort of men who come always unprepared to class and want the notes of the lesson in advance to study instead of the longer text. Men who only learn to study after many bitter experiences, their early experiences having led them to rely always upon a teacher. Faults in schools do exist and the writer will touch upon a few on other pages, but these faults are being remedied each year as teachers come together and as more of the

high-class professors combine teaching and the practice of engineering. The courses of study have been so well tried out in the years gone by, and the number of men successfully educated at the schools is such a large per cent. of the whole that inferior instructors and assistant professors cannot do much harm when there is a real man at the head of the department. It is only when the head of the department is weak that the school suffers—this being true of any business.

Typical courses of engineering may be represented by the following, taken from the annual catalogue of the University of Illinois, Urbana, Ill. The figures following the subject indicate the number of recitation hours per week, each hour of recitation being assumed to require two hours of preparation. The university receives aid from the United States Government so a certain amount of military instruction is given. All engineering schools do not have military instruction.

FRESHMAN YEAR

Common to all courses.

First Semester

General Engineering Drawing	4
Trigonometry	2
Advanced Algebra	3
French, German, Spanish or English	4
Shop Practice	3
Military Drill	1
Gymnasium	1
Total semester hours	18

Second Semester

Descriptive Geometry	4
Analytical Geometry	5
French, German, English, Rhetoric or Spanish	4
Shop Practice	3
Military Drill	1
Military Regulations	1
Gymnasium	1
Total semester hours	19

SOPHOMORE CIVIL ENGINEERING

First Semester

Differential Calculus	5
Physics, Lectures	3
Physics, Laboratory	2
Rhetoric	3
Surveying	5
Military Drill	1
Total semester hours	19

Second Semester

Integral Calculus	3
Physics, Lectures	2
Physics, Laboratory	2
Rhetoric	3
Analytical Mechanics	3
Topographical Surveying	4
Railroad Curves	1
Military Drill	1
Total semester hours	19

Junior Civil Engineering

First Semester

Engineering Materials	1
Analytical Mechanics	2.5
Resistance of Materials	3.5
Railroad Surveying	5
Chemistry	4
Total semester hours	16

Second Semester

Hydraulics	3
Road Engineering	2
Graphic Statics	2
Astronomy or Geology	5
Steam Engines and Boilers	3
Principles of Economics	2
Total semester hours	17

Senior Civil Engineering

First Semester

Masonry Construction	5
Bridge Analysis	2
Bridge Details	3
Tunnelling	1
Metal Structures	1
Water Supply Engineering	4
Thesis	1
Total semester hours	17

Second Semester

Masonry and Reinforced Concrete Design	2
Bridge Design	5
Advanced Bridge Analysis	2
Engineering Contracts and Specifications	2
Seminary	1
Sewerage	3
Thesis	2
Total semester hours	17

Every senior student must prepare a thesis to defend his right to receive a degree in engineering. Modern thesis work generally is of a research nature. The time given above to thesis work represents the time given by the instructional staff in assisting the students in this work. The seminary item refers to the time devoted by the dean of the school in leading topical discussions on articles appearing in technical papers, thus making the boys ready against the time when they will leave school and must thereafter depend upon themselves in hunting up authorities, etc. If a technical school does nothing more than guide a student in the selection of and inspire a discriminating taste for good technical literature it accomplishes much, as was recently said by the editor of *Engineering News.*

Sophomore Mechanical Engineering

First Semester

Similar to Civil Engineering, with the omission of surveying, substituting:

Machine Shop	3 hours
Machine Design	2 hours

Second Semester

Similar to Civil Engineering, with the omission of topographical surveying and railroad curves, substituting:

Machine Shop	2 hours
Steam Engineering	3 hours

Junior Mechanical Engineering.

First Semester

Engineering Materials	1
Analytical Mechanics	2.5
Resistance of Materials	3.5
Power Measurements	2
Mechanism	3
Integral Calculus	2
Chemistry	4
Total semester hours	18

Second Semester

Thermodynamics	3
Machine Design	3
Seminary	1
Analytical Mechanics	3
Dynamo Machinery	4
Engineering Chemistry	3
Total semester hours	17

SENIOR MECHANICAL ENGINEERING

First Semester

Heat Engines	2
Mechanics of Machinery	3
Machine Design	3
Mechanical Laboratory	3
Seminary	1
Alternating Currents	2
Principles of Economics	2
Total semester hours	16

Second Semester

Design of Power Plants	3
Seminary	1
Thesis	3
Railway Engineering or Surveying	2
Economic Problems	2
Elective	2
Total semester hours	16

SOPHOMORE ELECTRICAL ENGINEERING

Same as Mechanical Engineering.

Junior Electrical Engineering.

First Semester

Engineering Materials	1
Analytical Mechanics	2.5
Resistance of Materials	3.5
Dynamo-electric Machinery	3
Electrical Engineering Laboratory	2
Electrical and Magnetic Measurements	2
Chemistry	4
Total semester hours	18

Second Semester

Hydraulics	3
Alternating Currents	4
Electrical Engineering Laboratory	2
Electrical and Magnetic Measurements	2
Steam Engineering	3
Total semester hours	16

Senior Electrical Engineering

First Semester

Seminary	1
Advanced Alternating Currents	3
Electrical Distribution	3
Electrical Engineering Laboratory	2
Electrical Design	2
Thermodynamics	3
Principles of Economics	2
Total semester hours	16

Second Semester

Power Plants	3
Seminary	1
Electrical Engineering Laboratory	2
Power Plant Design	1
Thesis	3
Mechanical Engineering Laboratory	3
Economic Problems	2
Electives	2
Total semester hours	17

A course in mining engineering has been established at the University of Illinois within the past two years and reflects the principal mining industry, coal, of the state. The following fairly typical mining course is that of the Montana State School of Mines, Butte, Mont.:

FRESHMAN YEAR

First Semester

	First Term Hours per week	Second Term Hours per week
Higher Algebra	3	3
Trigonometry	5	5
Chemistry, Lectures	3	3
Chemistry, Laboratory	9	9
English	2	2
Descriptive Geometry	2	2
Mechanical Drawing	6	6
Total	30	30

Second Semester

	First Term Hours per week	Second Term Hours per week
Analytical Geometry	5	5
Plane Surveying, Theory	3	3
Descriptive Geometry	2	2
Chemistry, Lectures	3	3
English	2	2
Chemistry, Laboratory	6	6
Mechanical Drawing	9	9
Total	30	30

SOPHOMORE YEAR

First Semester

Calculus	5	5
Physics	6	6
Chemistry, Lectures	2	2
Mineralogy, Lectures	2	2
Mineralogy, Laboratory	0	6
Surveying, Field Work	15	0
Topographical Drawing	0	9
Total	30	30

Second Semester

Calculus, Analytical Mechanics	5	5
Physics	4	4
Chemistry, Lectures	1	1
Chemistry, Laboratory	9	9
Mine Surveying, Theory	2	2
Mineralogy, Lectures	0	3
Geology, Lectures	0	3
Mineralogy, Laboratory	6	16
Total	30	40

JUNIOR YEAR

First Semester

	First Term Hours per week	Second Term Hours per week
Mechanics	5	5
Mining	2	2
Geology	5	5
Metallurgy, Lectures	3	3
Mine Surveying, Practice	15	0
Chemistry	0	6
Graphics	0	9
Total	30	30

Second Semester

Mechanics and Hydraulics	5	5
Mining	2	2
Geology, Lectures	5	5
Metallurgy, Lectures	3	3
Engineering Design	6	6
Geology, Field Work	3	3
Metallurgy, Laboratory	3	3
Chemistry, Laboratory	3	3
Total	30	30

SENIOR YEAR

First Semester

Geology	5	5
Mining	2	2
Ore Dressing, Lectures	0	3
Metallurgy	3	2
Power Transmission	3	3
Assaying	15	0
Geology, Field Work	0	3
Ore Dressing, Laboratory	0	3
Engineering Design	0	6
Total	28	27

Second Semester

	First Term Hours per week	Second Term Hours per week
Mining	3	3
Ore Dressing, Lectures	2	2
Ore Dressing, Laboratory	3	3
Metallurgy. Lectures	3	3
Metallurgy, Laboratory	3	3
Mechanical Engineering	5	5
Engineering Design	6	6
Petrography	5	5
Total	30	30

The attention of the reader is directed to the number of hours per week at the school of mining engineering as compared with the hours per week at the University of Illinois. Thirty hours is a pretty heavy course to carry, yet it is done in many schools and the students seem to be none the worse for it. Their work is no more arduous than that of youths of the same age employed in offices and shops and around mines. Assuming seventeen hours per week, each hour supposed to involve two hours of preparation and we have a total of fifty-one hours per week spent on studies. Assuming that four of the seventeen hours were laboratory work, which counts one-half, the student has then actually put in about fifty-nine hours per week on his work. This is an average of practically ten hours per day for six days. In the mining course above described the laboratory

periods may be deducted, that is, only the time placed in the schedule may be counted. It will be seen then that there is not a great difference. The work, however, at all mining schools is much heavier than the work at other schools. There is one item, however, to be fully considered in all statements regarding work at all colleges and universities. Very few students actually spend two hours in preparation for one hour of lecture or recitation. The children in the grammar schools put in five hours per day for five days and many of them spend two hours per day in home work, thus getting in thirty-five hours per week. Very few men who have gone through the average schools have considered themselves hard worked, except while in school, saying in later years that they could easily have carried more work if compelled to do so. Eighteen hours class and six hours laboratory, a total of twenty-one catalogue hours, is not too much to ask of engineering students, and if this were done and a longer course given, a more general education would make them better men and increase their opportunity to earn a living after leaving school.

The fact that students are required at many institutions to select a specialty at the end of their Freshman year, before they have a realizing sense of what the profession is, has been referred to. This happens for several reasons. In the first place there is a certain amount of advertising done

by all schools to attract students and when one school advertises a certain special course all the other schools near by feel compelled to follow suit or fall in the estimation of the public.

The newspapers are greatly to blame for getting parents of growing boys excited. A large city constructs a vast water works system and the project attracts the attention of special newspaper and magazine writers who play the thing for all it is worth. Little wonder when some of these men receive $50 per page. In the descriptions a great deal of attention is paid to the picturesque side of the engineer's work and the few engineers who receive large salaries are paraded before the public until the fathers and mothers begin to believe that their sons must study hydraulic engineering. The schools hunting for students scent the popular demand and immediately thereafter it is announced that courses in the highly paid specialty of hydraulic engineering are to be started. The work of the United States Bureau of Road Inquiry compelled the starting of many special courses in highway engineering. A great piece of sanitary work like the Chicago drainage canal or the Washington filtration plant calls for special courses in sanitary engineering. The wonderful interest in concrete work during the past ten years, due to the advertising of the cement manufacturers, has stimulated interest in concrete engineering and thousands of boys are specializing in reinforced

concrete design. Always the same idea to get into line on some kind of work that is exciting public interest with the idea that bigger pay may be had. Few of the young fellows who take up a specialty are really imbued with a love for engineering work, but are going into it with the mistaken idea that it pays well, provided a fellow can select the most popular line.

In the larger schools, owing to the sizes of the classes it is impossible for any teacher to teach more than one subject, so the schools are full of specialists, each clamoring to be the head of a department and this, added to the will-o'-the-wisp search of parents for remunerative vocations for their offspring hurts the profession. The writer, in common with the majority of engineers who have had a fairly broad experience, believes the designations of Civil, Mechanical, Electrical and Mining Engineer should disappear in the curriculum of the schools and there should be given one general engineering course, with special courses which the graduates may take later. This general course could be so arranged as to afford considerable choice of subjects in the last year, thus enabling a student to specialize along certain lines only after he has completed the fundamentals of all engineering work, and has had sufficient vacation experience to enable him to choose intelligently among a lot of offered courses those which he feels sure will be of the greatest value to him immedi-

ately upon graduation. The schools might also drop the three months' vacation and adopt the plan of the Michigan College of Mines, Houghton, Mich., and the University of Chicago, in which the year is divided into four twelve-week terms. The student may take three terms each year and complete the course in four years, or, by taking four terms each year complete the course in three calendar years. A proper engineering course, however, cannot be completed in four school years, or three calendar years if the greatest good is to result to the student.

As will be referred to further on the managers of large corporations and special interests are also largely responsible for the numerous specialties in engineering schools. The profession is now so well stocked with embryo engineers that the schools can well afford to cease adopting methods for attracting students and devote more time to turning out the very best possible product. The slogan of the advanced woman is "Not more children, but better children," and the schools having more than caught up with the legitimate demand for engineers can afford to say "Not more engineering graduates, but the best possible quality of graduates." How the state universities will be able to do this the writer will not attempt to answer, but the privately endowed institutions can well afford to do it. By a reduction in the size of the classes they will require smaller quarters and less equip-

ment and can afford to employ a smaller number of instructors, who should receive larger pay. Owing to the very large number of students and the resulting large number of underpaid instructors the best trained engineers are not always to be found among the graduates of the larger institutions with their well-equipped laboratories and shops. Many kings among engineers have been turned out of schools not sufficiently equipped according to modern standards, but with the log on which Mark Hopkins sat and the faithful old teacher whose heart is in his work sitting at one end, ready to prove that after all a sound training in the fundamentals of engineering science goes a long way when the material to work upon is of proper caliber. A good workman can do fine work with a very lean equipment of tools when his material is good. The best workman with the finest tools, however, does only a botch job with poor material. More care should be exercised in the admission of students and the publicity managers should be cautioned to be careful in advertising the engineering courses.

In European schools there seems to be no rule about the granting of degrees. The custom seems to be to give a diploma to a graduate, who then styles himself "Dipl. Eng.," and after he has acquired some standing and presents a thesis to show he possesses capacity to do original work, he is granted the degree of Doctor of Engineering,

the word "Doctor" signifying "A person of great learning; a superior teacher."

In America the degree awarded depends to some extent, in fact, largely, upon the attitude of the advertising department of the school. A false estimate is placed upon the salary attracting value of a degree by the boys who attend engineering schools and by their parents. Students are attracted to a school by the advertisement that upon graduation they will receive the degree of C.E. (Civil Engineer); M.E. (Mechanical Engineer); E.E. (Electrical Engineer), or E.M. (Engineer of Mines). The school, therefore, that is anxious to attract students is apt to give the professional degree upon graduation. The absurdity of this, however, is gradually filtering into the heads of the advertising managers of the best schools and the professional degree is being shelved by some and has been abandoned by others.

No school can graduate an engineer. The engineer must have experience added to the school training. The school can only give an education in the fundamentals of engineering science. Engineering is not wholly an exact science, but is mainly an art depending upon scientific methods for its existence and growth. The school gives only the scientific groundwork and hence should confer degrees only in science. The engineer supplements this scientific training with practical experience so that, by and by, the scientist sent out by the school

becomes a man who practises an art in a scientific way.

A few good schools still give the professional degree instead of a bachelor degree upon completion of the four-year course. The majority, however, of the better schools now grant the degree of Bachelor of Science. A student taking one or two years additional work in residence receives upon completion of this work the professional degree, but few except those who intend to become teachers take any graduate work. An attempt was made a year or two ago to have the schools abandon the professional degree altogether, for the letters C.E., M.E., etc., are merely abbreviations of the words Civil Engineer, Mechanical Engineer, etc., and, as such, are assumed by a great many men without college training, who are practising engineering. There are no laws to prevent them from doing so if they wish, so the professional degree is now not only an absurdity, but it is also meaningless. The men who have received it by doing extra work prize it, but wish there was some protection afforded the rightful owners.

Instead of the professional degree it is proposed to substitute the degree of Master of Science as a second degree, for graduate work. For a third degree the degree of Doctor of Science in Engineering is proposed for additional work of a research nature to engineering teachers and the degree of Doctor of Engineering for research work

for men who are practising engineering and have taken this additional work in residence. This degree of Doctor of Engineering to be also an honorary degree to be conferred on engineers eminent in their profession who have been in active practice not less than twenty-five years. Degrees are academic affairs and the younger engineers are just as well off with a diploma or almost any kind of a certificate setting forth the extent of the engineering education received. Older men prize degrees as an attest of standing. With teachers the degree is purely a matter of business and engineering should have degrees like any other university subject.

A great many men seek degrees and prize them so the way the matter often works out was called to the attention of the writer some time ago. A young chap who was a "shark" at mathematics and all the purely theoretical subjects and purely scientific subjects in his course, graduated from a high-class engineering school and tried to work as an engineer. To explain things that happened it is well to say that among many of his classmates he was known as "Kitty," the name being intended to designate something real nice and dainty. He was a positive failure as a practising engineer. He lacked tact. He lacked real horse-sense. He made people feel as if he might be soiled if touched or might cry if spoken to rudely. He lacked accuracy in most of the common-place work he was given

and was a hair splitter of the most exasperating kind. He was also greatly given to argument and had a poor sense of proportion, as applied to comparisons of school-bred and practically trained men. As an instance of how abjectly he failed to satisfy his employers he worked in five offices in a period of seven months in a busy year when men were in demand. He got a job finally as timekeeper on a construction job and held it one week after making a number of mistakes and showing plainly that he did not fit in with the rough work. The rush and hurry bothered him also, for he was, by nature and cultivation, made for the schoolroom and the library. In fact, he should really have studied for the ministry. He was a good-looking chap and had a kind heart, so that the men imposed on him with hard-luck stories everywhere he worked. Finally he landed a job as a tracer and general helper in a railway office, which job he held until the following fall, when he went back to school to take advanced work and obtain the degree of C.E. His experience of fifteen months in "practical" work enabled him to get a billet as instructor upon graduation. His short experience proved that he had not the makings of an engineer in him, or perhaps that what he might have had originally had been educated out of him. Although his college dubbed him "Civil Engineer" and the diploma hanging in his bedroom attests the fact, he is not one and never will be one in the sense that an

engineer is generally meant. To do the man justice it is fair to say that he is a shining success as a teacher. Rankine, however, the greatest professor of engineering, was a practising engineer for years and resigned as chief engineer of a railway to become a professor.

