ENGINEERING AS A CAREER

A SERIES OF PAPERS BY EMINENT ENGINEERS

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NEW YORK
D. VAN NOSTRAND COMPANY
1916

VAIL-BALLOU COMPANY
BINGHAMTON AND NEW YORK

THE YOUNG MAN AND HIS FUTURE AS AN ENGINEER

Introduction

"What can my boy do as an engineer? — what should he learn, or where should he go to school?" These and similar questions are asked every day by anxious mothers and fathers. The boy himself, as he approaches manhood, begins at first vaguely, then seriously, to consider these matters, and inquires how he may get into some job which will ultimately open opportunities for advancement.

When we consider that each year there are ten thousand young men who start on an engineering course, and many others who would gladly do so if they knew how to proceed intelligently, the importance of a full and correct answer to these questions is apparent. If we assume that the cash outlay of the parents is at least $500 per year for these ten thousand young men, or $5,000,000 per annum, and that in addition there is an expenditure of time and energy which otherwise might be used in earning a living and represents the value of say another $5,000,000, the financial importance of this problem becomes apparent.

But the outlay of cash and time represents only a small part of the concern of the general public in this matter of engineering education. If the right man gets into the right place his value to a community will be measured not merely by tens of thousands of dollars, but by achievements which rise beyond a money valuation. On the other hand, if attempts at securing an engineering education are misdirected, or the young man is not suited by temperament or other qualities for this work, then the loss to the community may be correspondingly great in depriving it of the services of a man who might be highly proficient in some other line.

The choice of a vocation is perhaps one of the most difficult of modern problems, and at the same time, like many other far reaching and difficult matters, has been given relatively little thought. It has been left largely to chance or to individual initiative. The boy or young man tries to make a choice at a time of life when his personal judgment is unformed, and before he has had the opportunity of acquiring any considerable amount of information. The attempt of this little book is to present to youth, to teachers in the high school, and to parents or advisers, some of the facts concerning the engineering profession in general, and of different branches of engineering in particular.

Each of the following chapters have been prepared as a separate article by an experienced engineer or expert eminent in some branch of engineering. Each writer has had in mind the question so frequently asked as to the probabilities of success of the young man going into his line of engineering work, and each has tried to answer the question in his own way. This has involved some repetition of thought and statement, but the fact that several men writing independently have brought out the same or similar ideas serves only to emphasize the importance of these.

Most of the articles were first published in the Cleveland *Plain Dealer* and in the *Scientific American* in response to questions asked from time to time about the opportunities and requisites for success in the engineering profession.

Each author has unconsciously written into his story something of his own characteristics or aspirations, and has pointed out a few of the causes which to him have seemed to lead to success or failure. We have thus presented a wide divergence in methods and ideas, but these are of a special value as showing how various successful, practical men have viewed the opportunities offered or have succeeded in overcoming apparent obstacles.

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ENGINEERING AS A CAREER

THE ENGINEER AND HIS PROFESSION

By Albert J. Himes *

WHAT IS AN ENGINEER? The world of to-day is so filled with works of engineering that every school boy might be thought to understand clearly what it means to be called an engineer. No doubt the boys have some good conceptions of the life and works of an engineer, but in general it is safe to say that the popular idea of engineering is very vague, very incomplete and withal very incorrect.

For one who inquires "What is an engineer?" it might be well to consider first what an engineer is not. He is not a scientist. It is not his function to discover the secrets of nature and lay bare more facts and laws for the further development of man-

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kind. He is not an artisan. He does not fashion with his own hands the materials which give expression to his thought in towering structures or unique machines. He is not a promoter who thinks bridges and tunnels and persuades financiers to invest their money therein. Neither is he a professor who delves in books and writes and talks familiarly of great engineering feats.

HOW THE ENGINEER WORKS. An engineer is a man who, having a liberal knowledge of scientific truth and due respect for Nature's laws, can both plan and carry out with safety and success the great works which are necessary for the convenience and welfare of mankind. Engineering is the practical application of mathematical and physical science to the needs of man. For instance, understanding the law of gravitation, he devises an office elevator to safely carry multitudes of men to the tops of our tallest buildings. Knowing the laws of the expansion of gases he constructs wonderful engines to furnish power to carry out his will. The scientist enunciates the law of gravitation, gives it expression in terms of mathematics and digests fully the wonders of its operation. The artisan builds the machine. He turns the cylinder and piston, assembles the engine, frames the cage and erects the guides.

The engineer makes the plan, determines the size and dimensions of the structure, provides for its safe and successful operation and estimates its cost and earning capacity. Before the first move to create the structure, it has been completely formed in the brain of the engineer. His language is one of blue prints. He does not talk in words. Every small detail is carefully described by the drawing in a form that is specific and definite. Misunderstandings and confusion are not a part of his life. He reads and interprets the drawings and watches with care the performance of the things which they show.

A more simple illustration of his work is found in the way that he measures the span of a bridge. Any one can hold the end of a tape line and read its figures, but only the engineer understands its meaning. He knows that the most careful measurement ever made is not precisely correct and as he coolly observes the operation his thought is that for practical purposes the measurement will do. He uses a steel tape because it is more accurate than the common sort, but the steel tape is longer in summer than in winter, it will stretch appreciably, and if unsupported throughout its length, the sag will modify the resulting measurement. And so in important work he uses a tape that has been carefully compared with a standard measure that is kept in a U. S. Government office at Washington, he takes the temperature and measures the sag and uses a spring balance to determine the strength of the pull. With all the information thus secured he does not use directly the reading of the tape, but calculates an amount to be added or subtracted from the reading in order to get the correct distance between its ends.

Spectators will think him fussy. His employers sometimes think that he is slow, but if left to himself the result of his labors is generally a marvelous agreement with the predetermined plan. Failures in engineering works are most often due to interference by men in authority who are ignorant of the necessities of the case and impatient of ways they cannot understand. Excessive cost of engineering works is most often due to additions or changes during their progress that are demanded by men who have not the imagination to understand the plans and foresee the result in advance of construction.

If one would understand the profession of Engineering, he must seek its acquaintance. Some one has said that the engineers are so busy making history they have no time to write it. This is true and has operated to their detriment. Not being understood, the credit has not been given them and the greatest good that can be done for the profession is for the members to learn to talk and to write with a facility that will enable them to be better understood.

CHARACTER. The greatest strength of an engineer is the justice of his position. Right is might and a clear presentation of his case will always command consideration. He is generally right, but often suffers himself to be browbeaten by men who are skilled in wire-pulling and misrepresentation.

Honesty is characteristic of engineers. It is the result of their training. Their habit of thought must be honest for success in their work. They cannot juggle with Nature. The force of gravity is never asleep. It must be reckoned with. It is the same with the expansive force of steam and with the potential of electricity. They are always the same. For the engineer who would cheat such forces the penalty is death. These thoughts are impressed upon his character and the deceitful engineer is abnormal and a failure in his profession.

The engineer is religious. He may have no creed, but his life is spent among the great things of Nature and her mysteries are ever present in his thought. The small mind grows familiar with electricity and is extinguished in a trice. The sublime grandeur of the natural forces and of their laws, of astronomy and the wonder of its infinite expanse, are his constant companions. There is reason for the prediction that the world's next great epic poem will have for its theme the achievements of engineering. In the past the poets have sung of love and war. It has remained for the engineer to secure for the arts of peace the dominant position in civilization. The triumphs of transportation, of electric transmission and of power development have revolutionized the life of the race and caused, during the last century, a greater advance toward the millennium than has occurred in any preceding thousand years.

Kipling has sensed the thought in the following lines:

> They say to the mountains, "Be ye removed!"
> They say to the lesser floods, "Run dry!"
> Under their rods are the rocks reproved —
> They are not afraid of that which is high.
> Then do the hill tops shake to the summit;
> Then is the bed of the deep laid bare
> That the Sons of Mary may overcome it,
> Pleasantly sleeping and unaware.

But the bitterness that pervades "The Sons of Martha" is not of the spirit that "conquers the earth."

If

> "Her sons must wait upon Marys sons —
> World without end, reprieve or rest"—

the glory is theirs. To serve one's fellowmen, to add to the safety, the comfort and happiness of mankind is a divine gift and brings one to intimate fellowship with the Creator.

PRECISION. Engineering has been termed the precise profession. It is a popular conception that engineering design is the result of calculation and therefore mathematically precise. This notion is far from the truth and has in the past led to some very awkward situations. It is the scientist that is mathematically precise. If an engineer is measuring earthwork that is worth twenty-five cents per cubic yard, he uses an ordinary tape line, which he knows will not give a high degree of precision to the results. This is because the irregularities of the ground surface are such that with a more perfect tape the results would be no better. In measuring a smooth brick pavement worth about three dollars per square yard, he uses a steel tape and gets a much closer result. It is always his aim to adjust the precision of his work to the needs of the case. The timber of a railway trestle is measured sometimes to the nearest sixteenth of an inch, but fine machined steel is frequently calipered to the nearest thousandth of an inch.

SAFETY. In calculating the strength of a structure it is obvious, if one will but think, that the load must be an assumed average, that the actual strength of the material varies considerably with its nature and quality, and that the resulting design, to be safe, must be calculated from liberal values. This gives rise to a technical term called the factor of safety, and it is commonly talked among laymen that the average factor of safety is four. That is, in their thought, a structure safely designed and built will carry four times the load for which it is planned. This is one of the most pernicious notions the engineer must combat. If he knew to a pound the weight of a load and if he knew to a pound the strength of his material, he could build a support that would carry the load, but fail, perhaps, with the addition of another pound. But he never knows these things so precisely; and with the knowledge which he has, it is his function to design safe structures, making use of the judgment derived from experience as a substitute for facts that cannot be known.

If the engineer says that he has used a factor of safety of four, he means that having made his calculations with certain assumed values, his structure would carry four times the assumed load if all his assumptions were correct. But because of the innate perversity of material things he knows that his ideals are not fully realized and that somewhere between his plans and the finished structure there may lie a hidden defect of fatal possibilities, and he has used this safety factor to guard against disaster and to insure long life to the structure.

It is selfish penuriousness that prompts the construction of works of insufficient strength. One reasons that a structure will stand with a factor of safety of two and perhaps his connection therewith will be severed and his profit realized before the failure comes. This sophistry is a weighty reason why all structures that may threaten the safety of human life should be constructed under the supervision of men of established integrity and skill.

LEADERSHIP. An engineer should be a leader of men. He occupies of necessity a commanding position among his co-workers and without a goodly supply of the qualities of leadership the highest success will not be reached. The times are rife with rebellious thought and one who listens may come to think the exercise of authority a crowning sin. Children are not trained in obedience either at home or in school and among adults the breaking of a rule or the evasion of a law is a gleeful adventure. Such conditions are born of ignorance and malice. It is impossible to erect a great steel building without the most perfect discipline among the workmen.

No great effort involving the co-operation of a multitude of men can be successful without a clock-organization and the faithful observance of orders by its every unit. But organization and discipline are not synonyms of despotism. History shows that the greatest leaders have been both loved and revered by their men. It is needless to say that a small minded man of selfish aims and meanness of spirit would fail to qualify in this important particular for the life of an engineer.

GROWTH. In recent years the greatly increased popularity of technical and scientific education has produced such an influx to the ranks of the profession that talk of overcrowding is frequently heard and there has been a lessened rate of increase of attendance at colleges of engineering. The profession has proved so attractive that persons whose motives seem purely mercenary have sought to stimulate the education of engineers just as the steamship companies stimulate the travel of immigrants, and we have with us now, as a result of this commercialism, a multitude of young men claiming the title of engineers, who have learned too little of science and mathematics to permit their advancement beyond the grade of skilled workmen.

But talk of overcrowding brings to mind the fierce labor riots along the Erie Canal during the early development of railroads. Graphic accounts of these disturbances are filed among the Assembly Documents at Albany. Their origin was founded in the belief that the development of railroads would destroy the business of building canals and that there would be no work for the laboring men. Looking backwards over the years of phenomenal railroad development and remembering the difficulty that has been experienced many times in securing a sufficient supply of labor and that in spite of the rapid increase in population, one can hardly believe in the sanity of the advocates of such ideas.

The case of the engineering profession to-day is in a measure parallel to that of the canal builders. Having attained the summit of engineering achievement in the building of the Panama Canal, the pessimists whose peculiarities were so vividly described thousands of years ago in the book of Ecclesiastes, see only retrogression and decline. But engineering art is too young, too virile for such a fate. We have problems to solve which will cause the Panama Canal to occupy a much smaller portion of our field of vision than it does to-day.

The regulation and control of the Mississippi River is such a problem, and while to-day it appears impossible, there is little doubt but that the time will come when its waters will be controlled and the immense areas of land that are annually devastated by its floods will become productive farms, and the appalling losses be greatly lessened. Our irrigation problems, the Salton Sea, the Grand Canyon of the Colorado River afford opportunities for engineering works of the highest order. The improvement of transportation lines through cities, streams and mountains will call forth our utmost energy and skill. Water supplies and the sanitation of cities are of immediate necessity, and it will be many, many years before our highways can attain a development comparable to those of the ancient Romans.

There are fashions in engineering as in spring hats. Just now reinforced concrete holds the stage. Stone masonry is a thing of the past. At one time canals were popular. Then came the railroads. Now better highways are much desired and canals are looming in the distance.

But of lack of engineering problems, there is none. It is not a case of lack of work but how much work we can do. How soon will we be strong enough and skillful enough to undertake hopefully other and larger problems that will add still more to the delightfulness of the beautiful land in which we live. The words of the poet:

> "Who loves to work, and knows to spare
> Can live and flourish anywhere"

should be ever with us. Dissension and controversy were never milestones on the road to success. Untiring industry, willing and unselfish co-operation are the needs of the hour.

EARLY TRAINING. He is a fortunate engineer whose early training and education has been planned with an eye to his future profession. Much of the fitness which a man may have for the work of his life is the result of early environment and training, a conspicuous fact in the lives of engineers. It has been commonly remarked that young men from the country display a superior aptitude for surveying. This is to be expected. The country boy has many opportunities to acquire a self-reliance and resourcefulness in his peculiar environment that are useful on extensive surveys. He learns to wield an axe or a saw, to outwit an angry bull or a vicious dog, to build a fire and to find his way through dense woods in the dark.

In the city this development is supplied to a degree, and in some respects excelled by the training of the technical schools. It is essential that an engineer should be intimately familiar with the properties of structural material and this knowledge he can now gain in some of the city schools. He handles the iron at the forge and in the lathe and pours it molten from the furnace to the molds which he has made. He cuts the wood and fashions it into forms of which he has first made careful drawings. He does these things because of the pleasure he feels in building with his own hands, but at a later date when called upon to construct great works he uses the materials wisely because he knows them as friends. He knows their properties and capabilities and putting them together, each in its proper place, there is produced a thing of strength and usefulness.

Engineering appeals to boys because it requires a vigorous, active life which includes much adventure and hardship. The latter may not appeal to his mother, but a healthy boy loves to test his endurance and measure his courage and strength with full-grown men. And in engineering he can find his fill. From the bowels of the earth to the mountain peaks, there are surveys to make and railroads to build. There is work in Alaska, China and Africa as well as in lands more like home. There are strange men and strange animals and stranger currents and storms and secret dangers.

The football field is a fine place for a prospective engineer. It develops his nerve and his will.

Discipline is of prime importance and it is becoming increasingly rare. The responsibilities and temptations of an engineer are greater than most men realize and only men of the strongest and highest character pass unscathed through the crucial tests.

But it is too much to enumerate the virtues of mankind. With one virtue a man may attain some success. If perchance he has a second virtue his success may be doubled. But when he has attained high station, a single fault, if unrestrained, may work his downfall. The scriptural specifications for human success are to be revered. "Ambition ruined Cæsar," and the rest of the unholy traits are ever active in the eternal process of bringing us all to the level of the meek and lowly.

STUDIES. The studies which are peculiarly designed for the development of an engineer are mathematics and science. Of course there are others but of these the nature is such that they are rarely pursued except at school, while descriptive texts can be read at any time. No boy who is to become an engineer can absorb too much algebra, geometry and physics unless it be to the exclusion of other knowledge.

There are varied lines of engineering work. In some, there is much to be done with a modicum of mathematics, in others there is need for all the learning of Simon Newcomb. So if there be much learning it will not lack a useful field and if the learning be scanty there may still be a field of small dimensions and small reward.

There is competition among the colleges to see which one can publish the longest list of studies. It makes the poor boys dizzy and serves to befog the light. A few subjects carefully selected and thoroughly taught will do far more to develop a useful mind than the most elaborate curriculum hastily skimmed in the time allotted for a college course. It might prick the pride of a college president to know that his own institution had failed to cover the whole realm of human thought, but when more attention is given to the development of men and less thought to the making of encyclopedias, the beneficial effect will be quickly apparent.

Surveying, hydraulics and applied mechanics are essential for an engineer. Geometry and drawing are taught in the high schools but their study should be continued at college. Trigonometry must be learned from A to Z. It is the basis of a great variety of computations. If these subjects have been studied thoroughly under good teachers, the foundation for an engineering education has been laid. A completed education does not exist. A professional man must study always. In college his greatest need is to learn to study, to grow familiar with books and their use.

GENERAL EDUCATION. While the subjects

already named are most directly useful in engineering, the benefits of a more general education must not be overlooked. Engineering is a learned profession and its members must of necessity be well versed in a great variety of knowledge. In general the engineer is charged with the practical application of natural science. Beyond that his relations with other men are such that a knowledge of logic and law are very helpful. He should be a good accountant and be familiar with the use of indexes and files. In the mad rush to secure an income it has been common to neglect the study of English. No man can be a good engineer until he has developed a logical mind and to such a mind any idea of professional success without the best possible control of one's native tongue is preposterous in the extreme. All intercourse between men is through the medium of language and it should be one's first concern to attain the greatest possible facility and correctness in expressing his thoughts. Too little education, too hasty preparation, has wrought great injury to the profession.

COLLEGE TRAINING. There has been much discussion about the possibility of becoming an engineer without a college education. Some men have done so but the problem is simple. A remarkable athlete can win a contest with a handicap, but most of us are glad to win with all the advantages possible. No better answer can be made.

EMPLOYMENT. Because of the nature of the work, perhaps the majority of engineers are obliged to travel from place to place and forego the pleasures of a permanent abode. By so doing their experiences and breadth of view are greatly increased and their development is more rapid.

For a young man seeking employment it is far better to find a place on some work of great importance and in the service of a man of great ability than to select a position which pays the highest salary. No salary can atone for the injury that comes from the development of false ideals and the confidence that comes from a thorough knowledge secured from the masters is invaluable.

The young graduate seeking employment is most likely to find work as timekeeper, draughtsman or as chainman on a survey corps. It is common for young men to feel that their first positions are unworthy of their ability and to show some discontent. Could they understand that the period is one of probation and that if alert and attentive, the knowledge acquired from observation is of more value than actual practice in the things they do, their satisfaction would be greater. It is wisely ordained that a soldier shall develop from the lower ranks to the higher and it should be so with engineers.

No organization can stand the strain of incompetent direction. Failure and bankruptcy are the natural results. In our great corporate enterprises of the present day the greatest need is that the leaders be wisely chosen. Failure in this at the top of the ladder results in the capitalization of error upon error and excessive final cost of production. The corporations must eliminate competition to cover the blunders and the trust is born. Publicity and regulation may result in improvement but more thorough education and better engineering are remedies nearer at hand. These things can be influenced directly by the profession and they should always be uppermost in its thought.

SHALL MY BOY BECOME AN ENGINEER?

By Franklin DeR. Furman,* M. E.

RAPID GROWTH. Forty years ago there were no technically educated graduates in mechanical and electrical engineering in the United States. Forty years ago there were no triple or quadruple expansion steam engines, no commercial oil or gas engines, no steam turbines, no dynamos — the compound steam engine was the highest developed form of motive power, and the world had been waiting thousands of years for that. Forty years ago the Atlantic cable was not yet prepared for continuous service, and there were no telephones, no phonographs, no electric lamps, no trolley cars, no automobiles, no aeroplanes, no wireless telegraphy.

Such light as there was to guide the profession of mechanical engineering from the earliest times

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up to the time of Watt's double acting expansion engine in 1782, was as the light of the stars at night; from Watt's time to the eighteen seventies, it was as the dawn; but in the seventies the daylight had come. Permanent and trustworthy service by cable commenced in 1872; the reversible action of the dynamo and its use as a motor was discovered in 1873; the triple expansion engine was introduced in 1874; the gas engine, also the telephone, was patented in 1876; the electric lamp became a commercial success in 1879. The first technical graduate in Mechanical Engineering received his degree in 1873 and the American Society of Mechanical Engineers was organized in 1880. The progress of the past forty years in mechanical and electrical engineering has been simply marvelous. The mind cannot fairly comprehend the vast and powerful aggregate intellectual forces that have been at work during these four decades.

The writer has no mind to claim any undue credit for the wondrous unfolding of engineering advancement after 1872 for the technically educated engineer, for he knows full well that most of the startling inventions and many of the striking discoveries have been and ever will be made largely by self-developed minds combining unusual strength and daring. Such minds have been few indeed, and where one has succeeded many have failed, the lives of such workers leading either to brilliant success or to bitter failure. Even those who have had the greatest success have generally given at first only the simple demonstration that their inventions would work, or that their discoveries were roughly successful. The refinements and the reliability necessary to general usefulness came later, perhaps with the inventor's own development but always with the co-operation of others.

Who else then, besides the great inventors, are responsible for the great burst of advancement in the last forty years? Who did the great work of perfecting and refining the myriads of little things that had to be perfected and refined before the great inventions became serviceable? The plain thoughtful mechanics of the '70s and '80s and '90s did a very, very large share, but would it be right to say that their art would have accelerated at any notably greater rate after 1872 than it had before, unless strong aid had been lent to it by the thoughtful and scientific work that began to be accomplished at that date by the newly created schools of mechanical and electrical engineering which started at that time?

NEW IDEAS. The number of students in those days being few, and the application of science to shop and manufacturing methods relatively small, the early professors devoted their time largely to investigations and publications of their work. These writings were open to all, and many mechanics did better work because they were able to produce better material, and to machine it better because of better tools suggested very often by these writings of the professors. Soon the students of these technical colleges began to go forth and to carry personally into the shop, the drafting room, and the manufacturing office, new ideas — ideas involving methodical and scientific application to everyday actions. These were eagerly sought by the enterprising layman, although generally without outward evidence of appreciation by the shop workmen, if we are to judge by the stories these early graduates tell us of their reception in the business world.

Nevertheless the new ideas and methods of the technically trained engineer, the better material and tools which his study of science enabled him to develop, and the opportunity these new developments offered to the untrained engineers and mechanics, started in motion a nation-wide and powerful advancement in mechanical and electrical engineering out of all proportion to any rate of advance that had preceded it.

