DENKI READERS

BOOK III

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DENKI-GAKKO

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CONTENTS

LESSON I.

RECENT RESEARCH DEVELOPMENTS OF THE WESTING-HOUSE ELECTRIC AND MANUFACTURING CO.

By C. E. SKINNER

In the late '80's the Westinghouse Electric and Manufacturing Company occupied a building at Fayette Street and Garrison Alley practically in the heart of Pittsburgh's business district. The Laboratory consisted at that time of a single room with perhaps half a dozen workers, these men being also responsible for certain commercial design work. The facilities available would hardly equal the present facilities of some private laboratories of high school boys interested in experimental work. Mr. Westinghouse was making his epochal fight for the introduction of alternating current against what was considered by many people as overwhelming odds. There was some question as to whether alternating-current motor would ever be practical and the alternating-current ampere-hour meter had just made its appearance. Almost the sole application at that time for alternating current was incandescent lighting, and although making headway, it was not in a happy condition due to many inherent construction and operating difficulties. The only instruments for the measurement of alternating current and voltage were the Siemens Electro Dynamometer and the Cardew Volt Meter, and these could hardly be called instruments of precision. Alternating-current watt meters were unknown. The chemical laboratory consisted of a single desk with a few bottles of reagents. No attempt was made to do any metallurgical work. The science of dielectrics was practically unknown, insulation design, like many other design features of the day, being a question of cut and try. High voltage break down tests of insulation made their beginning only in the early '90's. The first high voltage alternating-current transmission plant necessitated a study of the dielectric properties of oil. Specifications for the purchase of materials and routine physical tests were entirely absent from the conduct of the Company's business. The systematic study of magnetic materials, both in sheet form and in castings and forgings, was undertaken at a somewhat later date.

It was through the trials and tribulations, the successes and the failures of the engineers of those earlier days that there came a recognition of the absolute necessity for systematic study and control of the materials and processes entering into the construction of the machines manufactured by the Company. As there was a wider use of electrical devices, new phenomena were observed which required study so that their laws might become known and either utilized or avoided as they were beneficial or harmful.

With the removal of the Factory to East Pittsburgh in 1895, with much larger manufacturing space and the

increased activity in whole electrical field, individual laboratories were provided for studies along specific lines. A chemical and physical laboratory was provided. Specifications for the purchase of the materials of construction were written and the knowledge which came from their application and that which could be gleaned from other sources was utilized to better the conditions surrounding the production and use of the Company's apparatus which was rapidly growing in size of units, in its application to new fields and in its spread to all parts of the country and even to foreign lands. The various laboratories grew in size and importance and along with this growth there came a recognition that a group of research workers more or less independent of the routine examination of materials, the checking of designs and the elimination of shop and field troubles was necessary. As a result, a Research Department was organized and a laboratory built and equipped. Those responsible for this laboratory kept before them an ideal that for each major type of material or phenomenon there should be provided equipment and a staff, second to none for their study. Special provision was made for the four primary groups of materials entering into electrical machinery and devices; namely magnetic material, conducting material, insulating material and construction material. Special groups were organized for the study of specific problems which were of major interest at that time. For example, the devices employing a high vacuum were coming into use and provision was made for a series of studies which would aid in the development of experts who would be thoroughly familiar with the ways and means of producing, measuring and maintaining vacua under the conditions which would be necessary to produce apparatus in which high vacuum was essential. Provision was made for metallurgical studies, particularly magnetic materials and alloys. Insulation and the organic chemistry connected therewith were specially provided for.

With this start and with some outstanding successes in the devices and products emanating from the laboratory, the growth and importance of the Research Department has been phenomenal. The older magnetic materials have been improved. Great improvement has been made in many of the non-ferrous alloys which of necessity form a part of the Company's products. The transformer-oil problem has been studied continuously and most of the difficulties surrounding the use of this material in earlier days have been eliminated. A very large amount of information on the physical characteristics of materials of all kinds and under various conditions of service has been obtained and put in the hands of the design engineers. Many advances in radio broadcasting have been either brought about or aided through the work on vacuum tubes, microphones, loud speaker and many other phases of the work. Picture transmission by wire and by wireless has been improved in quality and very greatly increased in speed. Sound and vibration studies have greatly

increased the knowledge in these lines and outstanding improvements in design and construction of the devices and machinery have resulted. Phenomena previously considered of scientific interest only have been employed in fields of usefulness in some cases making radical changes of existing apparatus necessary.

New and improved materials, improved processes of manufacture, new instruments and devices, have come from this laboratory in rapid succession. The first outstanding success was in the field of radio, with the development of a new type of tube, which helped materially in popularizing the broadcasting which had been originated by Station KDKA. Regular meetings are held for the purpose of describing and discussing the work in progress and the accomplishments of the research workers. These meetings are attended not only by the research staff but by the interested parties in the engineering, manufacturing and sales departments. The most cordial and cooperative spirit prevails throughout the laboratory staff and this extends to all other departments of the Company. By this means, each research worker has the advantage of the advices and counsel of his fellow-workers and consultation and cooperation with all interested departments is obtained. It may be said, therefore, that the research work of the Company is participated in by all those who are interested and as a result, the products of the laboratory are thoroughly sold as soon as these products are available. It frequently happens that members of the research staff, members of the Engineering Department and members of the Manufacturing Department, cooperate in the actual research. Products of the laboratory are extremely diverse, consisting of improvements in existing materials, the development of new materials, improvements in existing processes, the development of new processes, the development of new devices, the furnishing of necessary information on materials, processes and devices to the interested Engineering Department, the assisting in the elimination of field troubles and many other activities.

Research workers are encouraged to publish results of their researches and to appear before technical and scientific societies, thereby giving prestige both to the Company and to the individual worker.

A classification of accomplishments is difficult but the list which follows is intended to give some more specific idea of the character of the out-put of this laboratory. As some of the researches are carried on in connection with other departments these may properly be included and credited to the research activities of the Company.

Insulation Studies.—Perhaps no other part of electrical machinery and devices is more troublesome than the insulation. Materials of almost endless variety are used for insulating purposes, and none are ideal. Ever increasing requirements for higher voltages, higher temperature service, decreased insulating space, and many others, have made the research in insulation and insulating materials one that

has required continuous attention and will require attention so long as the electrical industry persists. Some of the outstanding studies have had to do with heat transference through insulation.