From the school which graduated "Kitty" another man of the same age graduated a year or two earlier. He made friends on every piece of work on which he was employed. In the office and in the field he seemed to be equally at home. When he was laid off it was because the job had ended and all his past employers praise him highly, except one, who was a pretentious man of small parts on whose pet hobbies the better educated young man, pardonably bumptious because of his youth, stepped rather hard a few times. After several years of successful work he applied to his Alma Mater for the professional degree. It had so happened that opportunity had, as yet, thrown no important work his way, his positions having all been minor ones as assistant. He made good, however, and is a graduate of whom a school should feel well satisfied. He will do big things some day when the opportunity comes, for it is in him. His request for the professional degree was not granted "because his ability to do original work is not proven and the work he has so far been engaged upon has been in minor positions carrying little responsibility." The reasons for declining to give

him the coveted degree may be good, but he was further informed that if he put in one year of residence work he could obtain it. It is plain to anyone that the man who is now sporting the degree of "Civil Engineer" is really a Master of Science and such should have been the degree given to him. If he did not feel the incongruity of the matter the second young man, the real engineer, would not feel so bitterly over it. He does not object in the least to the school placing a high value on the professional degree, but he feels queer when he meets "Kitty" and knows that the school calls him an engineer while practical men under whom he tried to work call him things not so complimentary.

The graduate of a technical school should be able to think and reason mathematically. He should not think in mathematics, which is something different; the man who does the latter being better fitted to become a physicist, or a teacher of mathematics. No student should become absorbed in the tools, for, if he does, he will forget their proper use. Too many graduates come out with very vague ideas of their life work and this is due to the fact that even the best school cannot make an engineer of the unfit. It is a reminder of the old proverb about the silk purse and the sow's ear.

Many practical men, unaware of the difficulties under which a teacher must labor, condemn wholesale the American schools and praise the schools of Europe, especially of Germany. No one doubts the

very high standing of the German schools, but the difference is in the lower grades rather than in the higher schools, the technical high school in Germany corresponding to our technical schools here. Many eminent Germans have said the American engineering schools are as good as any in the world, as engineering schools, but that as schools devoted to research and research methods they are inferior to the schools of Europe. The American public school system is based on the idea that each male pupil has an equal chance to occupy the Presidential chair and that each girl has an equal chance to become the wife of the President. This idea is carried out to some extent in the engineering schools, where the endeavor seems to be to train boys to fill positions as chief engineers. Restlessness, envy and discontent are marked American traits and these, in part, account for the success of so many foreign engineers who come to the United States and succeed, even with the handicap of having to learn a new language. Few teachers in American engineering schools tell the truth to their pupils about conditions as they actually exist. Nothing is said about the ninety-nine privates in the company, to use a military simile, but the captain is a hero. The captain himself, however, is only a minor officer and it is the colonel over twelve captains and the generals over three or nine colonels, who are held up as examples for the emulation of the boy. The majority of the schools

do not aim to fit the boys to fill the positions in the ranks and fill them acceptably, so that finally the private may become a corporal, the corporal a sergeant, the sergeant by hard effort becomes a lieutenant and then having placed his feet on the lower round of the ladder of promotion, his future is secure. The majority of the graduates look upon themselves as cadets in training for a commission which is theirs by right of scholastic training, upon graduation.

The boys may be taught to do the work that belongs to the minor positions, but they are taught no respect for the work, it being regarded as something disagreeable which all young fellows must do for awhile, but which should not be done for a long time, nor be considered as anything more than a bit of perfunctory training. The German studies for the power that education gives him. The American boy studies to enable him to earn big money and escape drudgery. This is shown by the rush toward specialties reflecting big work being done in the vicinity of the homes of the students. The German does not grumble at the prospect of six years of severe training, during which time he imbibes a love for the work, while the constant cry of Americans is that vocational courses in portions of engineering work be cut down to two years.

A prominent educator, in addressing a class of engineering students said, "Our aims are high. If

I thought that this school will turn out any men who will be nothing better than draftsmen and detail men all their lives, I would feel ashamed and deem the school a failure." It is unfortunate remarks such as this that cause many men to fail, "For who hath despised the day of small things."

The German idea of education is different from the American, so that boys going to the technical high schools are better trained in the minor things than the average American boy is trained. At the higher schools there is also a difference due to the fact that the "private docent" in Germany, the "tutor" in Great Britain, have no prototype in American schools. The student here is wholly at the mercy of the lazy or incompetent instructor for his drill in mathematics and the studies lying at the foundation of the training for his future life work, seldom coming in contact with the high-grade professor until in the two final years he has good stiff courses to take with him, predicated upon perfect preparation. If he flunks he must go to a private tutor and pay him $1 per hour for cram work. In the foreign schools he can desert the regular instructor when he has taken his measure and go to the outsider, the "privat docent," who is, however, a recognized institution and not wholly an outsider. The higher teachers are often recruited from the ranks of the "privat docents," or "tutors," who have demonstrated their fitness. It is no uncommon thing in a

European university to find a "privat docent" in fairly active competition with a well-known professor.

The writer has no wish to be ranked with the men who are wholesale in their condemnation of American schools of engineering. He has no wish to be ranked with the men who condemn at all, but he is not blind to some grave defects which are easily remedied and which exist because few teachers are able to realize that their former students have grown to be men, and actually have a better knowledge of conditions than the teachers themselves. Few men whose opinions are worth anything care to see much of a change from standard curricula.

Engineering teachers have organizations, as before mentioned, in which many prominent practitioners hold membership. In many schools the alumnæ are represented on the governing boards and these men endeavor to correct defects they observed while students. There are many teachers who are not graybearded book worms, but who are live, energetic men who made a success of practical work and later took up teaching from choice. Many of them are of high rank as consulting engineers, and in conventions of engineers are listened to with respect and are placed at the heads of good committees. "Common sense and mathematics" are a good combination.

Considering the fact that the financial reward

of the teacher is limited and fixed in amount, a deadening influence on most men, it is gratifying to meet so many high-minded, energetic teachers whose fondness for their work leads them to stay with it when everyone who meets them knows they are able to compete with the best men on the outside. The writer never visits an engineering school without experiencing the charm that holds men in the walls and believes that in many ways the rewards of the profession are greater for the high-minded, high-grade teacher than for the leading practising engineer. All success cannot be measured in financial terms. One amusing thought, however, is that all engineering teachers class themselves with the best of the active practitioners and thus count themselves very much underpaid, this having considerable to do with their lack of results.

The principal defect in engineering schools is the "inbreeding" caused by a too rapid growth of the engineering department and lack of sufficient funds to procure proper instructors. Many instructors are of the "God-to-be-pitied" class, so that a home is necessary for them. The pay in the grade of instructor is so low that a man who is well adapted to go out into the world and win a living in competition with other men in the same line of work will not consider it. The result is that numbers of young men graduate from a school in the spring and in the fall enter the same school

as instructors, their knowledge limited to what is taught within the walls of that institution, and, like all small men, become vainglorious and prideful within a few years so that progress for them is impossible. The boys who pass under their hands are in a pitiful plight. In mathematics and physics especially, these men are bad, for after conducting one class through the text book the teacher can rest his brain and become just as lazy as he likes, and that is often very lazy indeed when a man's brain begins to atrophy, so that many professors actually get the idea strongly fixed in their heads that "once a teacher, always a teacher," regardless of whether their work is productive of real results. On this point the reader is referred to an editorial entitled "About Dismissing Professors," in the *Popular Science Monthly* for March, 1911.

Many instructors did try practical work for a short time after graduation, as will be remembered was the case with "Kitty," but returned to the school, like a cat to a comfortable home, when opportunity offered. Teaching is a distinct calling and many do make excellent teachers finally, but the present hap-hazard way of holding on to teachers without requiring definite results from their work is not seemly when taken in connection with such a practical profession as that of engineering. Teachers should be better paid and should be retained, as other workers are, only

when they prove their ability. Many teachers resent very strongly the idea that their work should be measured by results. The college to a teacher is a home, and sometimes a graduate, smarting under insult, injustice and incompetency, has to wait twenty years before he can get on the governing board of his Alma Mater and attend personaly to the discharge of a teacher he knows to be unfit.

Practical men frequently state that in no line of work can a man make a living with less real effort and smaller results than as a member of a teaching force in a college, engineering schools not excepted. The same trouble is found in public offices and in the offices of all large corporations where there are enough good, earnest, hard workers to enable a lot of lazy incompetents to hold down jobs without detection. The pay of a professor lags about ten years behind the average of the pay of engineers in active practice. At the start there is scarcely any difference, but the teaching engineer has an advantage in that he holds practically a life position, where he may, if he wishes, work with all the enthusiasm and energy of the clock-watching clerk. The pay of a good professor never rises above the average the first-class, successful engineer may figure confidently on securing after fifteen years' work. A good professor however, often makes a great deal of money as a consulting engineer, his work

for the school being the finest sort of advertisement.

A vast improvement might be made in many schools by making it a rule to require all instructors to be graduates of other schools, with not less than two years' practical experience after graduation. The instructors should not be employed upon one study, but should be required to be prepared to teach at least four subjects, one subject each semester, thus compelling them to grow. It is deadening for a man to teach graphics all his life, or to carry advanced algebra year after year, or to teach any subject in which the advance to-day is small, if there is any advance. Too much specialization is the trouble with the schools, not alone in the courses taught, but in the teachers.

In American schools there is a class of teachers known as "flunkers," who seem to think that about 25 per cent. is the minimum number to "flunk" at examination. What would be thought of a workman in a factory if 25 per cent. of his product day after day were condemned? How many days would he last? A teacher who regularly flunks a high number of his students is a misfit, for a real teacher will soon remedy the trouble, if there be any other trouble than laziness on his part. Sometimes it appears to an outsider that instead of the teachers who handle the students during the first two years being the most poorly paid, the case should be reversed and the pro-

fessors in the foundation studies should receive the highest pay and take charge of the students from the day they enter college. The graduate requires his mathematics during the last two years of school and during the three years immediately following graduation. The higher engineering problems, for which he is most carefully trained by the highest paid men in school, are things he cannot hope to approach for many years after graduation, for the outside world deems considerable experience is first necessary. When ready finally to take up such problems there should be no difficulty in reading up and studying the matter, for on such projects one is seldom unduly hurried. It is really in the fundamentals, the tools of his work, he should be best trained.

Require not less than two years' practical experience before appointing a man an instructor and also require recommendations from his employers, to insure getting an intelligent man. Do not select as an instructor a graduate of the institution. No man should be appointed an assistant professor until he has been an instructor at least five years, and in the case of an assistant professor there is no objection to taking a graduate of the institution, providing he has had not less than two years' practical work, and has taught in another engineering school not less than five years. This will do away with "inbreeding" and should keep men alive.

To ascertain just how well the teachers are doing their work permit the graduates to help improve conditions. The fifth year after graduation, thus allowing time for the clearing away of youthful bitterness and animosity, each graduate should be sent a blank to be carefully filled in, in which he is to reply categorically to a list of inquiries respecting the members of the teaching force at the school while he was there. This report to be confidential between the man who makes it and the President of the institution. The graduates can thus have full opportunity to help their Alma Mater and show-up the weak points of the teaching staff, and if the head of the institution is fit for his position he will know what to do, and how to do it. In studying such reports he is not dealing with immature graduates, but with men who are experiencing the hard knocks of life, after having supposedly been prepared for their life work at the school whose instructors they are invited to criticise.

The essential difference between engineering instruction in Germany and America is that the attempt is made in Germany to give a complete scientific course and train men in the application of science to industry. They graduate technicians there. Even with the amount of practical work now required, the graduate is a technically-trained scientist, who understands that his education is for power, and that it alone does not entitle him

to high pay, but that it does open wide for him the door of opportunity. The American ideal has been lower and too much the result of listening too closely to criticism. In fact, the principal faults in the American schools are due to the endeavor of the teachers to give the students what a century of training has shown to be about right, and, at the same time, try to satisfy the selfishness of men who want well-trained, narrow specialists without bearing any of the expense of training them.

When specialties are discussed it is well to remember that it is difficult to train a man thoroughly in a minor subject without causing him to lose the sense of proportion he must maintain, if he is ever to be more than a part of a machine. Whether all the boys are fit to be engineers or not, they represent a select lot of humanity when they finally finish the grind and get their diplomas. A large percentage of them should amount to something later in life. That more do not meet with considerable success is due to the wilful blindness of the deans, who act as employment agents for large corporations, in their anxiety to advertise to the world that "this school, owing to its excellent methods of instruction, cannot supply the demand for graduates." It requires the use of the short, ugly word to properly characterize these statements in many cases.

Many large corporations like to fill their offices

and works with well-educated men, because the average young educated man has been advised by his instructors to work for low pay during the first years after college "to gain experience." Thus these chaps give rather more for the money than men not so well trained. When a man has been selected for a place because he has exhibited superior qualifications he naturally expects a regular increase in salary, year after year, even if small. When, as so often happens, he finds he has been put into a position where there is no hope of advancement and little hope for better pay he becomes discontented. The discontented ones are marked for discharge and when the next annual crop of graduates is harvested, a spell-binder from the corporation goes to the school and leads the entire class to the slaughter house, the dean rubbing his hands gleefully and taking never a thought in after years for the poor, misguided victims, who might have been spared if he had carefully investigated in advance the positions offered and had acted like a father to his boys. The process is just one little remove more cruel than the merciless processes of nature, as set forth in the works of Dr. Darwin. Out of it a few men do succeed, but the waste of effort is needless and the waste of money represented by the sacrifices of the parents of the slaughtered boys is criminal.

Some students enter American schools with so poor an idea of what engineering involves, and

are so plainly adapted to the calling, that the problem of the often insufficient preparation is most important. Dr. W. G. Raymond, Dean of the Engineering Schools, Iowa State University, Iowa City, Iowa, has adopted a method which is similar to what is known as "Seminary" in European schools. The student, unable to keep up with the class, is taken from the class and taught topically, practically individually, until his sense of perception is dilated, when he goes back into the class, and it has been the experience that such men are leaders in class work for the remainder of the course. This is "unit" instruction, and, as the engineer works on the "unit" system in after life, it is good that some of his instruction, especially if he be backward or deficient, should be on this system. Professor Schneider of the University of Cincinnati has been very successful in establishing combined courses, wherein the students and instructors alternate between the school and manufacturing establishments, the length of the courses being six years instead of four, in order to enable the student to sandwich in the practical work without losing what he requires of theory. These combined courses are now becoming standard in other schools, the "Seminary" method of Dr. Raymond requiring more work on the part of the teacher and also requiring, on an average, a better grade of teacher in the minor subjects. The engineering course of the future will be not less

than six years in length, and will combine the schools, the shop and the topical study and discussion.

The engineering course of the future will not all be given in the engineering schools. Since fully 90 per cent. of the men employed in engineering work do not require the complete education the engineer should have, much of the work of preparing the large majority can be done in the high schools. Two years can readily be added to the courses in the high schools, so that boys wanting to go into technical work may be specially trained. In the additional two years can be given all the algebra, trigonometry and analytical geometry now given in the technical school. The high school, in the additional two years should also give descriptive geometry and drawing, the drawing course being so arranged that finished draftsmen, not designers, may be turned out fit to do the ordinary work in the offices of engineers, architects and manufacturers, such work as the younger men are given. The high school can also give as much chemistry and physics as the average engineering school now gives. The use of surveying instruments and the elements of land surveying can also be taught in the high school. The shop work of the average engineering school, which is generally an advertising feature of ridiculously little practical use, can be given in the high school. This additional work on the part

of the high school will answer the wide-spread demand for short-term vocational courses and relieve engineering schools of much elementary work. The engineering schools can then maintain their courses at four years, demanding as entrance requirements all the above work in the high school. The first three years of the engineering school will then be a general technical training, with plenty of culture studies, the students specializing in the final year only, and not specializing narrowly.

CHAPTER IV

HOME STUDY COURSES

In an earlier chapter the writer has said something about men who take up engineering studies in order to improve their standing and provide for advancement. He has no sympathy with the man who can afford the time and expense to attend a resident school and yet deliberately neglects such an opportunity in order to learn the business "practically," whatever that may mean. For the man who is really fit to be an engineer and who is unable to do anything more than study alone he has the utmost sympathy. For many years the writer has conducted classes in evening schools, where the service, rather than the small salary, is considered to be compensation, and he is now a member of the educational committee in the Y.M.C.A. Institute, so that he thinks he has a pretty fair understanding of the men who imagine they would like to "learn more to earn more." There are enough mature earnest men to justify him in giving up a chapter to guidance in home study, but he is frank to say that an enormous number of men are filled with desire and not with ambition, the difference not being plain to many.