MISUNDERSTANDINGS. But in the early days, as in the present day, although not to so great an extent by any means, the young, technically trained engineer, minus the practical training, did not get along very well with his brother, the practical engineer and mechanic, who was minus the theoretical training. They mixed about the same as oil and water and there was so little oil and so much water, the oil did not have a good chance to show how well it could lubricate the wheels of progress. But to-day the field is dividing; it is large enough to have a recognized system for the oil, and one for the water, and both have learned to appreciate and respect the value of the other and the dependence of one on the other.

Where the position and the particular usefulness of the technical trained engineer is not understood or appreciated, there is still friction, which leads to criticism of the technical graduate, criticism that is undoubtedly meant to be honest, but which is founded on a lack of understanding of the essential and underlying conditions of the great world progress in mechanical and electrical engineering during the past forty years. And where this criticism has been loudest and strongest and most widely circulated, it has been ineffective in detracting from the great work in the engineering colleges simply because those to whom the criticisms were directed understood far better than the author of the criticism what the technical graduate stood for and the part he was taking in this great world progress. Furthermore, the public generally believed, what the technical college catalogue statistics show, namely, that over 95 per cent. of the graduates are successful in life in that they have a good livelihood doing a responsible work and enjoying educated, cultivated, and refined surroundings, and of these many live in affluence and are prominent in their home communities. The man who secures a diploma from any of the large engineering schools is assured of an opportunity of attaining a substantial position in life and no limit is placed on his ambition.

NEED OF ENGINEERS IN MANUFACTURING. With such facts as these (which are known by the present writer to be true because of his personal knowledge and labor in compiling the records of *every graduate* of the first college of mechanical engineering in the United States) the manufacturers and engineers in this country are familiar in a general way, and they have not taken seriously the loud and sometimes vicious attacks of those who have struggled hardest to stop the great wave of scientific and practical advancement. The most notable of all of the critics of technical education who made his wonderful progress and financial success without technical graduates at his elbow as he claimed, failed to see that his own success was due very largely to the development of better material for him to use, better tools for him to use, and better methods for him to use, which he and his working force, great as it was, never could have developed alone. The benefits of the application of science to engineering and manufacturing, which have had their small and often unnoticed origins in the technical colleges, and which have had their practical and ultimate development often at the hands of the practical mechanic, have flowed in to benefit the man who criticized as much as to benefit the man who believes and co-operates in the great progress of the time. This progress has been so great and so vast and is so evident to all, that it can afford to extend its benefits to all.

Much is left yet to be done by the mechanical engineer. The land, the sea, and the air have been conquered, and the world has probably seen in these last forty years more diverse and remarkable inventions and discoveries than will ever again be seen in any future forty-year period in the world's history. But it cannot be said that no other future period will not outstrip the present in progress of a most valuable kind, for in spite of our great achievements, the one great desideratum of civilization, namely, economy of life and processes, has scarcely been touched. There is a great field here for technically trained engineers and when this field of our industrial progress is cultivated many years hence, there will ever be the demand for the technically trained man to keep it in order.

The mechanical engineering profession is still in the very early morning of its life and it opens up to young men, who have a liking for mathematics and mechanics, and at the same time a cultivated and balanced mind, an assurance of a high and respected position in life.

MECHANICAL ENGINEERING

By Worcester R. Warner *

WHAT THE MECHANICAL ENGINEER DOES. The term "Mechanical Engineering" today covers a broad field, including not only the application of mechanical principles to machine design and construction throughout industrial lines, but also the mechanical solution of difficult problems in electricity and hydraulics and many other applied sciences.

The mechanical engineer, to be successful, needs a high development in many directions; a good general education, natural mechanical talent and tact are among the most important elements of his training, and these three might, perhaps, be mentioned in the reverse order; for if one has the third and second, he can readily acquire the first. Three other talents which, to be successful, he must develop, in this as in any other career, are initiative,

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executive capacity and administrative ability. The supply of these is always limited. Capable leaders, here as elsewhere, are few, while the large majority seem adapted only to follow; but our striking inventions, our tall buildings and our vast engineering works of every sort, give us the best proof that we have great engineers among us.

In our own country, the construction of the Panama Canal is one of the greatest engineering feats of any age. All branches of mechanical engineering were brought into play in cutting apart the isthmus that tied two continents together. Gatun Lake, covering more than 170 square miles, had to be made at an elevation of 85 feet above the level of the two oceans, and canal locks one thousand feet long, with gigantic gates, constructed and operated so as to raise 50,000-ton ships from ocean to lake and take them across the isthmus and down into the other ocean.

The disastrous floods of the turbulent Chagres River have been tamed by the lake, and, on the completion of the canal, will furnish water for raising and transferring the ships from ocean to ocean, and also supply electric power for lighting Colon and Panama and operating the railroads and the industries of these two cities.

WATER POWER CONTROL. Our wonderful Niagara Falls has, under the guiding genius of the mechanical engineer, contributed a part of its surplus water to the generation of electric power which is distributed over a large section of the State of New York, furnishing power for trolley lines and industrial enterprises of many kinds. It is to be hoped that wise legislation will so permanently limit the amount of water taken, that the beauty and grandeur of the Falls will not be impaired.

The water powers of our rivers, all over the country, are being developed and in some cases the electric current is conducted many hundred miles, to supply the general industries of the cities and towns within its radius. But our engineers are not content with the generation of power, even though it mounts up in the millions of horsepower. In our western States, after the water has thus passed through the turbine wheels, it is sent over many square miles of arid land, making it by such irrigation the best agricultural section of the district.

In Switzerland the mechanical engineer has caught the torrents as they rush down the mountain gorges and used the power to send trolley cars to the summits, and in one instance (near Interlaken) this power is boring a tunnel inside the mountain, near the surface, which next year is due to reach the summit of the Jungfrau, three miles high. Several openings are cut to the surface, where observation stations are built, giving superb views of the Alps.

This list of wonders might be many times multiplied, but our discussion would not be fair without a few samples of another kind.

NEED OF ORIGINALITY. The lack of some of the qualities mentioned earlier compels many an engineer to try to follow in the footsteps of the successful leader and to forget progress in making a poor attempt to imitate; in fact, such often show themselves content to copy even the mistakes of others.

Take, for example, the early touring cars which were designed in France. The only means provided for entrance and exit to the back seat was an inconvenient opening at the rear of the body, or a ladder at the side. I have often seen the latter. Our engineers copied this heresy and nearly all makers of touring cars used it for years, while the innocent riders had to be content to get in and out by walking through the mud, unless the ladder was provided. In the light of modern design, this seems almost incredible.

Equally inexcusable is the fact that American engineers copied foreign auto designers in placing the guiding wheel and control levers at the right hand side. This was correct in England, where, by law, vehicles must drive on the left side of the road or street. Is it not strange that for so many years our American people, when riding with the driver, have been content to get in or out in the street instead of on the sidewalk? Even the electric autos, all having the left drive, did not seem to educate our engineers; but happily many have now awakened to their error.

A technical magazine, recently, in explaining the alleged advantages of the long-stroke motor, stated that its greater power is gained by the increased "leverage" of the cranks and connecting rods; and the statement was not corrected in a subsequent issue. Evidently the author, in his studies, missed the A B C of Mechanics.

The patent papers and a technical description of a new anti-friction wheel and axle were recently explained to me with pride, the inventor claiming that by its use 30 per cent. in power is gained over the best present methods. My comment to the effect that roller bearings show an efficiency higher than 95 per cent. did not feaze him an atom, showing that he was painfully short on the mathematics of mechanics.

When an engineer has learned to investigate and analyze a problem without prejudice, and independently of preconceived opinion, he will not make mistakes like these noted, but will adapt Nature's laws to the needs of man in the most direct way. The competent engineer accomplishes this by efficient plan; for without efficiency in engineering, efficiency in manufacturing is plainly impossible.

RAILWAY ENGINEERING

By A. W. Johnston *

EARLY RAILROAD WORK. Railroad engineering, as apart from the general practice of civil engineering, has had a somewhat slow evolution from the inception of a railway as a means of transportation to the present time.

A Railroad Engineer, as commonly understood, in the earlier history of railroad construction, was primarily the man who spied out the land and determined the location of the line. He was, in some senses, a wanderer over the face of the earth. His training was largely in the school of experience. He lacked the instruments of precision now deemed essential to accurate results. He had few precedents to guide him, but in most instances he triumphed over difficulties in such a manner as to win

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the approval of those who came after him. On his ability as a locator of railways depended very largely the efficiency of subsequent operation. Some of the most distinguished men in the general profession of engineering came into prominence by their ability in locating and constructing railways.

Some railways of the earlier type, once constructed and in operation, got comparatively scant attention from an engineering staff. Very often records of surveys and land plans, and all such data, the preservation of which to-day is regarded as imperative, were either not properly compiled or entirely neglected. In my earlier experience in the engineering department of a prominent railway, I was charged with the duty of a complete resurvey of a line which had been newly acquired, and in the archives of which not a scrap of paper covering surveys or profiles or rights of way could be found. A complete resurvey and determination of land lines was thus compelled. This instance illustrates one phase of early railroad engineering.

TWO KINDS OF RAILROAD ENGINEERS. In the progress of railway development, there has been a gradual evolution of engineering species, so that to-day, it may be said there are two general classifications of railroad engineers; Engineers of Construction and Engineers of Maintenance. In some instances the Engineers of Construction are yet wanderers over the face of the earth; they are the explorers; they carry the banner of civilization into remote corners, and upon their judgment and skill as engineers, as well as upon their executive capacity as administrators, hinges largely the future efficiency of the routes they open to commerce. In other cases, Engineers of Construction are staff officers of large systems of railways, engaged in directing the opening of branch lines or the improvement of existing lines, or in other instances, directing new "construction" as apart from what is known as "maintenance."

Engineers of Maintenance of Way are usually charged with the duty of conserving the property, which involves a knowledge of track maintenance, and of bridges and structures of all kinds, water service, drainage, signals and interlocking, and of the multifarious details entering into such subdivisions of the work.

QUALITIES NEEDED. The young man contemplating entering the broad field of engineering as a life's work, should have a predilection for the mathematical and mechanical sciences and a determination to pursue, with fixed purpose, some one of the several paths along which his predecessors have built up the landmarks of engineering progress. In recent years the vogue for technical education has drawn a good many young men up to the gateway of the engineering professions, with a high degree of enthusiasm, only to find themselves unprepared to meet the exactions of the taskmaster, who knows no halting nor turning back, the Science of Engineering. And this Science of Engineering, in its various aspects of every-day railroad practice, demands the best that is in its devotees. The young student looking out upon the world around him, perhaps does not fully realize that the great problems of transportation which confront the nation to-day, are in a large sense problems in railroad engineering, and that he who masters them makes a lasting contribution to the world's best work.

In dealing abstractly with the two general subdivisions indicated, Construction Engineering and Maintenance Engineering, it should be understood that they rest upon the same foundation, or start from the same roots, and the difference in practice is largely a matter of convenience in administration.

The Engineer of Construction on original railroad location does have a different viewpoint from the man who follows him later as a Maintenance Engineer, in that he creates the property and the latter conserves it.

A priori both men have started with same initial equipment as to technical training, and should have the same incentives; faithfulness to the profession, desire for advancement and earnestness of purpose.

The diversion of paths is often a matter of opportunity, to be retraced or pursued as the personal talent of the young engineer fits into the solution of the problems ahead. How often it has been said out "at the front" in discussing comparative personal equations, So and So "is a born locator," meaning one who by intuition selects favorable routes. He has a natural aptitude for judging distance, rise and fall of ground, and on a reconnaissance of territory almost unerringly indicates the most favorable preliminary line. He succeeds as an Engineer of Construction. His roommate might never succeed on construction, but might fill with credit, and, perhaps brilliancy, an exacting position on Maintenance.

The heroics of railroad engineering abound in both branches. We are apt to be told in public prints and official reports of the brilliant work of able engineers who develop the country by original constructions, rather than the equally brilliant, but less conspicuous service to his company, of the equally able Maintenance Engineer, to whose door the press representatives rarely come.

SCOPE OF WORK. Railroad engineering embraces, as has been intimated heretofore, all the many forms of the application of science to everyday life. This is true, whether we deal with Construction or Maintenance, but is probably true in a more extended sense of the latter.

The American Railway Engineering association represents the highest type of the development of railroad engineering, as applying to both Construction and Maintenance; in fact, under its organization come together the best recommended practice, and the young student of engineering can find no better compendium to aid him in judging of the character of the broad field which lies before him than its official reports.

Every railroad has its own special problems to be determined, sometimes along general lines, more often by original or unique methods of work.

In original construction, difficult situations, met with great skill and foresight, have induced very great professional approval, and rightfully so, while on the other hand, reconstruction of existing lines, especially in important terminals under traffic, requiring engineering skill, comprehensive plans and a high degree of administrative capacity, have all but passed unnoticed. The engineer's reward in both instances is the satisfaction which comes from duty well performed.

The young man, entering upon the career of a railroad engineer, will ordinarily conclude, after a year or two, that the procession up ahead moves quite slowly. The first eight or ten years of his career must be regarded largely as still preparatory; he is putting some of his technical knowledge into play more or less of the time, and eventually he learns to differentiate between the application of pure science to his everyday problems, and the application of principles based on the experience of the profession.

Some five years after I had left school and was engaged on the operating staff of a railroad manager who was an engineer by training, my "Rankines Engineering" was lying on my desk, and the old chief engineer of the line, a very able constructor, and brilliant man, came along, picked it up, carefully looked it through, and looking at me over his spectacles said: "Is this your book?" Upon being assured it was, he then asked in a quisicay way: "How much have you forgotten?"

The young engineer will also probably conclude after a few years that as a money making profession in a large way, railroad engineering does not afford any alluring inducements, but if the sole aim of the young aspirant from college is to barter and trade in the market places of commerce, he will not enlist in a cause which offers to its adherents but limited opportunities for acquisition of large wealth in money.

SAFE OPERATION. Railroad engineering, as practiced to-day, calls for the highest form of intelligent interpretation of the scientific method as applied to the most practical of everyday problems.

There has been thrust upon the railroad engineers in recent years a grave responsibility for the safe operation of railways. The public, through legislative action, has demanded almost revolutionary practices along certain lines. Rail manufacture, signal installation, electrical operation, are all presenting special problems, calling for the highest type of technical knowledge. Specialization along such lines is inevitable, and the young engineer has a constantly widening field from which to choose.

ADMINISTRATIVE CAPACITY. The railroad engineer is not necessarily limited in his advancement in railroad service, to progress along strictly engineering lines. On many roads the opportunity to take up so-called transportation problems is not denied him, and many of the railroad officers of important railways were trained as engineers, and as time goes on, there will undoubtedly be an increasing tendency to give such men an equal chance with the man whose sole training has been along so-called practical lines, but the young engineer who would aspire to advancement in transportation work, must not (as was concisely put by a railroad president now deceased, and himself an engineer) remain so long a technical engineer as to make him a poor administrative officer. This last suggestion emphasizes the need of differentiation, in the mind of the young engineer, between the value to him of exact thinking which comes from the study of the engineering sciences, and the ordinary training received outside of engineering schools. Pure mathematics may not assist him in systematizing the administrative features of a large construction corps, but it does aid in prompt and sane determination of many of the everyday so-called purely practical problems. Not all the able engineers were trained in technical schools, but they had to acquire and apply the principles of engineering science by observation and by contact along the slow and ofttimes tortuous road we call "experience," so the young man who chooses the field of railroad engineering for his life's work, must get his foundation of the sciences somehow or somewhere, and then patiently and persistently build up his storehouse of experience. There are many paths in the field before him; opportunity lies along them all. Let him be ready to seize it at the proper moment.

The problems of transportation, involving the best solution of the problems of railroad engineering, afford a constantly extending field for development of the highest type of administrative capacity. The call for leaders who think sanely and administer wisely will be as loud in the generations ahead as ever in the past. Let the young student of engineering not falter at the outset of his journey, because the valley of preparation is wide and the summit of the mountain of achievement pierces the clouds.

HYDRAULIC ENGINEERING

By Chester W. Larner *

NEED OF CONGENIAL OCCUPATION. "What shall I do for a living?" This is a vital question to every ambitious boy, but not an easy one to answer. Like all the other big questions of life, the solution must inevitably come from within and not from without. The only key is intelligent self-analysis. Good counsel and advice from others may be of material assistance, but in the end each individual must solve the personal equation for himself. If there is any worth within him which he cannot find himself there is small chance that it will ever be discovered.

Parents generally feel a very natural responsibility for the future of their children. They try to

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guide the youthful bark of destiny into quiet waters and often feel that they are entirely competent to select the proper course to be pursued. This is a matter easily overdone. To decide arbitrarily what a boy shall do for a living without due consideration of his natural tastes and proclivities is as wrong and as injurious to his future happiness as it would be, later in life, to choose a wife for him without regard to his own feelings. To appreciate this one need only observe the numerous misfits graduated every year from professional college courses, and the many unfortunate individuals whose vocations have been selected by their parents, most of whom never achieve success commensurate with their natural abilities unless they happen to have sufficient backbone and initiative to get out of the rut and follow their own inclinations.

The selection of one's life work is no easy task. Fortunate, indeed, is he who reaches middle age in the enjoyment of a mutually satisfactory partnership between himself and his work. Thousands of men of considerable innate ability flounder about from one thing to another for years, and sometimes all their lives, in their efforts to find congenial employment. Most of this wasted effort is due to lack of self-analysis.

Difficult as the problem may be, it devolves upon each individual to solve it for himself. He alone knows what work is congenial and satisfying to his ambition. His friends may help him in many ways with information and advice to determine the relative desirability of different kinds of work, but the question of whether a given occupation is suited to him or not is one for the man himself to decide.

To the young man with a natural taste for engineering, many lines of work are presented. Construction work is roughly divided into civil, mechanical and electrical engineering, but these divisions overlap to such an extent that it is necessary for a specialist in one branch to have a considerable knowledge of the other branches if he is to be a well-rounded engineer. It is for this reason that most courses in technical colleges are of a general nature until the last year, when the work becomes specialized. Indeed, it is an open question if all undergraduate engineering courses should not be alike, leaving specialized work until the post-graduate course.

OPPORTUNITIES IN WATER POWER DEVELOPMENT. Hydraulic engineering in its various applications offers many opportunities to the young engineer. The great works of this nature in progress on every hand are constantly attracting public attention. The Panama canal, the great irrigation projects of the west, the numerous water power developments all over the world, water supply systems for large cities and the improvement of navigable rivers for water transportation, all suggest great present and future opportunities for the hydraulic engineer.

Probably the most active branch of hydraulic engineering at the present time is water power development. The utilization of flowing water for the production of power is one of the oldest of the engineering arts. It antedates the production of steam power by many centuries. In fact water power of the cruder sort is as old as history itself, and there is little doubt that the power of running water was utilized for the purposes of man during ages of civilization so remote that no written record has survived.

Combustion engines using directly the energy generated from gases are of later development than steam. Windmills date back to the twelfth century, but they have been of little importance owing to the fact that they can be used to generate power only in small quantities and then only for intermittent service. Power generated in commercial quantities directly from coal or from the heat of the sun is a possibility which may be realized in the future, but as yet it is no more than a vision of the scientific investigator.

People at large do not as yet fully appreciate the growing importance of water power development to the industrial and civic progress of this country. Although the development of water power in small quantities for various industrial purposes has been common for many years, it was not until the perfection of the alternating current generator made long distance transmission possible that it began to receive any marked attention. The hydraulic turbine or water wheel has been from its inception the most efficient prime mover known, but until long distance electric transmission became a commercial possibility, water power development was retarded by a serious handicap. Before that time the power developed had to be used at the place where it was generated.

Water power sites are usually remote from large cities or industrial centers where a good market for power exists. This gap is now bridged by the long distance transmission line. The fact that a good power site is many miles from a good power market no longer prohibits the development of that power. Plants are now in successful commercial operation where the power has to be transmitted more than 200 miles and doubtless with the further development of electrical apparatus this distance will be materially increased.

ELECTRICAL GENERATION. Most of the large water power plants built during late years have been for the generation of electricity. The generators are directly connected to the turbines, and it is now possible under the best conditions to convert about 90 per cent. of the potential energy of the water into electric current at the switchboard.

At present steam is practically the only competition of water for the generation of power in large quantities. With the best of steam apparatus not more than 12 per cent. of the potential energy in the coal is delivered in electric current at the switchboard.

ACTIVITY IN WATER POWER. Water power development in this country is now in a state of marked activity, and the development is certain to keep step with the increase in the demand for electricity. Furthermore, the demand for electric power is certain to be far out of proportion to the present normal increase, due to the growth of our population and our industries. Water power is ordinarily cheaper than steam power, and lower cost to the consumer stimulates the use of electricity not only for purposes for which it is already commonly used, such as lighting and power for factories and street railway lines, but also for many new purposes, such as the electrification of steam railroads, electro-chemical processes, metallurgical work, and many other industries which are dependent for commercial success upon cheap power. Already some of our largest railroads are using electricity developed by water power to haul their trains, and no doubt the next twenty years will witness extraordinary progress in this direction. The aluminum industry in the United States and Canada alone is now using several hundred thousand horse power of electricity, all generated by water power. The electro-chemical industries of this country are at present far behind those of Europe, and the next decade will unquestionably be marked by unprecedented growth along these lines.

Unless some revolutionary change in the art of converting coal into electricity is discovered, the cost of developing power by steam will steadily increase, due to the increase in the cost of coal. On the other hand the cost of water power should decrease. At the present time water power is a comparatively new proposition to the investigating public, and the cost of financing is higher than it will be in the years to come. As the country becomes more thickly populated it will not be necessary to transmit power to as great distances as at present, which will also tend to reduce the cost. In addition, the regulation of the flow of our rivers, which can be economically accomplished after they are more fully developed, will tend to eliminate periods of extreme low water which now reduce the commercial output of many plants far below the normal capacity.

The young engineer in search of a profitable field for his efforts will do well to consider the opportunities afforded by water power engineering. Many important plants have been already built, but as yet the field has hardly been scratched. The latest estimate of water power developed in this country is about 5,000,000 horse power, whereas the undeveloped horse power is roughly estimated at between 60,000,000 and 80,000,000. Furthermore, practically all of the important plants built within the last ten years have been extending and increasing their capacity ever since they were built. Then, again, many of the older plants are rebuilding and modernizing their equipment. This is a continuous process which will never end, and suffices to show that the work of the water power engineer will not be finished even when all of the water power is developed.

RAPID DEVELOPMENTS. Water power engineering is now passing through a transitional period. Precedents are being frequently overthrown, and the practice of to-day is not the practice of a few years ago. The largest water power plant in the world, and probably one of the largest which will ever be built, was put into commercial operation a short time ago in Keokuk, Iowa. This plant will eventually utilize all of the normal flow of the Mississippi River. Five years ago few would consider the possibility that such a mammoth plant could be built, and yet to-day it is in successful operation, supplying electricity to St. Louis, 135 miles away. The turbines, which were built in this country, were of such unprecedented size that all of the European builders who were consulted advised that no shop could ever build them. They have been built, however, and have fulfilled the expectations of all concerned. Even before the Keokuk plant was finished work was started on another large plant at Cedar Rapids, on the St. Lawrence River, where the turbines, although fewer in number, will be even larger than those at Keokuk.