Synthetic Resins.—With the advent of bakelite, the original success in the synthetic resin field, an enormous amount of research work was required to properly utilize this new material. In most instances its characteristics are the exact opposite to those of the natural resins. It has many extremely valuable properties and a good many limitations. Every new application of this material has required development and research. Prior to the advent of bakelite, the process known as the micarta process had been developed which gave a product with many outstanding advantages over previous insulating materials. This process, in a word, provides for the manufacture of laminated insulating products such as combinations of paper and mica in a machine which applies heat and pressure in the forming of tubes, sheets, etc., with both mechanical and electrical properties of very superior merit. The binding material in the original micarta process was shellac. The substitution of synthetic resin gave a much more satisfactory product from the physical standpoint, and in many cases a less satisfactory product from the insulation standpoint. The insulation qualities of the bakelite micarta have been greatly improved, and provide a product which has no competitor for very great variety of uses, both from the insulation and the mechanical standpoint. Gears of cotton duck impregnated with synthetic resin are very largely used. During the war, propellers for airplanes were developed, a finished and complete propeller being moulded in a single operation from cotton duck impregnated with synthetic resin. Manufacture of these propellers has been continued and they have figured in many of the sensational flights, including high altitude records, the flight from California to Australia, the sustained flight of the Question Mark, and many others. An enormous use of this material is made in the construction of radio devices and many others. An extremely difficult problem in the large high-voltage oil-circuit-breaker construction has been solved by the use of laminated wood with synthetic resin as a binder, and processed under pressure which reduces it to approximately one-third of its original dimensions, very greatly increasing its strength, and resistance to mechanical shock.

Corona Action.—In high-voltage turbo generators there has been much difficulty from time to time due to the action of corona at certain points in the insulation. This action results in an eating away of the insulating material and seriously limits the voltage at which generators may be run. Extensive studies have resulted in the development of a high-resistance coating material which permits the corona to be disbursed without injury to the insulation. For many years the limit of voltage of generators has been around 15,000. With this new process, generators with a

voltage of 22,000 to 25,000 become entirely practical and even higher voltages are being considered.

Transformer Oil.—The transformer-oil question has been the subject of continuous research since the beginning of its use in transformers, which was in the very early '90's. One of the outstanding difficulties has been that of sludging. It was early found that the usual transformer oil heated to the normal operating temperature of the transformer. This matter has been studied by the manufacturers and users of oil-insulated apparatus in all countries where transformers are manufactured. International cooperations in the development of methods for determining the sludging characteristics of transformer oil is under way, but as yet there is no general agreement as to a test or even a series of tests which will quickly and satisfactorily determine whether oil is sludging or non-sludging. Our own laboratory has made continuous studies of this question for more than thirty years, both as to the determination of methods and as to the development of oils satisfactory for use. The result to date has been the development, through our research work, of a single oil suitable for all insulating work, such as transformers, oil switches and other oil-immersed devices which long-time test and a considerable amount of service has shown to be practically free from sludging under all normal operating conditions. The use of a single oil for this purpose is of tremendous importance, providing as it does, for the elimination of excess stocks, difficulties from accidental mixing of various kinds, simplification of recovery of used oil, and many other desirable features.

In addition to the question of sludging, there are many other characteristics of the oil which have required very special attention. The development of methods of producing a very superior oil has been studied at length and these promise further improvements in this very vital part of all oil-insulated apparatus.

Magnetic Materials.—The study of magnetic phenomena and magnetic materials has occupied our attention since the establishment of the first laboratory at Garrison Alley more than forty years ago. The development of silicon steel in 1906, completely eliminated the aging which was giving a very great deal of trouble at that time and at the same time reduced stand-by losses very materially. The losses per unit weight of material were cut in half by the original development of silicon steel, and these remaining losses have again been cut in half by new subsequent developments. It is not known what the limitation may be for further reductions but studies have been continuously under way with the best talent and equipment extant. The development of a nickel steel having high permeability at low inductions, has been of enormous value in the radio industry. The development of cobalt-steel magnets has made many changes possible in measuring instruments, particularly in devices such as the oscillograph. Estimates have been made indicating that the savings from reduction of stand-by losses amount to eight millions of dollars per year. This is really a saving in fuel at the power station.

Many phases of the magnetic problem have been studied which have resulted in the development of such materials as hipernik, cobalt-steel magnets, and other or unique value for specific applications. Special studies have been made in connection with the development of materials of extraordinary purity in order to arrive at the fundamentals of magnetic phenomena. Many new test methods and testing apparatus have been devised to forward this work. The analysis of carbon, for example, is now made accurate to .0005 by a purely mechanical method, which consists in heating the sample to over 1000°C. in a vacuum, burning the carbon to CO_2, then freezing out the CO_2 by liquid air in a trap, then expanding in a chamber of known volume, the gas pressure in this chamber giving the measure of the amount of carbon in the sample tested.

Litharge.—A cement made of litharge and glycerine is very largely used in connection with certain applications, such as the cementing of porcelain insulators. Very radical differences in the behavior of this cement as made from different shipments caused a very great deal of trouble. Some cements would set satisfactorily, while others would not set at all. After a very great deal of study, a research worker discovered that when subjected to the influence of ultra-violet light, litharge which was unsatisfactory would be unaffected, and that which was satisfactory would quickly turn dark. No difference in chemical composition of the two classes has been found, but it is apparently a question of a difference in crystallization, which is detected by this very simple test. Suffice it to say that this simple expedient has completely eliminated the troubles with litharge cement. Good material also heats where mixed with glycerine.

Rare Metals.—In the branch of the laboratory operated by the Westinghouse Lamp Company, a very great deal of work has been done in the production of certain of the rare metals in a remarkably pure state. Uranium has been produced in workable quantities. This is of value in the production of X-Ray tubes. Thorium has been produced in quantities sufficient to permit its application in a number of investigations and tests, and with the determination of most of its physical and other properties. The production of these metals has been made possible through the use of high-frequency vacuum induction furnaces. Most of these metals are readily oxidizable so that it is utterly impossible to produce them in the presence of oxygen.

Copper-Oxide Rectifiers.—The discovery of the fact that certain types of copper oxide formed on copper would permit the passage of current in one direction but not in the other, led to the development of the copper-oxide rectifier which forms a very compact rugged device and has found enormous use in radio apparatus. Like many other phenomena, the rectifying action is dependent on exact processing and a

very great deal of research work was necessary after the discovery of the phenomenon, to bring to perfection an apparently extremely simple device, consisting as it does of a pile of copper-oxide washers, between each pair of which is interposed a lead washer and the whole solidly bolted together with insulated bolts. Whether this device may ever be developed for large power remains to be seen.

Oscillograph.—The late Joseph W. Legg undertook the development of a special type of oscillograph, in fact, practically devoted a dozen years of his life to this work. His investigations and his designs have expanded the art of oscillography to a tremendous extent. His accomplishments and the extension of the uses of the oscillograph into many fields are worthy of more time than is permitted for this paper as a whole. Vibration problems have been studied and solved. The oscillograph has become a convenient tool for general use in place of apparatus available only to the most expert manipulators. Through its use the deaf are being taught to speak in a fraction of the time required by older methods. Piano tuning may be accomplished by the most inexpert with great exactness. Intelligence tests have been undertaken through the measurement of the rate of the transmission of a stimulus on the part of the subjects under test. The action within the cylinders of internal combustion engines may be studied with a degree of accuracy hitherto impossible. Obscure vibration problems have been solved. Many forms and combinations of the oscillograph are now obtainable for a great variety of uses.