The advantage of being able to attend a night school is that one has the help of a teacher, a great boon to men taking up the different studies connected with engineering. In some "practical" schools the instruction is individual and the schools are open all the year. They exist to supply a demand for education from men who wish to quickly increase their earning ability and many of them labor under the disadvantage that the teachers do not guide the students in a course of study. The students dictate to the teachers as to what they want and if the teacher thinks differently some other school gets them. A few of these schools are excellent, but the majority are run solely to make money and for the good of the profession should be suppressed.

Many high-class institutions now have evening courses, but as the income of the school is not dependent upon the money received from the students, the cost generally being far higher than the amount charged for tuition, each student is expected to enter a class and receive class instruction. The courses extend over practically as many months as the courses in the day school, but this in years means more than double, for the evening classes continue for only about six months in each year and for two or three evenings in each week. Night-class students generally want something in a hurry and the course that only occupies their time for half the year, and is arranged to cover

from three to six years looks apalling. Another drawback is the class method, due to the necessity for keeping down instructional cost, so that when the student misses an evening once in a while, he becomes discouraged.

The Association Institute in Chicago has adopted an excellent method in which courses in the night school are arranged so that each may be fully completed in a season. Instead of compelling a student to start in at the rudiments of all engineering science, he is taken as far as his previous training will permit in the subject he has chosen, endeavors being made to have him later take more of the fundamentals and finally pursue intermediate and advanced courses covering the same ground. This may be radical and a copy of the methods of the schools run for profit, but the aim of the school is to help the student and the small fees charged indicate sufficiently that there is no financial profit in the enterprise.

Correspondence schools are a great improvement over night schools, on account of the all-year study, but they do not furnish a flesh and blood teacher in the room with the student. The man who takes a correspondence course in a reputable school has well-prepared lessons regularly mailed to him and his progress depends wholly upon himself. If he requires help he has only to write to receive it. The courses, however, are stiff and a

marvellously small per cent. of those who start remain to finish.

Before the days of evening and correspondence schools many men studied alone, poring over books, in the course of many years acquiring enough knowledge of the essentials of engineering science to get along well. It is a solitary way and not to be preferred to the well-organized methods by class or through correspondence. Many, however, prefer to study alone, and to the end of time there will be those who would rather buy a book and be self-tutored in spite of the easier and better ways. For the men who insist upon being self-tutored the following courses are offered, the writer vouching that he knows a number who have achieved considerable success by home study.

The main difficulty in studying alone lies in knowing just what books to buy, many expensive trials being made. Few men know how to advise a young fellow in the purchase of books for self study, and, as a rule, most men will advise books away above the comprehension of the inquirer, because of his insufficient grounding in the rudiments. The self-tutored man finds plenty of books dealing with the particular specialty in which he is interested, but runs afoul of the mathematics plentifully besprinkled over the pages.

The first thing required is that the student be expert in common fractions, decimal fractions, ratio and proportion. The best way to study these

subjects is to resurrect the old school arithmetic and go through the sections dealing with the foregoing subjects. The higher branches of mathematics will be of no practical benefit and cannot be properly studied by a student not fairly expert in ordinary arithmetical operations. At the present writing there is no good book on the market written for the instruction of self-tutored men in arithmetic. There are some excellent British books for the purpose, but the American student finds them exceedingly hard to use because of the absurd monetary system and system of weights and measures used in all the examples for practice. The examples themselves would be most excellent practice were it not for the fact that the American student feels he is wasting his time dealing with subjects for which he will never have practical use.

During the present year (1911) a new book has appeared entitled "Mathematics for the Practical Man," by George Howe, M.E. ($1.25), which explains in simple language the fundamentals of Algebra, Geometry, Trigonometry, Logarithms, Coordinate Geometry and the Calculus. This, it is seen, must be preceded by Arithmetic. The author gives numerous examples to be worked and his manner is extremely lucid. No better book can be taken up by the self-tutored man who wishes to study mathematics.

One book, however, is not enough, for the

views of another man are helpful, the teacher being able often to make clear things not plain from a study of the text book. The self-tutored man has no teacher, so for additional explanation he should buy "Algebra Self Taught," by Paget Higgs (60 cents). This is rather an old book, containing no examples to be worked out, the writer confining himself solely to the philosophy of mathematics. Study Howe thoroughly, working out all the examples, and use Higgs for reference and collateral reading. When Howe is completed, study those subjects in Higgs which Howe does not treat so fully.

At this point the courses separate. Students studying civil engineering or architecture should follow with "Elementary Practical Mathematics," by M. T. Ormsby ($2.25).

Students in mechanical engineering should study "Practical Calculations for Engineers," by Larard and Golding ($2.00), following with "A Primer of the Calculus," by E. Sherman Gould (50 cents).

Students in electrical engineering should study "An Introduction to Practical Mathematics," by F. M. Saxelby (60 cents), and then take, by the same author, "A Course in Practical Mathematics" ($2.25).

The student should now be able to read intelligently and enjoy any mathematical book published. An interesting book for reference and home study

after one has completed the first two books mentioned, is "Practical Mathematics," by Knott & Mackay ($2.00). The section on Strength of Materials should be studied first and then that on Trigonometry. The other subjects may be studied as the student's interest in the matter dictates.

After completing the books above mentioned it often happens that a man wishes to learn more about mathematics, and an excellent book to buy in such case is "Higher Mathematics for Students of Chemistry and Physics," by J. W. Mellor ($5.00), a book intended for self instruction. In studying mathematics no real power is gained by reading until the principles are understood. To thoroughly understand the subject means many hours of monotonous drill on problems.

It is always assumed that the self-tutored man is employed in some capacity in the office of an engineer or architect, or in the office or shops of some manufacturing concern. If he is engaged in mercantile pursuits he should not try to get into engineering work by home study or even by means of the correspondence school. He will meet in his books a great many statements which will be fully intelligible only to men in the business. The writer makes a special plea to every man to stick to his trade or calling.

After completing the course in mathematics take up:

Elements of Mechanics, Merriman ($1.00).

Strength of Materials, Merriman ($1.00). There is a larger book by the same author having the same title, but the small one is best adapted for self-tutored men.

Materials of Machines, Smith ($1.00).

Mechanics' Problems, Sanborn ($2.00).

Chemistry and Physics of Building Materials, Munby ($2.00).

The student having completed the above list and having presumably studied each book thoroughly, is in a position where he is free to select for himself. No technical book should bother him because of the mathematical expressions or references to certain statements in mechanics.

Drawing is a most important subject, and the most complete book for the self-tutored man is "Mahan's Industrial Drawing," new edition by French ($3.50).

All engineers, and also architects, will require the information given in:

Elements of Graphic Statics, by Cathcart & Chaffee ($3.50).

Steam Power Plants, by Meyer ($2.00).

Power and Power Transmission, by Kerr ($2.00).

Elements of Electrical Engineering, by Kinzbrunner ($2.00).

For general information on subjects of great value buy:

A Text Book on Physics, by W. Watson ($5.00).

Descriptive General Chemistry, by Tillman ($3.00).

The man wishing to study surveying should be in the employ of a surveyor, or of a civil engineer doing considerable surveying, and study:

The Surveyor's Hand Book, by Taylor ($3.00).

A Manual of Land Surveying, by Hodgman ($2.50).

Hodgman deals with the laws governing the recovering of lost corners and boundaries, a very important part of a surveyor's work. The surveyor, however, should not limit himself to one or two books, but should have in his library the books of Johnson and of Gillespie. Major Rees of the Corps of Engineers of the United States Army has written a remarkably good book on Topographical Surveying and Gribbles' "Preliminary Survey" ($3.00) is full of methods of considerable value and interest.

The civil engineering student should read thoroughly:

Civil Engineering as Applied in Construction, by Vernon-Harcourt ($5.00).

Engineering Work in Towns and Cities, by McCullough ($3.00).

Water Supply, by Folwell ($4.00).

Sewerage, by Folwell ($3.00).

The student interested specially in structural work should study:

Bridge and Structural Design, by Thomson ($2.00).

Typical Steel Railway Bridges, by Thomson ($2.00), following with:

Steel Mill Buildings, by Ketchum ($4.00).

Walls, Bins and Grain Elevators, by Ketchum ($4.00).

Highway Bridges, by Ketchum ($4.00).

The student of mining engineering will require all the preceding mathematics, physics, chemistry, drawing and surveying before taking up:

A Manual of Mining, by Ihlsing & Wilson ($5.00).

Prospecting for Gold and Silver, by Lakes ($1.00).

Prospecting, Locating and Valuing Mines, by Stretch ($2.50).

Mining, Mineralogical and Geological Law, by Shamel ($5.00), following with any of the books already mentioned, which he believes might be helpful to him.

It is, of course, understood that no attempt has been made here to give a list even approximately complete of the *best books* on any particular subject. The only thing the writer has endeavored to do has been to assist the reader in selecting *good first books.*

For the encouragement of men who missed earlier opportunities and are determined to supplement the deficiencies in their earlier education, the two diagrams here presented are interesting studies.

The first is a copy of a diagram frequently used by modern contractors for the purpose of rating their foremen, and is taken from a job of which the writer had charge. The horizontal lines rep-

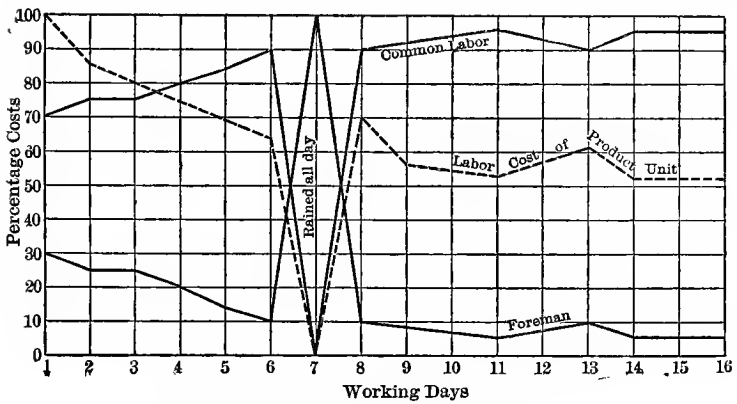

Fig. 1—Labor Cost Per Unit of Product.

resent percentages and the vertical lines represent days. On the first day the cost of the product, assumed here to be a yard of concrete, is taken as a maximum, for the men are green and the foreman not acquainted with his crew, it being the first day of the work. Therefore at 100 per cent. the start is made for cost of product. The crew was small and the cost of the foreman was 20 per

cent. of the total expense for labor. It will be noticed that actual costs are not given, everything being represented in percentages. The second day the crew was increased in size and the percentage cost of foreman was consequently reduced and there was a considerable reduction in cost of product. With each succeeding day there is a reduction in percentage cost of foreman, with a corresponding increase in percentage cost of laborers, the cost of the product falling. Finally, as the men become well trained and accustomed to the work and the foreman also gains in experience, the cost reaches a minimum and becomes fairly constant. An ideal diagram would show all the lines smooth.

This diagram is made each day from the reports of the timekeeper and cost clerk and plotted for the information of the supertintendent; and the foremen themselves. The percentage cost of the foreman is expected to be fairly smooth after getting started, but the cost of the product varies, owing to accidents, or to a neglect by the foreman of his work. When the superintendent reads the diagram each day and finds the cost of the product rising, he can find the cause and quickly stop the waste. By means of such diagrams all modern manufacturing business is kept track of, contracting being merely migratory manufacturing.

If all workmen are well trained and so intelli-

gent that little guidance is required, the cost of foremen becomes very low. All workmen are not intelligent and the most intelligent are not always the most industrious. Intelligent directors of work are, therefore, required, and they are, of course, the specially trained men. Such diagrams show that education and training pay. In order to direct the vast numbers of poorly-trained men there must be numbers of better-trained men, and, as technical education becomes more common and the general intelligence of ordinary laborers rises, the educated men must be far better educated than the average if they are to receive better than the average pay.

The second diagram is taken from the Transactions of the American Society of Mechanical Engineers, Vol. XXV, 1904. This diagram was prepared under the direction of Mr. James M. Dodge, to illustrate his Presidential Address before that society in December, 1903. Mr. Dodge assumed that all boys have a potential value of $3000 at the age of 16 years. He considers four groups of men working in the mechanic arts—the unskilled labor group, the shop-trained or apprentice group, the trade-school group and the technical school group.

Data is lacking as to the progress of the unskilled labor group from the age of 16 to the age of 22, when the average weekly wage is $10.20. This continues to be fairly level for a few years and then,

of course, will drop as the laborer becomes weakened through disease, excessive labor or age.

The apprentice or shop-trained worker has a

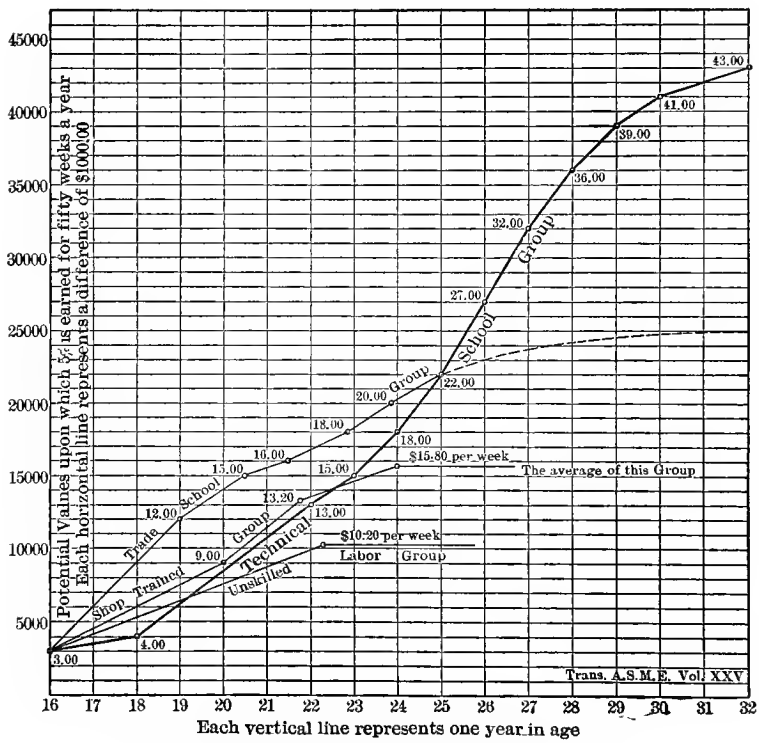

FIG. 2—The Money Value of Technical Training.

potential value of $3000 at the age of 16 when he enters the works in good health and with good habits. Assuming the working year to consist of fifty weeks, he receives $3 per week, which amounts

to 5 per cent. interest on his potential value. His accumulated experience increases his potential value, until at the age of 24 it reaches $15,800 and he draws interest, in the form of wages, to the amount of $15.80 per week. This is practically his maximum, and is practically 50 per cent. more than that of the unskilled laborer. The writer objects to the word "unskilled" when applied to ordinary laborers, for the word does not fit. His experience has shown him that many of these men are wonderfully skilled in the work with which they are intrusted and, therefore, wishes to make a plea to substitute the word "untrained," for the other more objectionable word.

Mr. Dodge stated experience showed that 5 per cent. of the apprentice group, acquiring the machinist trade, rise above the line made by his average man; 35 per cent. follow the line closely; during the period of training about 20 per cent. leave of their own accord, and, as near as can be ascertained, go to other shops and continue in the line originally selected; 40 per cent., however, are found unworthy or incompetent, and are dismissed, probably never rising to the $15.80 line. On this point he remarks:

"Appenticeship of to-day in many establishments does not make the man, broadly speaking, a mechanic—in a majority of cases he is a specialist or tool hand, and not comparable with the old mechanic, who was a worker in metals, had some

practical knowledge of steam and prime movers, could chip, file, work on lathe, planer, drill press or as an assembler, and was competent to meet the varied and unusual conditions found in general construction and repair work."

The young man fortunate enough to secure three years' training at a good trade-school enters a machine shop at the age of 19 and can command $12 per week, equal to the apprentice at 21 years of age. His three years in school, during which time he was earning nothing, have proven equal to five years practical shop training, but in reality the difference is greater, due to his broader training in theory and general processes. A study of the line of this group shows the advantage to be permanent, the line of average earning being about 50 per cent. above that of the apprentice. The dotted extension of this line shows a possible increase in value, while, of course, a few exceptional men may go far higher. It is for these three groups that the numerous correspondence, night and vocational schools exist, and for them that the home study courses have been planned.

The young man who prepares himself for entrance into a high-grade technical school at the age of 18 is presumed to have a potential value of $4000 at that age, although he is in the non-earning class until he graduates at the age of 22, when his four years' course in the technical school ends. His entering pay in the works puts

him six months behind the apprentice and two and one-half years behind the trade-school graduate. In six months the technical school graduate overtakes the apprentice, at which time both are earning $14.00 per week. The technical school graduate reaches the $15.80 line nearly one year before the regular apprentice. In three years' time the technical graduate overtakes the trade-school graduate. The line then becomes more curved until, at the age of 32, just ten years after graduation, the technical school graduate has a potential value of $43,000 and receives the 5 per cent. interest on this valuation in the form of a weekly salary of $43.00, at which age the pay of the trade-school graduate may be assumed to be about $25 per week. The curve on the diagram ends here, but the writer has plotted it to a probable maximum of $45.00 per week fifteen years after graduation, with a prospective drop after the age of 45. The compensation of the average graduate in mechanical engineering is thus seen to be at a practical maximum fifteen years after graduation of about $2250 per year. This does not seem large, but it is well known that some exceptional men, or men who had exceptional opportunities, earn far more. This, likewise, applies only to salaried men.