Work of this sort is very interesting and full of opportunities, much more so than other branches of engineering which have passed through the development stage and settled down into the routine of practical use. Steam power, for example, has many applications to various lines of work, but most of them are thoroughly standardized. This standardization tends to eliminate the opportunities for original work which are open to the hydraulic engineer, and which, in the very nature of things, will continue to present themselves, because water power development can never be standardized to the same extent as steam.

RANGE OF CONDITIONS. Steam is used under pressures which vary between comparatively close limits, whereas water power plants know practically no corresponding limitations. They are in operation under heads varying from 2 or 3 feet up to 5,000 feet, and utilize stream flows as small as a brook and as large as the full flow of the Mississippi. Each particular combination of conditions must be given individual treatment, and often there is little or no precedent upon which to base the design.

Naturally the results depend almost wholly upon the ability and ingenuity, and not infrequently the courage, of the engineer.

Handling water under low heads and at correspondingly low velocities is a different problem from handling it under high heads, where the velocity may be as high as 400 or 500 feet a second. The tremendous force of such a stream can only be appreciated by those who have witnessed its destructive power. It will penetrate solid bodies as effectively as a drill, and in turn, is itself almost impenetrable. It is impossible to shoot a rifle bullet through a high pressure jet of any considerable size, and the blow of an ax will rebound from it as if it were a bar of steel.

The character of the plant in all its features must naturally change to suit these different conditions. The water must be diverted from the source of supply in different ways, and different methods must be adopted to convey it to the power house. The design of the power house and the machinery must be taken to regulate the flow of the river by means of controlling works built many miles from the plant. Often the water will be taken directly from the pond or forebay into the wheel chambers, and, again, it may be conducted for miles through tunnels or pipe lines to the plant, necessitating elaborate precautions to prevent bursting of the conduit if the flow of the water should be suddenly checked.

Such are the conditions which the hydraulic engineer has to face to-day. There is no lack of opportunity and there is no dearth of work. Men of ability and experience are unquestionably in demand, and no man taking up this work at the present time will fail for lack of opportunity. If he has ability and will study the work his advancement should be adequate. Let him remember one thing particularly, and that is that experience is one of the engineer's most valuable assets, and experience is a matter of detail. Most college graduates overestimate their fitness for practical work. They leave college with the idea that their education and training fit them to step into positions of responsibility, and, unfortunately many teachers dispense this sort of "advice" to their students.

IMPORTANCE OF DETAILS. As a matter of fact, in everyday work, good engineering is almost entirely a matter of detail. The difference between a good machine and a poor one, for example, is usually to be found in the details and not in the general scheme. A genius may be able to support himself by the evolution of brilliant schemes which other men develop, but the average man cannot do it. "Touching the high spots" is not ordinarily a very lucrative employment.

The man who works out the big ideas is a worthy object for emulation, but at the same time it is well to remember that he has not been engaged in that spectacular occupation all of his life. It is safe to say that he did not take it up immediately after his graduation from college. In all probability he has gone through the usual round of drudgery and tiresome detail that is essential to the development of any capable man, whether he be an engineer or otherwise.

VALUE OF THE DRAFTSMAN. There seems to be an unfortunate tendency on the part of many men to look down upon draftsman and drawing room work. This sentiment is responsible for the feeling against such work on the part of young college men. They have an idea that it is beneath them.

This view of the matter is entirely illogical. Drawing room experience is an indispensable part of an engineer's training. There are engineers who have never had it, but they are handicapped to that extent. The drawing room is where the real work is done, and all successful engineers know that an efficient drafting force is just as indispensable to good engineering work as an efficient engineering staff.

METALLURGICAL ENGINEERING

By J. H. Herron *

WHAT BRANCH OF ENGINEERING? To every young man who thinks he has made his decision to take a course in engineering, this question must invariably arise; if not before entering college, at least before the beginning of his second or third year.

Perhaps before considering this question in detail it may be wise to see whether sufficient thought has been given to the subject in general, i.e., "am I sure that I wish to be an engineer, or am I qualified by natural desires and tendencies to fit into the life and give myself up to the activities of the engineer?"

There seems to be somewhat of a misapprehen-

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sion regarding the profession of engineering, and this should be corrected as far as possible. This condition of mind may be accounted for by the tendency of present day novelists to make of the engineer a hero of romance. While the true engineer loves his profession he realizes that it is not, more than other professions, a path of roses.

CREDIT FOR RESULTS. The engineer in addition to a natural fondness for his work must be honest, unselfish and patient. There are times when temptations will assail him in subtle forms and he must be honest and strong to resist. Much of the work of the engineer is done with little personal profit. He frequently receives the credit for what he has accomplished, but even this, at times, is denied him and such credit goes to the undeserving, therefore he must give up these stimulating returns and content himself with his own knowledge of a work well done. The engineer who was the real inventor of the so-called Corliss Valve Gear, which revolutionized steam engineering, received practically no profit from his invention, and it was not until later years that he was recognized as an inventor. To-day, few outside the engineering profession have ever heard his name. The engineer is primarily a director of men and as such he must frequently become the buffer between two opposing elements. This will at times try his soul. These things are all inseparable from any branch of engineering and must be well considered before the subject is further entered into.

CO-OPERATION. The exceedingly rapid and extended growth of accomplishment in the field of engineering requires that the student shall have a thorough preparation in the branch of engineering that he shall select to study, and ultimately must expect to closely specialize it. It has been recognized for some time past that in all large work it is better to have the co-operation of a number of specialized engineers than that all shall be in the hands of one engineer. Co-operation is without doubt the watchword of the engineering future. One eminent engineer has said, that much better results could be gotten by several *special engineers of ordinary ability* than by one general engineer of extraordinary ability.

In all branches of engineering the student must have some natural aptitude toward the particular branch which he desires to study. It is not enough to say "I shall be this," for it to come to pass. Every man, no matter in what branch of engineering engaged, must have the power to dream and to bring his dream to pass in the accomplishment of something for the benefit of his fellow men.

PLACE OF METALLURGICAL ENGINEERING. In this age of iron and steel, and other metals, there is no more important place in the economy of engineering than that filled by the metallurgical engineer. It is upon him that the responsibility rests to take the ore that nature provides and to fashion it into forms available to his brother engineers for use in the fabrication of the many machines, structures, etc., upon which all depends. Owing to the tremendous strides made in the manufacture, treatment and use of metals, notably alloy steels, in recent years, it is felt that we are entering upon a new era in metallurgy and in the future, wonderful developments in engineering endeavor along these lines may be looked for.

The metallurgical engineer is more a combination of the scientist and engineer than is usually found in other branches of engineering. He must devote much time to research work, which belongs to the realm of science, and as an engineer must be able to take results of his research work and make it commercially practical.

TWO DIVISIONS. Metallurgical engineering properly falls into two divisions:

First. That which appertains to the manufacture of the different metals from their ores into ingot or other forms for ordinary use.

Second. That which governs the selection of different metals and the subsequent treatment to render them useful for certain specific purposes.

In the first instance the metallurgical engineer must watch the manufacture of material from the ore to the commercial product. Upon his skill and honesty will depend much of the success of the design and fabrication of all classes of machinery, bridges, buildings, etc. Inferior materials delivered to the fabricator may result in subsequent failures entailing loss of life and property.

The second division of this subject is one which is comparatively new, and will in consequence be treated at greater length.

SELECTION OF MATERIALS. Until a few years ago, the selection of iron, steel or other metals for any particular requirement was left to the metallurgical engineer who had made the material. As manufacturing needs developed, and it was found that the metallurgical engineer, in such capacity, was not the user to any extent of the material that he manufactured, and therefore did not have the fullest conception of the needs of the user, a new branch of metallurgical engineering, coming under the latter heading, was found necessary. This branch of the subject has for its purpose the proper selection of material and its subsequent preparation for certain engineering operations, so that now, as a rule, great care is exercised, not only in the selection of material but in its thermal treatment. Such treatment has at times nearly doubled the physical value of the material for service.

The metallurgical engineer is, perhaps, primarily a scientist, that is, he must have such a knowledge and understanding of chemistry and physics that he can think in them. Unless this is possible, he would be unable to meet the problems constantly arising and which he must frequently solve without the aid of existing literature on the subject. The research necessary requires that he shall have sufficient knowledge to be able to understand the phenomena resulting from his experimental work. In order to properly observe and record experimental phenomena the metallurgical engineer should have more than the ordinary mathematical mind and training, since his work requires the degree of exactness only possible to such a mind. As an engineer, he must be able to take the results of his experimental work and make it a commercial success in such place or connection where it seems desirable.

It was the work of the late Frederick W. Taylor, the well known efficiency engineer, and Mr. Maunsel White, metallurgical engineer, along experimental lines that resulted in the discovery of the so-called high speed tool steel. The introduction of high speed tool steel in turn has necessitated the redesign of nearly all metal working machinery. There are now coming on the market tool alloys, which, their discoverers claim, are as far in advance of high speed tool steel as high speed tool steel was in advance of ordinary tool steel.

Perhaps the greatest development along this particular branch of metallurgical engineering has been caused by the need of the automobile industry. Here was a problem not met with before where a high degree of strength was necessary with light weight. There was the cost of upkeep of the automobile, which included tires, fuel, etc., and the requirements of speed, all of which contributed to the necessity of reducing the weight to a minimum. The metallurgical engineer made this possible by the development and the introduction of alloy steels together with the necessary thermal treatment to obtain the greatest possible strength. As a result, we now hear of comparatively few failures, and the automobile salesman impresses the prospective purchaser with his familiarity with nickel, vanadium and chrome nickel steels and their heat treatment.

KNOWLEDGE REQUIRED. The duties of a metallurgical engineer are to study the physical requirements of a particular part of a machine or structure or the amount and kind of load to which it is subjected; to select the material best suited to the part and service in question and to decide upon the heat treatment necessary to produce the desired physical properties. This, of course, necessitates the chemical examination of the material to determine whether it is of the desired composition, and the inspection and testing of the material physically to determine whether it possesses the desired physical properties. All of this pre-supposes:

a. A knowledge of the service to which a material is to be subjected; the extent and kind or character of stress applied to the part in question.

b. A knowledge of the action of metals under different kinds of stress.

c. A sufficient knowledge of chemistry to be able to determine whether the material is of the desired composition.

d. A knowledge of the effects of thermal treatment upon the physical properties of the material.

e. A knowledge of physical testing and the necessary experience to draw proper conclusions from such tests.

The microscope has opened an entirely new and very interesting field in metallurgical engineering. This particular division of the work is designated by the term "metallography," and the engineer engaged in such work is known as a metallographist. Metallography has enabled the engineer to determine many things which have heretofore been seemingly beyond solution. By such means it is possible to ascertain the approximate mechanical and thermal treatment to which any material has been next previously subjected, thereby enabling the metallographist to learn what mistreatment, if any, has been given a material either in manufacturing, subsequent melting or preparation for use. Even at times the cause of a failure in service may be determined and proper measures taken to prevent a repetition of the same fault. Such work has been of incalculable benefit to the whole manufacturing industry. With the opportunity and prospect for its future developments, much is to be expected from its use.

Practical work in metallography is only possible after considerable training on the part of the engineer.

If, after considering all reasons for and against, the student has decided to become an engineer, he must then with great care select the particular branch for which he feels that he can qualify. As human knowledge on this subject increases there becomes less room for the indifferent one. Success will come only to those who are willing to give of their strength without permitting the thought of material gain to occupy too much of their horizon.

As the future will be one of co-operation the engineer must be willing and anxious to work with his fellow engineers, recognizing in them their respective abilities.

DIVERSIFIED INTERESTS. Since the science of metallurgy is but in its infancy, metallurgical engineering opens to the student a field possessing, perhaps, a more diversified interest than any other branch of engineering. Much of the satisfactory performance of all machines, steel structure, etc., will depend upon his knowledge and skill. It in turn requires more the training of a scientist than is usual.

The world of to-morrow may be under the direction of the engineer. With the increasing need of the technically trained man at the head of large manufacturing interests, there will be development along new and diversified lines, and new classes of engineers will result. There may eventually be a large class of business men educated as engineers in order that they may the more readily meet the problems confronting them as executives. More and better iron and steel will be necessary and without doubt metallurgical engineers will become the executive heads of the large iron and steel plants. With engineers at the helm of our large industries there will be less danger of erring, due to ignorance, and the world will be a safer place in which to live.

ELECTRICAL ENGINEERING

By W. H. Abbott *

NATURAL TALENTS. For a young man who is about to choose a profession, it is often a most perplexing question what that profession should be. Happy is he who has a most decided predilection which is actually based on the peculiar bent of his mind. The inherited callings, for instance being a doctor because one's father is a doctor, is a most dangerous thing, since it so frequently happens that the candidate has never had a chance to even consider anything else.

Every mind seems to have additional powers in certain directions. Under a competitive system of existence it is more than wise to follow this line of least resistance, no matter how desirable it may be to cultivate the qualities which we lack in order to make full rounded men. I would suggest that

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the qualities lacking be selected as hobbies and cultivated during one's leisure time.

THEORY OR PRACTICE. Another point on which the young man is very likely to go wrong is that he thinks he should not take a college course, but should begin at the bottom and work up on the practical side, since the practical side is so highly prized in the business world. This seems logical and is if he will remember that he must learn everything covered in the college course, even though he does begin in the shop. Practice is a wonderful thing as an aid to theory, and if one starts early enough it does not matter very much which comes first, but both must be had. Getting the theory by one's self, even with the aid of a correspondence school, is about the most grinding process that can be imagined. The college course, in connection with the college laboratory, is probably the easiest solution of a most difficult problem.

Further than this, even in Electrical Engineering, there are positions to which an engineer may aspire which do not require an engineering training, yet an engineer may fill them to advantage as compared with a man with a business training only. Such positions always carry with them salaries and a consideration superior to that of engineering alone, and are obtained not by engineering ability but by those other qualities which distinguish men and which qualities are greatly enhanced by a college training. The qualities themselves are, however, probably inborn and cannot be originated by any form of training.

WISE CHOICE. The first question that the candidate must decide is, has he the quality of mind which would justify him in choosing some form of engineering? The quality of mind which probably embraces all forms of engineering is that of an infinite curiosity directed more particularly to happenings in the world we call matter. For instance an infinite curiosity pertaining only to men should make a sociologist, to mind alone a psychologist, to all things equally a philosopher. To the above curiosity as to matter must also be united the desire to be a builder or operator; this last being the distinction between the quality of mind of the scientist and the engineer.

Given the curiosity and the actual desire for manipulation, one can safely conclude that he is fitted for some form of engineering. The matter of choice then becomes paramount. Again it reduces itself to a question of quality of mind. The various branches of engineering differ almost entirely in the size of particles of matter dealt with and the kind of motion to which they are subjected. For instance in bridge and structural work the masses are usually large and the condition of lack of motion is the cardinal principle; in hydraulics the masses of water are frequently acres in extent and the motion usually slow. The same applies to mining. In railroad work the masses are smaller and the motion faster. In mechanical work the elements are usually small and the motion fast. In metallurgical work the particles in action are very small and the motion becomes that of the molecules of the matter. In pure electrical work the masses are the smallest and the motion exceedingly fast, being that of the smallest divisions of matter. In other words we progress from matter at rest to matter in its highest stage of motion. The choice should therefore depend on which of these divisions of size and motion most interests us. Which we can most readily visualize and think about without undue strain. At the very bottom they are probably all equally difficult but not for all minds.

No doubt the psychologists will soon have some tests worked up that will enable us to distinguish much more clearly as to what are our mental qualifications. Many mistakes would be avoided if some decisive tests could be applied.

SIMILARITY OF WORK. At this point, however, it is important to point out that since the divisions between the branches are graduations of mass or motion or both, they necessarily overlap. This is particularly true of electrical and mechanical engineering. All truly electrical phenomena show themselves or are produced by mechanical means and usually more or less complicated mechanical tools. Hence these two divisions go so closely together that many college faculties for a long time refused to separate them. Even though the separation has now been made practically universal, it seems that the practice of many students in combining the two courses is advisable even if it takes somewhat longer.

The similarity of mechanical and electrical engineering is strikingly shown by the main subdivisions of each.

Electrical engineering — Light, power, transportation, transmission.

Mechanical engineering — Power, transportation, transmission, manufacturing.

Both are doing practically the same work, but are doing it in a different way. The electrical method in nearly every case is to substitute for a series of mechanical forms some simple electrical form usually operated at a higher velocity. This substitution of electrical details for mechanical details is proceeding very rapidly in all manufacturing industries. To make such substitution requires, however, as wide a mechanical knowledge as an electrical. It will not be at all surprising to find a strong subdivision springing up in the future, the specialists in which will call themselves electro-mechanical engineers, in the same way that we already have electro-metallurgists. The quality of mind for each of the above leans strongly to the electrical. This is seen very clearly among skilled workmen in construction operations. The best mechanical helpers are uncertain of themselves as soon as some piece of electrical apparatus is injected into a machine. Many of them seemingly cannot think along the combined lines and are willing to give up on little difficulties on which they would have spent hours in striving for a solution along mechanical lines alone.

The very latest developments indicate that the close connection between electrical and mechanical engineering is rapidly extending to all departments of engineering. In other words that we are to have electro-metallurgists, hydro-electric engineers, electro-mining engineers, and electric railway engineers. All of them must get their initial training along electrical lines and then specialize among the subdivisions, the subdivision thereafter becoming their principal subject. In other words, the province of electricity in these subdivisions seems to be either in the elimination of mechanical parts or in an increase of output, hence the engineer must be most thoroughly acquainted with the fundamental possibilities of electricity.

If then a young man is attracted by electric phenomena, that is, can readily visualize the unseen, and in addition is strongly attracted by some other department of engineering, he can readily combine the two and find a field sufficiently wide for all his ambitions.

OPERATION. All actual practice of engineering divides itself into

Operation
Design.

Operation includes all erection work and must be the field of the majority of engineers. In electrical work, due to the large factories establishing student courses, this fact has been somewhat overlooked. The factory for the manufacture of electrical apparatus is the home of the designing engineer, hence if, from the financial standpoint, it is necessary for a young engineer to advance rapidly, and he is not a born designer, he had better not spend too many years in the factory.

The operating engineer should be active physically and have a more general education than the designing engineer. He will come in contact with the public at every turn and the public will not appreciate his detailed knowledge of electricity or mechanics. A man who knows things in general will appeal to them as an able man and success in many places is determined by what the public thinks.

The operating engineer must also have a knowledge of business or merchandising. All successful operation is measured by the two sides of a ledger account. An operating engineer must face that ledger and know something of how the accountant manipulates it. Reputations are made and marred behind the bookkeeper's desk as well as around the work benches. An operating man that can check accounts or make up his own statement of what it is costing him can weather more storms than one who is "in the hands of his friends." In many departments of operation the social side of the manager counts for much. In electric light operation it frequently makes the difference between a successful and an unsuccessful man. The ability to dance well will make stronger friends and more of them than artistic draftsmanship, although that is desirable. In other words a full rounded man is the one looked for as manager of all public service corporations and the number of these is legion.

DESIGN. The designing engineer must be a specialist. He is the student of the engineering fraternity. His theoretical training should be most thorough. He must have that rare combination, the mathematical mind combined with originating genius. Most of all he must realize the importance of details and the detailed history of his profession.

The number of positions open for designing engineers is small. The road to design is up through the drafting room and out through the complaint department. All present day practice is toward standardization, which much reduces the field of the designer, and that not infrequently to the damage of the apparatus turned out. Standardization has been carried to its greatest extreme in this country. The largest field still open is in the design of systems or combination of units, as in laying out power houses, transmission lines, or factories. This, however, more frequently falls to the operating engineer than it really should, due to the operating man being in closer contact with the owners or financiers of such enterprises.

CHEMICAL ENGINEERING

By M. C. Whitaker,* D. Chem. Engrg.

A SCARCELY-TOUCHED FIELD. The education of men for the applications of electrical energy has kept pace with the development of the dynamo, the motor, the telephone and the telegraph, wireless telegraphy, etc. Our railroads, buildings, bridges and municipal works are directed and developed by the products of numerous schools of civil engineering. No one would question the wisdom of the establishment of schools to provide the training for these engineers. The scientific and industrial development in their respective fields has amply justified the existence of such schools and the demands for their graduates are constantly increasing. There still exists, however, a branch of engineering, the scope and possibilities of which are greater than all of the others

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combined, and that is the field of manufacture involving the principles of chemistry. The value of the chemical products manufactured in the United States during recent years aggregated over $8,000,000,000. The development of the men to build up, manage and operate the numerous units going to make up this great industrial division has, until recently, been largely a hit and miss matter.

Who is best equipped to design, build and operate our factories and processes founded on chemical principles? Certainly not the electrical engineer, educated to work around the pivotal point of electrical theory and with little or no knowledge of chemistry. Certainly not the mechanical engineer, specially trained in the development, use and application of power and energy; nor the civil engineer, educated in the theory and practice of construction; nor the mining engineer, educated to win the raw materials from the earth. Among the classes enumerated, we find only those who are specialized in the recovery of raw materials and those trained to make applications of the finished products. The intermediate step — that of manufacture — has been entirely omitted. Our failure to recognize the need and to provide men trained in the application of engineering methods to chemical problems is amply illustrated by reference to the history of a number of our noted developments. The chemistry of the Solvay soda process was available for thirty-five years before the engineering difficulties were solved. Our present water-gas system lay dormant for fifteen years before engineering talent could make it commercially successful. The principles on which the wonderful contact process for sulphuric acid is now operating, were well known to the chemist for many years before the indispensable chemist-engineers were found to solve the large scale applications. The electro-chemical principles published by Faraday lay fifty years awaiting the development of the mechanical and electrical appliances needed to perform the chemical functions. The European monopoly of the world's supply of sulphur was broken by a man who had the courage and skill to engineer well-known physical and chemical principles and thus create a new American industry.

In the other engineering branches there is usually a prompt application of newly discovered principles, but in the chemical field there is often a long delay between the publication of a new idea and its successful industrial application. Innumerable illustrations might be cited to show the lack of correlation between the science of chemistry and modern engineering development. If the principles followed in the training of mining, civil, mechanical and electrical engineers are correct, and their results seem to justify this conclusion, the field of chemical manufacture has been sadly neglected, and the difficulties experienced in the upbuilding of many of our now successful processes have been due to a scarcity of men trained in the special field of chemical engineering.