Klydonograph and Cathode Ray Oscillograph.—The invention of the klydonograph using Lichtenberg figures, by Mr. Peters a few years ago, together with the more recent application of the cathode ray oscillograph, have been of tremendous importance in the study of high-voltage phenomena of all kinds, particularly artificial and natural lightning. These devices have made the study of transient phenomena on the high voltage transmission lines of the country possible. With their assistance, we are in a fair way now to secure information which will permit the reduction of difficulties on transmission lines by transmission phenomena to the irreducible minimum. They are tools in daily use in our high voltage research laboratory.

Photo Elasticity.—Through the use of polarized light models of mechanical structures made from transparent materials may be studied, showing with great certainty the points of maximum stress, and, therefore, the weaknesses of such structures. This method, originated elsewhere, has been developed by us to the point where our important structures of many types have been investigated and many improvements in the mechanical designs of our machinery effected. One of the very interesting studies was made by producing moving pictures of the strains of gear teeth. These pictures show the different results which obtain with the use of gears of high accuracy, gears poorly cut, and gears out of alignment due to displacement of their centers.

High Temperature Tests of Metals.—The increasing steam temperatures, particularly in turbine machinery, have brought in a new series of problems in connection with physical testing of the materials used in such constructions. Elaborate studies have been made of the physical characteristics of materials under conditions similar to those in this essential service. Radical improvements in both material and construction have been effected through these studies. These include studies of materials such as that used in boilers, steam piping and also studies of materials for high temperature services other than that directly in connection with high pressure steam plates.

Noise and Sound Analysis.—One of the important problems in connection with all machinery and particularly in connection with street railway equipment, is that of noise. A very considerable amount of attention is being given to the development of more quiet operation equipment for all places where noise is objectionable. This has led to the development of a device for the analyzing of noise and sound, which consists essentially of a microphone which transforms the noise into electric current, a filter which can be adjusted to single out any particular frequency and a meter to measure the current resulting from the noise of this particular frequency. With this device, the various noise frequencies can be separated out and their intensity measured. Studies of gear noises, for example, have resulted in the application of means of deadening the usual noises found in railway motor gears. Very great improvements have been effected by placing a line of deadening material in the gear directly under the gear teeth. This device can be used for a very wide range of studies of this class.

Vibration.—The elimination of vibration from machines of all classes is of primary importance. The causes are often obscure, and the cure frequently difficult. Broken shafts in both prime movers and in power-driven machinery are only too frequent. In certain water-power plants vibration has been so pronounced as to seriously endanger the life of the machinery. Devices for studying vibration somewhat similar for studying noises have been developed and these studies have resulted in the locating of excessive vibration in turbine blades, in locating the difficulty with large machinery, whether due to unbalance or to resonance vibration in the foundation or otherwise. An outstanding case was that of a water-power plant where the vibration of the waterwheel and generator unit was so severe as to endanger the whole plant. The cause of the vibration was found to be in the relation between the number of the runners in the turbine to other parts of the machine. The recommended cure is that of changing the number of runners in the revolving part.

Ventilation.—With the greatly increased output of generators, motors, and transformers, the question of ventilation becomes of prime importance. Several years of intensive

study has been devoted to this question by experts, who are also familiar with the mechanical and electrical design features of the apparatus involved. Laboratory studies in connection with these ventilating problems have involved the development of models, testing and measuring devices, and have required a very great deal of study and test, including the measurements of the rate of transmission of heat through insulating materials, through laminated iron, both with and across the laminations, and many other detailed phases of the problem. These studies have resulted in greatly increasing the efficiency of cooling systems, the practical elimination of so-called hot spot temperatures, and has effected a very considerable reduction in the size and weight of apparatus for a given output. More recently cooling of generating apparatus by means of hydrogen or helium has been undertaken and machines embodying this method of cooling are now in service, with a very considerable further gain in output of machines of a given size.

An undue amount of breakage of heavy springs resulted in an extensive study of the fundamentals of the design and the formula used and discovery was made that an error in the usual spring formula of small importance on ordinary types of springs became controlling as the diameter of the spring wire approached the radius on which the spring is coiled. In using the usual formula, this error in certain cases became sufficient to stress the material well beyond its elastic limit and the revision ot the formula has put the spring design on a proper basis and eliminated the trouble. This revision was made possible through the results of an elaborate research.

With the use of heavier and heavier locomotives, track stresses, particularly of curves, becomes a very important matter. A devise has been developed which gives accurate readings of these stresses and thereby indicating the precautions necessary to secure construction which will be satisfactory. This same instrument permits the testing of various types of locomotives in relation to their effect on track stresses and data has been secured which aids the designers of locomotives to minimize such stresses.

Carbon-Brush Research.—A continuous carbon brush research, lasting over a number of years, has resulted in the development of means selecting satisfactory brushes, and has pointed the way to a very greatly improved method of manufacture.

By-Products of Radio.—No single development has been more fertile in the production of new devices and new applications than that brought about through the development of the tube used in radio. We are familiar with the remarkable development of radio broadcasting. This is so well known that no further comment is needed here. As some of the by-products of radio which are not so well known, we may mention the following:

Grid-Glow Tube.—Mr. Knowles in our Research Department discovered that a three-element tube which, quite similar in construction to the ordinary radio tube, would have an extraordinary sensitivity and amplification factor under certain conditions. This tube consists in anode, cathode, and grid, and is filled to a suitable pressure with one of the noble gases, such as neon. With voltage applied between the anode and cathode no current will flow if the grid is thoroughly insulated. A current in the grid circuit of exceedingly small proportions will cause current to flow in the anode-cathode circuit. The amplification factor of this device can be made to have a ratio of one to one hundred million. This has opened up a wide field of applications, some of which are very spectacular in their performance, such as the starting of the electrified steel mills at Homestead from New York by the Chairman of the Board of the U. S. Steel Corporation, Judge Gary, passing his hand within an inch or so of a crystal globe placed on his desk in his New York Office. The capacity current thus produced was sufficient to permit sufficient current to flow to send the necessary impulse to the waiting apparatus in Homestead, 430 miles away.