CHAPTER V

HOW TO HUNT AND HOLD A JOB

THE average engineer is known as a "job chaser." Not only in vacation time must the engineering student hunt jobs, but periodically after graduation the same experience must be gone through. The majority of engineers work on salary, the terms of employment are uncertain and in slack times thousands of men are turned adrift.

Mr. Onward Bates, President of the American Society of Civil Engineers in 1907, took occasion in his presidential address to classify the active members of the society with a view to studying the subject of engineering employment. He assumed that as the percentage ran in the society so it would run throughout the ranks of the profession, although the American Society of Civil Engineers represents probably less than one-fourth the total number in the country, and these the more successful.

In percentages the employments were as follows:

United States Government Service..	7.7	per cent.
State and Municipal Service.....	12.7	"
Railway Service (all kinds).....	15.2	"
Manufacturing, Contracting, etc....	17.6	"
Consulting Engineers.....	20.2	"
Architects, Teachers, Editors, Misc...	5.1	"
Unclassified	21.5	"

The men marked "Unclassified" were those who gave merely an address for the annual register, but failed to give the nature of their employment. A few may have been retired and the majority, no doubt, belong to the numerous class that is seldom blessed with a job lasting a whole year, although their pay may be good.

By "Consulting Engineers" is meant men in private practice, and Mr. Bates assumed that more than three-fourths of all engineers are dependent upon salaries and less than one-fourth receive fees as compensation for work. Mr. Bates assumed that what was true of members would be equally true of associate members and juniors, but the writer believes, as careful study of these two grades would show, the percentage of men dependent upon salaries to be nearer 90 per cent. for the entire membership, for we do not know how many of those engaged in manufacturing, contracting, etc., were on salary or in business for themselves.

A member in this society must be not less than 30 years of age, qualified to design as well as superintend construction, in active practice not less than ten years, of which at least five years must have been in responsible charge of work. Members, therefore, may be assumed as being fairly well settled.

An associate member must be not less than 25 years of age and engaged in active engineering work for not less than six years, of which one year

has been in responsible charge of work. An associate member is, therefore, one who is being made into an engineer, and, generally, is not yet settled.

A junior must be not less than 18 years of age and have had two years' practical experience, or be a graduate of an engineering school. His connection with the society ceases when he becomes 32 years of age, unless sooner transferred to a higher grade.

There are other grades of membership in the society, but the three above noted constitute the bulk of the membership, and counting them as constituting the entire membership, the percentages are as follows:

Members	49 per cent.
Associate Members	37 "
Juniors	14 "

Practically none of the juniors and but few of the associate members are in private practice, or in business for themselves, so, from the standpoint of the man who is seeking employment upon engineering work, it may be assumed that nine out of ten of his competitors are in like case with him, transient employes.

The young engineer is exceedingly hurt by the fact that his education seems to be so lightly regarded as a qualification entitling him to high pay and that his degree is laughed at. He resents being set as a foreman, timekeeper or setter of line

and grade stakes over illiterate men who get better pay. Many young men complain, and too large a number become chronic kickers. A few write letters to the technical papers, which letters are discussed until the editors close the discussion for the time being as leading nowhere. The discussion ranges from grave to gay, and many seasoned veterans take a heartless pleasure in poking fun at the "fresh graduate." These discussions recur at fairly regular intervals of about five years and elicit nothing new. They come around about as regularly as the discussion of standard moot subjects in engineering circles, and, indeed, this problem of the earnest young man, with his first glimpse at actual conditions, may be said to now constitute one of the "moot" subjects, which the regular reader of engineering periodicals must expect to have called to his attention half a dozen times in his professional life.

The fact is that the education does not entitle the young chap to high pay. It simply gives him an opportunity to secure employment, and places him in a better position than the man who is not so well educated. It gives him broader opportunities to secure employment than the self-tutored man, who is, of necessity, a specialist and, therefore, limited in his powers to move about. Many young fellows learn a great deal in offices about certain kinds of work in which their employers are specialists, but when times get dull and they are

laid off, their chances for employment are very slim as compared with the college graduate. The diploma, therefore, is merely a card of introduction, the education a permit to remain in an office and give proof of ability.

Some young men secure permanent positions early, and advance slowly and steadily until they become the highest officers in a corporation, for corporation employment is most common as an engineering probability. The majority, however, roam for many years from one piece of work to another before settling in one place, and it is strange how few become expert at selling their services. Most of them seek a new place with a decided feeling of resentment, and often become sarcastic when discussing prospective employment.

To hunt a job is an art and some seasoned men have it pat. Much, of course, depends upon the employers, but long practice makes a man perfect in reading character and approaching prospective employers, some of whom ask for letters of recommendation, while others profess ability to "size a man up." It is well to secure as many letters of recommendation as possible so they will be ready when asked for.

An engineer makes many changes and should ask for a letter every time he is laid off. The employer may profess a willingness to answer all inquiries from prospective employers, but this profession of willingness on his part should not pre-

vent the applicant from getting the letter. When a past employe changes positions frequently, the old employer sometimes experiences annoyance when called upon frequently and finally ceases to respond, especially when some years may have elapsed. Men also die, and after that event the experience had under them is of no value as an asset, there being nothing to support the claims of the applicant. Some engineers, when politely put off when requesting a letter, have had a friend write to inquire about them, this friend turning over the letter of recommendation when received, to be traced so that blue prints may be made of it for future use.

One engineer, with whom the writer is very well acquainted, had a humiliating experience, which shows how valuable it is to have documentary evidence when required. He was seeking a position on a certain kind of work, and, in conversation with the prospective employer it was found that they had many mutual acquaintances, among them an engineer in a distant part of the country, under whom this engineer had once worked, and whom he regarded as a very good friend. Without his knowledge this engineer was written to and asked about the applicant, the reply being that he did not know anyone of that name. The prospective employer sent for the applicant, and, without a word of comment, laid the letter before him.

The engineer read the letter over slowly, and then from his pocket drew a letter seventeen years old, in the same handwriting, on the same letterhead and signed by the same man, in which he testified to having known him for the past five years and praised him very highly. The business man compared the two letters carefully and had a good laugh. He had them photographed side by side and sent the photograph to the engineer in the distant city, the return mail bringing a letter of most abject apology. Seventeen years was a long time for the memory of the successful man, but the man who had never had a chance to rest his feet, but was a perpetual "job chaser," suffered keenly at the thought of an old friend so completely forgetting him. To make the story complete, he got the job he was seeking and it lasted a full year.

Many employers advertise as follows for men:

SUPERINTENDENT—A construction company taking general contracts for reinforced concrete building work, desires the services of a first-class superintendent. Must be familiar with all branches of work entering into the construction of factory, warehouse, office and public buildings. State age, married or single, salary expected and when open for engagement. Work to be in the Metropolitan district. Address "G. 26," Engineering News, New York. 26-2t

WANTED—At once, by cement company doing its own designing and construction, a competent all-round draftsman, fully able to check and handle wide variety of work unaided. Experience in reinforced concrete, mill buildings and machinery a necessity. Permanent and good place for man who knows his business. In answering, state salary expected and experience. Address "B.A. 26," Engineering News, New York. 26-2t

WANTED—Concrete engineer, technical graduate, of five years' experience, to design and estimate reinforced concrete structures; state age, training, experience and salary acceptable for immediate employment. Address "H. 1," Engineering News, New York. 1-3t

It will be noticed that each applicant is to state the salary for which he will work, and he must give his experience, which, of course, means sending on copies of letters of reference. Firms advertising in this way never reply to the letters of unsuccessful applicants, seemingly taking a cruel delight in keeping them in suspense, for even the most seasoned "job chaser" is somewhat of an optimist and hangs on for a long time in the hope that his letter will bring him success. A postal card notification that he was unsuccessful is a decently courteous act which would cost little. The applicant never knows to whom he sends his application, and, as the appointment is made solely from the written record, the man who will work for the least money is generally chosen. Letters are never returned, and many inexperienced young men have lost valuable letters which they foolishly sent to prospective employers. The writer, many years ago, commenced making tracings on cloth of his letters of reference and sending blue prints of them when applying for a position. The prospective employer thus saw a facsimile of the letter, and if he did not return it, only the cost of the blue print was involved.

A letter of application should be brief and to

the point. A badly written, misspelled letter is no recommendation, and all letters should read as if written by a man who knows what he wants and how to ask for it. The writer always knew how to spell, for he was a pupil in grammar schools before plain sewing and such fads were introduced, the recreation for good students being a spelling bee, and the punishment for bad ones being the memorizing of many pages of hard words with their definitions. Thanks to his fondness for reading, he was never at a loss to express his meaning when he wrote a letter, so two of the gravest faults of young graduates namely, poor spelling and ungrammatical letters, he was spared. He was, however, a most abominable penman, about as bad as the majority of young chaps who do not intend to become bookkeepers, and so take no pains with their writing. On his first job after leaving school he received a letter from the president of the company expressing pleasure with the letters he had written the company, but ending up with the request that he use a typewriter thereafter or cease from writing to firms with which the company did business, as his handwriting was so poor that it looked as if the company employed a cheap man. It was true they were having their work done cheaply, but the writer flattered himself that it was not a cheap man who was doing it. The rebuke was kindly meant and was received in the proper spirit, a copy book purchased and a severe

course of training begun, until a fairly legible hand was the result, for which he has never ceased to feel grateful to his old boss.

A personal application for a position should not end with a visit. Leave a card containing name and address and a statement as to kind of work wanted, together with references. This card should be the regulation 3- by 5-inch card index size, and all information should be lettered on it by the applicant, as a means of showing a sample of his work. This involves considerable labor, of course, but it pays, for such a card is filed for reference, while smaller cards will be thrown away almost as soon as the applicant closes the door on leaving the office. A hektograph, the size to print such cards, does not cost much, and is a good investment. A few days after calling make a written application and follow it a month or so later with another. Few applications are kept more than thirty days, for a man is supposed to have obtained a position within that time.

The subject matter of this chapter is inspired by the desire of the writer to assist young men to sell their services in the best way. He had many years' experiences as a "job chaser," and also as an employer of assistants, so can give instruction on this most important subject as a result of experience on both sides of the desk.

Instead of resenting the fact that work must

be hunted for, remember the traveling salesman who must make his rounds regularly to keep customers of his house in line. The engineering graduate "hunting a job" is a salesman engaged in selling his services. If too conceited in appearance, or, if too meek and modest and shrinking he will not be employed. His proper attitude should be one of perfect confidence, unmarred by self consciousness; he should also be neat and have an appearance of frankness and businesslike alertness. Some day the weary round may cease and the "job chaser" settle down to steady employment, all the better for the hard training. The period of "job chasing" depends considerably upon the date of graduation, for the graduates in dull years may be wanderers for twenty years or more, perhaps for life. The lucky ones, who graduate in flush times, may not go through a period of "job chasing" of more than two or three years' duration, many securing positions immediately upon graduation, which are in the line of promotion, and may finally end in great importance and high standing.

To hold a position a man must be competent to do the work and do it quietly and intelligently. Industry is a great blessing, and the industrious man has much to be thankful for in the possession of such a great blessing as the habit of industry. The diligent, earnest man will be certain to succeed if he loves his work, can keep out of debt and

does not acquire bad habits. The world greatly needs men who can do detail work and do it well, year after year, not bothering about the place above, but ready to take it when vacant, concerning themselves only with the work in hand. A great fault with many men is that they are not steady, nor of a contented disposition, this being responsible for the promotion of the steady men, who step into the places left vacant by the restless ones. Restlessness and the kicking habit have made tramps of many promising men. Nothing except laziness, combined with drunkenness, will so certainly kill a man's chances for success as the acquirement of the insidious kicking habit.

Some students like surveying and do not like drafting. Surveying and field work can be done only at certain times of the year, and this work is not particularly well paid. Drafting now offers fairly steady employment, and while it does not pay well in the lower grades, it pays better than field work after a time, and the chances for promotion are better in the office than in the field. The man who is good, both inside and outside, is the best, and the inside man has the best opportunities for meeting the responsible heads of the company for which he is working.

No better advice can be given to the ambitious young man than to tell him to be as good a draftsman as it is possible to be. Forget the job higher up and aim to fill properly the job in hand. Read

and study all the time, and try to associate with men who can teach something. Avoid the kickers, to be found in every organization, as the plague. By acquiring a knowledge of the business one is always ready for promotion. Do not study with a view to getting the job next higher, but study because of a love for the work. The writer has had to turn away many fine young fellows because they were not well drilled in the details of the small work a young fellow is generally put at after graduation. Perhaps, if given an opportunity, these boys might have been found competent to be chief engineers, although that is extremely doubtful, but they will get no opportunity to show their worth in such high positions until they demonstrate successfully their ability to fill minor positions carrying little responsibility. "He who would be served must first learn to serve."

The following from the commencement address, June 1, 1910, at the School of Mines and Metallurgy, Rolla, Mo., by Dr. Charles Sumner Howe, President of Case School of Applied Science, Cleveland, O., should be taken to heart by every engineering student:

> The successful engineering graduate will subscribe for the leading technical magazines in his line of work, and he will not only subscribe for them—he will read them, in order that he may keep posted in regard to what men in his profession are doing, not only from the engineering standpoint, but from the manufacturing standpoint as well. Too many technical graduates never take a technical journal.

They say they do not need it for the work they are doing, which is probably true, and if they continue in that frame of mind, the probability is they will never need to take the journals, because they will not rise to positions of high enough responsibility to make it necessary. The successful man—the man who is willing to do all that is in him to do—must know what other men are doing, and he must put his knowledge to use in the work which he does from day to day.

In hunting and holding jobs the graduate must remember that in the United States more than 200 schools of college grade give engineering courses, and the annual crop of graduates five years ago was estimated at practically 4000. There are many night schools and private institutions giving short courses and partial courses. There are several good correspondence schools and a number of inferior ones. The surplus graduates of schools in every country in the world come to the United States, for it is imagined that in a comparatively new country there should be good chances for engineers to succeed. That so many do succeed while so many American graduates fail, is a sad commentary on the American.

Much suffering and trouble would be avoided if more of the graduates would look upon their course as one in applied science and not a vocational subject, as the modern idea of education in opposition to the ancient as expressed in the now useless classical course. This being true, it is not necessary for them to try and

practise engineering. Those who find the conditions of employment in engineering work unsatisfactory can go into any other business for which they feel adapted, knowing that their college course has been a very practical and useful one. Such men will really be technically educated business men, and in later years should be valuable members of boards of directors and officers in large corporations. If their engineering education does nothing more than lead them not to interfere with the work done by engineers in the employ of their companies, it will serve them and the stockholders well.

The graduate should lose no time in becoming a member in one or several of the leading technical societies. This gives him standing immediately, and while the societies do very little in the way of assisting members to find employment, fix rates of pay, or establish codes of ethics, they are great forces for the advancement of the profession. In fact, the present solidarity of the profession is due entirely to the numerous societies in existence which provide reference libraries and places for meeting and for the discussion of technical subjects, foster acquaintanceship between men in one line of work and issue periodicals devoted to the improvement of the work of engineers.

The oldest national society of engineers in America is the American Society of Civil Engi-

neers. Membership in this society is based upon the idea that all engineers are civil engineers.

The American Society of Mechanical Engineers seemingly classifies all engineers as mechanical.

The American Institute of Electrical Engineers has a very large membership and is rapidly growing. The grade of member calls for very high attainments and the associate member grade is a large per cent. of the total.

The American Institute of Mining Engineers is the leading society for the promotion of mining engineering work.

All the foregoing societies have headquarters in New York City. Many members are members in several or all of the national societies, as well as holding membership in local city and state societies.

The Western Society of Engineers has the same requirements for membership as the American Society of Civil Engineers, and has, also, a student grade, so that boys in technical schools may join, receive the proceedings, and, finally, when they graduate, go into the society as juniors, feeling, from the day they enter school, that the older men in the profession are interested in them. This society has headquarters in Chicago, with a membership pretty evenly divided among all the branches and specialties of the profession. The large reference library in the Monadnock Block, in the heart of the business district, is a center

for members from all over the country, who make it their headquarters while in Chicago.

In nearly every state there is an engineering society holding an annual meeting for the presentation and discussion of papers, which are later printed. In the larger cities there are local societies and clubs, some of the national societies having local chapters as well.

In the opinion of the writer, before another generation, there will be but one national society in the United States, namely, the American Society of Engineers, divided into sections about as follows:

Structural and Bridge Engineering,
Municipal and Sanitary Engineering,
Mechanical Engineering,
Electrical Engineering,

and such other sections as may have enough specialists to warrant the organization. This is the plan on which the Western Society of Engineers is conducted and it works very well. By combining all the societies in this manner the engineering profession will be compact and can work well as a unit. The largest society of engineers in the world is the German Society of Engineers, having numerous special sections. The present arrangement in the United States and Great Britain, resembles unpleasantly the division of medical men into schools.

There is a strong influence abroad in the ranks of the profession, markedly so among the younger and foreign-born engineers, tending toward organization and the fixing of wage scales, although the majority of engineers feel that anything savoring of trades unionism tends to lower the standing of the profession. An increasingly large element is seeking some protection through legal regulations to determine the status of surveyors and engineers, a few states now having license laws. Legal regulation of land surveying is a necessity for mathematical requirements are very simple; a knowledge of law and practice being most essential.