Other engineering developments are already being hampered by unsolved chemical problems. Some of these problems remain unsolved from lack of knowledge, some from lack of resources to pursue the necessary investigations on an illuminating scale, and others from the failure to centralize engineering resources around the focal chemical point. Railroad engineers are demanding improvements in the chemical composition and manufacture of steel to reduce the number of catastrophes occasioned by the rapid increase in the speed and weight of trains. Disintegration of structural materials like cement and steel are hampering engineering development, and chemical manufacture itself is handicapped by a lack of refractory metals and materials. Fuel problems, food problems involving the conservation of life and property, are becoming more pressing as a result of the advance of general engineering. In almost every one of these difficult and important problems, the solution will come through a better knowledge of chemistry and its applications.

Some of our leading institutions are fully alive to the importance of chemical engineering as a profession and are providing excellent courses of training both in the fundamental sciences and also in the study of the applications. These chemical engineering courses require new and expensive laboratory equipment quite different in kind from that heretofore used in engineering school instruction, and infinitely more varied in its scope. The development of great laboratories of chemical engineering will naturally offer the best facilities for the investigation of great industrial problems. In such schools, men with a knowledge of the theoretical sciences may be taught the best application known to the combined engineering profession.

IRON AND STEEL MAKING

By S. T. Wellman *

ROOM FOR WORKERS. Is the profession of Iron and Steel Making a good one to follow? This is a question that is asked many times by young men who are trying to make up their minds as to what their life's work is to be.

This will depend very largely on the man. Many would not like the business at all, and some, as I have seen them do, would turn out and leave at the first sight of what the work and the conditions are, saying in effect, " None of that for me."

One young man, that I remember, many years

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During several years previous to 1870, he built Siemens Regenerative furnaces in Pittsburg, Brooklyn, Worcester and South Boston, Mass. In 1870 at the Bay State Iron Works he built the first open hearth furnace to make steel on a commercial scale. He is inventor of a tilting open hearth furnace and of the charging machine which made the open hearth furnace practicable.

Mr. Wellman is Chairman of the Board of Directors of The Wellman-Seaver-Morgan Co., also past president of the American Society of Mechanical Engineers and of the Cleveland Engineering Society; member of the American Institute of Mining Engineers, the American Iron and Steel Institute and of the British Iron and Steel Institute.

ago, at his first sight of a Bessemer Convertor turning up, sending as it always does a shower of fire across the building, turned and fled at headlong speed and never stepped inside the works again.

To me the iron business is the most fascinating in the world, all of the processes are interesting. New problems, mechanical and metallurgical, are constantly coming up to be solved.

There is plenty of room in the iron business for workers, but none for drones. The young man who adopts it for his life's work must have in the first place a good physique, he must be strong and healthy in mind and body, not afraid of work or dirty hands or rough clothes. He must expect at times to make long hours, when he is learning the business, and at times he will have to do a great deal of night work.

EDUCATION DESIRABLE. A college or technical school education is not absolutely necessary, but it is very desirable. The young man who starts in the business without such an education, must make up for the lack of it by a lot of self education at home, if he wishes ever to reach the top of the ladder. That it is possible to do this is shown by the careers of many of the brightest and most successful men in the business. Night and correspondence schools are open to the poor working boy who has the ambition to rise, and who is bound to learn all that is worth learning in his chosen profession. The very fact that he has to work hard, in the face of all kinds of difficulties, to learn what he is after, is the best beginning of a training for what is to come.

POVERTY NO BAR. Many times, when asking professors at technical schools and colleges to send me graduates for different positions, I have said to them, " Everything else being equal, I would rather have a poor boy who has worked his way through college, than a rich man's son who doesn't know the value of a dollar, and whose chief reason for being at college is to have a good time."

The common opinion is that the poor boy is the one who is handicapped in making the race for real success in life. I am not sure but that this is wrong, and that it is very possible that the rich man's son, surrounded by every luxury, who lives in a beautiful home, with a doting mother watching over him, who never learns or knows the value of money, is the one to be pitied, and is really the boy who is handicapped.

The best assistant that I ever had was a young man who was the son of a barber. He graduated at the high school, after which he went to work in the office of an iron works in his native town. In a year or two he had saved five hundred dollars. With this and the addition of one thousand dollars which his employer loaned him, he went to Germany where he stayed four years. This amount of money paid all of his expenses. Of course this was possible only by the exercise of the most rigid economy. He entered the University of Berlin, where he graduated, taking the highest honors that any American had taken up to that time. He spent all of his vacations in various iron works as a learner, thus not only getting at the details of the business practically, but making many acquaintances that were very valuable to him in after life. It is needless to say that he succeeded in everything that he took hold of. A man who goes at things in the earnest, enthusiastic way in which this young man did, is always sure to succeed.

TRYING THE WORK. A most excellent way for any young man to do who is trying to make up his mind whether he wants to learn and follow the iron business, is to spend one of his vacations, or a portion of it at least, in some steel works or rolling mill.

After this experience, if he makes up his mind that he wants to learn the business and follow it as a profession, he can go back to school and go to work in earnest to learn any and everything that will help him in his chosen field of work.

I believe it is a most excellent plan for a student to spend at least a month of each year out of his vacation in some works, seeing the thoroughly practical side of the business. Every time after doing this he will go back to college with fresh courage and a better understanding of what he needs to learn, and he will see how necessary is the purely theoretical part of his business.

Of course, no matter what profession a young man follows, one of the great advantages of a course at college is the associations and the acquaintances he makes there, which will always be pleasant and useful to him in later life.

EXPERIENCE. When he has finished at college and obtained his coveted degree, he must not think that he is fitted to take charge of any works, or even a department of it. If he has sense, he will know that he is only learning the theory of things, but the hard practical part, he has yet to learn.

A man who expects to be a leader in any business should know every detail. He should be able to take any workman's place for a short time. I don't mean to say that he should work at every branch of the trade long enough to become a first-class workman, but he should work at it long enough to get a thorough, practical understanding of it. If he does not do this and does come to a position of responsibility, not understanding the details in a practical way, the workmen will very soon find it out and they will be sure to take advantage of his ignorance.

Of course, if a young man goes into the iron business and expects to earn a living with his hands and muscles only, and to be merely a workman, skilled or unskilled, book knowledge will not help him very much. He might as well stop with a common school education. But if he wants to make his brains and not his hands do the work, he must get all the help possible from the best that books can teach. Of course the scientific school is the best place to do this.

HANDLING MEN. Workmen who have a superintendent under whom they have learned their trade, are much easier managed than if they had brought their trade with them, and its details are in any part a secret from the management. If they know that the superintendent knows as much about it as they do themselves they appreciate that, having taught them, he can teach others. Strikes are not likely to happen where the management is in such hands.

GROWTH OF THE BUSINESS. To my mind, the business of the Iron Master is the most interesting of any of the great professions. Every part of the work is full of the most interesting and picturesque detail — from the taking of the crude material from its bed in Mother Earth to the turning out of the finished iron and steel, and nowhere is it carried on in such magnificent scale as in this country in which we live.

Its products go up into the millions of tons, employing hundreds of thousands of workmen and every branch of the engineering profession.

The mechanical details of all of the necessary machinery have been so perfected that we are able to compete and send our products to every part of the world, and this in spite of paying from four to ten times as much per day for labor as is paid in other parts of the world, and also in spite of what is practically free trade and other numerous handicaps.

A few details may be interesting, showing the rapidity and cheapness with which some of the work is carried on.

In the Messabe Range in the Lake Superior district the iron ore is loaded from its bed in Mother Earth by steam shovels carrying from four to six tons per shovel. A twenty ton car is loaded in five minutes or less. These cars are hauled in trains to the ore docks from which the steamers, carrying from ten to twelve thousand tons each, are loaded in from two to four hours.

Forty to fifty million tons of iron ore are brought down from Lake Superior each year and unloaded at the various lakeports by immense machines which take from five to seventeen tons per shovelful. The largest of these machines is able to load a fifty to seventy ton car in less than five minutes. This ore is carried to blast furnaces in trains often numbering one hundred cars. Some of these trains carry over seven thousand tons of ore.

The blast furnaces are of enormous size and production. Most of them exceed five hundred tons of pig iron a day. Many of them turn out over two hundred thousand tons per year.

The steel works are on an enormous scale, twenty ton Bessemer convertors being not uncommon, while open hearth furnaces making one hundred tons per heat are quite numerous. No one thinks in these days of building smaller than fifty ton open hearth furnaces except for steel castings. The first open hearth furnace built in this country forty-three years ago, had a maximum capacity of five tons. Four to six open hearth furnaces are charged by one open hearth charging machine, which is controlled by one man. To do this work in the old fashioned way, by hand labor, would take from thirty to forty men.

The rolling of the steel shows the same progress in labor saving. The great rail mill at Gary, Indiana, if kept supplied with ingots, can easily produce five thousand tons of finished rails in twenty-four hours. This is more than one month's production of many mills in Europe.

I mention these figures to show what has already been done and the magnitude of the business. It has already gone far beyond what the most optimistic a few years ago thought possible.

Our great country has only commenced to grow and the iron business must grow with it. Very many good men are needed in the various branches, and there is plenty of room at the top of the ladder.

MARINE ENGINEERING

By J. C. Workman *

EDUCATION AND EXPERIENCE. The Marine Engineer of any ability is generally well paid, but if the young man, though he may possess the finest college education, expects large remuneration from the beginning, he will be disappointed in this profession. In either the engineering end of the business or in the hull construction branch, experience is a great asset.

The question as to whether a college education is essential in this branch of engineering has been very thoroughly discussed by Messrs. Carnegie and Crane. My own opinion, after some twenty-six years in the business, is that it all depends upon the man. However, the man with the college education will make more rapid progress than the man who,

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When the American Shipbuilding Company was formed in 1899, he was made chief draftsman of the combination. In 1911 he was made its chief engineer. He obtained his technical education at Franklin Institute, Philadelphia.

after his day's work is over, has to grind over his books with a tired brain. The company with which I am associated always shows a preference for college men, or at least boys with manual training experience.

However much experience the so-called self made or practical man may possess, he is constantly compelled to consult the scientific or college man, on many difficult and perplexing problems which can only be worked out by the technically trained mind.

NEW PROBLEMS. From the crude little "Clermont" of 1807 called "Fulton's Folly," which took thirty-two hours to make the first trip up the Hudson from New York to Albany, to the great German liner "Imperator," with her vice admiral, four captains, crew of 1,000 men in an enormous hull 918 feet long, 98 foot beam, 57,000 tons displacement on load draft, propelled by Parson's turbines of about 65,000 horsepower, combining speed with the most luxurious appointments and conveniences for her passengers, is the progress of merchant marine.

From Perry's flagship, the "Niagara," built of green lumber, with her primitive armament, to the 30,000 ton modern battleship with her battery of 12-inch guns, and protected by the best steel armor from 12 to 18 inches thick, is the story of the wonderful achievement of naval engineering of a century.

The young man who decides to take up Marine Engineering as a profession will find it most fascinating in either of its branches, hull design or propelling equipment and auxiliaries. There are beautiful engineering problems to work out, and such a variety — no two jobs alike — all vessels designed to meet the special requirements under which they are to operate.

First there is the fresh and salt water classification, the deep draft and light draft type, the latter in use on shallow lakes and rivers and usually of the side or stern wheel types. These are seen on the Ohio and Mississippi rivers. Many of this type have been built in the United States for South America, such as the steamer "Mamore." There have recently been built at Port Arthur on Lake Superior, two very fine steamers of this class, to ply on the Kootenay Lakes of British Columbia. These boats run on a draft of four feet six inches and make twenty-two miles an hour propelled by light tandem compound engines working under two hundred pounds pressure per square inch, and developing 1200 horsepower. A unique feature in the construction of these boats is the fact that they were completely built at Port Arthur, and then shipped in a knocked down condition by rail to Nelson, B. C. The first of these steamers is the "Nasookin," 227 feet over all, 40 foot beam, 8 foot deep.

The stern wheeler lends itself particularly to shallow lakes or rivers because it can be so easily steered. Usually it has two rudders, and the flow of water from the wheel against the port or starboard rudder alternately, causes the boat to come about very quickly.

PASSENGER SERVICE. A good example is found in the new side wheel steamer "Seeandbee" of the Cleveland and Buffalo Transit Company, probably the largest vessel of her type in the world, as well as the most comfortable in her appointments. Before her plans were perfected, months of conferences were necessary between the owners and ship builders. The many years experience of the owners taught them just what was most essential in cabin space and convenience for this particular route from Cleveland to Buffalo. For instance, many people have asked, why do they build side wheel steamers with inclined engines for this class of trade, when a vertical marine engine could be built with less than half the weight and cost? There are several convincing answers to these queries.

First and most important, this boat has a night run, and has accommodations for sleeping 1,500 persons who go to bed for the purpose of obtaining a good night's rest. With the type of engine in the "Seeandbee," which is an inclined compound engine of great weight and strength, developing 12,000 horsepower on about thirty revolutions per minute at a speed of twenty-two miles per hour and without any perceptible vibration, this result is obtained. A vertical marine engine with a high number of revolutions, though designed with the greatest care as regards balancing, invariably causes considerable vibration.

Then the question of deck room gained by the side-wheel type is of enormous advantage, having great breadth over the guards, giving increased room on the freight deck and more space for staterooms and cabins.

The advantage of maneuvering, starting and stopping quickly, of steadiness in rough weather, is greater with a side wheeler than a screw propeller. So it all works out for the comfort and safety of her passengers, and that is what the management endeavors to do.

The machinery of this steamer is particularly interesting to engineers, as it has novel features in valve gear, such as the introduction of the Walschaert gear commonly seen on locomotives. This mechanism drives a Corliss gear for the two low pressure engines with adjustable cut off and the poppet type valves on the high pressure. This arrangement, probably the first of its kind ever tried on a marine engine, has proven a complete success. This is an illustration of the above mentioned necessity for the Marine Engineer undertaking new things.

FREIGHTERS. The bulk freighter is designed with the view to carrying the greatest amount of cargo on a given draft. Her lines are not as graceful as a passenger boat or yacht. She is built to carry freight at a moderate rate as it is not profitable to carry freight at express speed. The vessels of the freight class on the Great Lakes usually are limited to eleven miles per hour when loaded, and twelve to thirteen miles when light. Experience has demonstrated this to be the most economical speed at which to operate.

The experimental tank at Washington, D. C., has been of great assistance to shipbuilders in determining the exact power required to drive any particular model a certain speed on a certain horsepower. These models are usually made of wood carefully sand papered and varnished, an exact reproduction of the proposed vessel, and drawn through the water at different speeds, carefully noting the power required at each step. While we know that the resistance of a ship moving uniformly at any speed may vary as the square of that speed, the power to overcome that resistance and propel it at any speed varies as the cube of that speed. But so many elements enter into the calculations for speed, such as resistance due to skin friction, resistance due to eddy making, resistance due to wave making, that it requires very experienced hands to calculate with nicety the required power without the use of the tank as a check on their calculations.

YACHTS. The yacht is in an entirely different class from either of the other types mentioned. It usually has very fine lines, and is designed for speed and for the comfort of the rich owner. She must be a thing of beauty and grace, cabins and interior finished in the rarest woods, as expense is usually no object. The American shipbuilder finds so little profit in this line of work that he is well satisfied to allow his English brother to monopolize the business. One of the finest specimens of the naval architect's art is the new "Winchester," with a speed of 32 knots, built by Yarrows & Company for Mr. Peter Rouss of New York. The aim of the engineer is to obtain the design of least weight consistent with the greatest strength. In other words, to give the vessel the greatest possible carrying capacity. It is with this end in view that the so-called "Isherwood System" of vessel construction has been introduced.

By the Isherwood System we mean the main framing of the vessel is longitudinal or runs fore and aft, instead of transverse, thus insuring a lighter boat and a stronger construction longitudinally, besides having advantages from a ship building standpoint. In the old method of construction, liners are necessary between the framing of the vessel and the plates, due to the lapping of same. These liners amount to about 2 per cent. of the shell. A vessel constructed under the Isherwood System will weigh from 8 to 10 per cent. less for the same strength than under the transverse method, and enable her to carry more cargo on the same draft.

BUSINESS SIDE. Then there is always the business side to be considered. Though an undertaking may be a complete engineering success, if the financial part is not satisfactory there is small credit for the engineering end. It may have failed through lack of proper supervision in the shop or on the field, or it may have been the designs were expensive from a machine shop point of view. A little more consideration in the drafting room might have saved the profit.

I have spoken of the great value of observation; among the most prized possessions of engineers are their private note books. Text books and treatises are great helps to them, but the personal notes and sketches of good details, the results of personal experiences jotted down from time to time, also well tried formulas and results of tests that they have from their own knowledge secured and know can be depended upon, are of the greatest value.

The modern warship, ocean liner or first class cargo steamer is becoming more and more a concentrated power station or great machine shop. The old fashioned sailor is fast disappearing, sails and rigging are becoming a thing of the past. The comforts and luxuries of every sort demanded by the traveling public have made the ship more of an engineering problem than formerly.

The Marine Engineer must have a good idea of Electrical Engineering as this equipment is becoming more and more of a necessity on shipboard and is likely soon to be used on all auxiliary machinery. The electrical apparatus on warships and big liners is enormous — the cost of electrical equipment on one of our latest battleships was $300,000.

OIL ENGINES. The Diesel oil engine, or the internal combustion motor, has opened up a new and interesting field for the marine engineer. While so far not very much has been accomplished in this country, a great industry has been developed abroad, and a large fleet of Diesel propelled vessels are in the commerce of the world. Tankers up to 15,000 tons displacement are being built with this type of motor, as well as some German warships. At present there are but two of any size being operated on the great lakes. The "Calgary" of about 700 horsepower, and the "Fordonian" of 900 horsepower. Both of these are foreign built vessels and Canadian bottoms.

The chief difficulty for the Diesel motor in the United States, where coal for marine purposes is so cheap, is the uncertain supply of crude oil or petroleum, which cannot at present be satisfactorily or regularly procured at a reasonable price. If this were not so, I can see no reason why this method of propulsion would not rapidly supersede the present steam engine. The principal advantage is economy in operation as regards the amount of fuel consumed which is only about four tenths of a pound per horsepower, while the coal consumption is from one and a half to two pounds. There is a smaller engineering force, also a gain in weight and space by doing away with trimming, a longer radius of steaming under one fueling, also a saving of fuel while the vessel is in port and many other advantages that might be mentioned.

PLENTY OF OPPORTUNITY. The opportunities in this country for the marine engineer are many. If he wishes to follow the profession of a designer, he will find shipyards of more or less importance on nearly all the rivers and lakes from Maine to California. If he wishes to follow the sea, there was probably never a greater demand for young men of education than now. On our own lakes good men are needed. The old type of engineer is fast becoming a thing of the past and our big steamship companies are looking for men of engineering education. They find it pays to have their investment in the hands of men who understand the theory of it all, as well as the practical end. Some of them have established winter classes for the betterment of their men.

The remuneration for this type of men is very good and exceeds that of the average office man by far.

In consequence let me emphasize the importance of having at least most of the qualifications that have been spoken of in this article. Unless you are a born engineer, you are not likely to be a success as I have been taught to measure success.

SANITARY ENGINEERING

By R. Winthrop Pratt *

PUBLIC HEALTH. Sanitary engineering comprises the design and construction of all engineering works which are built for the purpose of protecting the public health. In other words sanitary engineering relates to the practical application of the principles of public hygiene, through the medium of civil and hydraulic engineering, combined with chemistry, biology and physiology. The term "public hygiene" may be defined as "the science and the art of the conservation and promotion of the public health." It has for its functions the prevention of

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At present he is consulting engineer to the city of Cleveland in charge of the Sewage Disposal plans and investigations and also of the preparation of the detailed plans for the new water filtration plant.

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premature death, and the promotion of life, health and happiness in communities through the elimination of unfavorable environmental conditions.

Speaking more definitely, the field of sanitary engineering comprises the installation and maintenance of public water supplies, water purification works, sewage systems, sewage treatment works, and garbage disposal plants; also the ventilation, heating and plumbing of public and other buildings. The last named work, however, is generally considered as being in the field of the architect, ventilating engineer or plumbing expert.

ANTIQUITY. Probably the first sanitary engineer on record was Moses, who gave instructions (Deut. xxiii: 12, 13) that all refuse be carried outside the camp and buried or burned, thus establishing a primitive sewage and garbage disposal system. The aqueducts and drainage systems in ancient cities were distinctly sanitary engineering works, although the motives and basis of design were quite different from those of the present day. The inhabitants of those cities established a water supply or drainage system, simply because they desired to be clean and comfortable. The fact that these works protected the public health was then incidental, as nothing was known of the science of bacteriology or the germ theory of disease, it being once believed that sickness was caused by the presence of evil spirits (Demonic theory) or to the improper proportion in the human system of blood, phlegm, yellow bile and black bile (theory of the four humors).

A NEW SCIENCE. Sanitary engineering as it is now considered did not come into prominence until after the development, about thirty-five years ago, of the science of biology, which resulted in the working out of the principles governing the causation and transmission of such diseases as typhoid fever, cholera, malaria and yellow fever. The greatly increased concentration of people in cities and communities during the last thirty or forty years has created an urgent demand for sewerage systems and water supplies; and the development of tropical countries has called for the highest skill of the sanitary engineer. The most notable example of the importance and effectiveness of sanitary works and well administered sanitary laws is the Panama Canal, which could not have been built but for the elimination or control of the causes of the infectious diseases which had existed in the Canal Zone for years past.

A recent illustration of the possibilities of good sanitation combined with good medical service, is afforded by the National Encampment at Gettysburg, July, 1914, of the Northern as well as the Southern veterans of the Civil War. Gettysburg is a small town of not over 4,000 people. Previous to the Encampment it had a public water supply, but no modern sewage disposal system. To safely care for about 100,000 old men, many in poor health, in such a small place and in the hottest weather, was a difficult problem and authorities estimated that at least 500 deaths might be expected. The United States and Pennsylvania state health officials took charge of the sanitation; and with ample funds at their command, secured proper water supply and sewerage facilities, built rest rooms, hospitals and dispensaries and provided an organization of physicians, nurses and inspectors. As a result, the number of deaths during the encampment was only ten instead of five hundred, which was lower than the rate would have been if the soldiers had stayed at home.

TRAINING AND QUALIFICATIONS. The most prominent sanitary engineers now practicing in this country have obtained their training in different ways. Some have been first trained as civil or hydraulic engineers, and have later studied or practiced chemistry and biology to an extent sufficient to make them well qualified sanitary engineers. Others have begun as chemists or biologists and have later obtained engineering knowledge and training. This latter class have succeeded in most instances by virtue of their natural ability and personality rather than by virtue of having had their preliminary training in the laboratory instead of through engineering work.

In view of the usual demands and responsibilities incidental to the practice of sanitary engineering, it would appear that the more logical program would be for the prospective sanitary engineer to secure first a fundamental training in civil and hydraulic engineering, and at the same time, or later, obtain such knowledge of chemistry and biology, as well as of the various branches of public health work, as may be necessary to properly qualify him for his profession. On the other hand, there is a certain group of sanitary engineers who are called to positions involving the maintenance and operation of water purification and sewage disposal works; and such men should have fundamental laboratory training in chemistry and bacteriology.