Picture Transmission.—The present development of picture transmission of wire and by radio is brought about through the use of devices which are really by-products of radio development. The improved photoelectric cell and the photoglow tube play their part in developments of this kind. The essential features of picture transmission are as follows:—At the transmitting end an intense beam of light is successively passed over each small unit area of the picture and reflected into a light sensitive device such as a selenium cell or a photoelectric cell. The current in the cell is proportional to the intensity of the reflected light which again depends on the lightness or darkness of each picture area. The current thus produced may be sent by wire or may be "put on the air" for wireless transmission. At the receiving end the process is reversed. The varying intensity light is made to travel over the area of the sensitive paper and on development the built-up replica of the original at the sending end is reproduced. There are very exacting requirements to be met by the synchronizing and other mechanism employed.

Television.—Television depends essentially on the same principles as picture transmission, but the difficulty consists in getting a sufficient powerful light response on the receiving apparatus to permit a complete picture or scene to be reproduced at the rate of sixteen times per second. In the ordinary picture transmission now fairly well established, a picture may be sent in four or five minutes. This means that the scanning device passes completely over the picture point by point, the pick-up changing the light intensity reflected from the picture point by point over the whole area in that time, and this is reproduced as electric current at the receiving end transforms to light in the same way. It will be seen, therefore, that the difficulties of

reproducing such a picture at the rate of sixteen times per second offers many difficulties, but there is every promise that these will be overcome and that television will become an assured fact within a relatively short time.

Talkies.—In the latest development of talking pictures, we depend on the by-products of radio for its advancement. Here again, sensitive devices which will transform light impressions to electric current are at the heart of the mechanism used. Two general schemes for recording and reproducing of the sound from the moving picture films are used. One is known as variable area and one as the variable density. In the first case, the sound vibration, after being transformed into light, operates to produce a jagged line on the film along the side of the picture. A light projected over this jagged line to a photo-sensitive cell produces current which is transformed into sound. In the case of the variable density scheme, the amount of exposure for different sound volumes and qualities is used in the same way. Considerable advance is being made in connection with the production of equipment for use in the home with the sub-standard 16-millimeter film. The difficulties here are greater than those in connection with theatre work, due to the smaller sizes of the film and the necessity for keeping the cost of the equipment in reach of the householder.

Loud Speaker.—It is only necessary to remind an audience of the difference in the quality of reception between the modern loud speaker and that of early make, in order to indicate the remarkable advances which have been made along this line. Our Mr. Hanna has been at the forefront of this development and no little part of the high quality we have today is due to the work of Mr. Hanna and his associates.

Deion Circuit Breaker.—One of the most outstanding and perhaps important development started from purely theoretical considerations checked by difficult laboratory experiments and with the final result that a practical device has been developed, capable of handling large powers up to voltages of possibly 25,000.

The fundamental principle on which this breaker is based is the fact that a voltage of not less than approximately 250 is required to break down an air gap no matter how small and when breakdown occurs the recovery of the insulating voltage of the layer of air next to the cathode is practically instantaneous. "Theory and experiment indicate that the first 250 volts are borne almost entirely by a thin layer of gas immediately adjacent to the cathode. Electrons readily leave this layer, but others to replace them cannot enter from the metal. The positive ions discharge into cathode: thus this cathode layer is deionized very rapidly." From considerations of this phenomenon, Dr. Slepian reasoned that if the arc caused by the opening of a circuit could be split up into a large number of small arcs by insulated metal plates, the fractional part of the

whole between each pair of plates being such that each arc would be less than 250 volts, extinction of the arc should be accomplished at the end of the first one-half cycle after the arc is established in the multiple group of electrodes. A practical construction finally took the form of an arrangement whereby the arc is magnetically driven into a chamber consisting of a multiplicity of copper plates closely spaced and insulated from each other. These plates provide a circular path for the travel of the arc and the arc is kept moving by means of the magnetic field impressed on these plates. It was further necessary to provide a static shield so arranged that there will be a relatively equal division of the total arc into a number of sections provided by the stack of copper plates.

Field tests on the Commonwealth Edison Company's circuit in Chicago, of 3-pole, 2,000 ampere, 15 kV breaker, showed very satisfactory performance, breaking as high as 25,000 ampere without difficulty and without any signs of deterioration of the breaker. This breaker while not as yet ready for the market may in the future exert a profound influence on central sub-station design as it has the possibility of completely eliminating oil from oil breakers for this service.

The Deion Circuit Breaker may truly be called a by-product of radio since it was through studies and considerations of radio devices that led to the discovery of the fundamental principle on which this circuit breaker is based.

High-Frequency Therapeutic Effects.—It has been discovered that living beings in the field of a very short wave generator experience an increase in temperature. The significance and value or danger, of this phenomenon is as yet not much more than a speculation. There is a possibility, however, of its being of very great value to the medical profession, providing, as it does, a possible means of increasing the body temperatures of patients who are suffering from sub-normal temperatures. Naturally, this must be tried out with great caution until it is definitely established that such influence is not dangerous but beneficial. This is another by-product of radio, coming as it does from a discovery in connection with experiment of short-wave transmitters.

Electric Welding.—Electric welding in itself is not a recent research development, but the exceeding rapid advance in the use of arc welding for the construction of buildings, bridges, electrical machinery, and many other uses, has demanded a very considerable amount of research work in connection with this general activity. This research has taken the form of a study of strength of the welds, the study of the character of the welding under different conditions, studies to develop methods of test for completed welds without destroying the weld and many other phases of the question. The advance in welded constructions themselves has been truly remarkable. In our own plant the major part of the large machinery is now constructed almost wholly from

rolled material by the arc welding process. Much of the cutting to shape is done by the use of the oxygen cutting torch. All this has made radical change in the manufacturing equipment for this class of machinery. It is confidently expected that this type of construction will extend into almost every branch of the machinery business. The day is probably not far distant when the riveting hammer of the steel worker on steel-frame building will be silenced and replaced by welding. True, many detail changes in design must be made in order to adapt welding to such constructions but, in general, there is both a savings in time of construction and in the amount of material required by the use of modern welding methods.

(Delivered upon the lecture-meeting of the Institute of Electrical Engineers of Japan.)

LESSON 2.

TRANSATLANTIC MEETING

Time and distance were annihilated in a spectacular way when, for the first time in history, two gatherings of engineers, one in New York and the other in London, talked freely and easily to each other, and their remarks were heard by hundreds of people gathered in the auditoriums in both cities as readily as if all the speakers were on the same platform.

A new era in the communication art was thus inaugurated during the Winter Convention of the American Institute of Electrical Engineers at which a joint session with the British Institution of Electrical Engineers was held. The occasion marks an important milestone in the history of engineering achievements, and adds further luster to the already brilliant accomplishments in the records of the participating societies.

It was not without a feeling of awe that the New York audience awaited the salutation of the Chairman, 3,000 miles away, but the messages came from across the ocean so promptly, clearly and naturally that the novelty of the demonstration would hardly have been recognized if the locations of the speakers had not been known.