It is hard to admit, but it is true, that the men who pay the poorest wages, or salaries, to young men are the engineers with big reputations, whose charges for their own services are exceedingly high. The reason is that young men flock to their offices, seeking to shine in the reflected glory, many even offering to work for nothing for a year or two in order to say they had this experience; like Paul sitting at the feet of Gamaliel. The writer feels that license laws will not help the general public to distinguish between good and poor engineers, however beneficial they may be in the case of land surveyors. They will help the 20 per cent. in private practice, but will be of no assistance to the 80 per cent. in the ranks of engineers who work on salary, nor the more than 95

per cent. on salary of those who are employed on engineering work, but have not yet attained the engineer grade.

The present tendency is to give better pay to men of experience who have proven their ability, and maintain the pay of men in the lower grades at a low level, this being caused by the enormous number of graduates and their disposition to work for low pay "to gain experience." Protected by law against competition with incompetent men, it will be comparatively easy after a while to use this same law to hold men down and keep them longer in subordinate positions. Membership in a national society is a better recommendation than a certificate from a politically appointed state license board.

CHAPTER VI

DOES IT PAY TO STUDY ENGINEERING?

THE drawbacks to any vocation are best understood by the men engaged in it. The half-serious joke of the lawyer is that no man is fitted to take up the study of law until he has acquired a taste for sawdust without butter as a steady diet. The physician has adopted that joke as one peculiarly fitting to his calling, and in the funny columns of a college paper the writer saw the joke recently credited to the president of a well-known engineering school. Thus the story which was credited first to Lord Eldon, in 1780, may really have been original with a barrister in the time of Nero, just as the story of Stonewall Jackson's brigadier, who built a bridge before the engineers "got their picter of it did," is told by Julius Cæsar about his quartermaster and engineer.

Competition is keen in every line of endeavor. It has always been keen and will always be keen. To those who long for the good old times it does no harm to say that the best authorities on economics and sociology say it requires fifty thousand acres of land to support one hunting savage. People in a state of savagery are continually on the verge of starvation and grumble at every new birth in the tribe because of the increase in com-

petition. The males being hunters, therefore producers, the birth of females is deplored. Perhaps this is too far to go back for the good old times.

Before the era of the manufacture of power, barely one hundred and fifty years ago, the lot of the educated man without private means was pitiable. All manufacturing was done by hand, and nearly every man was a handy man. Wheat at five shillings a bushel and wages one shilling a day, less than one hundred years ago makes present-day grumblers at high prices seem like queer people. The high cost of living has been a never failing topic of conversation since the beginning of speech. In those good old days, one hundred and fifty years ago, the college-educated man, who had worked his way through college, and failed to secure an appointment to teach or preach, was lost. He was trained with gentlemen and with cultivated tastes for the fine things of life without means to gratify them, it is small wonder that he started the discussion "Does a college education pay?" Business was not done then on the scale it is done to-day and openings as clerks and accountants were few. The improvement and and development of the steam engine, which meant the actual manufacture of power on a scale hitherto undreamed of by the owners of water wheels, put the educated man to the front. Education became a fetich, and to-day is so essential as to be commonplace.

Fifty thousand acres required to support one savage and to-day some countries support a population of five hundred people to the square mile, almost one to every acre. It is the engineer who has made this possible. He designs and makes machines which manufacture power. He builds railways, which annihilate distance and make all men neighbors, so that the gospel is being carried to all the lands and war will soon be a rarity. He puts wires everywhere so that "We are as close to you as your telephone" has become an advertising slogan. He tunnels hills, bridges rivers, paves streets, brings pure water into houses and takes away the waste matters so that health is preserved, drains swamps and irrigates the dry hills and plains, carries workmen to their work and back to their homes in rapid transit cars, so that the actual working time has been cut down fully 25 per cent., and the average earnings have been increased, yet the cry is heard that the good old times were best when there was less competition. The good old times when the most wealthy lived in draughty houses, and comfortable chairs looked like sentry boxes, when people died on the average ten years younger than the average to-day; men and women were old at 50, and decrepit at 60, whereas to-day men of 60 look as if in their prime. The kings in the good old days had no better food than the average man of to-day, and baths were

such a rarity that strong perfumes were used by all who could afford them.

This long preamble is to soften the statement that the average engineer is a kicker and is sorry he took up the business. Competition is keen. The writer, after an experience of twenty-five years in the work, sympathises keenly with the average engineer and wishes conditions were better. Yet his eldest son will shortly graduate as a civil engineer. Not because engineering is necessarily a lucrative profession, but because the education is the modern education, one for service. The young man may practise as an engineer and he may not, but whatever happens to him he will have received the best education it is possible to give a boy at the present time, in the sciences that broaden a man. There is something also in the old belief that a boy has much better chances for success if he follows the business of his father than if he starts off in a new field for himself, where the experience gathered by those who preceded him is not available for his guidance.

A large number of young men enter engineering schools every year firmly convinced that engineering is a highly paid profession. If such were not their honest and firm belief they would go at something else, for they do not enter the profession with the spirit that prostrates a sculptor at the feet of a statue, or which leads the lover to cast a rose at the feet of the mistress of his heart. Going

into the work with the expectation of great gain and without the true spirit which makes a workman fondle and polish and ornament the creation of his hands, it is small wonder that so many engineering graduates speak bitterly of their calling. They like to recall the words of Satan in the Book of Job, "And the Lord said unto Satan, Whence comest thou?" And Satan answered the Lord and said, "From going to and fro in the earth and from walking up and down in it," the modern engineer being called "A poor devil," because his career upon earth so closely resembles the occupation of Satan.

Thousands of young fellows whose fathers are doing well at a trade go to college to study engineering and be the gentlemen in their father's trade, for a mechanical engineer is only a scientifically educated mechanician, the civil engineer a scientifically educated master builder, the electrical engineer only a scientifically educated electrical artisan. If these boys, with their superior education, would buckle down to work with their hands beside their fathers, or in their fathers' employ, there would be a big increase in the number of multi-millionaires in this and other countries. As a rule, the education gives the young men an idea that honest toil soils hands, whereas a few years of dirty hands directed by trained brains means, generally, a great many years later in life,

when one can afford the daily ministrations of a manicure.

This feeling against soiled hands is causing a great many disturbances in different parts of the country, if it is true that men can turn in their graves. Numbers of men have left fortunes to endow trade schools, and, the money getting into the hands of the wrong men, the result has been either the establishment of a manual training school, which, up to date, has not proven its value, or the establishment of preparatory schools for engineering colleges. The ideas of the founders were not followed, for the men who administered the estates knew little about the class the patron wished to benefit, and the ambitious man, whom they selected as head of the school, felt it beneath his dignity to be the head of a mere trade school. A proposed new institution has been described to the writer as "A superior grade of trade school," and the writer, thereupon, ventured to bet that an engineering course will be established when the funds are available, only to be met with a surprised "Why not?" Half the engineering schools in the country could be eliminated, or turned into low-grade trade schools with immense benefit to the country.

Too many graduates are turned out of engineering schools who are absolutely unfit temperamentally for the work. Their awakening is rude. The chances for success in engineering are

about as good as in any other learned profession, perhaps slightly better. None of the learned professions offer much chance to secure more than a comfortable competence at best. It is the mistaken idea that engineering is a combination of learned profession and remunerative business that crowds the ranks with the unfit, makes conditions of employment irksome and keeps down pay.

The chances for continuous employment are very slim. Many engineers never acquire a competency; the periods of non-employment often last long enough to get a man in debt. Once in debt his case is almost hopeless. He works for a salary when he works at all, and there is small opportunity to recoup losses, for the salaries are just large enough to live on. This recurrence of idle periods when the treasury is empty is the cause of most of the poverty and distress in the world. In this the educated man has no advantage over the laboring man. He is, in fact, worse off than the laborer, for he cannot descend to the doing of manual work without losing caste and being looked upon by his relatives as a failure. Men hold on, year after year, at first because to try to secure other work would be deemed a tacit confession of failure, and this would be damning, as in the popular mind engineering is the best paid business in the world; finally, the disheartened man is compelled to hang to the one thing he understands best, because he reaches an age when a man

finds it practically impossible to make a start without capital in some other line of work. If he were a merchant, whose sole business is to buy and sell, it would make little difference what he should finally buy and sell, but to leave a profession means to go into some line of work entirely foreign to all previous experience, and the throwing away of all the experience thus far gained.

After a number of years prospective employers begin to turn a man down because he has worked in too many places. It is a source of keen humiliation to many high-minded men that they have changed often and have not suceeded in getting a permanent footing, but they are in this predicament through no fault of their own. The engineering graduate, who is turned loose in the world during a period of business depression, such as is experienced in the United States at intervals of about ten years, seldom, if ever, gets solidly on his feet. He is a wanderer from job to job to the end of the chapter, be he the most capable man in the world and a worshipper of his calling. He further experiences poignant suffering in seeing class after class of young men graduate years later than he and step into good positions just because they happened to graduate in years when men were in demand and young fellows start at almost any pay they can get. This cruel condition is understood by some employers, but the majority

give it no thought and are disposed to blame a man who changes positions often.

Reference has been made to the artificial demand, which leads to many newspaper stories being written about the great demand for engineers and the short supply. There is another hateful thing which also causes a great deal of suffering, and is most unjust, namely, the fact that many head draftsmen and superintendents own stock in employment agencies which charge a fee for securing men positions. The writer has known of instances where forty draftsmen have been laid off for lack of work to keep them busy and of a hurry call being sent to an employment agency for men in less than a week. This happens so frequently that it is a strange thing that the directors do not look into the matter and investigate such wholesale changes. When a draftsman enters the office of an engineer and asks for work, saying that he had been just laid off by a certain company, and the engineer knows that company is at that very moment looking for draftsmen, it takes him but a few moments to decide that the applicant before him must have been below the standard or he would have been retained. These agencies charge 10 per cent. of the first month's salary for a position lasting less than six months; 25 per cent. of the first month's salary for a position paying less than $75 per month and lasting

more than six months; 40 per cent. of the first month's salary for a position paying more than $75 and less than $175, and lasting more than six months; 60 per cent. of the first month's salary for a position paying more than $175 and lasting more than six months.

The charge is not made that much of the seemingly unbusinesslike reduction in forces is made because some one is interested in a nearby employment agency. The statement is merely made that this might be a reasonable explanation since one man told the writer that he lost a position when the manager of his company found out he got a 10 per cent. commission on all business he sent to a certain agency, besides owning $500 worth of stock in the agency, on which his dividends were about 8 per cent. per annum. The writer had frequent dealings with a certain agency some years ago, and this agency he always believed, and still believes, did everything in a square way. Nevertheless, he declined to purchase any of the stock when it was offered him, because he did not like the idea of making money out of his unfortunate brothers in the profession.

There are reputable agencies, and it is fortunate there are, for otherwise many men would have an exceedingly hard time getting in touch with vacancies they are capable of filling. This question of finding employment for men is one that

should be taken up by all the engineering societies. An employment bureau could be established in every large city, supported by members of the different societies, for the sole purpose of securing transient employment for members. A small fee, say of 5 per cent. of the first month's salary could be charged until the actual cost of operating the agency is discovered, when the charges can be made to cover the actual cost only. In this way all the societies can secure new members and will be doing a needed work. If this work is properly done there will be heard less of the present agitation for license laws and the formation of organizations with trades union ideas and sentiments.

Some assistants in the office of Messrs. D. H. Burnham & Co., in Chicago, organized a few years ago the American Technical Association, which has nicely furnished offices in that city. This is a voluntary association of engineer assistants and draftsmen, organized as a mutual benefit association to keep the members employed. The dues are small and no fee is charged for securing a position. All that is asked of a man after he goes to work is that he keep up his dues so other men will be helped. The membership is growing rapidly and such an organization deserves to be encouraged. The way to help it is to send to the secretary when assistants are wanted, and finally the society will be able to keep a secre-

tary constantly employed on salary to do this altruistic work. Every large city should have a branch of this association, unless the large societies will unbend from their dignified position and take cognizance of the member who is never able to get a footing on the shifting sands.

Occasionally a man who has been on the rack for years does get a position where he apparently has a chance to make good. The first thing that happens is very often the starting up of what is commonly termed "the anvil chorus," by men longer in the employ of the company, who feel aggrieved at a newcomer being put over them and at a larger salary. With the objectors the question of competency is second to that of long service. The newcomer, interloper, according to the older employes, is generally a man of very broad experience, and has an intimate knowledge of systematic methods employed in many establishments. Generally he has worked out methods of his own for doing work expeditiously and economically. All attempts on his part to introduce innovations are opposed, not always openly, until he either resigns, or finally settles into the grooves and travels with the rest of the crowd, much to the disgust of the management, for his selection was due to a desire to have new life put into the work. His resignation is then either asked for, or his position from that time becomes a purely political one, held by finesse and not

gauged by material results. Few corporations know how much the fetich of system and red tape is costing them, but as young men go in at the bottom and gradually grow into conservative ways, it is seldom that an older man has an opportunity to break in and become permanently attached to a payroll, for he is a disturbing element. The pay of the middle-aged engineer is good when he is working, if he demands good pay and can show results. He works on the unit system, the system that implies good organization with a minimum of machinery that wears and induces lost motion.

It happens often to old experienced engineers that a firm will employ them on contract for a year and put them in sole charge of the construction or designing department, with instructions to systematize it and effect as much saving as possible. Their long and varied training having made them good organizers they go to work joyfully and finally get matters in such shape that they have an opportunity to take it easy. The organization is put in such good order that it runs like well-made and well-lubricated machinery. The reward of the engineer is to be "laid off" when the contract time is up, the young chap, who acted as principal assistant during the change, getting the position thus left vacant at half, or sometimes less than half the salary. The irony of the whole deal is often revealed when it is discovered that the young fellow knew months before that the change would

be made, and was told to prepare himself to take charge of the work, but say nothing to the older man about it. This is not uncommon.

When dull times come in all engineering establishments, the highest salaried men are laid off first, a recent graduate being advanced to the title at half the pay. His turn comes with the next panic period in business, for the schools are busy turning out graduates "to supply, if possible, the demand that exists for the graduates of this well-know institution," to quote from certain printed matter. Were such changes not made there would be no promotion possible for young men. Even in the army and navy, where the officers have life jobs, it is necessary to have retiring boards working, in order that there will be a movement toward the top strong enough to prevent discouraged men from leaving the service. The retired officers, however, go on half pay, while the thrown-off engineer has to hustle for a job, with the stigma of dismissal attached to him.

Many companies manufacturing engineering specialties will secure an experienced man of wide acquaintance to push their goods on commission. Thinking that here, at last, is an opportunity to quit salaried work and get into business for himself, the man pushes the goods hard, sometimes almost verging on the unprofessional in using the meetings of his society for places to introduce discussions that will bring out the name of his com-

pany, and finally opens the market. The sales then mount up in volume and he handles most of the business from an office by correspondence. It is then that the company begins to grumble about the amount of his commissions, and when the year ends he is displaced by a young engineering graduate working on a salary.

Engineers in private practice find that the character of their work changes from year to year. First there is a railway boom in their vicinity and they are railway specialists; then new towns are developed and they are highway specialists. When the section settles up more they are in demand for the purpose of building water works systems. Then follows sewerage and finally water purification and sewage purification. To-day most of the engineers in private practice are busy on the valuation of public utilities. No engineer in private practice can tell in January just what his principal work will be during the coming twelve months. Since this is the case with men able to support an establishment, and with the means, one would suppose, to keep to one line of work, how much more apt is the wanderer working always on salary, to change the nature of his employment with nearly every new job. When one considers this seriously, the teaching of narrow specialties in schools is seen to be absurd, except in schools situated near centers where the specially trained men can be absorbed as fast as produced.

It is not always, in fact it is seldom, the specially trained young man who gets the high pay, but the man of broad experience, who has acquired the ability to absorb quickly the essentials, which will enable him to perform properly the duties pertaining to the position in which he finds himself.

One engineer in seeking a position showed excellent references from many employers, all men of high standing. The gentleman to whom he was applying for employment said:

"I think your letters are all right and the parties to whom you referred me have answered promptly and favorably, but all the same I think there must be a screw loose somewhere. It seems to me a man of the ability with which you are credited should be settled. In fact, the letters are too good. You have never held a job more than eight or ten months, and I want a steady man. We have decided to get a young man, who will work for less pay and who is up in the very latest methods, and who has not been out long enough to have acquired the tramp habit that so many of you older men seem to have acquired."

"I guess it is all up with me then," said the engineer. "How long will this job of yours last, anyhow?"

"O, about seven or eight months, I guess. If we can get the right kind of a pusher it should be done sooner."

"What will you put the engineer at then?"

"Why nothing. This is the only time we have ever employed an engineer, and we will have nothing more for him after the building is completed."