INSTRUCTION. Courses in sanitary engineering are now given at some of the leading colleges. These courses comprise a thorough training in civil engineering, the design of structures and bridges, and hydraulics. Particular attention is given in these courses to the sanitary side of the questions of water supply, sewerage, drainage, and methods of purifying water and sewage, the relation between drinking water and disease and other questions relating to the public health. The sanitary engineer must understand the principles of chemistry and biology sufficient at least to co-operate with and interpret the results of the researches of chemists and biologists.

SCHOOL OF PUBLIC HEALTH. Quite recently, there has been established, jointly by the Massachusetts Institute of Technology and Harvard University, a School of Public Health to which graduate students only are admitted; and which confers upon its graduates the degree C.P.H. (Certificate of Public Health) and qualifies them to hold administrative positions in public health work. Students may enter this School of Public Health after receiving either a degree in Sanitary Biology, a degree in Medicine, or, with certain qualifications, a degree in Sanitary Engineering. The course after entrance is such as to supply the necessary medical knowledge to those entering with degrees in engineering or biology; and the necessary engineering and biological work for those entering with a degree in medicine. With the degree of C.P.H., the student will be fitted to take charge of health department work involving the practical application of all the principles of public hygiene or "preventive medicine."

DEVELOPMENT OF SANITARY ENGINEERING. The last thirty years have been largely a period of research in matters relating to the treatment of water and sewage. One of the pioneer steps in this country was the establishment in 1890 at Lawrence, Massachusetts, by the State Board of Health of that state, of an experiment station for the purpose of studying and working out methods of water purification with an idea of giving to the cities and towns of Massachusetts advice relative to securing safe water supplies and protecting streams against pollution. The results of the experiments at Lawrence have become classic in the art of water and sewage purification; and have been used as a basis in the design of large works in Massachusetts and in other states, as well as abroad.

CITY LABORATORIES. The value of the Lawrence researches, as regards water purification, was somewhat limited by reason of the fact that river waters in Massachusetts were different from those in the Middle West. In 1897 and 1898, therefore, the cities of Louisville and Cincinnati, in order to thoroughly study their respective problems of water supply, conducted extensive experiments on the treatment of the Ohio River water; and these have added greatly to our general knowledge on this subject. A few years later, the cities of Philadelphia, Pittsburgh and New Orleans also conducted tests on treating water supplies; and the results of these tests have served as a basis of design for water filtration works, since constructed not only in the cities mentioned, but also in other places. Several cities also have conducted tests on sewage treatment under their respective local conditions; and the total amount spent in this country to date for making these researches and tests equals about $1,000,000.

Owing to varying conditions in different parts of the United States with respect to geological and topographical and other conditions, methods of sewage and water purification suitable for one place may not be satisfactory for other places. As a result of numerous studies, however, the methods of water purification have been fairly well standardized during the last thirty years, so that an engineer may now be safe in designing a plant to cover a given set of conditions. The same may be said of sewage treatment methods, although probably to a less extent.

As regards the disposal of garbage, this question has been given less attention by independent consulting engineers than have water and sewage problems; and the progress in garbage treatment methods has been made largely by manufacturers who have worked out their own patented devices. More recently, however, city officials and others responsible for the solution of garbage problems have come to feel that it is worth while to call in consulting sanitary engineers to study the problem in an unprejudiced manner, rather than to deal only with patent owners and manufacturers of apparatus.

Summing up briefly the progress which has been made in sanitary engineering in England and Europe during the last forty years, it may be said that owing to the more thickly populated districts, much more study has been given to water, sewage and garbage problems. Water filtration and sewage treatment works were installed by London, the world's largest city, long before any of the American cities had thought of these problems. A number of German cities installed water filtration works some twenty years ago. The number of experienced sanitary engineers in England, and possibly in Germany, is therefore relatively greater than here, and their work has been of great value to American engineers affording data as to efficient methods, and equally important data concerning the methods which have failed.

OUTLOOK. The young man who may think of entering the field of sanitary engineering should analyze for himself, as far as possible, the conditions which will cause his services to be in demand. The amount of sanitary engineering work which is being or may be done in a given district depends primarily upon the degree to which the people of that district have been educated to see the need of proper sanitary works and upon the extent to which this education is reflected in the state laws. Cities have not in general been prompt in installing of their own accord sewage treatment works, especially where they are located upon rivers or flowing streams, and the direct benefit of sewage treatment is to those living on the stream below. It seldom has occurred that under these conditions a city has built sewage works unless forced to by a court order or by the state authorities. Therefore, in the absence of national laws controlling stream pollution, those states having the most stringent laws on this subject are those in which the most sanitary engineering work is being performed.

Nearly all state legislatures have passed some sort of laws seeking to control stream pollution, but less than a dozen of them have really effective laws. The laws of Ohio are among the foremost, as is evidenced by the fact that this state ranks second in the number of sewage treatment plants in operation.

As regards water purification works, these are usually built by reason of popular demand by the citizens for pure and clean water. As the standards governing the quality of public water supplies are constantly becoming higher, water purification as a branch of sanitary engineering is becoming more and more important.

Then, as mentioned above, consulting sanitary engineers have as yet given but little attention to garbage disposal in spite of the many involved problems in this branch; and allied to this are the problems of the disposal of city refuse, rubbish or dry refuse, and also of certain trade wastes. These afford an interesting and promising field of endeavor.

MUNICIPAL ENGINEERING

By Robert Hoffmann *

RECENT ORIGIN. Municipal engineering is a term which refers to an adaptation of engineering work that has developed with the growth of cities. The application of the name "municipal engineer" is of comparatively recent origin, and signifies a civil engineer, who specializes in the engineering work necessary in municipal development, and who is generally in the regular employ of a municipality.

Naturally the work is diversified, including, as it does, the many engineering branches represented in city work. Different cities vary in the number of branches of subdepartments, which are grouped under the control of what is generally termed the city

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After finishing college in 1893 he entered the city engineering department, where he has since been employed in various capacities. In 1907 he was made chief engineer.

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engineer, or the chief engineer of the department of public works, or public service, as the case may be. The smaller cities usually find it necessary to place all the engineering work required in their development under the control of such an official, but in the larger cities, where the amount of work would become too great for one department, it is frequently subdivided, so that water supply undertakings, city lighting, sewage disposal, or any other large and important subdivision is placed under separate supervision.

SURVEY DEPARTMENT. Usually there is a department of surveys, dealing with the laying out and platting of streets, the keeping of records connected with the establishment of survey lines and allotments, the numbering of houses, the naming of streets and other matters having part engineering and part legal relation to the proper laying out of a city's lands. Recently considerable attention has been given to "city planning." This could logically come under the direction of the department of surveys, and has to do with the proper development of growing cities, so that streets of adequate sizes may be provided, suitable parkways, breathing spots and playgrounds planned, proper channels for rapid transit fixed, and, in general, that the numerous activities and demands which necessarily accompany the rapid growth of modern cities may be anticipated by a suitable systematic plan of development of their lands, waterways and streets.

ROADS AND PAVEMENTS. Nearly all municipal engineering departments will be found to have a division of roads and pavements, having in charge the paving of streets. The usefulness of such a subdepartment appeals to all, as suitable pavements are recognized universally as necessary to commercial welfare, so that reasonable loads may be easily and safely transported. They are also necessary from the viewpoint of health, as a well paved city makes possible cleanliness and better sanitation. To select and plan proper pavements for varying conditions requires a broad knowledge of materials and methods used in road construction, and also an intimate acquaintance with the character and amount of traffic to which such roads may be subjected, as well as the nature of the surrounding section in which the road is to be located. Good pavements now require scientific planning and treatment, and must have the direction of an experienced engineer, capable of keeping abreast of the times, in matters of paving development.

SEWERS. The building of sewers is another important subdivision of municipal engineering. Sewers provide for the drainage of storm and ground waters, in addition to various waste matters removed by means of plumbing fixtures, and commonly known as sanitary sewage. Sewers comprise one of the basic city improvements, as without them no road can be properly drained, and no suitable condition established which permits the grouping together of buildings and people in sanitary surroundings.

Usually preceding a sewer system, and equally important, and even more necessary, is a good and wholesome water supply. The securing of a potable water supply has, ever since ancient times, required the talents of the best engineers, and many marvelous examples of aqueducts, tunnels, dams and reservoirs have been constructed, so that cities might be supplied with that great blessing, a pure and adequate water supply.

BRIDGES. As cities have grown, and streets were extended, it has been found necessary to construct bridges, so as to afford easy crossing of rivers, gullies and valleys, and as a consequence nearly every city has a subdepartment of bridges, performing some of the most interesting work in civil engineering. A beautiful, graceful bridge is admired by everyone, and the daring and ability whch have been shown in some of the bridge erections have become classic in engineering literature.

The elimination of railway grade crossings of city streets has, in recent years, added greatly to the duties of city bridge engineers, under whose direction such elimination is usually placed.

Where cities have water fronts the development of rivers and harbors likewise requires an important division of municipal engineering to supervise the necessary construction work.

The laying of sidewalks and frequently the repair and maintenance of structures built under the direction of a municipal engineering department also form subdivisions, requiring the attention of such department.

The work of all these various departments is more or less correlated, and to a certain degree must be considered in connection with city planning, as all are essential to the making of a modern city, and necessary for the welfare, health and happiness of its citizens.

MANY ENGINEERS NEEDED. As the amount of work carried on under the direction of the engineering departments of many of the large cities is extremely great, costing frequently millions of dollars annually, there is naturally a demand for a large force of engineers and assistants, who are called upon to plan and superintend the many projects which this enormous amount of work comprises.

There is considerable variation in the detail arrangement of the organizations of the different municipal departments. Usually, however, there is a chief engineer, having general supervision and direction; a number of assistant engineers, each one of whom is in charge of some important subdepartment, and a larger group of other assistant engineers, each directing some phase of the department's work. There are engineering corps for the outside work, such as the field work necessary in making surveys and miscellaneous measurements, and that needed in furnishing the information required, so that the construction work may be carried on as planned. Such parties or corps are usually composed of a chief of party known as a transit or level man, depending upon whether his work requires the use of a surveyor's transit or level, and in addition two or three helpers, known as rodmen, chainmen or axmen. There are also many inspectors needed in the field, whose duty it is to be always present when the construction work is in progress, so as to see that it is done in conformity with the specifications.

In the office there are employed many designers, calculators and draftsmen, who make the plans and drawings, figure out the estimated costs of work, calculate the payments due to contractors for completed construction work and also attend to numerous other duties connected with the office work of an engineering organization.

The compensation paid to municipal engineers is not high and is about on a par with that paid in other fields of engineering. If a young man starts in as chainman he will be paid from $40 to $50 per month. As rodman he may receive from $60 to $65, and as transitman from $75 to $100 per month. Draftsmen are paid from $70 to $125 per month, depending upon the class of work they are capable of doing. Assistant engineers are paid from $1500 upward per year, depending upon the character of work supervised, its magnitude and the city in which it is being done.

Experience in a field party as chainman, rodman and instrument man and in the office as draftsman is quite essential in the training of an assistant engineer. Experience as an inspector of construction work is also desirable, and the young man who obtains the opportunity to train himself as an inspector, as well as in the field parties, and as draftsman, is exceedingly fortunate, and will find it a great help in his later work as assistant or chief engineer.

Every position in engineering work, whether compensated by a small or large salary, is important; there, the young man entering this field of work, shows his wisdom if he considers his position of importance and tries to do his work as excellently as possible. This is the surest way of being called to the next higher position in responsibility, and receiving with it a more generous salary.

SPECIALIZATION. To be reasonably successful in municipal engineering work, it will in most cases be necessary to specialize, so as to learn at least one branch exceedingly well. This will make possible becoming the head of a subdivision or department. From the heads of departments a choice will generally be made when it is necessary to fill the position of assistant chief or chief engineer.

To receive advancement means not alone good effective work in the specialty chosen, but also requires that an interest be taken in the work of other departments sufficient to keep in touch with what is there being undertaken.

An interest in matters pertaining to civic welfare in general must be taken by every engineer in municipal work hoping for success, as it will be found, upon analysis, that in nearly all such matters, some branch of engineering is called upon to play some part. The engineer, therefore, who can see beyond the limits of his technical work, will always be of use in these allied matters. For example, the sewerage engineer, or the one interested in water supply, should in addition to the technical details of building sewers or purifying a water supply, be familiar with and take an interest in general sanitation, in street cleaning, garbage removal, and in all matters pertaining to public health. Similarly, an engineer of bridge construction, in order to make himself the valuable man he should be, ought, in addition to his studies in strength of materials and design of foundations, also to be a student of architecture, so that his work may not only be strong but also beautiful.

In all the various divisions of municipal engineering, the employes who wish to succeed should keep in touch with the public pulse, so that the work may be done in a manner to fit the changing conditions, and not necessarily in the way it always has been done. The old saying, "Be not the first by whom the new is tried, nor yet the last to lay the old aside," is possibly nowhere more fitting than in the applications of municipal engineering. This presupposes and makes necessary an intimate knowledge of what is being done elsewhere, requires frequent attendance at meetings of engineering and civic societies, also the reading of technical and other journals, whose contents relate to municipal affairs. To one who is willing to do all these things the pleasure derived will be its own compensation and make the work successful, even if the financial return be not as great as might be expected.

INCREASING OPPORTUNITIES. Wherever people congregate in large numbers to make their homes and carry on their business, there must be a demand for the work of municipal engineers. Where people mass, there must arise a demand for a pure and plentiful water supply, for efficient sewerage, well paved streets, connected where necessary by strong and beautiful bridges. Therefore, as the modern tendency appears to be that people will continue to flock to the great centers of population, our cities, it seems that municipal engineering should prove an attractive field for any engineer who is willing to work and take upon himself something more than the routine matters which may be forced upon him.

Great undertakings, the fruit of engineering genius, are no more lacking in city development than in the railroad or mining fields, which are well known to teem with accomplishments of a picturesque or spectacular nature. All admire the fortitude and ability of the early railroad engineers who penetrated the wilderness locating railway lines, and who brought into being long lines of steel, climbing almost unattainable mountains, and stretching across unpeopled, barren plains, all done so that the transportation facilities required by modern progress might be adequately provided.

Equally daring and momentous, though undoubtedly less picturesque, are the many examples of city streets, lined with huge buildings, and filled with busy traffic, which are bored through in order to build great drainage sewers, or construct subways for transportation purposes. Hour after hour, day after day, even unto year after year, a busy army is working away removing earth, then placing masonry and steel in its place, so that the health, happiness and comfort of a multitude may be conserved. All this requires the guiding hand of some engineer conversant with municipal conditions, so that a systematic development may be maintained. Think of leveling off a small mountain in Seattle, going miles upon miles for a water supply, as in New York city or in Los Angeles, lowering streets alongside of great buildings, as in Pittsburg, building the drainage canal in Chicago, ridding towns of disease by constructing sewer systems, as has been done in so many cases, or removing dangerous railway grade crossings. What can be more inspiring than being associated with the organization that plans, directs and completes undertakings of such magnitude, and having for their object the public benefit such as these.

Municipal engineering must be considered as a good and growing field of endeavor for the engineer who is ambitious, energetic and capable, but like most other lines of work, it offers little for the indifferent, lazy or incapable.

THE MUNICIPAL NEED OF TECHNICALLY TRAINED MEN

By Rudolph Blankenburg *

Municipal engineering began in Philadelphia with an official who was known as a " Regulator." His principal function seems to have been to see that the rain water running off of Dietrich Hydrocrimper's lawn followed the proper course, and did not unduly disturb his neighbors. All questions affecting water courses and the laying out of roads were left to this official. He worked practically without instruments.

After a while, the demands for improvements and supervision were such as required more technical knowledge, and some few instruments were introduced and used: thus the " Surveyor " made his bow to the public. From those days to this, the problems of municipal administration have been

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multiplying and with them increasing the number of experts. It would be very interesting to list the experts of different kinds now in the employ of the city of Philadelphia. We have undoubtedly over one hundred different kinds of technically trained and educated men whose knowledge of their subject has become sufficiently extended to be considered scientific.

DEMAND FOR EXPERTS. During the past generation or two, it seems to have been one of the fallacious contentions of democracy, as we have applied it in this country, that if you can get enough different people to consider and try to solve a given subject, you are then pretty sure to get a wise decision. In fact, at times and especially in some localities, the thought has been encouraged that the larger the number of people who discuss a certain subject, the more apt you are to get a sound decision. This false idea, applied to municipal administration almost with the passion of religion, has held it for ten or twenty years on a very low technical and administrative level. The idea was fostered by politicians who wished to keep possession of the municipal reins and purse-strings for their own selfish ends. They tried to teach the electorate that, if anybody who really knew anything about a municipal subject was called to act, their liberties were threatened in some mysterious way. But with the tremendous increase in the size of our city and the rapidly growing percentage of our population that lives within metropolitan areas, the game has gotten too fast for a mere playground. Even the ablest and most unscrupulous of our politicians and those who are holding on tightest to their political control are to-day calling in the experts and leaning on technically trained and educated men.

Probably the first example of this was the development of the New York city water supply. For over twenty years, that municipality has taken the position that the water supply, first of Manhattan and later of Greater New York, was too serious a matter to be made the football of politicians, and almost from the start this work has been in the hands of able men and practically free from political domination.

The present period is remarkable in that we are beginning to look upon practically everything that is done by the municipality as an engineering or scientific problem, as we are approaching everything from the standpoint of laboratory rather than thumb rule. Take street cleaning, for instance; there is rapidly being developed a formidable literature on the subject. More and more complicated and efficient street cleaning machines are being built. The hand paraphernalia is being studied in order to make it easy to get the best results, and an enormous amount of work has been done on the preparation and study of costs. The control of this work has been studied both here and in Europe, so as to be able to make the money expended give the best possible results. This was formerly considered a matter that was beyond the province of science or technical knowledge.

RAPID PROGRESS. After having said all this, it is fair to add that if you ask any street cleaning expert whether any part of our present methods will be retained in the street cleaning scheme of a few years hence, he will surely reply "no." In other words, everything that we are doing to-day is so far from satisfactory that it is bound to disappear and be supplanted by a system, the details of which we know but little to-day.

Another striking instance of our present day attitude is the matter of selection of laborers. Four years ago if anybody had suggested that high class physicians and other technical experts should be called to help solve this question they would have been laughed at. A laborer was supposed to be somebody who was just "a laborer" and no one asked any further questions. The other day, in Philadelphia, out of 450 men examined for laborers, perhaps two-thirds were rejected by the doctors and others who examined them, and rejected for perfectly obvious reasons. A great many of them were suffering from hernia and other maladies which clearly showed their physical disabilities for heavy laboring. At the present time, the tests that these men are being subjected to are largely physical, but now everybody admits that there are tests beyond these that must be developed if the city is to be a model employer. We must be able to determine what the chairman of the Civil Service Committee has aptly designated the man's "singing qualities" that is, the relative amount of joy he has in his work. A man who loves his work, no matter in what occupation, will do good work.

Street lighting is just beginning to take its place as a subject for scientific inquiry on the part of municipalities. Private corporations have been collecting an enormous amount of technical data, covering at least a part of this field, but up to within the last two or three years, cities themselves have had no technical data that could be depended upon. In this field the demand has come about through the various city and state Public Service Commissions. These commissions have inquired into the technical aspects of the work carried on by different public service corporations, and they have forced both city and state to employ men competent to compete technically with those in private employ.

Sewage disposal represents an entirely different class of municipal problem, requiring scientific attack, in that it is brand new. The best of these methods come from Germany, and they are the development of the last few years. The sewage disposal method which obtains over the greater part of Europe is now absolutely obsolete. Most American cities have not begun the study of sewage disposal problems.

SUITABLE REWARD. In the past cities have had too small a number of officials with large salaries and too large a number of laborers at low compensation. The tendency has been to have too many employees at medium wage; the consequence is that the best men have gone to other employers. If the city is going to place itself in the position where it can compete technically, it must learn that men with technical skill and training are commanding increasingly high salaries in private or corporate employ, and we must be ready to meet them or lose their services. At the same time, it must learn to do the lowest grade of work with men well qualified for it and paid more than they are paid by private enterprises.

A further evidence of the interest that is being taken by technically trained men in municipal work is that a number of the different colleges are now offering courses not only in municipal administration, but in municipal engineering. The number and scope of these courses are increasing very rapidly.

Efficiency in municipal government becomes more and more dependent upon men of thorough engineering and scientific training. Let the cities of our country vie with one another in taking the first rank in the advance line of thought and performance.

BRIDGE ENGINEERING

By Frank C. Osborn *

ANCIENT ORIGIN. Of all the various branches of engineering, as we now know them, that of bridge engineering is the most ancient. From the dawn of human history rivers had to be crossed and the primitive savage, when he placed a fallen tree trunk across a small stream became a bridge builder. When he had to give some consideration to the selection of a suitable site, determine the proper length of the log, the size necessary to carry the load and the best way of getting the log in position, he began to be a bridge engineer. When the stream was so wide that no available log would reach across and he had to provide

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a middle support of piled stones he was beginning to make advancement in the art. He knew nothing of our modern methods or instruments of exact surveying, of mathematics nor of the strength of materials, but he gained in knowledge by practical experience and each failure taught its lesson perhaps more forcibly than did the successes.

As small communities grew into villages, towns and cities, and civilization advanced, bridges had to be more capacious, stronger and of greater permanence. The character of its bridges has always been indicative of the enlightenment, culture and wealth of a community, and the history of the world is clearly reflected in the history of its bridges.

As timber was cheap and plentiful and cost an important consideration, it was largely used in early bridge construction. Piers and abutments were made of timber cribs filled with loose stones, and superstructures were made of hewn timbers framed together in various forms or of planks arranged in lattice form and joined by means of wooden pins or treenails, as they were called.

In some localities timber was scarce and stone plentiful and small bridges were made of flat slabs or beams of stone resting on stone piers. The ancient Greeks built many such.

In many cases neither stone nor timber was suitable. The materials may have been present, but the necessary tools or machinery, or the skill and experience required to utilize them were lacking. Certain locations, too, were unsuited for either stone or timber, even if the material and talent were available.

But even in those older days "Necessity was the Mother of Invention," and so the suspension bridge was born. The earliest types were crude, but they showed ingenuity and they accomplished their purpose and at small cost. A simple form consisted of a single rope carried across the stream or chasm and each end attached to a tree or other support. From the rope was suspended a basket or crude car which was drawn across by a similar rope or cord attached to it and leading to the other side of the bridge. Such bridges are still used in parts of India and South America, and some of them are of sufficient strength to transport loaded mules. The ropes were often made of plaited thongs of hide, of twisted vines or rushes or of split rattan.

Another simple form consisted of a single rope, stretched rather tightly, with a smaller one on each side and a few feet higher, to serve as a hand-rail to keep the passenger from falling off.