It is particularly gratifying and appropriate that these two great engineering societies, separated by the vast expanse of the Atlantic Ocean but bound together by the

common ties of advancement of science, invention and engineering in the field of electricity for the good of mankind, should be the first to come together in this new form of international assembly, made possible through the developments in one of the branches of our own profession.

The deep significance and far-reaching importance of this meeting were reflected in the eloquent remarks of those who addressed the joint session, and in the resolution adopted at the meeting.

The following resolution was adopted subsequently by the Board of Directors of the Institute:

Whereas:—On February sixteenth, 1928, there was held a Joint Meeting of the British Institution of Electrical Engineers, its attending members and guests being assembled at twenty-eight Victoria Embankment, London, England, with the American Institute of Electrical Engineering, convened in the Engineering Auditorium, New York, U. S. A., during which all of the proceedings were rendered perfectly audible to both assemblies by means of land and transoceanic communication channels made available through the cooperation of the American Telephone and Telegraph Company and the British Post Office; and

Whereas:—This extraordinary demonstration, the first of its kind in history, was successfully accomplished only by the perfectly concerted efforts, not only of the American Telephone and Telegraph Company and the British Post Office, but also of all of the individuals concerned in its preparation; therefore it is

Resolved:—That the Board of Directors of the American Institute of Electrical Engineers, on behalf of those members and guests whose privilege it was to attend the Joint Meeting, and also on behalf of the entire membership of the Institute, hereby expresses its thanks and its recognition of the efficiency, public spirit, and high technical achievement of these cooperating organizations as evidenced by this event; and especially extends its thanks and congratulations to the many technical assistants and workers without whose intelligent and faithful labors this proof of advance in applied science would have been impossible.

(Journal of A. I. E. E.)

LESSON 3.

THEY STARTED TOGETHER AS OILERS.

By H. M. FRIEND

While on a construction job in one of the largest generating stations along the Atlantic Seaboard, I had a desk in the office of the chief operating engineer, Luke Jackson.

One day the office boy remarked, "Mr. Jackson, the chief, has been right here in this power house thirty-three years."

Thirty-three years with one company, and especially in the same power station, is a mighty long time, I thought. And I at once became interested, and called on the boy for further information.

"That must be a record for the company," I said.

"No, it ain't," he answered. "Did you ever notice the old grayhaired man, Fred Jones, who cleans up the floor of the Turbine Hall? They both started here the same year, and both on the same jobs, working together as oilers."

The story of these two lives struck my imagination. Here was a remarkable example of two men with an equal start and the same environment. The career of one was development and success; of the other, stagnation and a stationary life.

What were the causes that made the two lives reach such different elevations, I mused, one travelling the road that led toward the top of the hill, while the other trudged the valley road all those years? Was it a case of favorites, or pull in the one case? Or was it a matter of effort and growth in the case of the man who went to the top?

So when Mr. Jackson stepped briskly into his office, I seized the first opportunity and said: "I was interested to hear something about your life, Mr. Jackson. How you started here as an oiler thirty-three years ago, and on the same job with that old man who is still out there on the floor of the turbine hall. I think yours a remarkable case."

His keen gray eyes lighted up, and there was a smile on his ruddy face as he turned to me.

"Yes, I have been here quite a while," he replied. "I started with this company in December, 1893, and have been in this one power house ever since, but there has been nothing unusual in my career. Every day in the week you meet chiefs who started as oilers or ash handlers."

He looked a man of forty-five, at his desk there—though I knew he was really fifty-eight. A kindly, likeable man, with a pleasant word for everybody. One could easily see that he had spent a happy life. With considerable energy and an active step, with rather small angular features, and a strongly pronounced rural accent, I should have placed him as a successful, educated farmer rather than an engineer. Yet when he talked on technical things you could

easily see where his heart was.

I had noticed that he was very modest. It was hard to get him to talk about himself. So I tried his favorite subject.

He Worked in the Old Mill.—"Did you know anything about electricity before you came here?" I ventured.

"Not the slightest," he answered. "My family lived in a small mill town—no electric drive in those days. The mills were all located on streams and were run by water-wheels. Our family was a large one and we were very poor. I started in the mill with only a few years of schooling. I worked in that mill for ten years till I was twenty-five. For those days I was getting a pretty good wage rate and my family thought I was doing quite well, but I couldn't see anything ahead for me at the mill.

Then times got bad and they would close down for a day or so every week. I began to figure that a steady job at a lower rate of pay would bring in more money; and the family needed all I could make. So during one of the periods of shutdown I looked around for a steadier job.

"In Norfolk, this city, which is only twenty-five miles away from my home, there was a central station which supplied the town with electricity. They never seemed to shut down, but ran all the time, night and day, and even Sunday. So I got a friend who knew the foreman there to try to get me a job, and, if possible, something to do with the electrical machinery. Well, I got a job as oiler. It was right in this power house. True, you would never know it was the same station. The ground on which it stands is the only thing that hasn't changed. Those totally inclosed turbine-generators of large output you see out there in the turbine hall are not so impressive as the big reciprocating engines that so astonished the boys of those days.

Starting Upward with Determination.—"Yes, Fred Jones was an oiler, too, when I started. Both of us celebrated our thirty-third anniversary with the company last December. That first year we often talked together about how to get ahead. The thing that impressed me was the little I knew about electricity. And I determined to learn something, whatever it might cost me in hard work.

"They had night courses in the Y. M. C. A. in Norfolk, and I started one on how to read blueprints. One night on leaving the Y. M. C. A. class I passed the superintendent of this plant. He stopped me and inquired what I was doing there. He was always interested in his men. I told him about the course, but he didn't say much.

"Well, I finished that course and had heard about the correspondence school course, so decided to take one on electricity. I took this and followed it through, working all the problems with a lot of interest and care. Then I took another course on electricity by mail, a more advanced one.

"By this time I had got to be an operator. In those days it was quite a different job from now. No well-organized maintenance crews to take care of all the trouble. I was supposed to be operator and emergency man, too. I don't know the equipment out there now like I did the old stuff. In those days men worked harder than they do now, anyway. Never thought much of working through two shifts when there was trouble in the plant.

He Thought He Was Fired.—"While on the night operating shift one of the most important things to affect my career happened. One night things were pretty quiet and I began thinking about the electrical course I was taking. So I got out my lesson and was working away on an electrical problem in great shape when a shadow fell across my paper. A cold feeling came over me. I knew I had been caught. On jumping up I saw it was the superintendent at my side and that he was watching me. It was strictly against rules to read during the shift, and so I fully expected he would fire me right then and there.