"Well, then," said the engineer. "Has it not struck you that every one of my past employers was in your case? I have made an enviable reputation in this particular line of work and can save you money even at the salary you say is high. I have been always employed as a specialist. A man hires me and lets me go when the work is done. He is my friend from that time on and always willing to recommend me. You need have no fear about lack of steadiness on my part, because my jobs are short time jobs. I am ready at any time to accept a good paying, permanent position. You employ a lawyer because of his experience, but his having worked for many people is a recommendation, not a drawback. The difference between the engineer and the lawyer is that the engineer works on a salary for one man at a time, and the lawyer works for fees for many people at one time. You can, if you wish, employ some engineer who is in private practice to do your work on a fee and keep a resident engineer on the job, but you find it comes cheaper to employ a man on a salary. You should consider that the more experience a man has had the more money he should be able to save you. The physician and the lawyer stay in one place and work for small fees, but the engineer, having to give his whole time on salary to

his employer, must work in many places and never has a home. He is continually making new acquaintances and being forgotten by the old."

The manufacturer saw the point and the engineer was employed, carrying the work through to a successful end and adding another good name to his list of references. He is not a perfectly happy and contented man, however, for he long ago passed the age limit for permanent positions and must continue to the end of the chapter a "job chaser."

Private practitioners have been referred to a number of times. Men employing engineers demand a showing of experience, so that a man cannot go into private practice as a consulting engineer until he has had considerable experience. Some young fellows at school announce their intention of opening offices as consulting engineers after graduation. Some try it for awhile, but they soon see the comedy side of it and the offices are closed; generally closed automatically by the exhaustion of the pocketbook. When a man goes into private practice too early in life his work is apt to be small in character, so that he gains no really valuable experience in the doing of it. By dint of hanging on he may finally secure enough small work to eke out a living, but the pay is small and the work of a petty character. Most of it is surveying. When the man of middle age and ripe experience goes into private practice

as a consulting engineer he has a wide acquaintance with many who can send friends to him, and it is not very difficult to get a start. To start, however, requires an office in a good location, with an assistant or two, and the expenditure of considerable money in promotion work. In a city like Chicago it requires a capital of at least ten thousand dollars, and an experience of not less than fifteen or twenty years, while in New York the cost will be double. The beginner may be very lucky in the first year and secure some clients of a good kind so that he will be fairly on his feet with the expenditure of less than two thousand dollars, but such happenings are like many strange things that Fate deals out to men; they go by the generic term of "Chance." There are losses in all lines of business, and the private practitioner in engineering is no exception to the general run of business men. That many fail in private practice is due to lack of capital, the item which causes so many failures in all business lines. There would be more successful men in private practice if the expenses of conducting the business and legitimate promotion work were not so heavy. The young attorney can go into private practice immediately upon graduation and do well, for he needs only to consult books to give opinions, and is seldom away from his office more than a few hours at a time. The young physician may open an office immediately after graduation and grad-

ually work up a pretty fair practice, his clients knowing always what his office hours are, and generally preferring a young man, for they consider him to be well up in the latest methods in surgery and medicine.

The engineer, on the contrary, cannot hope to succeed in private practice until he has managed to secure a broad experience and he must have his affairs so arranged that evidences of his experience can be produced upon demand to satisfy prospective clients. This then postpones his entrance into private work until near, or past middle age. His work is also of such a nature that it takes him, or his assistants, away from his office, and often from the city in which his office is located, for months at a time. He must, therefore, possess enough capital to be in a position to employ men on salary to go out and do the detail work and small work which cheaper men than himself can do, in order that he may be available for consultation and advice when needed by his clients. Until the engineer has enough capital to run his business in this manner he is no better than the wandering "job chaser," plus the expense of office rent, advertising and general promotion. A great many engineers open offices in a small way, going out and securing work and bringing it back to the office to attend to personally. Such men seldom get important work and life is always a struggle. The engineer in private practice must be a business man

and learn to employ competent assistants on work they can do as well as he, his part being to secure the work, guide it when it has reached the point where his judgement is worth many dollars to his client and act in emergencies. The consulting engineer satisfies the definition of Wellington—he can do well with one dollar what any bungler can do after a fashion with the expenditure of two dollars. The young man with insufficient experience is more or less of a bungler and the "practical" man is generally a bungler.

There is no rule to govern pay. The engineer has his fixed charges and it is the client who determines for himself just how much he can afford to spend on engineering services in order to save money. Occasionally, in fact, frequently, the client makes a mistake in employing a cheaper man than he should. Some consulting engineers charge, earn and receive fees of five hundred dollars per day. The number of men in the United States in so enviable a position may probably be counted on the fingers of a man possessing the normal equipment of fingers. Needless to say they do not receive such pay every day in the year, nor for many days in any year. The bulk of their income comes from work they undertake on percentage, the same as an architect. They serve a class of clients that makes it necessary to employ a large staff and rent offices in expensive buildings

so that some engineers are under an expense of from one to five thousand dollars per week.

The general charge for consulting engineers is one hundred dollars per day, with expenses added when the employment takes them away from their home city. A great many good men can be obtained for fifty dollars per day. Men who have worked up a fairly good practice on medium and small work and who are seldom engaged by the more wealthy employers, charge twenty-five dollars per day. The average engineer in private practice starts out with a charge of about fifteen dollars per day for strictly consultation work and ten dollars per day for ordinary work. In places of less than 25,000 inhabitants the usual rate is about eight dollars per day, while surveyors seldom charge more than five dollars per day for their work. The day of an engineer away from his office is not eight hours, but is generally counted from an hour before the sun rises until as far into the night as is necessary to get his notes in shape. A number of years ago the writer was located in a small western town and his charges were as follows: Important work of a strictly consultation nature, twenty-five dollars per day for less than one week, plus expenses, and when work lasted more than a week the charge was twenty-five dollars for the first three days, twenty dollars for the next three days and fifteen dollars for the remainder of the time. Few jobs of this kind

lasted more than three days, the sliding scale being an inducement to get longer employment, an artifice that often succeeded. For general work, such as surveying, drafting and taking charge of construction, ten dollars per day and expenses for less than twenty days' work; for more than twenty days' work, ten dollars per day for the first ten days and nine dollars per day for the second ten days, after which the charge was eight dollars per day for the following thirty days, dropping to six dollars per day and remaining at that level until the completion of the work. There were two reasons for this sliding scale, the first and most important being that it acted to make jobs last longer; the second being that the high-class work is generally the first part of every job. After the plans are made the work is of such a routine nature that the average employer is tempted to dismiss a highly paid man and employ a cheaper one to look after the execution of the contract. This is where the average employer makes a mistake, and few can be made to see it that way, but they are willing to employ as a superintendent, the man who planned the work rather than put on a stranger, provided the difference in pay is not great. The work in that section was of such a nature that no engineer could employ assistants to do his work, all employers insisting upon the personal attention of the engineer, so there was small opportunity to do much more work than

a man could do in the twenty-four hours, so mercifully allotted to a day. Sunday was a fine day in which to catch up. From the first of November to the following April the engineer had plenty of time to improve his mind, provided he was able to purchase books and papers.

When men in large cities ask less than twenty-five dollars per day and expenses for their services, it is understood they have severe competition; how severe it is impossible to tell. When the average engineer loses a salaried job and is looking for another he often takes up consultation work and hawks his services from office to office of men who employ consulting engineers. Taking up such work as a temporary expedient only and needing it to keep alive, he works for fees ranging from three to six dollars per day. When a negro preacher, who received an annual salary of fifty dollars, was told that it was mighty poor pay, he replied that he gave in return mighty poor preach. The laborer is worthy of his hire and the cheap man is generally dear at any price. When a man knows he is working for less than his services are really worth, and feels that his employer realizes it, he works always with a discontented feeling and gives just as little as possible.

The enormous growth in number and size of corporations conducting vast industrial enterprises has absorbed thousands of technically educated men annually, but the age limit for

employment has been lowered. The semi-socialistic policy of pensioning employes after they reach a certain age, or have completed a definite number of years of employment, compels employers to adopt a rule fixing an age limit for new employes. This rule also works to assist consulting engineers, who are employed on transient work requiring broader experience than any of the men in the engineering department of the corporation possess, but this is incidental. The fixing of a maximum entering age limit insures getting the maximum number of years of employment out of a man before retiring him. Fifty years ago the average age of college graduates was about twenty-one, while to-day few boys graduate from high school under the age of nineteen. The average age of engineering school graduates is about twenty-three, and the deadline in securing permanent salaried employment is between thirty and thirty-five. A corporation pensioning employes after thirty years' continuous service does not like to have men on the payroll long after they are sixty. If the young technical graduate, therefore, does not succeed in landing a permanent salaried job before the age of thirty-five he is doomed to roam the earth.

Men who specialize most closely at school are the poorest paid, as a rule. They so thoroughly prepare themselves in the specialty that they are narrow and, perforce, compelled to look for posi-

tions in which this knowledge is necessary. Manufacturers and corporations take advantage of this. When more assistants are required in certain departments the information is conveyed in some way to a nearby technical school, or an intimation is given to the omnipresent newspaper reporter or special writer that there is a lack of trained men for such work and that a job will be given to every young man who specializes in this particular subject. When the news gets out there is great interest manifested in it by the seniors, who have electives, and in the spring, the Dean, in a flowery speech, which is sent broadcast over the country by the Associated Press, announces that the entire graduating class was supplied with positions before graduation, and was, with difficulty, held in school until the last day.

Dissatisfaction with the prospects for advancement is soon manifested, and one by one the boys drop out, or are discharged for kicking and grumbling, finally leaving only a few, who, being relieved of close competition, do have some opportunity to advance. Frequently the men who are left and go to the top, are not the best of the lot, but they deserve what measure of success they achieve because they stick. The restless ambition, or desires, of the American boy and his quickness to resent exploitation gives the well-trained foreigner his opportunity. Coming from a crowded country where pay is low, the pay the

American considers absurdly low is to him, handicapped by the necessity for learning a new language very good and he stays year after year, proving himself steady and reliable. He has bred in him a feeling of content when his bread and butter are secure. His many years of scholastic training have given him a liking for the quiet studiousness of the laboratory, the computing room and drafting office, which the American boy, with his fewer years of less intense schooling, interspersed with practical outdoor life and indulgence in field athletics finds irksome. The foreigner is, therefore, preferred in many places for the reason that he fits in very nicely as a well-adjusted part of a machine. He is not obnoxious in seeking advancement, but is always ready for it when it comes. Many foreigners now head important enterprises in America because they stuck to a job when they had a chance. There are no rules to set before young men except to tell them that if they land in a place where the work is congenial, they should stay with it and provide for the future by living within their income. More men become well to do by saving than by earning high pay. The men who succeed best in the world are generally those who are content to wait for the pleasures of life after they have made arrangements to provide a surplus out of which the pleasures will be paid for. There are many solid pleasures in life other than the wearing of

fine clothes, eating fine food, seeing the latest plays and riding in automobiles.

Many professors advise their pupils to shift considerably the first few years after graduation in order to gain experience. Men who give such advice to-day have not kept up with the world, and do not know their advice is thirty years late in the United States, and is about one hundred years late as compared with the rest of the world. The law of supply and demand is pretty effectually settling this question of shifting around, and the world never looked with favor on the "rolling stone." Thirty years ago there was a dearth of engineers in the United States, and as much of the work requires a modicum of training, numbers of half-educated men entered the profession and some achieved considerable success. To-day there exists considerable difficulty in properly absorbing the surplus graduates of technical schools at home, in addition to "die Auswanderer" from the foreign school.

Getting down to salaries, there is no set rule. The employer fixes rates of pay and the engineer is free to take it or leave it, this being the reverse of the rule for compensating consulting engineers of standing. Much depends on the employer and much depends on the employe. In one building, in different offices, will be found men doing exactly similar work for different employers at widely differing rates of pay. The writer knows one man

who receives $3000 per year from his employers who fear every day that some one may make him a better offer. Across the street another man of the same age, and fully as good education and experience, is doing the same kind of work for a larger company and with fewer assistants, for $1800 per year. The men employing the higher paid engineer are satisfied with him and propose to keep him. They know they are paying what is generally considered to be much more than the market rate for the work he does, but they are satisfied and so it is nobody's business but theirs. The responsibilities of an engineer are so great that it would be an easy matter for an incompetent man, or a green man, to cause a loss on one piece of work which would amount to several times his annual salary. This man, therefore, holds on because he has made good, although envious acquaintances say he is a "bluffer." The lower paid man says that he holds one because he has observed that $150 per month is close to the dead line and that when dull times come engineers who receive more than that are not certain of their positions. He prefers a life job at $150 per month than the uncertainties that accompany better pay. He is no sport, but he has a nice little family and is buying a home on the installment plan.

Railways give considerable employment of a transient nature to engineers and the organization

of maintenance-of-way departments, together with the establishment of repair departments, and the fact that railways generally design all their own bridges and buildings and do less work by contract than was formerly common, has led to the permanent employment of many men, although the pay is not very high in the lower ranks and promotion is not rapid. For transient employment the pay is about as shown in the following table, it being an average arranged from a study of the pay tables of about ten roads:

District Engineer, supervising several parties on preliminary or location surveys	$125	to	$175	per month.
Chief of Party	85	"	150	"
Topographer	80	"	100	"
Transitman	75	"	100	"
Leveler	60	"	90	"
Rodman	35	"	50	"
Draftsman	65	"	100	"
Head Chainman	40	"	60	"
Rear Chaiman	30	"	50	"
Tapeman	30	"	35	"
Back Flag	25	"	30	"
Axeman	22	"	35	"
Stake Artist	25	"	30	"
Teamster	25	"	35	"
Cook	40	"	60	"
Flunky (Cookee)	20	"	30	"

The company furnishes tents and feeds the men in addition to the above pay; the men furnishing their own blankets. On construction work the pay is about ten dollars per month more, but the men pay their own board out of this, taking their meals in the contractors' camps or in nearby farm houses, the construction parties, as a rule, being small and moving around so much that the keeping up of a cook outfit would be too expensive. There being always a surplus of unemployed men, it is possible to equip and send out a full party within twenty-four hours from almost any fair sized city. These rates of pay also obtain on survey parties for irrigation and drainage work, although on such work the chief of party will receive higher pay. The chief of a railway party is not likely to be the chief engineer of the railway, whereas the chief engineer of an irrigation or drainage district generally goes into the field in charge of the survey work.

For the work mentioned the pay goes with the job, regardless of the experience of the man, provided his experience has been sufficient to insure him getting the work. Personal acquaintance has much to do with securing positions on such parties, high officials generally having relatives or friends to take care of. The writer has taken out parties when every man, except the cook and his helper, was competent to hold any position on the party, and some had been in charge of parties at some

time. He has also gone out with parties composed almost wholly of high school boys, "official sons," and college graduates, with little or no experience. His part was done when he dutifully took them out and the favor of the officials to their friends was done when the boys were given positions. That nearly all were sent back inside of a week as incompetent, simply meant a little more expense to the corporation and was expected; for the chief is held rigidly accountable for mistakes and is also expected to cover a certain amount of territory each day, so only a few green men can be retained if work is to be pushed. Summer survey parties are fine for college students seeking to gain experience and earn money while having a vacation in the open air. Some railway companies in the older settled states have a ridiculously low wage scale for such work, depending upon the work being done in vacation months by students seeking experience. These poor dupes fail to understand how injuriously they are affecting the wage scale, and the professors, who encourage it and sometimes act as chiefs of party, are censurable for being so short sighted.

Opportunity is half of life. A study of the two accompanying diagrams illustrates this most forcibly. Figure 3 presents a very nice curve of average income received by graduates of an institution situated near the most highly developed portion of the United States, tech-

nically and commercially; many of the graduates, no doubt, having gone into a business owned or controlled by relatives and many having, for some years, been in private practice in financial centers. The shaded areas give the highest and lowest incomes reported, the heavy line being the average of the averages for each year. The average income does not represent the income of men known as engineers, in the common accept-

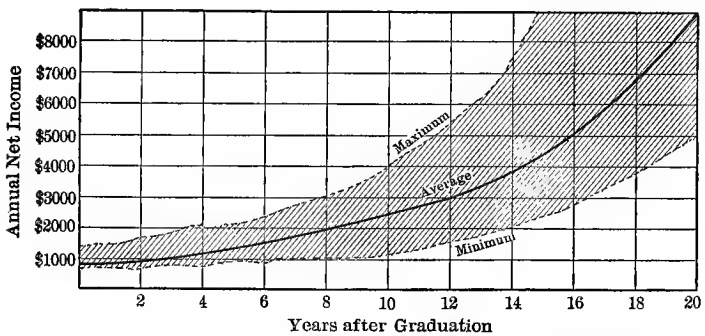

FIG. 3—Reported Incomes of Worcester (Mass.) Polytechnic Institute Graduates.

ance of the term, but represents the incomes of men who graduated in engineering courses. Similar curves can be drawn for classical schools of equal standing in this section of the country, the course of study having little to do with the curve.

Figure 4 is the result of a study of a western school of practically as high standing. The farmer boys of the middle west make splendid engineers, but their start in life is in a developing country, where the work is of a pioneering nature, and

pioneer work is always illy paid. The line representing the average income is almost straight, but up to the eighth year after graduation the two schools seem to be on an equality, thus showing that the young man is employed in minor positions carrying little responsibility. The greater fluctuations in income show that the Iowa graduates stuck more to technical engineering work than did the Massachusetts graduates, and the low average

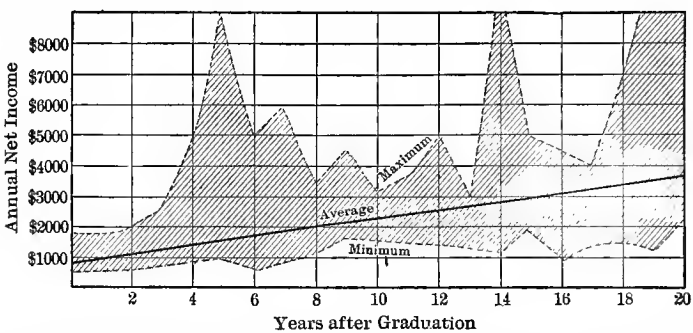

FIG. 4—Reported Incomes of Iowa State College (Ames, Ia.) Graduates.

would also indicate this. In the first diagram the average annual income at the end of twenty years is $9000, whereas in the second diagram it is about $3800. These two diagrams cover the period since the civil war, when, for about fifteen years, the country was developing so rapidly that engineering schools had difficulty in furnishing enough graduates. Similar diagrams thirty years from now will probably show a slight rise in the average income of graduates from western schools, with a

considerable drop in the average income of graduates from eastern schools.