Cantilever bridges of timber poles and logs have been built by the Indians of North and South America and by the Chinese. They were made by placing the logs in cob house form, each successive course stepping or corbelling out until the space between the arms was small enough to permit a single log to reach across it.

These primitive structures were the beginning of what is now known as bridge engineering. The arch was used probably 4000 B. C., and it has been made of mud, brick, stone, wood, concrete, cast iron, wrought iron, steel and finally of concrete reinforced with imbedded steel. It has taken various forms, circular, elliptical, parabolic and pointed. In the early days, and in fact up to a comparatively recent date, arches, as well as other types of bridges, were built by trial, by experimenting on small models, and by means of the knowledge obtained through the construction of previous structures.

INTERESTING EXAMPLES. An interesting example is that of a stone arch bridge in Wales, the Pont-y-tu-Prydd, which washed out shortly after being built and, as it had been guaranteed for seven years, the contractor was compelled to rebuild it. The second structure failed because the haunches of the arch were so heavy that the center of the arch was forced upward. This experience led to the building of a third bridge, in which the haunches were materially lightened by means of large circular openings and by using charcoal instead of earth for filling. This structure was a success, but the lesson was an expensive though valuable one.

A different case is that of the Britannia bridge, also in Wales, and designed by Robert Stephenson, which was built in 1845–50, and consists of two independent continuous, rectangular wrought iron tubes through each of which runs a railroad track. The piers were continued above the tubes in the form of towers to carry suspension chains for providing additional support to the tubular girders in case it was found necessary. On trial the tubes were found to have sufficient strength and the chains were never used. The expense of the stone towers was, therefore, shown to be entirely unnecessary. The judgment of the engineer has, however, been commended for the reason that his structure was unprecedented, involved a total expense of about $3,000,000, and that it was the part of wisdom to be safe rather than sorry.

Bridges were constructed by carpenters, masons, blacksmiths, preachers, priests and monks, and many of these early structures, notwithstanding the lack of scientific knowledge, were remarkable for the high degree of skill, boldness and ingenuity displayed. At times architects were associated with such work, and some of the most beautiful bridges of this and former times have been the result of a harmonious co-operation of architect and engineer.

RECENT PROGRESS. One of the most interesting features in the history of engineering is the fact that it is less than one hundred years since bridge building became a science. Many noble and notable bridges have been erected during the past centuries, but they had been built without knowledge of the stresses developed in the various parts of the structures or of the strength possessed by the different materials to resist such stresses. It is only since 1824 that we have had accurate scientific knowledge of the laws of elasticity as applied to simple beams and to columns.

It is even more remarkable that the first correct analysis of the stresses in framed structures was published only as far back as 1847. This book was written by Squire Whipple of Utica, New York, and it is said that he also set up the type and printed the book himself. Up to that time bridge building throughout the world was empirical and might have been called an Art, but not Science.

PLANNING. To-day the building of an important bridge involves scientific knowledge of various kinds and of high degree. A thorough study must be made of the characteristics of the stream to be crossed and of the materials underneath the riverbed. A decision must be made as to the depth at which the foundation shall be placed and as to the number and exact locations of the piers. This may involve several approximate and alternate estimates of cost of both sub- and super-structure for the total cost is the sum of the two.

After the site has been definitely determined the general design must be fixed. This involves a study of the loads to be provided for, width of roadway, kind of material to be used, wood, stone, steel or concrete, and other matters pertinent to the particular structure, its location and immediate and probable future use.

The general design having been evolved, accurate calculations must then be made to determine the stresses to which each member of the bridge will be subjected and to fix the form and size to properly withstand such stresses.

After the main features have been determined detail drawings must be made of each piece entering into the structure, and these drawings must show completely every form and dimension down to the size and location of each rivet and bolt. The drawings must naturally be accurate and the work must be made strictly in accordance with them, for the reason that the pieces are made and shipped as separate units and do not meet until they assume their final position during the erection of the structure. They should meet amicably and not have to be driven together with damaging force or cut and bruised before they can be made to meet at all.

The field of bridge building is a large one and will continue to be so for many years. As new steam and electric railways, new county and state roads are built, new bridges are needed. As grade crossings in cities are abolished much bridge work is required. The natural growth of many cities calls for new bridges across rivers or valleys. Old bridges of wood are decaying and being destroyed by fire. Many bridges, both old and new, have been completely destroyed by the floods of recent years. The steam railways, because of the continually increasing weights of locomotives and cars, are being compelled to replace their bridges with stronger ones. Some roads are already using the third generation of steel bridges.

QUALIFICATIONS. The question is asked, "What qualification should a young man have to enter the field of bridge engineering?" In the first place he should have natural taste for mathematics and drawing, because they constitute, to a great extent, the language of the engineer. He should also have imagination because designs are thought out before they are drawn out. He should have initiative and originality, for seldom indeed are two bridges alike, and each new bridge presents its own new problems. This continual variety is one of the fascinations of bridge engineering. It is certainly desirable, and most engineers would say it is essential that the young man have a technical education. His competitors have it and he is surely handicapped if he does not have it. If he has exceptional natural talent he may succeed without it, but his success would be greater and quicker with it. In addition he should have the qualifications that are necessary to success in any business or occupation; a sense of duty and loyalty to his employer, conscientiousness, a willingness to do whatever is assigned to him to the very best of his ability, together with self-reliance and confidence in himself. In any event, he should love his work, for it will be his daily companion for years, and loving it he will enjoy it and this means contentment, and "Contentment is better than riches." If his heart is in his work he will succeed, if not the chances are against him.

A young graduate from a first-class technical school can usually find a position as draftsman in the office of a bridge manufacturing company or contractor, in the office of the engineer of a railway company or with an engineer in private practice. He will get a salary at the start that will support him comfortably. From that time his success depends primarily upon himself, and progress is governed by the character of his work, his personality, circumstances and opportunity.

He may become the engineer of bridges for a county, city or state. He may become the chief engineer of a bridge building corporation and from that position become its president. He may become the engineer of bridges for a large railway system and from that become the chief engineer, and chief engineers of railway systems have not infrequently been made vice presidents and presidents.

ARCHITECTURE

By Benjamin S. Hubbell *

PRIMITIVE ART. In the very beginning Mother Nature imparted to many members of the animal kingdom the necessary knowledge required to construct some kind of shelter which would protect them from the elements and at least partially secure them against their enemies. In addition to this knowledge, to man was imparted the secret of creating and controling fire, and to the knowledge of this secret man owes his entire civilization. It gave him a most potent weapon against all other animals; it allowed him to warm his body, cook his food, and to fashion metal utensils, instruments and machinery with which he has been able to conquer and subdue the earth.

At first man erected a shelter simply as a means

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Mr. Hubbell graduated from Cornell in 1893 and took post-graduate work for a year. He is a Fellow of the American Institute of Architects, to which he was elected in 1903.

of protection, but he soon developed so that in order to satisfy him, the shelter must not only give protection but must also gratify his longing for the beautiful; thus architecture was born, and from that day to this it has been growing and developing.

All agree that the art of architecture is the greatest art of man. It is the art that has made higher civilization possible. It should be considered as a constructive art when the designer has simply satisfied the practical considerations of the problem, but when in addition to this the designer has created a building of beauty it should be considered a fine art.

History shows that from the earliest times architectural designers have striven to enter the elusive field of art and have earnestly tried to create buildings which will not only satisfy the practical conditions, but which will give pleasure to the eye as well.

Considered from an engineering point of view, a building is entirely successful when it meets the practical needs for which it has been erected, but if a building only meets these needs and does not appeal to the imagination and to our love of the beautiful, it fails from an architectural point of view. The foundation of all architectural design should be based upon the practical requirements of the problem and the superstructure should be raised on the theory of the proper proportion of form and suitable relation of color in the materials of which it is constructed. No building can be a perfect success unless both the practical and the esthetic requirements are satisfied.

SCHOOLS. To train the modern architect, schools in architecture have been provided in all civilized countries. The work that is being done in these schools is of the greatest importance to the architectural interests of our country, for they are not only training young men and women for the practice of architecture, but are also gradually educating the public to a fuller appreciation of the possibilities of the art.

The surest and easiest way in which a young man can fit himself to enter the practical field of architecture is for him to take the course in architecture at some recognized architectural college, but if this is not possible, he should remember that it is not necessary for him to go to college in order to secure an adequate architectural training, but that it is absolutely necessary for him in some way to secure a knowledge of the history of architecture and of the general principles underlying all good design and construction if he is to obtain distinction as an architect.

PRACTICAL TRAINING. After graduation the student should, if possible, supplement his collegiate training by means of foreign travel and study, and before thinking of entering into active practice should spend several years in the various departments of the office of some practicing architect of recognized standing and ability.

PERSONAL REQUIREMENTS. The young man should constantly bear in mind the fact that no one can achieve real success unless he possesses honesty, perseverance and courage.

To succeed in any particular field of human endeavor, especially in an artistic field, it is necessary that the youth possess some natural talent, but more than talent he needs energy and perseverance. Many young men who have started with a seeming lack of talent, have in the end, by conscientious effort, far outstripped their more favored rivals.

OPPORTUNITIES. The profession of architecture holds out to young men and women one of the greatest possible opportunities for a useful and interesting life. It is a profession in which they may exercise all the talents to which man is heir, and it is one that calls for all the qualifications that are necessary in the carrying on of any business or profession.

The successful practice of modern architecture requires talent along so many different lines that rarely can one individual properly cover the entire field, and for this reason the practice of architecture is often carried on by two or more architects, each of whom has special talent along a line that strengthens and supports the talent furnished by the others. Where the personality of the individuals forming such a combination is such as will allow of continued harmonious daily relations, such a partnership is most desirable — but if the personality of the individuals is not such as will allow of this harmonious relationship it is much better that each practice in his own name. In either case, where a large volume of business is handled, it becomes necessary to divide the work. This division may be made under four general headings, as follows: Finance and Business, Planning, Construction and Architectural Design.

In a large office each of these departments may be further divided, each subdivision being captained by a trained man under whose leadership the work of the department is carried forward by a corps of able assistants.

The organization of such an office should be similar to that of an army, the architect representing the commander-in-chief and the heads of the various departments representing his staff.

OFFICE ORGANIZATION. In discussing the organization of an architect's office, the writer has placed the departments in what seems to be their relative order of importance.

First comes the department of "Finance and Business," in which are handled all the questions relating to the financial interest and business management of the work placed in charge of the architect. On the successful management of this department depends the commercial success of the architect, for if an owner's business interests are not properly attended to, the architect cannot hope to retain the respect and allegiance of his clients. The head of this department is generally the senior member of the firm, but be that as it may, he must be a man of absolute integrity, and must, in addition to the talent and training possessed by every successful business man, have a thorough architectural education.

Next comes the department of "Planning," in which all questions relating to the plan and to the general composition of the design are carefully studied. The quality of mind that enables a man to do successful planning is the same as is possessed by the inventor, and is given to comparatively few men. The development of this quality requires much study and careful training and the exercise of the talent forms one of the most important and fascinating branches of the architect's work.

After "Planning" comes the department of "Construction" which takes care of the making of the working drawings, the solution of all the technical problems, including those under the heading of Civil, Mechanical, Electrical and Sanitary Engineering, the writing of the specifications for the various branches of the work, together with the superintendence of the construction of the buildings. This is the largest department in the office, and the one on which depends the practical success of the architect.

Last but not least comes the department of "Architectural Design." From some points of view this department should be placed first instead of last, because without it, real architecture could not be created. In this department are located the "dreamers," the men of poetic temperament, men in whom the talent exists not only to appreciate beauty in form and color, but the ability to produce it. This is the poetic, the artistic field, the realm of art, the department on which in fact rests the creation of the art of architecture as distinguished from the art of building.

Whatever may be the difference in opinion of architects as to the relative value of the four departments above enumerated, there can be no question that in the successful practice of modern architecture, all four are required, and that each must work in harmony with the others in order that the best results may be obtained.

RECORDS OF THE PAST. Looking back across the centuries, the student will see that man has always recorded his civilization and power in building, and will learn that it has largely been by the study of the remains of ancient structures that our scholars have been able to trace the history of the nations that are past and gone.

Through her pyramids, temples and obelisks, we are able to trace the history of Egypt in all her strength and glory, and to learn of the Egyptians' belief in the return of the soul long after death to reoccupy the body it had left.

Through her statues and temples, we may again see the refinement and cultivation of the Greeks and learn of their great love and appreciation of the beautiful.

By a study of the wonderful roads, aqueducts and monumental buildings of the Romans, we may get a vivid picture of the great military and commercial power of the Roman Empire, while by a study of the marvelous churches and cathedrals of the medieval period, we may plainly see the wonderful uplifting power of the Christian religion.

To-day the modern architect is not only aiding his contemporaries in securing the fullest benefits of modern civilization, but he is assisting in the writing of the history of his nation in lasting form. Is there any profession with a higher mission?

MINING

By F. B. Richards *

CHOICE OF PROFESSION. In this paper on the mining engineer, which is necessarily brief, I hope I may be able to treat the matter in hand in a simple way that may be of some help to young men contemplating a course in this profession.

The average boy in high school has very little idea of the qualifications that are necessary for an engineering practice, yet in his first year he must make up his mind whether to take a college course or fit himself for any of the various technical schools he may decide to attend.

He may enter a leading technical school of the country and along with 200 or 300 other boys take the general course of the freshman year, at the end of which he must choose one of the engineering courses — civil, electrical, chemical, mechanical, hydraulic or mining engineering.

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The average age of these boys about to enter their sophomore year and choose a technical profession is between 19 and 20. At this age the mind of the normal boy is somewhat immature, with generally preconceived ideas of all branches of engineering, which are to be somewhat shattered later.

When he leaves school he starts out in the world with his degree in engineering, and we will assume he has chosen mining engineering as a profession. He is a mining engineer in embryo, but let us digress and review what his ultimate development must be to reach a leading place in his chosen work.

Next to winning foodstuffs from the earth the mining of minerals from the earth's crust was one of the earliest vocations of man, and through all ages development has progressed slowly until the early part of the nineteenth century. Since the advent of steam and electricity and the coming of the trained mining engineer progress has been most rapid and the industry has to-day reached a very high state of development.

PHYSICAL AND MENTAL STRENGTH. The most efficient and successful mining engineers of to-day are necessarily all around men, physically able to go into the wilderness and the ends of the earth, if necessary; also mentally able to plan the attack on the largest of ore bodies by the most approved methods. These men must study carefully the geology of the location in which operations are about to be started, and if necessary to be sure of it, to make explorations by diamond or churn drilling and possibly test shafting, perhaps taking several months to a year or more in such work before a complete plan of operation can be reported to the owners of the property. This final plan must be most complete. It should show location of shafts, tunnels and open pits; the kind of machinery and power best adapted for extracting the ore, the facilities for transportation of supplies, the housing of men and a reasonably exact estimate of cost for the development of the ore body and a final approximate estimated cost of producing a ton of ore. If the ore should contain precious or semi-precious metals and must be treated by a milling process and the metals contained therein concentrated, the engineer should be able to conduct tests to determine the most approved mill for the process or at least have knowledge enough to supervise such tests and reach a correct idea as to what process would be best.

PRELIMINARY PLANNING. In the last few years the preliminary work of the mining engineer is perhaps best exemplified by the work done on the properties of the Utah Copper Co., Chino and Ray properties — great so-called porphyry copper deposits, where several years were spent in exploration, development and installation of machinery before a ton of shipping product was produced and the mines operated for months after starting before stable costs were attained. One of these properties, the Utah Copper Co., at Bingham, Utah, has produced and milled 20,000 tons of ore per day for weeks and months at a stretch, working on ore containing about 1.50 per cent. copper and making a cost of something over eight cents per pound and at times less than this. This result has been possible only by most elaborate engineering work and the courage of the management to back the recommendations of the engineers with a vast amount of money.

These properties above referred to are immense bodies of copper bearing rocks, where the mining engineer had first to determine the extent of the ore bodies, also the quality of the ore, and as they are operated largely through open pits to determine the cheapest and best scheme mechanically to handle the ore in large quantities; also to design milling plants to treat an enormous tonnage every twenty-four hours with the best possible extraction of copper.

Unfortunately we cannot have all open pits to work, in extracting mineral from mother earth, and the bulk of the mining of all minerals is through shafts or tunnels. The mining engineer, after his geological work is satisfactorily developed, must determine where shafts are to be sunk or tunnels driven. His preliminary development work should show him the best location, but it often happens the shaft must go through quicksand or bad ground and his ingenuity is often taxed to the utmost to make plans to get through it. After the ore body is reached, the opening of the same must be carefully considered. The points where levels and drifts shall be driven, the nature of the foot and hanging walls of the deposit, should it be a vein or a lense, must be taken into consideration, as the question whether the hanging wall is firm and strong or treacherous and shattered may determine the mining methods to be pursued for the extraction of the ore.

GENERAL KNOWLEDGE. The methods of underground mining will vary much with the conditions one finds. The common methods are timbering in square sets the entire ore body; by underhand stoping, overhand stoping or by opening up first the entire ore body by levels, drifts and sub-levels to the top of the ore and slicing out the ore from the top, letting the surface cave in, and follow the workings down as the ore is mined.

As the mine is operated, accurate maps must be kept up of all the underground working, which means much underground surveying and work in the drafting room if the property be a large one. Ventilation must be studied and provided for. This is of the utmost importance, especially in coal mines where there is a constant escape of gas from the coal into the workings. Anything but the best and most approved methods of ventilation used here would be criminal on account of danger of explosion and consequent loss of life.

The mining engineer whether in charge of a property or employed in a consulting capacity, should be enough of a metallurgist and chemist to have a fair knowledge of the treatment of ores in the extraction of their metals and the cost of same; also the commercial value of ores in the markets. He should also be able to check estimates of contractors and pass upon their work to properly safeguard the interests of his principals.

INTEGRITY. From this brief summary of what is expected of an efficient mining engineer, and it is largely superficial, as much more could be said of this profession and its ramifications, one can see that these men are trusted with vast enterprises and millions of dollars are invested in mining schemes on their reports and recommendations. Necessarily they must be of the highest integrity and honesty, and granting that they are all of this, they occasionally misjudge mining properties, generally when in their early stages and cause losses to their backers. But this does not often happen with the highly trained man who has acquired in connection with his profession the practical knowledge of mining. There are black sheep in every profession and occasionally the engineer lends himself to promotion schemes by coloring his reports, but the great majority in the profession are men of the highest type.

PRACTICAL EXPERIENCE. Let us return to the embryo mining engineer who has just graduated. His fond parents feel that he must have a great career ahead of him and he himself thinks it should, after possibly the first year, be plain sailing to an ample competence. He goes to those people he may know in the mining industry seeking, of course, a position as mining engineer or at least as an assistant engineer. He may succeed finally in securing a chance to assist the chemist in analytical work at some mine where considerable of this kind of work is required, and as chemistry has been part of his education he feels competent to do this easily, but would, of course, prefer to be the head engineer. His first day in the laboratory is a revelation to him; instead of the slow, careful work of the school laboratory, where he was taught theory with some practice, he sees what he considers slapdash methods and hurried work, one man turning out forty to fifty analyses a day and he is sure the work is inaccurate and against all his teaching. If he has a logical mind and is willing to begin all over again, he will find these methods are accurate, but specially schemed out for rapid work. From this point on, if he is willing to keep his theory in the back of his head ready for use and learn the practice of that laboratory, and furthermore if he has a fair amount of energy and is willing to work he soon goes into the engineer's office, then underground on the survey where he makes a friend of "Cousin Jack." He finds him a plain human man, with practical experience and a good fellow. This same "Cousin Jack" will teach him a lot more and soon he is on the road to that competence.

As an illustration of what has been done, I know of a man who went through one technical school, specialized in another of higher grade and when he graduated, in addition to his course in mining engineering had taken a course in electrical and mechanical engineering besides. He had been a fine student and had worked very hard for five years at college; he went to one of the leading mining engineers in this country, who secured for him "a job" in a mine in the West. He started mucking ore underground, that is, shoveling the ore into tram cars after it was blasted down, and it was hard work. In a short time he went into the mill, became later foreman; then chief engineer. He is now manager of a group of properties. Every proposition in engineering goes through his hands for approval and consideration. In addition to this he is responsible for the organization under him and the results obtained. It is needless to say the salary also fits the responsibilities.

THEORETICAL TRAINING. From my own experience I feel that the man taking the course of mining engineering in any of the leading technical schools should realize that at best he is going to get all of the theory that he is able to absorb in connection with his profession, but very little of the practice, which he will acquire later in real work. He should be well grounded in mathematics, know his geology, mineralogy, chemistry, as much of mechanics as he can get, know enough of electricity and the appliances for its use as possible and be competent in surveying, in addition to which he should acquire as much knowledge of the common metallurgical processes for extracting metals from their ores, and mining and milling methods as the textbooks can give him. After this it is entirely up to himself and his natural aptitude for this profession as to how fast he goes forward and how far he can ultimately go. He must have enthusiasm and love for his work and be physically able to stand the strain. In this profession the conditions in the various mining districts of the world are different and probably more varied than are met with by the men in any other engineering profession. There are new conditions arising all the time, even in old established districts where the geology is known and where methods have been worked out.

In conclusion he must be honest in his work or he will never become of real value to his employers and will not last long in his profession.

OPPORTUNITIES FOR A MINING ENGINEER

By Henry S. Munroe *

The life of a mine may be divided into several stages:

1. Prospecting; or the search for mineral deposits.

2. Exploration; or the proving of the deposit.

3. Development; operations preparatory to mining.

4. Exploitation; that is, operations connected with the extraction of the mineral and its preparation for market.

TRAINING. The training of a young mining engineer, as it has been developed in the thirty or

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He has been president of the Mining and Metallurgical Society of America and of the Society for the Promotion of Engineering Education, and vice-president of the American Institute of Mining Engineers.

more leading mining schools in this country since 1863, has proved eminently successful and the graduates of these schools are rapidly displacing the men without technical education who formerly had the field to themselves.

A mining engineer must be a good geologist, with training both in theory and in field work, to fit him for the examination of mineral properties and for the work of proving and developing them. The practical man, without such training, can literally see no farther than the point of his pick. Large amounts of money have been wasted and many sanguine expectations have failed of realization by reason of the misdirected enthusiasm of uneducated men. The trained mining engineer makes mistakes, it is true, but he realizes the limitations of his knowledge and proceeds with caution, testing carefully every step of the work.

Mining operations, of course, rapidly exhaust any ore body, even those of considerable size, so that the search for new deposits continues throughout the life of most mining enterprises and in extreme cases this exploratory work may prove to be the largest item of expense in mining operations. There is opportunity here for great saving by carefully planned work in the hands of well trained men.

The development of a mine and the erection of the plant call for engineering ability of a high order. The mining schools therefore provide (or should provide) instruction in the elements of civil, mechanical and electrical engineering for the mining students. The subjects should be taught from the standpoint of mining conditions and mining requirements. The arguments which have been advanced in this series of articles for these professions will therefore apply to the technically trained mining graduate in this part of his professional work.