"He asked me what I was doing. I told him that I was working an electrical problem in my correspondence course. Then I waited to be fired. Instead, however, he brought over a chair, sat down beside me and worked problems with me for more than an hour. And I had expected to be fired at once. Little did I know it then, but this was one of the most important moments in my career.

"A few months later the chief operating engineer died and the superintendent recommended me for the job. He fought so hard for me that I got it. There have been four changes in superintendents over me since then, but somehow none of them has fired me. That's the whole story. You see there was nothing out of the ordinary that I did."

Modesty was a strong characteristic of this man, and he really felt that way about it. But to me it was the best example I had seen where earnest attention to the job, combined with study and self-education, had brought results. And all the more striking by comparison with the other oiler, who had remained just where he started.

I recalled now that on several occasions I had seen Mr. Jackson busily engaged at his desk in the solving of an electrical problem. He was still following the policy of self-education. My thoughts turned toward the oiler who was still on the floor.

"The contrast between your job and your companion oiler's job is rather striking, Mr. Jackson. How is it you got so much farther ahead than he?"

"Both of Us Couldn't be Chief."—"Well," he said, "both of us couldn't be chief. When the job was open I was an operator, of course, and had a better chance of being considered than an oiler."

Not content with this modest explanation, I questioned one of the men in the office when he and I were alone.

"Well," he said, "Fred Jones could have done worse. He has had a steady job for the last thirty-three years—

never been laid off once. Saved some money, too. He told me about it. Enough to help him get along in his old age."

It seemed to be a case of lack of ambition. A steady, easy job, enough pay for a modest living, and a cautious thrifty temperament looking out for his old age. If he, too, had taken up the correspondence-school course and had fitted himself for the next higher job, he would have been at least an operator in this or some other company.

The story seemed too valuable to keep to myself. On my next encounter with Mr. Jackson, I said, "There are young fellows starting as oilers in plants all over the country and your case, Mr. Jackson, would make a valuable example for many of them. Why don't you give them the advantage of your experience and the inspiration of your success?

"The correspondence schools have been after me for a long time to let them use my picture and my name, but I really can't see how it could interest anybody," he replied.

"Your case is already an inspiration to me," I rejoined, "and I know that if you could help just one young engineer climb one round nearer his goal you would gladly forget your modesty and let your story be told."

"I never thought of it that way," he answered, "but I should like some young fellow to be impressed with the importance of studying his line of work and if you promise not to disclose my name you can use my little story as an illustration." (Power)

LESSON 4.

HUMANIZING TECHNICAL EDUCATION

Purdue University Takes Lead in Development of System Which Benefits Students and Employers Through Rating of Students' Personality as Well as Scholarship

By R. C. WOODWORTH

A sincere attempt to develop the personality and character of technical students as well as impart engineering training is being made in the schools of engineering at Purdue University, Lafayette, Indiana. Technical education is often accompanied by the accusation that it overlooks the human element, but Purdue's attempt to "Humanize engineering education," after six years of development, is meeting with considerable success and is attracting widespread interest in the outside engineering world as well as within college walls, especially from employers who find the system invaluable as a guide in selecting graduates for employment. Prof. A. A. Potter, dean of the engineering schools at Purdue, is known as the father of the movement. A former president of the Society for the Promotion of Engineering Education and a recognized leader in the engineering education world Professor Potter has seen his dream develop to the point where other institutions of higher education have recognized its value and set up

similar systems.

The movement, when first started, resulted in the organization of a personnel bureau at Purdue, which at the present time is headed by J. E. Walters. The bureau in reality makes a character analysis of each student, keeping a complete record of the mental, physical, religious and social development of the students during their university careers. It works on the theory that studies and work develop the student's mind, the athletic department develops his body, the church betters his character and the personal system should improve his personality.

The system gets under way with the registration of the freshmen as soon as they arrive. Each entrant is required to fill out a series of blanks giving a record of his life and past experience, along with information concerning his family. In the latter part of his freshman year the student fills out a reference blank containing the names of fifteen people who are qualified to rate him on the characteristics of his personality. It is provided that five of the references named be teachers that the student has come in contact with at the university, five be students, and five be men who have no actual contact with the university.

Personality rating blanks are then sent to the fifteen references, who are asked to rate the student's personality through the medium of the questions printed on the blank. The blank itself perhaps explains the system better than any description. That used at Purdue has the following questions:

1. ADDRESS AND MANNER: (Does he leave a good impression? Does he talk well? Is he popular? Has he a good bearing?)
2. ATTITUDE: (Is he rational, agreeable to reason in his views? Interested in his work? Optimistic? Self-controlled?)
3. CHARACTER: (Is he reliable? Dependable? Absolutely honest? Responsible? Clean? Just? Courageous?)
4. CO-OPERATIVE ABILITY: (Can he work with others? Is he accommodating? Loyal? Willing to learn? Tolerant? Tactful? Is he a good mixer?)
5. DISPOSITION: (Is he cheerful? Courteous? Congenial? Enthusiastic and not conceited?)
6. INDUSTRY: (Is he a hard worker? Has he perseverance? Is he persistent?)
7. INITIATIVE: (Is he a self-starter? Does he recognize, start and develop opportunities to a successful conclusion? Is he original?)
8. JUDGMENT: (Has he common sense? Observing and reasoning power? Foresight? Resourcefulness? Does he know values and the relations of things? Is he practical?)
9. LEADERSHIP: (Does he understand men and can he command their respect? Has he executive

ability? Does he precede and direct men?)
10. NATIVE CAPACITY: (Is he naturally accurate, systematic, bright, alert? Has he an inherent knowledge of facts and data? Can he concentrate? Does he learn readily? Has he a natural aptitude for work?)

The rating scale ranges from one to ten. There are five general classifications—poor, low, average, high and highest. Poor ranges from one to two; low from three to four; average, from five to six; high, seven to eight; highest, nine to ten.

References are advised in filling out the blanks to make the ratings in comparison with men of similar age, educational preparation and environment. As soon as the fifteen ratings are received in the personnel office, they are averaged so that the prejudices of one or two will not greatly affect the total average. The ratings are then compiled and recorded on the student's personnel record, along with the scholastic record of the student.

But the activity of the personnel bureau does not stop there. If the general average of the ratings on all the characteristics is low, the student is called into conference by the personnel director or a member of the staff and asked why he has impressed fifteen people as being low in particular characteristics. The troubles of the student are discussed in detail and methods of improvement are then suggested.

This same general procedure is repeated in the third, or junior, year. As soon as the date from the references supplied in the junior year reach the personnel office, they are compiled and a careful study made of the ratings in comparison with the ratings of the freshman year. If the characteristics are not improved after the junior rating, the student is called in for another conference. Suggestions for improvement are continually made to students with low characteristics, and in the senior year another chance is given for improvement.