These diagrams are presented just as the average newspaper or magazine would present them. The reports from which they are taken go into considerable detail and would hardly be interesting to the reader of this little book. To read the full discussion confirms one in the opinion that, as a rule, showings of averages are misleading without an accompanying full discussion. The report from the western school seems to the writer, whose experience has been almost wholly between Chicago and the Pacific coast, to represent conditions more accurately, so far as the technical engineer is concerned, than the report from the eastern school. Both reports are on selected bodies of men and do not, by any means, represent the entire body of the profession, for a great many men practising engineering and calling themselves engineers, are non-graduates. Instead of the lines of average income representing actual averages, they represent to the majority of graduates, the amounts they should be entitled to receive in the years given. That is, the pay shown as an annual average, represents what should be twelve times the monthly pay an experienced engineer hopes to receive when employed. It is really awkward to have to explain that the average line on Figure 4 is here referred to, the average line on Figure 3 being a dream after the fifteenth year is passed.

The average engineer, chasing from job to job, may work awhile for over $200 per month, and, after a period of idleness, take a place at a little over $100 per month. A good draftsman can generally secure fairly steady employment, although the pay, as a rule, is not high, for so much of the work can be done by partially educated boys and men. One designer can keep many draftsmen busy and on some classes of work one computer can keep two or three head draftsmen with their assistants fully occupied.

Engineers are a product of civilization, and, therefore, get along best in populous centers. They are closely dependent upon capitalists for employment and when capital is not active the engineer rests. Three generations ago Horace Greeley gave his famous advice to young men to go west. To-day a great many engineering students announce that upon graduation they will go to the growing western states where engineers are in demand.

The writer spent two-thirds of his professional life in states west of the Rocky Mountains, and has found the East better, so far as chances for continuous employment are concerned, and far better when the question of pay is considered. Every western state has a state university and many have an agricultural school and school of mechanic arts as well, largely supported by United States funds under the provisions of the Morrill

Act. All these schools have engineering courses arranged to meet local needs. They graduate more men than are required to fill vacancies, so that every eastern man who goes in adds to the congestion and increases the severity of the competition. The writer has been in over fifty places east of the Mississippi Valley, having populations of more than 3000, in which there were no signs to be found of engineers or surveyors or architects, and it took diligent inquiry in some of them to discover that men were living there, or close by, who could be engaged to do some surveying. It is a perfectly safe statement to make that in every hamlet containing more than 1000 inhabitants in the far western states a good surveyor can be found, and in the average place of more than 3000 inhabitants, there will be an average of about one and one-half engineers and architects to every 1000 of population. In one place of 1700 population the writer knew two graduated civil engineers, one of whom paid office rent and the other had a room at home fixed up as an office; two non-graduate civil engineers; two land "butchers"; one graduated mining engineer; three non-graduate mining "experts"; two architects, one of whom also took building contracts. Such a condition of affairs is not at all uncommon in the mountain states of the West.

To thinly settled parts of the world the engineer should never go with the expectation of

becoming wealthy, or even moderately successful in the practice of his profession. He will find in those countries nearly all of the inhabitants to be fairly ingenious men in many ways, of small means, and they do not call upon the engineer to do much outside of surveying. They use "practical" men to do work the engineer is employed to do in the more densely populated sections, where all men must of necessity be specialists. On the frontier the book-taught, school-bred man is not classed with "practical" men, who are supposed to be horny-handed sons of toil. The work in sparsely settled parts of the world is of a petty nature when financed by the local inhabitants and can just as well be done by less well prepared men than the graduates of a good school. That is, it is done well enough to satisfy the men who pay the bills, for the amounts spent are small, and fine economics are of the "stingy" sort, real economic saving being unknown.

When large work is undertaken on the frontier it is financed from the large cities and the engineer in charge is sent out from the home city of the corporation. He is generally fully supplied with assistants, most of them being sons of men having influence with the directors, many being relatives of officers in the corporation. The local engineer in the frontier town is looked upon with curiosity by these men from the great city where wealth is stored and has small chance for employment. It

happens occasionally that the man sent out is not fully competent to handle the work and a local man can be picked up who is perfectly competent. The chief engineer makes this local man his principal assistant to practically take entire charge, the chief making a good reputation out of the ability of his assistant. This is something that happens in lines of work other than engineering.

It is a pretty good plan when an engineer finishes an engagement out on the edge of civilization to return to the financial center before his money is gone, instead of going into private practice in a new country, only to be finally starved out. On a salary a man can live anywhere, and, under proper conditions, a man should elect to live where he most enjoys life. If conditions are not right then he should live where a living is most readily obtained.

The true engineer is a man of action, resourceful, ingenious, executive; the sort of man who would succeed whatever line of work he took up. The work of computing quantities, calculating strains and stresses, drawing lines upon paper, is only clerical work after all. It is of a higher order than ordinary clerical work, such as requires practice rather than education, but it is, nevertheless, clerical. If a young engineer is not settled in some permanent position within ten years after leaving school, he should cast around for some other line of employment, brave his relatives, who

never can be brought to understand conditions, and make a new start. Successful men always win success by passing over the heads of those who fail.

The question is often asked, "Which branch of engineering pays best?" So far as financial rewards go there is little choice. In all branches there are successful as well as unsuccessful men. If the intending student has no ideas upon the subject himself, and his parents have no connections whereby they can advance him in any special branch, he should not go into engineering. The choice may pretty safely be left to the boy if he is bent upon being an engineer. Something more than casual advice should influence one in the selection of a career.

Steady employment of engineers is to be expected the closer they keep to manufacturing lines. For this reason mechanical engineering and electrical engineering are considered good. The starting pay, however, is small and promotion is very slow. In this connection a study of the charts of average income is good, for the fluctuating income and low average is in a section of the country with little manufacturing.

The steady job with a future pays, as a rule, poorly at the start. The transient job is always comparatively well paid. Within the past few years, however, there have been indications that the maximum for mechanical and electrical engi-

neers has been reached and the curves of average income are flatter. The boom period has pretty nearly ended, and the period of slow, steady growth, proportionate to population, has set in. Machines are being rapidly standardized, which calls for less skill on the part of the office employes. Salaries may be slightly larger in the high positions, but they will stay at the present level or slightly decrease in the lower grades, which, with the increasing cost of living, means an actual reduction in incomes as now reported. Future graduates in mechanical and electrical engineering must expect to work for many years at low salaries, competing with boys trained in the shops, who study mechanical drafting in the evenings.

The exploitation of electrical engineering students by large corporations has been shameless. It has been a common practice to send men to a school with offers of positions for the entire graduating class. The entering salaries range from $40 to $60 per month, and each man is given the impression that the company looks upon him as a possible second Edison. Promotion in the main is slow, and the writer knows a number of young fellows now getting only $90 and $100 per month after five years' work. They would have done as well with a $50 course in bookkeeping and stenography at a business college. They may, of course, be exceptions, but electrical engineering graduates have told many "hard luck" stories to

the writer, which had much to do with his deciding that, after all, the civil engineering course was the best for his son, with some additional work in the electrical engineering department at school.

The electrical business is controlled by a few large corporations and to one of these a young fellow must tie himself. The chances for a future are not particularly good, so far as ultimate pay is concerned, but a living wage is almost always certain for those who care for a life-long job on a salary about equal to that of the average clerk, who did not spend $2000, nor one-tenth part of that amount, on his education. It has been remarked before that some men do succeed who can hang on, and the successful men are not always those who would have been picked as probable successful ones, when at school. Often mediocrity wins where intelligence of a high order fails, because of the ambition that goes with intelligence.

When mining engineers get fairly started their pay is good, but in the course of time every mine is worked out and a new job is sought. In the mining business changes in the directorate and management occur more frequently than in any other business, for the average investor does not look upon mining as a business, but regards it as much of a gamble. If profits do not come up to expectation there are insurgent owners of stock who rise and take control, discharging competent men, and very often putting charlatans in their places. The dis-

charged men always labor under the disadvantage of having to explain why they were discharged from a mine that was not closed down, but is still operating. Few mining engineers can expect a life-long job with one company under the best of circumstances, and they get in the habit of calling a three- or four-year job "permanent." This overturning of management and discharge of men is not peculiar to mining, but is common in all lines of business, the average director being no more competent to manage a business than is the average politician to run a city. Many business enterprises would fail were it not for faithful, hard-working, often browbeaten employes; men with the special training their employers lack.

The general education of the civil engineer is perhaps the best fitted to prepare a man for engineering work, for it is the most broad of all the branches, except mining, and even that is now being divided into specialties. The present civil engineer could be improved by adding another year to be put in on mechanical and electrical subjects. Upon leaving school the well-trained civil engineering graduate is competent to enter the office of any engineer in any line of work and be a competent assistant. If he was well trained he should be a fair mechanical and architectural draftsman, and have a pretty good knowledge of prime movers. This added to his knowledge of the mathematical, physical and chemical sciences, the properties of

materials, ability to design structures, etc., gives him far better fighting chances than his more narrowly trained brother students, who specialized on smaller subjects.

The business of contracting has been fairly revolutionized by technical graduates, this being a field of endeavor in which the engineer is fitted to shine. Not many years ago the contractor was not looked upon as a business man, but as pretty much of a speculator. To-day contracting is a legitimate business. When a manufacturer can determine his costs properly he is in a position to conduct his business at a profit. The system and method introduced into the business of contracting within late years by engineers, have converted it into a manufacturing business, carrying no more risk than that of any other manufacturing business. There are a few old style contractors in existence, but their number is growing less, and many, even of the most conservative, employ engineers, thus putting to shame the few men who still claim that the school instruction is not "practical" enough. The training in exact analysis which every engineering student receives, is just what is needed in every line of business, and has been justified by the experience of contracting since engineers took it up.

The civil engineer has good opportunities to start in at the bottom of the ladder in mechanical and electrical engineering work, and advances very

rapidly up the ladder in general contracting work. He has also good preliminary training for working as an architect, provided he possesses artistic talent. It is gratifying to see the numbers of young civil engineers who enter the employ of architects to do the structural designing and act as outside superintendents of construction. The putting in of deep foundations is a specialty in itself and, of course, no one is so well adapted to this class of work as the young man trained as a civil or mining engineer. The old-time civil engineer, who was almost wholly a surveyor, has disappeared and the present day surveyor is that and nothing else, for a man who has taken a full engineering course seldom cares to settle down to the practice of "land butchering" in a small country town.

The education of a civil engineer is an excellent preparation for general business, for nearly all men are concerned more or less with construction enterprises in these days. This training is superior to the study of Latin and Greek, no matter what line of work a man goes into. A business man having two sons whom he intends taking into business with him, but prefers that they have a college training first, can hardly do better than have one study law and the other civil engineering, before going into his office to learn the business, with a view to partnership later.

Salaries of young engineers, when they are

working, are generally pretty fair as salaries go for young men. It is a shock to them, however, when they learn that salaries do not necessarily increase with age and experience, but are governed very largely by responsibility, hence "salaries go with the job." The curves of average income in the two diagrams elsewhere presented, show an increase as the years go by, which is due to the fact that this is governed largely by the men who have permanent high-paid positions, and by those who are in business for themselves, as well, also, by the fact that, all things being equal, the older men are generally trusted with greater responsibility. The bottom edges of the shaded areas must not be overlooked, for averages are very deceitful. The maximum and minimum salaries at the end of the twenty-year periods may be given by a much smaller per cent. of the total number of men; that is, the averages for the first few years may have been obtained from a very large number and the higher averages from a small number, which, in reality, was a small per cent. of the number still living.

That salaries and the pay of men who have to seek employment may be low has no effect on men in private practice, and those whose varied experience leads them to be selected to conduct important work. These men get pay commensurate with their experience and ability. The average pay of lawyers, surgeons and physicians is less than $600

per year, yet it is well known that there are men in each of these callings whose incomes are much larger than the salary of the President of the United States. The average man, after all, has little to do with the income of the more fortunate man. Each man receives what his services are believed to be worth, and every properly equipped man starts with an equal chance.

If he wishes to succeed, the young man must bear in mind the old saying, "Seest thou a man diligent in his business? He shall stand before kings. He shall not stand before mean men." The greatest measure of success comes to the man who makes the fullest use of his opportunities. We may float upon the stream of life, but to some extent we have the ordering of our ways. Patience, ability, industry, strict economy, rigid honesty, good habits, avoidance of inferior and weak associates, these all bring their own reward. Given a number of men, each with enough ability to do the routine work of his calling, success becomes a matter of the man and his opportunity rather than matters of exceptional ability or genius. Opportunity is one half, and the man is the other half. It is much a question of temperament, rather than ability, provided one has ordinary ability and sound training as a basis.

There is more to life than meat, clothes and money. For the man who is imbued with the right spirit of the engineer and loves his profession

there is a serene satisfaction in doing his work well and holding his head high. The world is out of joint in many places, and the engineering profession is not alone in offering salt drink to its devotees. No calling is free from drawbacks, and engineering especially is no occupation for the man whose sole motive in selecting it is the belief that pay is always high, advancement certain, and great wealth the sure end.

Life is like a swiftly flowing stream, carrying upon its surface many floating objects. Some keep near the center and move on serenely with no disturbance of any sort, clear to the ocean in which the river ends. Others float near the edge, unable to get near the middle, and these occasionally strand, lying on the sand bars until a rise in the stream carries them to another shallow where they again rest. Still others are caught in some eddy and float round and round in restless circles until they become waterlogged and sink, unless, in the meantime, a rise in the stream, or some other disturbance takes them again into the main current. In the spring many millions of blossoms appear upon the fruit trees, but we cannot predict the fruit crop from the blossoms. Many infants are born, but few reach maturity. It is a law of life that not all men reach the fullest success, to this extent proving that all men are not born free and equal, although the politicians do so declare. Real success lies wholly in a feeling of

work well done in the line of endeavor for which a man is best qualified and which commands all that is best in him to stand forth.

Surely the man who "directs the great sources of power in nature for the use and convenience of man," should find a comfort in such work that will compensate for many moments of bitterness when on tours of apparently endless "job chasing." To make the ways straight in the wilderness, to carry food to the people of all nations, to make fruits and grains and flowers flourish in erstwhile desert spots, to be the means of spreading intelligence broadcast, to build highways which draw nations together and thus end wars and misunderstandings, to increase the power of the world to the end that one man is as five hundred of the men of olden times—surely this is a great work.

Of the truly successful engineer no better memorial can be had than the following from the poem by Edward Everett Hale, entitled "The Unnamed Saints":

What was his name? I do not know his name.
I only know he heard God's voice and came;
Brought all he loved across the sea,
To live and work for God and me,
Felled the ungracious oak,
With horrid toil
Dragged from the soil
The thrice-gnarled roots and stubborn rock;

With plenty filled the haggard mountain-side,
And, when his work was done, without memorial died.
No blaring trumpet sounded out his fame;
He lived, he died. I do not know his name.

No form of bronze and no memorial stones
Show me the place where lie his moldering bones.
Only a cheerful city stands,
Builded by his hardened hands;
Only ten thousand homes,
Where, every day,
The cheerful play
Of love and hope and courage comes;
These are his monuments, and these alone—
There is no form of bronze and no memorial stone.

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APPENDIX

THE OPINIONS OF ENGINEERING EDITORS

Some time elapses between the delivery of the manuscript of a book to the printers and the time of publication. Much as an author regrets this fact, in the present instance it has been a boon, for the insertion of two editorials from leading engineering papers has been rendered possible. The writer realizes that the ideas he has given of the profession of engineering are so totally at variance with the ideas of the newspaper-reading public, that this corroborative testimony is required, for the editorials closely reflect all that has been said in the preceding pages.

It will, perhaps, do no harm to say that Chapter VI was written four years ago, at the request of an editor, who wanted an article on the subject: "Will It Pay to Study Engineering?" He promptly declined the article when received, writing as follows: "You certainly must be mistaken or your experience has been unusual. This is the first time I have ever read such statements regarding the engineering profession, which is universally

considered, I might say is known, to be very remunerative." No arguments could move him, and one of his corps of special writers prepared the sort of article he wanted, which appeared on the front page of an educational edition, in the latter part of the summer, filled with advertisements of schools, a goodly number of technical schools being listed. The writer later submitted the article to a newspaper syndicate, four newspapers and three magazines, finally being compelled to write this book, in which it is the final chapter, in order to have it printed. In the light of this information the editorials are doubly interesting.