The actual operations of mining, the support of underground excavations, problems of ventilation, drainage and hoisting of minerals, provisions for the safety of the men, all demand engineering ability and broad knowledge of the manner in which similar problems have been attacked in other mining regions and in other parts of the world. The practical man, whose experience is often confined to one kind of mining and to the methods of work in a few mines, or mining regions, is not so well fitted as is the man of wider knowledge to cope with new conditions or to attack the new problems which are continually arising.

OPPORTUNITIES. Among the incidental advantages of a technical education is the practical training in many lines fitting the young graduate for useful work in subordinate capacities. He can find employment at a fair salary either as a draftsman or designer, and should be competent to prepare plans and specifications for mine structures. He is familiar with surveying instruments and can plan and execute underground and surface surveys. He has had training in analytical chemistry and assaying, and can readily find employment as chemist or assayer at mines and metallurgical works. And finally, his training in geology, metallurgy, and engineering fits him for immediate usefulness and makes him a valuable assistant in any and all of these directions. His school training and the numerous problems required of him in his field, laboratory and design work give him facility and confidence in attacking similar problems in professional work. He has acquired a wide acquaintance with technical literature, and he can readily turn to such sources of additional information when necessary. He has come into intimate contact with professors and lecturers, and has made many friends among engineering students of his own and other classes. After graduation he will meet many alumni of his professional school to whom his diploma will be a very valuable letter of introduction. Such friendships and acquaintances with men of his own and allied professions are likely to be most serviceable.

Mining, like other professions, embraces many specialties; coal mining, the mining of precious metals, the mining of great ore bodies, placer mining, mining for salt, boring for oil and gas, the concentration of minerals, gold-milling, and many others. In these special fields great advances are being made to-day by the graduates of technical schools. We may fairly say that the art, both of mining and of the preparation of minerals, has made greater advances in the last fifty years than in many centuries preceding.

It is, of course, not possible in a mining school to train a young man for the immediate practice of his profession, nor for positions of great responsibility, but like lawyers, physicians, civil, mechanical, and electrical engineers, the young graduate must have his period of apprenticeship in which he shall supplement his school training with training in business matters, in executive duties, and in the practical operations of mining. The trained man, however, can, and does, shorten this period of apprenticeship and takes better advantage of his opportunities, and in the end may become more really practical than the practical man, more business-like than the man who has graduated from the bookkeeping staff, and a better executive than the man who has risen from the ranks.

THE LURE OF PRIVATE PRACTICE

By Ernest McCullough *

VALUE OF ADVICE. The Italians have a saying when freely translated: "He who profits by the mistakes of others weaves for himself an impenetrable coat of mail." It is with the idea of equipping the worker with the machinery for weaving this impenetrable coat that the present book is undertaken. However, the writers honored by the invitation to take part in its preparation cannot forget what Robert Burdette said about advice to young men: "Take a bowl of clear water. Thrust

* The author of this article was born in Staten Island, N. Y. in 1867, spent his boyhood days in Kansas City, Mo. and Wyandotte (now Kansas City, Kas.), and graduated in civil engineering in San Francisco, Calif., in 1887. He remained in California until 1898 when he went to Idaho where he resided until 1903, working throughout the States of Washington, Oregon, Idaho and Montana. Since 1903 he has lived in Chicago where he is a well known consulting engineer, being now (1915)) First Vice President of the Western Society of Engineers. He has had the typical experience of engineers who graduate during periods of business depression and his experience has been of varied character. He is known to the profession through numerous books and technical articles in engineering periodicals. He has written a book entitled "Engineering as a Vocation" for the guidance of parents in determining upon a career for boys with a leaning toward engineering work.

the forefinger of your right hand firmly into the water, as nearly as possible in the center. Hold it quietly for a moment. Withdraw quickly and watch for the hole. The hole you find represents the impression made by good, sound advice on the mind of the average young man."

In the hope that the young men who read this article are a trifle better than the average the writer will attempt to give some good advice to the more ambitious, for unfortunately it is the ambitious ones who fall in greatest numbers in the battle of life. The cautious, conservative plodder has far better chances of success and happiness because every day is an opportunity to him, whereas the ambitious one attempts to create or force his own opportunities. Few men recognize opportunity when it comes but the contented man is in better shape to meet and rise to it than he whose spirit chafes under monotony.

SERVICE. The ideal of the engineer should be that of *service,* to do for others what they cannot do for themselves, to do this part — though small and dreary — toward realizing the ideals of a higher and better civilization. The most enduring joy comes from this inward satisfaction of a day's work well done rather than from the applause of the multitude or the receipt of big fees. Many young men, however, cannot appreciate this. They are filled with ambition to rise at once to eminence in their chosen profession. They want to be leaders, and attain what is considered the highest position in the profession, namely that of "consulting engineer." To them working in an office or on construction work is only a period of apprenticeship of short duration after which they see in their day dreams the magnificently equipped office, in the anterooms of which millionaires stand waiting to seek the advice of the eminent engineer.

Few can reach this eminence, and the great majority are doomed to disappointment unless forewarned. They must accomplish their best work as "the hired man." Few have ability or opportunity to become "consulting engineers." The field for such is necessarily limited, and those who can not enter it, but must remain in the ranks of less striking but useful service, should be satisfied in doing their part. Their engineering education has at least enabled them to be of more use and value to the world and to themselves than otherwise might have been possible; although it may not enable them to become especially prominent.

This fact should be clearly kept in mind, and while it is proper and necessary to have these day dreams to stimulate effort, yet the hard ground of fact should not be ignored. The field for the consulting engineer is limited. He is practically unknown in continental Europe, at least as he is known in English speaking countries. In the United

States a consulting engineer is usually a well known man who through age and opportunity has acquired a good deal of experience. Lately there has been exhibited a tendency to use the words as freely as in Great Britain where the term "consulting engineer" is applied to all engineers in private practice. Thus, it is getting to be not uncommon to see youths only a short time out of college hustling for work and using engraved cards proclaiming them to be "consulting engineers."

When a young lawyer opens an office he needs to have a library, or have access to a library, stocked with books which contain records of precedents to guide lawyers in giving opinions on legal points. Asked for an opinion, the lawyer gives the subject careful consideration by carefully ascertaining what courts have done and tries to form a shrewd guess as to what might happen to his client in case he were to depart a trifle from the beaten path. Having obtained all the evidence possible from the records he writes his opinion. It is quite likely he may have to defend it in court, therefore the more knowledge he can obtain from books the better he is off. A young studious man has a very good chance to make an early success.

The case of the young M.D. is not very unlike that of the lawyer, for he will handle only ordinary cases, medical men having trained the public long ago to appreciate the value of asking for the assistance of highly skilled, experienced specializing consultants. The lawyer and the medical man also enjoy the benefits of being engaged in work for which there is a constant demand, for until men think straight and act straight the lawyer will be busy and until men live straight and cultivate a proper feeling of community interest the medical man will never lack patients.

EMPLOYMENT. The engineer, from the root form of the word, is "The Ingenious Man." His services are required only when men build, or plan to build, works whereby some financial benefit is to be received. The engineer is one of the trained workmen employed. He is busy when capitalists are spending money and he rests when they lock up their funds to await a time when it will pay better to invest in new enterprises than to let money lie idle. The engineer under such circumstances is subject for employment to the laws governing the employment of all industrial workers. It is a pity this is not brought home strongly to engineering students. No harm can be done by acquainting them with the facts, whereas numbers of disappointed, broken men testify that ignorance, rather than lack of opportunity, was their undoing.

Some older engineers humorously refer to all engineers as "Job chasers." It is, alas, too true a characterization of a large number. Most of these men started on the "job chasing" career because of the advice that they attempt in the first few years after graduation to gain a broad experience and shift often. This advice was good thirty or forty years ago but is bad advice now. The schools are turning men out too rapidly to-day to make such a scheme profitable and, with the growth of the idea of efficiency, employers look askance at men who have worked in too many places for short periods. The demand of the world to-day is for steady plodders who will stay and grow up with the business. Under the best of circumstances the average engineer will work for many employers during his life, for not all employers of engineers have places where engineers may progressively advance. An engineer who remains with one concern for ten or more years is seldom in the engineering department at the end of that time.

The average workman on construction work is out of employment about one-fifth of his time up to the age of 30; about one-fourth of his time between 30 and 35; about one-third of his time between 35 and 45 and after 45 is fortunate if employed half his time. The engineer, being a high grade workman and a director of those less fully trained, is employed with them and is subject to the same laws. His compensation may sometimes be greater but he has no better opportunity for constant employment, so long as he sticks closely to real engineering work. Therefore the first advice to give to young men who study engineering is to save one-third of their pay when working. No matter how small the pay forget one-third of it each pay day and put it in the bank at interest. This is to be a reserve to keep up the curve of income so it will approach a straight line when the average for life is struck. Temptations to invest come frequently and the small interest paid by savings banks soon begins to look very small indeed. It is perfectly proper for a man to attempt to increase the earnings of his money but it is not right to take undue risk. When may a man begin to invest and how much should he invest? He should not begin to be tempted by bonds and stocks, mortgages, or other forms of investments until he has in a bank drawing interest enough money to support him and his family for a year while out of work. It is not uncommon for a good engineer to be out of employment for a whole year. The writer knows first class experienced engineers at present out of employment who have not earned a month's pay for nearly two years.

The second piece of advice the writer would give is "Stick to your job." The job should be the means of earning a living and should be only incidentally a part of the schooling to gain experience. Men of ambition and high spirits are often more to blame for their failure to become settled than they themselves comprehend. It does not do to be too easily offended; to be too impressed with one's personal dignity; to look with tolerance on the employer who does not know as much about the job as his hired man. The man employed should realize that in some way or other his employer must be at least his equal, if not his superior, or he would not be the employer.

FAME. The third piece of advice is to be sensible on the question of fame. It is but a temporary flash. Of the millions of men famous in their generation in a limited circle, how many names survive? The real object of a young man should be to say when his time comes to die, "I have not accomplished all I set out to accomplish, but if the world is the least bit better for my life in it then I die content." It is better to be loved by the helpless and unfortunate than to stand high in the counsels of men who envy and disparage, even while they acclaim. It is better to leave a paid up insurance policy and money in the bank for the family, even if a man is not well known a block away from where he lives, than to keep a family half starved for years while the father seeks fame and finally on his death leaves the widow and children to charity.

The majority of engineering graduates seem to be more anxious to use their scholastic training as a stepping stone to great success which will make their names known, than as a valuable asset in the attempt to gain a competency and accomplish good in the world with the surplus. Consequently the big cities and the small villages hold numbers of discouraged men who tried too early in life to go into private practice.

EXPERIENCE. In talking with the most successful consulting engineers one cannot but be struck by the recurring remark that few went into private practice voluntarily. The greater number managed to be kept on some pay roll or other until along in middle life during a period of business depression they had to strike out for themselves. They possessed ripened judgment, had done big things and had a wide acquaintance and a comfortable bank account. Going out for themselves they carried into their work the rush and enthusiasm which bring success. When approached by prospective clients they were able to show a convincing record so that men were willing to intrust them with great responsibilities. These men do not have to consult books to give opinions. The best books are usually several years behind current practice in engineering, being written as text books for students. The periodicals coming weekly and monthly serve the older experienced men, but few of them have time to read even a small part of the current literature. They are real engineers such as the man described by Wellington as "he who can do well for one dollar what an ordinary man can do after a fashion for two."

Business men do not consult engineers for what can be had from books for they can read the books themselves. They do not consult engineers to obtain second hand opinions but consult them to get the benefit of a ripened experience. This experience can only be obtained properly by working on big things for big men or for big corporations by men who stick to the employers for years and years. At small salaries perhaps but the sticking is the thing and the saving of a fund for the dark days is another thing, which added together makes possible the days of big things. Stick, work hard and save: these words should be engraved on every class room wall and be printed in every text book.

The fourth bit of advice the writer would give to young men is to abandon the idea of endeavoring to work up a private practice until after an experience of at least twenty years in salaried employment. Now what is the man up against who tries to enter upon private practice before he is of middle age with the experience years alone can bring? In the first place the men with large problems do not come to him. They have first class engineers in their employ and when a consulting engineer is thought to be needed a real consulting engineer is called in. This leaves only the smaller work to the small man, and the young man with limited experience is a small man. When he hears of cities intending to inaugurate public improvements and endeavors to get the work he finds himself competing with men of extended experience in such work and finally has to quit, discouraged because experienced men stand so much better chance. He then has to fall back on strictly competitive work not requiring much experience. Much of the work done by men trained as engineers is of a comparatively simple character. Men who have such work done know it to be simple, so give it to the lowest bidder. Owing to changes in employment due to the completion of work, there is always a plentiful supply of draftsmen and surveyors temporarily out of employment, who will work at rates barely keeping body and soul together merely to eke out an existence until another salaried position comes along. A large number of foolish men each year open offices on small capital, financial and engineering, who bid low on work thinking thus to obtain a start.

CAPITAL NEEDED. A man cannot do much work without a large expense for offices and helpers. The helpers must be paid weekly. If not paid on the day agreed they refuse to work. The parties having the work done often make a man wait for his pay until the structure is completed, because they fear the financial responsibility of the engineer; this is the only protection they have in case mistakes are discovered On many jobs the clients make the engineer wait for months for his pay simply because it is a habit. Thirty to sixty days' time is common in which to pay bills in the business world and the engineer in private practice is a business man subject to all the trials and tribulations of business men, such as slow payment or non-payment of bills, overhead expenses, inefficient help and necessity for borrowing money to keep afloat, even while apparently very busy. In fact the more business an engineer has of a competitive kind the less personal attention he can give to the technical details of the work on which he is engaged, for much of his time is spent in securing the work, arranging for funds to pay bills and collecting accounts. To do all this and compete with men temporarily out of employment and men who are trying to get a start by doing work at low prices in a short time kills all ambition and sometimes leads sore pressed men to do things thought to be slightly off color even among business men but which are crimes in the eyes of professional men.

AGE LIMIT. The time comes to all engineers when they go up against the age limit. The writer, with other engineers, laughed at the idea of an age limit, for he believed experience was paid for and men of experience were sought when big work was afoot. He reached the age limit himself and then believed the stories he had heard and believes all he hears on this point. So he went into business for himself and refused to consider competitive work, as his experience justified him in doing. He found competition but it is of a better kind than the younger man meets. He found that when it came to designing structures he had to compete with large corporations who furnished designs free, in return for which the men for whom they did the work specified their goods. This is another objection to private practice which is discussed by engineers in their society meetings and there seems to be no way of overcoming such competition. Many of the corporations employ high grade engineers whose advice it is needless to say is not and cannot be disinterested. The writer's practice is developing along the lines of real consultation work wherein men employ him because of his experience. Much of it is in the courts as a witness in lawsuits involving engineering questions and in an advisory capacity to attorneys employed by men who should better employ engineers, leaving it to the engineer to employ a lawyer if required. The engineer is not long in business before he ceases to be surprised at the confidence the majority of men repose in lawyers. It is not an uncommon experience for the testimony of an experienced engineer to settle a case after the expenditure of thousands of dollars in legal expense, when his employment instead of an attorney in the first place would have settled the matter at a cost of a few hundreds of dollars, or perhaps less than one hundred dollars.

EARNINGS. The earnings of well established consulting engineers are large and the reports of the fees they earn fire the ambition of the callow youth. The way, however, of the man in private practice is beset with many hardships. Some the writer has endeavored to set forth. It is impossible to say all one could say if inclination permitted. The object of engineering training is to fit men for the battle of life, and when the preparation is obtained the recipient should then try to sell his services where they are needed at as good a price as he can obtain. When the time comes that he is compelled to go out into the world as a professional man, selling his services as a competent advisor to those who need better advice and service than their less experienced salaried employees can give, his success is certain if he is a hard worker with a large circle of influential acquaintances and a good bank account.

The remark is often made that ninety per cent. of the men who embark in business for themselves fail. This was by many attributed to lack of ability, but an analysis of the causes of failure showed that by far the greater number failed because of lack of capital. In the case of engineers the capital consists first of proven good experience backed by first class references and secondly to money. The writer is not certain which of the two is the more important except that he does know without a good experience of many years all the money in the world will not help a man, except it be to purchase an interest in a going concern.

Except in years of business depression there is a large demand for technically educated men. There is also a large demand for stenographers, bookkeepers and general business assistants of limited experience with a training in the fundamentals of business. For a young graduate engineer to attempt to stick to the technical side of his work and do badly the work in positions where less of this information is required is on a par with the action of the business college graduate who declined the position of manager because in that position he would have no use for his knowledge of bookkeeping, thus wasting the money spent to obtain this knowledge. The biggest men in the engineering world to-day are those who used their training to obtain a footing and did the work that came to them realizing that the college work was intended only to properly introduce them into places where opportunities abound. Opportunity is one-half of life, common sense and gumption is one-third and special technical training is the remaining one-sixth. Each is essential in about the degrees stated.

VOCATIONAL GUIDANCE

By James F. Barker *

VALUE OF TIME. Johnny Jones, do you know that your time is worth $16.00 a day in school if you intend to become an engineer? This is probably more than it ever will be worth again. Do not say you have enough of arithmetic, but let me show you how my statement is true.

I have enough self-assurance to believe that I was naturally endowed with sufficient native ability to have made a good average clerk with an earning capacity of say $80 per month. Anything over and above that must be attributed to something other than heredity. What was it? As I look back over my life I cannot attribute it to chance; it must,

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After leaving college he went to work as architectural draftsman with D. H. Burnham & Co., Chicago. Later he entered the employ of the Allis-Chalmers Co., Milwaukee, and continued with them until he began teaching in high school. He has been engaged in teaching for sixteen years, the last six of which have been spent in his present position. He is a member of the Cleveland Engineering society.

therefore, have been my education, the only influence in my life other than heredity or chance.

I received an education both in engineering and architecture. I started at 23 years of age as a draftsman in the office of one of Chicago's most noted architects at $15 per month, and worked for an entire year at that wage. At the end of a year my wages were increased to $15 a week. My progress from that day until this is due, I believe, to the opportunities given me for preparation. Now let us figure out what has been the cash value of this education, and what is the value per day of the time devoted to it, because to the time spent in getting an education must be given credit for the increment over and above $80 per month of my salary.

VALUE OF EDUCATION. In order to secure the training required of an engineer one should attend high school, and usually an engineering college. Most high schools operate 200 days a year; and a four-year course, therefore, consumes 800 days. One so inclined can usually find profitable employment during vacations. A college course takes a slightly less number, so that a total of 1,600 days would certainly cover the time given to securing a formal engineering education. Now, if you divide the total amount which a man with an education earns over and above what he would earn without the education you should obtain the average value per day given to the training.

Some years ago a table of wages of men in various lines of work related to engineering was prepared and published in one of our prominent engineering periodicals. From statistics prepared from a large number of inquiries it developed that it is not too much for an engineer to expect an annual income of $2000. The difference then, between $960 and $2000 is the annual value of the education. This amounts to $1,040. At 5 per cent. this represents an investment valued at $20,800. That is, an engineering education has an intrinsic value of at least $20,800. Can you afford to turn such a valuable acquisition aside, if you are possessed of the necessary qualifications and opportunities for securing it?

Now suppose, on completing the grammar grades, a boy goes to work, and his average wage ultimately amounts to $80 per month, though this is a high rate. If he works until he is 56 years old, and has steady employment, he will have worked forty years, and earned a total of $38,400 during his working lifetime.

Suppose, however, he had attended school until he was 23 years of age then entered the engineering profession and remained in it until he was 56. He would have worked a total of thirty-three years. At first he would not earn his maximum, but by the time he was 35 statistics show that he would be earning considerably more than $2,000, so that an average of that amount is not too high. Now, \$2,000 for thirty-three years amounts to \$66,000. That is, the education alone is worth to the possessor in dollars and cents, over and above his normal earning capacity, the difference between \$66,000 and \$38,400, or \$27,600. But how much time was required and what did it cost to secure this latent earning power? Sixteen hundred days and an average outlay of not to exceed \$2,000. The 1,600 days were, therefore, worth \$25,000 or \$16 per day.

Perhaps there would be less truancy if every boy figured that he lost \$16 a day for every day he is absent from school. And yet, figures for my own case, while I was securing an education, show a better rate than \$16 per day. If I was ever truant I am glad I have forgotten the occasion.

But I do not want to appeal to you in behalf of the engineering profession solely upon a money basis. The calling has many other features that make it worth while as a career, as other articles of this series have pointed out. At one time the learned professions included a comparatively small number of vocations, notably, the law, the ministry, medicine and literature; but in modern times the term has come to include a much larger field. Notable among these new vocations is engineering.

SPECIALIZATION. Specialization is the requirement of the day, and a man enters the engineering professions at a great disadvantage if he is without special training.

Several exceptions to this general rule come to mind. To-day one of the noted mechanical engineers of the country is a man in charge of the biggest department of the Allis-Chalmers Company. This company employs 5,000 men, and is engaged in some of the largest of mechanical engineering projects in the United States. This man did not have a higher education, but by inheritance and environment he has had every opportunity for profit and preferment. Some few special cases of this nature come to mind, wherein men have by sheer force of natural endowment and environment won fame and advancement as engineers. Opportunities for the untrained man, however, are becoming fewer and fewer, and to-day, if one would succeed in the profession he must seek special training.

In order that no time may be wasted in the professional schools certain standards of scholarship have been set up as a necessary preparation for entrance. This preparation ordinarily comprises the work covered by a high school course. Four years in an engineering college usually completes the formal requirements for the profession.

CAREFUL PREPARATION. In periodicals one daily sees advertisements picturing the factory manager directing the workman applying to him for instructions; one on each side of the desk; one the master and the other the servant. Then the advertisement goes on to state that courses are offered which will so perfect any man that he will have the choice of the two places at his command and all for a little evening study. These advertisements are successful in their mission of securing students because so few people really know what comprises an engineering education.

In the East Technical night high school of Cleveland, Ohio, are now enrolled nearly 800 men and women engaged in pursuits, many of them closely allied to the engineering profession. Frequently they apply to the school for admission to courses in engineering without knowing what they seek. Men who have had less than a common school education ask for admission and for instruction in this mysterious branch. The advertisements referred to are largely responsible for this misconception by the masses as to what constitutes engineering. In preparing for such a career the road is long and is not an easy one, and there are no short cuts to the front ranks.