In addition to the rating of personality, the personnel office, through its contact with the students, naturally serves as an agency where students are made to feel that they may go freely for advice. No matter what their problems may be the personnel director makes an effort to give assistance, and if he cannot, advises the students where to go for the information or help.

One of the biggest opportunities of the personnel bureau comes in the senior year when the time for consideration of employment arrives. With the records of three years' supplementing personal conferences in many cases, the personnel director is able to give expert advice on the type of position that a student will be fitted for. The system works to the mutual advantage of the student and the employer, for the employer may get invaluable information concerning the positions for which students are fitted, and the student may get advice concerning the best type of

position to accept.

Nor does the interest of the personnel bureau cease with the graduation of the student. After sufficient time has elapsed to allow employers to gauge the caliber of work that is being done by a former student, a "Progress Blank" (another form of personality rating blank) is sent to the employer. If the report is unsatisfactory, this information is transmitted to the alumnus together with suggestions that may help in eliminating deficiencies mentioned by his employer. Letters are sent to the employer asking his co-operation in giving the graduate the best possible opportunity and encouragement to improve. Sometimes a visit is paid to the employing company by a representative of the personnel bureau in an effort to iron out difficulties.

Proof that industry approves of the personnel system is furnished in the fact that the initial funds to start the bureau were donated by the Indiana Manufacturers' Association and that this organization has continued to bear a substantial proportion of the current expenses from year to year. Hundreds of letters have been received from industry lauding the system and from students and graduates who have been benefited by its workings.

(Journal of A. I. E. E.)

LESSON 5.

TWENTIETH CENTURY STREET LIGHTING

Street lighting from the first primitive methods to the present-day ornamental-post system has had a fascinating development. As early as 200 A. D., an effort was made by the people of Rome to light their streets at night for protection and safety. We also find in the early records of the eighteenth century a reference to a municipal street-lighting company which was organized in Paris to illuminate the streets of that city. In 1879 at Cleveland, Ohio, U. S. A., electricity was first applied for street-lighting purposes; twelve open-tyye electric arc lamps were placed there in the public square.

These arc lights were accepted generally for some time as a standard for street lighting purposes. However, it was the tungsten-filament lamp that gave the real impetus to the efforts to progress in the art of street lighting. Later this type of lamp was improved by filling the bulb with a gas which gives us our modern gas-filled electric lamp. These lamps were the first high-powered light source to successfully compete with the arc lights.

With the introduction of this lamp the older type of post for a cluster of arc lights was supplanted by the single-lamp standard, and from this change grew the development of the modern ornamental post system.

Ornamental posts give the builders of lighting systems an opportunity to design lamp standards that blend harmoniously with the architecture of the surrounding buildings. Another important advantage of this system is that the intensity of illumination can be graduated in accordance with the conditions of the various locations.

In these modern days, when adequate street lighting is recognized by civic leaders as being a most important factor in the growth of cities and towns, it is difficult to realize that, a few years ago, little attention was paid to the lighting of thoroughfares. But because of the remarkable developments in electrical and illuminating engineering, the growth in civic pride, and the beneficial results wherever modern lighting systems have been installed, there are very few cities today which do not have attractive ornamental street-lighting systems.

There is no reason why any city should not have well-lighted streets. Approximately 25 per cent. of the normal expenditures of the average city is for safety and protection and only a very small part of that amount is spent for street lighting. With the expenditure of just a few cents per capita, additional for street lighting a city can increase the safety and protection of its citizens and in many cases it can decrease the cost of other municipal services.

LESSON 6.

LECTURES TO WOMEN ON PHYSICAL SCIENCE

CLERK MAXWELL.

Place: A small alcove with dark curtain. The class consists of one member.
Subject: Thomson's Mirror Galvanometer.

The lamplight falls on blackened walls,
And streams through narrow perforations;
The long beam trails over pasteboard scales
With slow decaying oscillations.
Flow current, flow, set the quick lightspot flying,
Flow, current, answer lightspot, flashing, quivering, dying.

O look! how queer, how thin and clear.
And thinner, clearer, sharper growing
The gliding fire! with central wire,
The fine degrees distinctly showing.
Swing, magnet, swing, advancing and receding.
Swing, magnet; answer, dearest, what's your final reading?

O love! you fail to read the scale
Correct to tenth of a division.

To mirror Heaven those eyes were given,
And not for methods of precision,
Break contact, break, set the free lightspot flying,
Break contact, rest thee, magnet, swinging, creeping dying.

(Electrician, April 27, 1928, p. 468.)

1383 LIVES SAVED

It is estimated that the railroads of America, as the result of systematic safety contests among employes during the past five years, have saved the lives of 1383 employers, and have prevented over 180,000 additional serious accidents to employes.

These estimates are based on official Interstate Commerce Commission statistics, comparing the 1923 accident rates of these railroads with the lessened accident totals which have been achieved as the direct result of systematic and competitive safety contests among employes.

In recognition of this splendid safety work among these railroads for the year 1928, the National Safety Council last month presented a number of awards to the winners of the Railway Employes' National Safety contest. The awards were presented by Major Henry A. Reninger, president of the National Safety Council.

(A. I. E. E., Vol. 48, June 1929, p. 468.)

LESSON 7.

FARADAY THE DISCOVERER

JOHN TYNDALL.

When from an Alpine height the eye of the climber ranges over the mountains, he finds that for the most part they resolve themselves into distinct groups, each consisting of a dominant mass surrounded by peaks of lesser elevation. The power which lifted the mightier eminences, in nearly all cases lifted others to an almost equal height. And it is with the discoveries of Faraday. As a general rule, the dominant result does not stand alone, but forms the culminating point of a vast and varied mass of inquiry. In this way, round about his great discovery of magneto-electric induction, other weighty labours group themselves. The investigations on the extra current; on the polar and other condition of diamagnetic bodies; on lines of magnetic force, their definite character and distribution; on the employment of the induced magneto-electric current as a measure and test of magnetic action; on the revulsive phenomena of the magnetic field, are all, notwithstanding the diversity of title, researches in the domain of magneto-electric induction.

Faraday's second group of researches and discoveries embrace the chemical phenomena of the current. The

dominant result here is the great law of definite electro-chemical decomposition, around which are massed various researches on electro-chemical conduction and on electrolysis both with the machine and with the pile. To this group also belongs his analysis of the contact theory, his inquiries as to the source of voltaic electricity, and his final development of the chemical theory of the pile.

His third great discovery is the magnetisation of light, which I should liken to the Weisshorn among mountains —high, beautiful, and alone.

The dominant result of his fourth group of researches is the discovery of diamagnetism, announced in his memoir as the magnetic condition of all matter, around which are grouped his inquiries on the magnetism of flame and gases; on magne-crystallic action, and on atmospheric magnetism, in its relations to the annual and diurnal variation of the needle, the full significance of which is still to be shown.