CALLING IN THE STUDENT

(*The Engineering Record,* September 30, 1911)

THIS is the period at which the up-to-date purveyor of education is beginning to realize the results of the publicity campaign of the last season. The traditional college president has always until now been a bald-headed and bespectacled minister of the gospel, clad in shiny broadcloth and dividing his time between homilies to his assembled flock of students and instructing them in Paley's Evidences. But we have changed all that and to-day the personage chosen to head an educational institution is very likely to be a polished and smooth-spoken man of affairs, smartly dressed and ready to meet all sorts and conditions of men

with the persuasive affability that leads to legacies. His chief function is administrative, and he is become, in fact, the manager of a species of educational department store, keenly anxious to advertise his wares and judging the success of his campaign by the number of customers who attend his bargain sales of learning. The change may be, on the whole, for the worse or better, but the thing which here concerns us is the nature of the advertising campaign which is carried on and the veracity of the claims made for the goods advertised. There is no educational pure food law which compels nostrums to be labeled with their percentage composition, so that when a skilfully worded advertisement proclaims the virtues of mechanical engineering syrup, or electrical engineering cough mixture, the would-be customer knows as little of its real virtue as the man who reads the certificate of a centenarian to somebody's stomach bitters knows how far those bitters vary from ordinary whisky or whether the centenarian ever lived.

To be quite serious, the situation in technical education calls for comment, for the publicity methods adopted by some institutions, from the humble but profitable correspondence schools to the university with 4000 or 5000 students, are often open to somewhat severe criticism, chiefly because the respective courses advertised are proclaimed as nostrums, a few doses of which must inevitably

lead to distinguished success, measured in dollars. Unfortunately, of course, those who take the medicine do not always or often reach the expected result, and learn too late that the published certificates of excellence are slightly misleading. It is the purpose of this comment to present some of the hard facts regarding the courses of treatment commonly prescribed.

As regards the engineering professions, nothing is further from the fact than the common delusion that they are especially promising and lucrative. They are honorable callings, very alluring to those whose tastes run in technical lines, and guaranteeing a decent livelihood which may rise to distinguished success if supplemented by extraordinary ability, rare good fortune or an exceptionally powerful pull, these three additional factors being here rated in increasing order of practical importance. Many statistics have been published in the last few years regarding the earning capacity of technical school graduates at various periods after graduation. They sound well, but in point of fact they are no more encouraging than what could be derived from similar statistics gathered from the graduates of non-technical institutions of similar grade, or from men of similar ability and opportunities trained only in mercantile pursuits. The group last mentioned would practically be impossible of comparative investigation, for the simple reason that of late years it

has been the fashion for young men of good ability and from well-to-do families to acquire a collegiate education of one kind or another.

There are certainly no large prizes to be drawn in the ordinary course of events from the engineering lottery, and investigation of the affairs of any large company would show that the big salaries do not fall to the lot of the engineering force, however competent. Now and then they may be drawn by men who have received technical training, but in virtue of circumstances quite apart from that training. If one were to judge education by pecuniary results, as shown by statistics, it is altogether probable that the supreme place would be taken by Harvard or Yale, not in virtue of any special excellence of the education there to be obtained, but from the simple fact that both these institutions have drawn in large numbers students whose antecedents have foreordained them to pecuniary success. A few men in any given class who inherit the great business interests which mean large apparent earnings raise the average to a point that bears no relation to the value of the course of educational training they may have followed.

As an example of the fallacy of statistics one may profitably examine the claims made in the last few years for the so-called business courses of the post-graduate variety. The nominal result indicates great rewards for the diligent student, but a

little examination of the situation makes it perfectly evident that few or no young men have time or money to devote to post-graduate courses in finance, unless they have already within reach openings for which this additional training is merely a convenient preparation. Many men of large affairs proclaim bitterly and justifiably of the lack of trained men for positions of high responsibility, but save in very rare instances these positions do not go to young men whose sole recommendation is education and ability. The college-educated man who quickly lands in an important position generally does so because he has been trained with reference to putting him in that particular position.

The "business course" is not wholly a hollow sham, for it imparts information of which, with opportunity, great use may be made, but the opportunity is generally the cause rather than the result of the training. Mental discipline in engineering or otherwise is, in and of itself, a good thing, and on the average the well-trained man stands a much better chance of making good when opportunity offers than the untrained man. In so far, institutions of learning do not either fail of their purpose or claim virtues that are not theirs, but the young man who is drawn to them by the publicity campaigns inaugurated of late years should enter without roseate illusions, and with full realization that the most he can hope for is the discipline and

training that will enable him to make the best use of his abilities, if he ever gets the opportunity to display them.

WHAT CAN THE ENGINEERING PROFESSION DO TO IMPROVE ITS POSITION?

(*Engineering News*, August 17, 1911)

THERE may be some among our readers who, on reading the above title, will question whether engineers need do anything to improve their position. There are plenty of platitudes in print describing the grandeur of the engineer's work, the heavy responsibilities he carries, his advantage over other men in being able to make his work an imperishable monument to his ability. We think, however, most engineers who are daily confronted with the bread-and-butter problem will agree that the present position of the engineering profession leaves very much to be desired.

It is generally agreed, we take it, that at least nine out of ten members of the profession are receiving less for their work than what can be considered a fair compensation, when the degree of responsibility, the uncertain tenure of the employment, the long period of training and experience required to attain a high position in the profession, and the income earned by successful men in other lines of work are all taken into account.

The exceptions to this rule—the engineers who

are amassing a competence or wealth—are very largely the men who have given up the professional practice of engineering and taken up some line of business. It is often said that engineering is a poor business. There is, however, plenty of good and profitable business in connection with engineering work.

Certainly, this situation is not one to be approved. It will be admitted, of course, that the professional man in any line of work, if we except the modern surgeon and the corporation lawyer, does not expect to gain a fortune, as fortunes are rated nowadays, in purely professional work; but at least he ought to gain a comfortable living and a chance to save a competence for his family and his old age.

It need not be said that engineers are mercenary in holding that the work of their profession ought to be better paid. It is well understood that the public to-day pays scant honor to success, unless that success can be translated into terms of dollars and cents. The engineer wants a larger income not alone because of the income or because of what it will yield for himself and his family, but because he realizes that his position in the community in which he lives and the respect that he and his fellow-members of the profession can command is greatly reduced if he is compelled through meager salary or inadequate fees to live on a scale far below that of his neighbors. And what applies to the man in the higher ranks of the profession

applies also to the younger men—to the rank and file, clear down to the beginners. We find men doing work requiring expensive education, a high degree of skill and, more than all else, a high grade of honor and trustworthiness. We find men meeting all these requirements and yet receiving compensation which is too often below that of the skilled workman who is a member of a union.

We shall not attempt to discuss in detail the causes which have led the engineering profession into this situation further than to say that they are traceable in general to the reaction in higher education against the old time training which led nowhere and to the widespread desire among well-to-do parents to fit their sons for the work of a profession rather than for a business career. Whatever the causes, they are beyond the power of the engineer to remove.

The fact must be faced that the profession is overcrowded at the present time and will continue to be overcrowded for a long time to come. This means that the supply of engineers is in excess of the demand and that by the process of competition, wages, salaries and fees inevitably tend toward a minimum below which the supply is reduced by men taking up some other line of work.

It has been seriously proposed by some engineers to follow the example of the trade union and attempt to limit competition and fix a standard scale of wages for draftsmen, instrument men, etc.

It is extremely doubtful whether such a plan could possibly be made operative and whether, in the event that it could, it would be, on the whole, a benefit to the profession. Inevitably, by such a procedure the profession would forfeit something of the public esteem which it now enjoys. Further than this, it must be admitted that to a certain extent competition is beneficial to the profession. If we can have competition that will enable the best and ablest men to rise to the top, competition that will displace the third-rate and fourth-rate men, because men of greater ability can be found to fill their places, we might then see an actual benefit to the engineering profession from competition.

In order to view this question in an intelligent and constructive way, we must view it from the side of the public as well as from the side of the engineer. The public complains that the work of the engineer too often is poorly done. There are too many mistakes; there is too much extravagance. The men dealing with large affairs claim that, while there are plenty of engineers who can do this or that or the other special task, they do not know how to find engineers whom they know to be trustworthy to deal with the largest problems and not make mistakes. It is recognized that such engineers when they can be found are literally worth their weight in gold. In high positions of executive responsibility, the engineering man-

agement often makes all the difference between profits and losses; between success and failure.

It is not often realized, we believe, how difficult is the task of the man who wishes to employ a competent engineer, and how much more difficult the task is than it was twenty-five years ago! Not because there are fewer competent engineers, by any means; but because engineering work covers a far wider range, and the profession has grown so large that engineers themselves are often at a loss to find the right man for a special task. It must be said, too, that the public does not fully comprehend the great difference between different grades of competency in engineering. The public is too much inclined to put all engineers into two classes—the good and the bad. It does not realize that there are all grades between the extremes.

An excellent illustration of the attitude of the public toward this question is furnished by the legislation which has been proposed requiring all engineers to pass an examination before an official board and receive a license in order to have the privilege of practising their profession. Talk with almost any layman on such proposed legislation and he will express the opinion offhand that it would be a good thing to have some such law so that the public would be protected from incompetent engineers. He has no appreciation of the flimsiness of any such barrier as a protection to the public.

We have so fully discussed this particular question in recent months that we do not need to consider it further here, except to point out that, from the standpoint of the public, there is real need that it should be assisted in the selection of competent engineers. It will be admitted, perhaps, that the banker or the capitalist engaged in large enterprises knows fairly well how to gauge the ability of the engineers he is accustomed to employ, but that is only one limited aspect of the case. Take the engineers engaged in municipal work: How does the average city council know how to pick out the right engineer when it wants to build a bridge or system of water-works or engage in a large scheme for road improvement? How shall governors and mayors and public boards know how to select the right engineers for the works they have in charge? Nor is this question limited to public works. The great bulk of the members of the profession engaged in mechanical engineering are in the employ of manufacturing concerns. How shall the superintendent pick out the right man for a chief draftsman? How shall the president find the man he needs for a superintendent? How shall the board of directors get the right man for the executive head of their concern? Upon such selections as these the financial success of many a concern will directly depend. But in how many cases is a certain man selected for an office

simply because they do not know where to find a better one?

When one stops to think of it, is there any commodity of commerce of such great value which is bought and sold by such crude and imperfect methods as is high-class professional and executive ability? There are recognized exchanges for buying and selling cotton and grain and metals and stocks. There are even exchanges for buying and selling the ordinary grades of labor; but when it comes to the highest class of professional service, on which so much depends, the buying and selling is done in a manner which leaves everything to be desired.

Let us take an actual example: Here is a mechanical engineer who has been for nearly half his lifetime in one position, having responsible charge of a certain class of work. He has attended strictly to business, but his work has been technical rather than executive and he has made no wide circle of acquaintances. Some business change occurs. Perhaps the controlling interest in the company changes hands. The works may be closed, or operated under a different system. The new owners have no use for his services. After twenty years of steady work he is thrown out of a position and he has little more idea how to find another one than if he were newly landed on earth after a journey from Mars. Further, and what is one of the most unfortunate features of the whole

situation, a man cannot offer his own services for sale without immediately depreciating their market value by 50 per cent. at least. We may say this ought not be so, but we must recognize the existent fact. The mere statement that a man is out of a job and is asking for another always counts against him.

Take another illustration and a very common one: A man is engaged in a steady position, but at work which he knows to be much below his capacity to perform and at a salary much less than he feels he would be worth in a more responsible position. How is such a man to find the opening that will place him where he wants to be? In some cases, it is true, a man is fortunate enough to have employers or superiors who place the obligations of brotherly kindness above mere mercenary considerations and who are willing that a man should make an effort to better himself without imperiling his present position; but this is far from being always the case.

It may be said, in reply, that there are certain engineering employment agencies carried on by private enterprise which make a business of registering engineers who are open to offers of positions and who, with more or less industry, canvass possible employers. It may be admitted that these concerns do, after a fashion, serve as exchanges whereby the buyer and seller of certain classes of engineering work are brought together and en-

abled to do business. But many a man is loath to place his honor and his professional reputation in the custody of such organizations. Further, these concerns deal only with positions in which salaried men are involved. No solution to this problem can be considered complete which does not deal with the employment of engineers for public work, etc.

We wonder if many engineers have not at some time or other in their lives felt the need of some organization of high standing which could offer their services in the market without in any way lowering their own self-respect or lessening their market value. We do not believe any organization carried on as a private enterprise can meet this need, no matter how well managed or by whom conducted.

At various times in the history of Engineering News, the project has been canvassed of organizing in connection with this journal of some such high-class exchange for professional services as is here proposed; but it is our belief that this is not a field in which private enterprises alone can do the best work. It is our belief that this work should be undertaken by the organized engineering societies of the country, and that it is the most important responsibilty which now lies before them.

It is true that in a small way a number of engineering societies have already undertaken something in the way of an employment exchange.

The American Society of Mechanical Engineers, for example, has for many years published at frequent intervals a bulletin containing a list of its members who are open to offers of new positions, together with a list of employers desiring engineers. In numerous other societies the secretary's office has become more or less of a meeting ground for the members out of work and those looking for engineers.

The criticism we would make upon such work is that, while it is good as far as it goes, it falls far short of what ought to be done to put the buying and selling of high-grade engineering services on a dignified and proper basis. Instead of being a mere trifling side issue, it should be fully organized and important department of every engineering society, and it should be conducted on a business basis.

Let us explain a little more fully what we have in mind: Suppose in the American Society of Mechanical Engineers, for example, there were a complete register including every member of the Society open to offers of a position, or to engineering work of any sort, in a consulting or other capacity, and stating concerning each man all the information that an employer or a client would desire to know. Such a list should, of course, be carefully classified. All the different grades of work would be included so that the society could satisfy applications either from the directors of

a manufacturing concern in search of the right man for an executive head, or, at the other extreme, from concerns having openings for student members just graduating from college.

It is recognized, of course, that, before any concern selects an important executive officer, personal interviews will be had and thorough investigation of the man's past record will be made. The Society employment exchange would not recommend one man or another, but it would place in the hands of a concern in search of a vice-president, a superintendent, or a chief draftsman the names of three men or eight men or twenty men who would be eligible candidates for the position. It would show for each of these candidates what their entire experience and professional record had been. It would give the names of the men best qualified from personal acquaintance to speak as to the ability and character of each candidate suggested.

We believe that this service, if conducted as it might be conducted, would render greater benefits to the engineering profession and to the public which employs engineers than any other work in which the engineering societies of the United States have ever engaged. Of course, there would be difficulties in the conduct of any such organization. There are difficulties in accomplishing any useful and important task. There would be room, of course, for favoritism to creep in and for the

Society to be made a tool to advance the interests of a certain few who were on the inside, with respect particularly to the recommendation of men for the highest positions.

It does not seem to us, however, that this is a strong argument against the undertaking of any such work. When the essential principle of professional work is honorable adherence to fair and impartial standards, we cannot believe that it is impossible for the organizations representing the engineering societies of the United States to carry out such an important trust in an honorable and impartial manner. If any of the societies are not now organized so that they are truly representative of the membership at large and so that the governing body can be trusted with large responsibilities by the membership, then reorganization is needed in any event.

Of course the argument will be brought forward that there would be dissatisfaction with a Society on the part of certain of its members who would fail to get positions and who might even have their present positions jeopardized, because it would be found possible to provide better men in their places. But failure to benefit such men is no reason why a Society should not do what it can to benefit its abler members. The fact must be faced that, with all the care taken in the selection of men for membership in the national societies, there is included in the membership of all of them

a certain proportion of men of low grade. Of course, a Society cannot, in justice to its reputation, assist to place such men in positions where they are likely to bring discredit upon the profession. Nor would it be likely to under the plan we have suggested above, under which those desiring to employ engineers would be simply given a list of eligibles, with their qualifications, experience and references and the employer would make his own selection.

It is worth while to emphasize the fact even farther that the public needs this service from the engineering organizations as much as, if not more than the profession itself needs it. Millions of public funds to-day are being wastefully expended because of the failure of the public to place high-grade experts in charge of the technical departments of public work. This is realized by very many intelligent citizens, but the difficulty they experience is in distinguishing the real expert from the man who poses as one.

If the engineering societies would each create an organization and make known their abilty to furnish a list of high-class experts available for any class of engineering work, we believe their services would be in demand by city councils, by mayors, by governors and heads of state departments and even by many departments of the federal government, besides the demand from private business concerns.

Such a work by the societies would supplement and systematize the work which is now being done by many engineers, by the deans of engineering schools, by the heads of important engineering firms. At present when a man wants an engineer for an important piece of work and does not know where to find him, he writes letters to half a dozen people or firms who he conceives might know of such a man. All these people, as a rule, take time from their regular work to answer these queries to the best of their ability, knowing that they themselves may need aid in a similar search at any time. At the same time the engineer who is out of a position, or who is in a position and wants a better one, is writing twenty letters to people he knows who might suggest where what he wants can be obtained.

Such monumental inefficiency in connection with the buying and selling of engineering work is a disgrace to the engineering profession; but the individual engineer is powerless to help himself and can do very little to aid others.

Only through the organizations representative of the engineering profession can a systematic method be established for bringing the competent engineer into touch with the employer who desires first-class professional service and is willing to pay for it.

The four great national engineering societies have on their rolls over 21,000 members, who con-

tribute annually some $300,000 for their support. These societies have the standing and reputation and public prestige to undertake such a work as we have proposed and make it a success. We repeat that it is the most important responsibility which is now before them.