FUNDAMENTALS NEEDED. In choosing engineering as a profession certain fundamental endowments are prerequisite. Not long ago a fond mother applied at the school for the admission of her son, stating that he was "just a natural born mechanic," basing her belief upon his ability to construct certain simple mechanical toys. She wanted him to come to the Technical high school and study engineering. I inquired if he had completed the eighth grade. "No," the mother said, "he could not see any sense in the arithmetic that the eighth grade teacher was endeavoring to have him master." He wanted to leave school because of his distaste for mathematics. Now, mathematics has been called the basis of engineering and a young man who possesses no taste for this subject or facility in the handling of it should not attempt to enter the profession. Men engaged in the profession and those who are training our youth to enter upon this career say that a thorough knowledge of mathematics is fundamental. The young man who has no natural taste for mathematics would do well to stop and ponder before giving any further thought to engineering. It might be well to recite the list of mathematical branches usually required in engineering schools. They are arithmetic, algebra, plane and solid geometry, trigonometry, descriptive and analytical geometry, differential and integral calculus and applied mathematics or the mechanics of engineering. This means not less than three full years of mathematical study beyond the requirements of a high school course. It is plain, therefore, that the fond mother whose boy "just hated arithmetic" had no conception of what he would have to master in studying to become an engineer.

Further, a knowledge of the common branches of science is fundamental. There are many students entering the high school who have never had a taste of this delectable branch of knowledge, and when we give them physical geography, a subject dealing with the why and wherefore of the earth's surface, they find great difficulty in mastering even this simplest of the sciences. In fact, our percentage of high school failures is greater in this branch than in mathematics.

To be successful in engineering, training in mathematics and science is absolutely necessary; a good knowledge of written and spoken English is a further requirement.

SELECTION OF WORK. Of late years we have heard much of vocational guidance, and various plans have been formulated for assisting our young people, about to enter wage earning, in the wise selection of a pursuit. In the United States there are 2,000,000 girls and boys between the ages of 14 and 16, one-half of whom are out of employment. Under our former state educational laws a drop of about 6,000 pupils was annually taking place in Cleveland between the second and the sixth grades, so that probably that number were leaving school and only half of them entering the industries. The other half are not employed, and many of them are on the streets idling away their time. Most of these girls and boys take the first job that comes to hand without any reference as to whether they are fitted for the work or not. They do not know whether the calling is adapted to their training or where the job will lead them. In fact, throughout the United States our children are not trained in the public school for any special vocation. Investigators in other cities call these hit-or-miss jobs that the boy finds for himself, "blind alley jobs," because usually they lead nowhere. In offering educational facilities for life work France, Germany and England are far ahead of us.

AIDS IN SELECTION. Some of our larger cities, notably Boston and Buffalo, are seeking to aid, by counsel and otherwise, the boys and girls of their communities in selecting their life work. In Cleveland various philanthropic, educational and other agencies are advocating the establishment of a bureau of vocational guidance; first, that a proper and comprehensive survey of the industries of the city be made; second, that the opportunities in the way of advancement open to girls and boys entering the industries be properly understood; and third, that a public agency for the placement of these young people be established, though this last is a much mooted question.

So far as the engineering profession is concerned the opportunities in the calling are fairly well understood and the nature of the duties of an engineer can be readily learned from any one of a number of sources. But whether or not a young man is fitted for the work is altogether another matter.

At the East Technical high school of Cleveland during the past five years a plan has been worked out, the purpose of which is to assist the boys in selecting their life work.

In the organization of the school a boy is placed in charge of an instructor, who becomes his guide for the entire four years of his course. The first two years are largely a period of observation on the part of the teacher, but at the end of the second year the instructor is able to help the pupil to choose the work which may lead to a livelihood. At this time a young man who wishes to enter upon a course that will prepare him for a college of engineering selects the proper studies to that end. The instructor who has had the young man in charge can readily determine from the records whether or not the student has done well in mathematics and science and whether or not he is likely to be able to carry forward the work of an engineering college.

NEED OF GUIDANCE. I have in mind the son of a well-to-do citizen of Cleveland, who was very ambitious to go to Purdue to study engineering. The young man was industrious, painstaking and thoroughly reliable, but he was not an apt student in mathematics. My own training was that of a mechanical engineer and I was confident from my experience that the young man would have great difficulty in mastering college mathematics, nay, that it would be almost an impossibility; that he would probably not remain in college to finish the training required of an engineer, and that two or three years would be wasted in an attempt to fit the boy for a calling for which he was not suited.

I have in mind another boy similarly weak in mathematics, but a splendid machinist and a good mechanician — a boy who could be placed upon a job with the assurance that he would complete it and do it well. To-day he is employed at a high wage in the shop of the Santa Fé railway in the southwest, but it is my belief that, had he sought to study engineering, he would have met with failure because of lack of natural endowment.

This school has not been running long enough to know whether or not the boys who have been directed into the engineering profession are to make good — the future alone can determine that — but we have been very successful in directing boys into other lines.

Recently a play was to be staged at the East Technical high school and scenery had to be made. Of course, we could not think of buying such equipment. A boy who had been directed to the study of design by his instructor, who was also his guide in the school, was chosen for the work. His natural tastes were along the line of interior decoration, and our scenery, designed and executed by him, was a success. But of more importance than this was the discovery of the boy by himself. Last week one of Cleveland's foremost decorators wrote me of the progress of this boy in his chosen line. It is difficult to seek out the natural aptitude of our young people, but some agency of city wide scope should be established for this purpose.

On the other hand, another young man who graduated some years ago was imbued with the desire to become an engineer. He had maintained himself all through high school by lighting lamps, for which he received $18 per month. Later he went to work for the National Electric Lamp Association for the purpose of earning and saving sufficient money so that he could study engineering at college. In the high school we found that he had ability with books, that he did well in mathematics and stood high in science, that the grime and dirt of a shop was not beneath him, that he did not have the inordinate desire for white linen which most modern school training gives a boy. When he went to work in the laboratory of the National Electric Lamp Association they found that they could use his services to advantage. He gained some engineering experience and became still further convinced that engineering was the profession for him to follow and to-day he is preparing himself to that end.

LOVE OF THE WORK. If our career is to be a success we must be so imbued with the spirit of it that every phase of our life work is a delight. The man who cannot take pleasure in the drawings he has to make or interpret, who cannot see the beauties of handicraft, and who cannot take pleasure in the contemplation of construction, whether of bridge, canal or building, had better not enter the profession.

A man who has no ability in constructing things himself has no place in the calling. You frequently hear a man say, "I cannot drive a nail or draw a straight line"; certainly such a one has no place in a business, the whole energy of which is devoted to the production of real tangible results.

But how to discover the latent possibilities that lie within us? That is the question. For an engineer I would lay down a few fundamentals. First, a taste for abstract studies like mathematics; second, a fondness for natural science; and third, ability to plan, draw and construct; fourth, initiative, perseverance and industry. To the man possessed of these, opportunities will not be lacking.

SCIENTIFIC MANUFACTURING AND ITS OPPORTUNITIES

By Waldemar Kaempffert *

NEEDS. The modern manufacturing corporation, which requires acres of floor space to carry out its processes, which each day converts whole trainloads of wheat, leather, or iron ore, into flour, shoes, or steel rails, needs brains more than brawn. So vast are its operations that it pays to save a few cents in the production of a ton of pig iron, to devise a steam shovel that will scoop up five tons of ore at a time with a slightly less consumption of energy than was possible before, to analyze chemically the wastes of manufacture and to devise means of utilizing them. No manufacturer can afford to ignore the technologist. Competition is no longer confined to the selling market. There is a rivalry in improving manufacturing methods as well as in merchandising. Millions are annually spent by

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business men on scientific and engineering investigations that would have been regarded as purely academic twenty years ago, but the ultimate commercial value of which is immediately apparent to the broad-minded merchant of to-day. Even the manufacturer who employs only a dozen men must engage in this intellectual rivalry. He cannot always afford to engage permanently a laboratory expert, but he must at least obtain the advice of a consulting chemist or engineer if he is not to be utterly crushed.

SCIENTIFIC STUDIES. Despite its utilitarian and commercial character most of the scientific investigation undertaken by the great modern manufacturing corporation has a fascination all its own. Indeed, the results achieved often affect not simply one particular industry, but a whole science. In the City of Cleveland, for example, one of our great electrical companies maintains a number of laboratories, the sole purpose of which is to improve our methods of illumination, and to give us a light which is more efficient than anything now produced. The studies there conducted involve chemical and physical research of a high order, physiological and psychological studies of the effect of various illuminants on the human eye, engineering researches that will measurably bring us nearer to the "cold light," of which illuminating engineers have lately written so much. In a word, the entire subject of light is studied with a thoroughness never before attempted, and with a total disregard of money. Who can doubt that research so conducted will not simply enrich the world with illuminants better and cheaper than anything we have now, but that the whole science of optics will assume a new importance?

Because of the huge capital which it commands, the modern manufacturing company can experiment on a stupendous scale to realize an idea correct in theory. The development of the Curtis steam turbine, for example, involved the expenditure of millions. That vast sum was not spent in empirical experimenting, but in practically testing the thermo-dynamic views of engineers whose one task in life was the perfection of the steam turbine. Work such as this is comparable with the finest research conducted in any university. What is more, it is richly paid for; for your great manufacturing corporation, unlike your great university, is not niggardly in rewarding the trained men to whom the development of its processes is due.

TRAINING TRIUMPHS. It has been supposed that the all-devouring trust crushes its weaker rival by the sheer weight of its money. The truth is that trained minds easily triumph over mere money. In twenty-six public hearings, recently held by the House Committee on Patents, to consider the views of inventors and manufacturers on the advisability of introducing compulsory licenses into our patent system, it was abundantly demonstrated that the trained technologist is more than a match for the trained capitalist. The patent counsel for the greatest sewing machine manufacing company in this country testified that, were it not for the experimental laboratories conducted by three or four smaller sewing machine manufacturers, the company that he represented would undoubtedly monopolize the market. In other words, a handful of highly paid and splendidly trained technical men were able by sheer ingenuity to cope with the dominating company.

Before the same Congressional committee Mr. Spencer B. Miller, a well known engineer, drew a vivid picture of the manner in which a modern manufacturing company utilizes trained engineers. Mr. Miller has made a life study of conveying machinery. To him we owe the system of coaling battleships at sea, which has been adopted by the United States Navy. He revealed the manner in which his company had deliberately studied market conditions and devised machinery to meet special needs. Cypress logs, for example, had long been hauled out of Louisiana swamps at an enormous cost. Mr. Miller was engaged to devise the best mechanical system possible for taking out the logs. He did so with such success that not only were cypress logs eventually sold far below their old price, but that swamp land, which had once brought only $1 an acre commanded $75 an acre. Experts like Mr. Miller, trained in technological schools, are needed more and more. The American telephone system, a marvel of efficiency, is the creation of a dozen engineers whose work is confined entirely to the improvement of telephonic communication. They are engaged at princely salaries to meet the needs not only of to-morrow, but of the day after to-morrow, to devise systems for which there is no immediate use, but which will become of paramount importance when a city of two million inhabitants has increased in population by one hundred per cent.

Those who have read the addresses of the recipients of the Perkin medal, awarded for distinguished achievements in chemical engineering, must be struck with the opportunities that await the trained man in that one field alone. Herman Frasch told how the application of chemical principles enabled him to rid Canadian oils of their sulphur, and thus to make them more generally salable, how he had improved the methods of salt mining, and above all, how he had successfully solved the problem of raising to the surface the sulphur buried beneath Louisiana quicksands, after a dozen men before him had failed. So, too, James W. Gayley, an academically trained metallurgist and a former vice-president of the United States Steel Corporation, showed how, with his dry blast process, he had markedly improved our methods of reducing iron ore.

At the International Congresses of Hygiene, Chemistry and Testing Materials, held recently in this country, paper after paper was delivered bearing ample testimony to the achievements of trained men in modern industry, and therefore indirectly proved the opportunities that await the technical graduate. Thus, in discussing the production of synthetic rubber by Harries and Hofmann, Prof. Duisberg showed how all the resources, both technical and financial, of a great German chemical company are being used in an endeavor to produce rubber by artificial means so cheaply that the chemical factory can some day compete with the plantation — a work on which dozens of trained chemists have been unremittingly engaged for years. Prof. Bernthsen showed how important has been the aid of the trained chemists, employed by the company of which he is the head, in reducing nitrogen from the air so that the exhaustion of the Chilean nitrate beds, so frequently prophesied, is no longer a cause for alarm. Nearly every one of the papers read before the societies mentioned was prepared by men who are employed by European and American manufacturing companies. They revealed how refined are the scientific methods which are now necessary in carrying out manufacturing processes on a large scale, how hopeless it would be to attain the same result with the aid of men who have not had the benefit of listening to a great teacher in a great technical institution and how increasingly necessary is the employment of the technical graduate in modern industry.

INCOMES OF TECHNICALLY TRAINED MEN

By David Edgar Rice, Ph.D.*

EARNING POWER. In the choice of a vocation, the probable income is naturally a factor of considerable importance. This factor is very often veiled under the more general term "opportunity," but opportunity means simply the active demand for the service offered, and where labor is concerned, this demand is usually expressed in terms of the wage.

Educational institutions that offer a variety of courses of training are frequently called upon by prospective students to give some statement as to the relative opportunities in different lines of work. Does electrical engineering offer a broader field than mechanical engineering? Is the mining engineer more likely to secure profitable employment than the chemist?

These and similar questions may be considered from a theoretical point of view, but as the proof

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of the pudding is in the eating, so the most direct and convincing answer to such questions is to be derived from a study of relative incomes, where accurate information is available.

INCOMES. An investigation of this character has recently been completed in New York. The data have been gathered from more than one thousand men who, within the past nineteen years, have completed courses in this school. These courses are two years in length and cover the fields of mechanics, electricity and chemistry. They do not profess to be engineering courses, but are rather of the so-called "industrial" type, offering technical and practical training intended to prepare young men for positions of responsibility above the grade of skilled mechanic in mechanical, electrical and chemical manufacturing and industrial plants.

The men enter these courses at an average age of from eighteen to nineteen years. Some of them have had three or four years of a high school course, but little or no practical experience. Many of them, on the other hand, have had a considerable amount of practical experience, but are without the preparation afforded by a secondary course of study.

The data here presented, therefore, indicate the earning power, which may, on the average, reasonably be expected by intelligent, capable young men in these industries who have taken two years to train themselves technically for the positions of more importance and responsibility than those of skilled mechanics.

The information was collected directly from the graduates themselves. Each graduate was asked to state his income, not in exact figures, but by means of code letters covering a fixed salary range. Below $1,500 each salary group had a range of $250. Above $1,500 the range was $500. The median of the range of each group was taken as the actual figure in making up the average. To this extent the figures here given lack absolute accuracy. The error possibly resulting from this cause was to some extent offset by plotting the average incomes of the different classes in graphic form, drawing a smooth curve through the several points, and taking off the averages from these curves.

The table herewith given shows the average incomes of the graduates of the mechanical course for each year after graduation, the average incomes of the 20 per cent. of each class having the highest incomes, and the average of the 20 per cent. having the lowest incomes. For the mechanical course, the so-called course in steam and machine design, the period since graduation ranges from half a year to eighteen and a half years.

In connection with this table it must be borne in mind that the earlier classes are comparatively small in number, and that the returns from these classes also are less complete. The data for these classes are therefore somewhat less reliable, representing averages made up from the experiences of comparativly few individuals. For classes that have been out more than ten years, the number of men represented is less than twenty. For classes out less than ten years the number ranges from twenty to forty-five.

MACHINE DESIGN. The table gives the facts for the graduates of the course in steam and machine design, the oldest course in the school. The first column gives the average for the class. It shows that at six months after graduation, when practically all members of the class may be presumed to be fairly well settled in their positions, the average income is approximately $875. For a period of about ten years after graduation the annual rate of increase is practically uniform, and is, on the average, about $140. At this point it becomes noticeably less, being reduced to an average of approximately $100. It is, however, interesting to note that even to the last there is a constant increase in the annual income, indicating that the men who have been out in practical work for more than eighteen years since their graduation have not yet begun to reach a limit to their earning capacity — a very strong argument in support of the advantages of technical training.

The second and third columns give the average incomes, respectively, of the higher fifth and lower fifth of the several classes. They serve merely to show the salary range and call for no special comment.

In comparing the facts given in this table with corresponding data from other institutions, it should be borne in mind, as has already been pointed out, that these are not engineering courses, but two-year courses of practical character, intended to give the essentials of a technical education to men who have had but little preliminary training, and who as a rule are compelled by circumstances to work their way upward from the ranks.

AVERAGE ANNUAL INCOMES FOR MECHANICAL MEN.

Period after Graduation.	Average of class.	Highest fifth.	Lowest fifth.
Six months	875	1,250	700
One year	940	1,375	710
Two years	1,075	1,575	750
Three "	1,225	1,810	850
Four "	1,375	2,050	925
Five "	1,500	2,300	975
Six "	1,650	2,500	1,010
Seven "	1,775	2,750	1,075
Eight "	1,925	3,000	1,150
Nine "	2,075	3,200	1,225
Ten "	2,225	3,425	1,275
Eleven "	2,325	3,650	1,320
Twelve "	2,425	3,825	1,375
Thirteen "	2,525	4,000	1,425
Fourteen "	2,625	4,150	1,500
Fifteen "	2,725	4,275	1,575
Sixteen "	2,825	4,475	1,625
Seventeen "	2,900	4,550	1,675
Eighteen "	3,000	4,675	1,750

Editors' Note

Those who have made a study of engineering salaries recognize the difficulties met in securing definite information that is reliable. But it is safe to say that the graduates of the industrial type of school from which Dr. Rice obtained his statistics on the preceding page could hardly be expected to command a financial return that will average as high as the graduates from technical schools of college grade.

In a table of salaries of graduates from a technical school of college grade located in the eastern section of the United States, the salaries are practically the same for the first six years as the average on page 207. Then there is a divergence, growing in amount until at the end of eighteen years the college graduate is receiving from two to three times the salary of the graduate from the school of the lower grade.

A committee of the American Society of Civil Engineers has been collecting and tabulating for the past three years information pertaining to the salaries of civil engineers. It would be well for the youth looking toward the engineering profession as an occupation to study carefully the report of this committee and to obtain supplementary information from engineers practicing in the branch of the profession he contemplates entering.

TECHNICAL MAN IN BUSINESS

By John Ritchie, Jr.*

EFFICIENCY. The manufacturing world of to-day depends on the man who is technically trained. This is becoming more and more evident, and each year the scope of such men is becoming more extended, as specialists, as superintendents and managers, and administrative positions. And at the same time the call for men whose powers of observation and adaptation have been cultivated is on the increase. Having been in the past an employer of considerable labor, and in the older days and under older methods a manufacturer, the dependence of the business methods of to-day on the man with technical training is the more striking to me. Further than this, it has been my good fortune to see many good men rise to important places and to realize how much of their success was due to the special education which the technical school gave them.

There was a time, and this within the memory

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of men who did not consider themselves old, when the words "conservation" and "efficiency" were not in the merchant's vocabulary, and when business simply cared for itself. The goods were made in leisurely fashion by day labor; the material was bought from hand to mouth; the standard of product was a variable one and the cost of product was in effect a rough guess. The price was fixed, and the merchant knew that he could sell at a profit. The man who bought a stock of goods or manufactured a storehouse full of them had simply to sit down and wait with the certainty of disposal of them to advantage to-morrow or next week. This was in the lavish days of the development of this great country, when there was plenty for everybody.

That time has passed. The man who is to be successful in manufacturing or selling merchandise or assure profit to himself even in that staple industry, agriculture, must follow scientific methods. He must be ready to compete with others who are keen-eyed and intelligent. If he is a storekeeper of old fashioned mold, while he is waiting for his goods to sell themselves, his neighbor, who is trained in technical ways, has made improvements, so that the stock of the conservative one is out of date and suitable only for the bargain counter.

There are thus most excellent reasons why business men are turning more and more to the technical schools for young men who are usable at the outset and who may be developed along the lines of the greatest benefit to the product. The student who has passed his four years at a technical school of the highest grade must have acquired a fundamental knowledge of chemistry and a valuable acquaintance with materials, including those most subject to manipulation. Manufacture consists practically in processes of manipulation. These processes convert the material into products more or less refined, and in the transformation there lies the opportunity for efficiency or waste.

Such schools go further, and give a good foundation in mathematics; and the possibility of comparisons by tabulation and graphic diagrams, which are a sealed book to the old school business man, give a basis whereby economy and efficiency — as far as materials go — may be estimated.

Knowledge of materials means much more in other departments of the business. A man who has knowledge of this kind can test what is offered to him. He has the means of making the raw material conform to a desired standard, and will reap the advantages that must accrue to him in the evenness and reliability of his own product. Further than this, such a man can select between materials when there is a choice. He is fitted to find new materials that may supplant the older ones, and he has the education that will permit him to add advantageous qualities to the materials that he wishes to use.

LABOR STUDIES. Materials are but a portion of the story of efficiency, for there is labor and the mechanical plant. Labor is very important, for in an industry that is producing an article that is not of the highest excellence of finish, it may overbalance the cost of material in the ratio of say three to five. The technically trained man has already acquired the habit of studying, and it is a study to handle men. The success or failure of an establishment may depend upon the fitness of the men to the work they are expected to do. This is realized in technical schools, and already the best of them seek to strengthen their courses by adding something of the direct study of man. But fundamentally the man who studies man is the one who can place his labor most efficiently, and he does it because it is a technical problem.

There is much stress laid on efficiency when it comes to dealing with labor, and there are not a few, who in the rush of newer methods, feel that the workers must be merely machines. Here there is a substantial error, for the handling of labor, like any other acceleration, must be in harmony with the purpose. It is an injury to reduce all laborers to mere automatons. Each industry and each establishment has its own limitations. The man who is properly trained is able to study his own plant as an individual problem and to determine on its own merits, without unfortunate Procrustean standards, where scientific management may be advantageously employed.

INDUSTRIAL EXPLORATION. Any one can glance over the daily papers, and the special ones that have sprung up about all the industries, which may bring opportunity to any man's door, but it is not every man who has the perception to realize what these announcements mean. Here the training of the technical school, in the broadness and keenness of vision that it gives, is of great advantage.

The man with technical education will not attempt to supplant the architect in the latter's specialty, but he will be competent to consider the proper location and arrangement of his buildings, and he will know all about his prime movers and his coal pile. He will be able to rate in their true places the different factors, and converge them all to the greatest benefit of the whole establishment. He will be able to estimate the value of heralded improvements and judge whether they are promising ones. He will be able to let go when older methods fail by the newer standards, and he will avoid, what is not so rare in this country, the mortification of seeing an up-to-date rival growing up in his very shadow, and absorbing his business through more efficient management.

Then again, and most certainly not to be underestimated, technical training is of the utmost value in industrial exploration. There is constantly the need of production along undeveloped lines. All kinds of business is groping, so to speak, in semi-obscurity, seeking new fields, new methods, new materials. Here it is that a man with the knowledge of the materials and a knowledge of the methods and with a mind open to catch the latest information that science has to offer him is bound to win.

Only a quarter of a century ago it was the practical man who had worked up, who was at the head of the concern. It was the bobbin boy or the lineman who had grown to be the president. To-day it is the man technically trained, the engineer. He is making his way with all speed. He is yet young. But he is growing older and is winning his spurs surely and certainly.

THE END