These are Faraday's most massive discoveries, and upon them his fame must mainly rest. But even without them, sufficient would remain to secure for him a high and lasting scientific reputation. We should still have his researches on the liquefaction of gases; on frictional electricity; on the electricity of the gymnotus; on the source of power in the hydro-electric machine, the two last investigations being untouched in the foregoing memoir; on electro-magnetic rotations; on regelation; all his more purely chemical researches, including his discovery of benzol. Besides these he published a multitude of minor papers, most of which, in some way or other, illustrate his genius. I have made no allusion to his power and sweetness as a lecturer. Taking him for all and all, I think it will be conceded that Michael Faraday was the greatest experimental philosopher the world has ever seen, and I will add the opinion, that the progress of future research will tend, not to dim or to diminish, but to enhance and glorify the labours of this mighty investigator.

(Preface to Experimental Researches, Everyman's Library.)

MOTION PICTURE CAMERA IN ELECTRICAL TESTING

The following brief résumé of an article describing the use of a motion-picture camera in making certain electrical tests is given through the courtesy of Mr. Frank E. Fisher, of Chicago.

The general method is to mount the meters, which vary with the type of test to be run, on a panel and then take moving pictures of the instruments. Thus, the data taken by an ampere-hour meter, voltmeter, wattmeter, frequency-meter, speed indicator, etc., are accurately recorded on the film and can be studied at leisure. This method obviates the use of a man to read each instrument, thus avoiding the inaccuracy of the human element.

The readings may be taken on 16 mm. or 35 mm. standard film and many of the cameras on the market which have a fairly wide range, can be used. A spring-operated camera has been tried with good results.

(A. I. E. E., Vol. 48, Nov. 1929, p. 799.)

LESSON 8.

COMMUNICATION ENGINEERING

So far as the tasks of the inventor and the engineer in improving systems of electric transmission of intelligence are concerned there is a difference in the problems of the "wire" and the "wireless" engineer.

In telegraphy and telephony by wire the betterments over a period of twenty-five years have resulted mainly from improvements made in the media extending between the terminal instruments—the line and the cable. The telephone transmitter and receiver, for instance, are today almost identical with what these devices were forty years ago. The quality of transmission thirty-five years ago was as good as it is today. The improvement has been that the distance has increased from, say, one hundred miles to two thousand miles.

The telegraph has improved in dependability and speed, also mainly as a result of improved line construction and maintenance, increased insulation, and improvements in aerial and underground cables. The Morse Key, the relay, the sounder, and the apparatus of Morse multiplex working have changed in construction; not in principle. True, the development and extension of printing telegraph systems stands as an advance in terminal apparatus, but much of the success of present day printing telegraph systems is due to betterments in line circuit conditions over those which were available to early printing systems.

It would appear therefore that aside from ingenious mechanical refinements and extensions of terminal plant and organization to care for the growth of telegraph and telephone traffic, that the engineering gains which account for improved transmission have been mainly those involving "line" conditions.

In radio telegraphy and radio telephony, the inventor and the engineer in order to produce system which will be improvements upon present systems have only the field of terminal apparatus in which to work. The medium connecting transmitting and receiving installations (aside from guided carrier systems) is not likely to be subject to treatment of a sort that would affect the grade of transmission through it of radio signals.

The radio engineer has no choice but to aim to develop terminal apparatus which will render the grade of transmission desired when the intervening medium is in a condition least favorable to the maintenance of dependable operation.

Radio terminal apparatus might be designed to have what could be termed a Factor of Surplus. Transmitters of given design and given power input embodying this factor might be expected to provide satisfactory service throughout the occasional periods when the least favorable media conditions prevail. Good design might provide that conditions are

favorable or normal the strain upon the Factor of Surplus could be reduced permitting immediate economy in operating costs.

The fact that the problems of radio are problems of terminal apparatus only, accounts for the pronounced alterations noticeable, after the passing of a few years, not only in the design but in the principle of radio equipment.

(A. I. E. E. January, 1924, p. 1.)

LESSON 9.

STEINMETZ BECOMES AN AMERICAN

JOHN WINTHROP HAMMOND

A warm, pleasant afternoon—the first of June, 1889. The waves of the lower bay. The French immigrant liner La Champagne working her way through the passing sea traffic, and off ahead of her a sight for the soul to gaze upon and never forget—the great figure of Liberty, with her quenchless torch!

Many wondering eyes looked up at that figure from the deck of the French liner; eyes that had never seen the spectacle before. The young German, Steinmetz, looked eagerly with the rest. But he was frank in saying, in his later years, that he was hardly any more contemplative, at the moment, of the symbolism thus arisen before him, than were the other immigrants in their exciting realization that America was at hand.

Yes, here was America! Young Steinmetz, turning from the heroic statue, looked with equal wonder round about upon the busy scenes of the great port, the vessels looming up with the drift of smoke about them, and the first suggestion of the bustling city, the ever-astonishing waterfront of the western metropolis.

The spirit of it all took hold upon him that sunny afternoon, coming up the harbor. He felt the surge of adventure.

The sights, the sounds, the smells of this new sea-washed shore were all about him. America and her advantages were swiftly imagined as he stood there.

And they were inevitably more sharply defined than is the case with the young man who is born on the soil and grows up in the land, having his country's grandeur unfolded gradually before him.

But the more unpleasant realities of life, as encountered in the process of landing from an immigrant vessel, intruded upon his romantic fancies.

It was a Saturday afternoon when the vessel docked.

The cabin passengers were put ashore at once. But those in the steerage, Steinmetz and Asmussen among them, were held on board until Monday. Saturday and Sunday were warm, pleasant days; but on Sunday night the wind changed, blowing damp and cold through an open port upon Steinmetz's head as he slept.

This sudden veering of the breeze, his first experience with the fickle North American climate, complicated his landing experience most uncomfortably, for he awoke with a very bad cold, which caused one side of his face to become swollen, and made him feel miserable generally.

Yet he hopefully confronted the immigration officers, accompanied by his loyal friend. Together they landed at old Castle Garden, now the Aquarium, forerunner of Ellis Island.

If Steinmetz had been alone that day, his dream of coming to America might have ended abruptly right there at Castle Garden. His forlorn appearance, swollen face, empty purse, and stumbling English caused the immigration authorities to shake their heads. His knowledge of English was so scant that when the officials asked him if he knew the language he could only reply, "A few." After some minutes of searching questions and puzzled answers the official decision was reached and made known to him.

He could not land! He must go back to Europe!

The tremendous disappointment that leaped into his eyes when he understood this decree did not alter the official attitude. With disconcerting briskness they sent him to the detention pen.

But his traveling companion saved the situation. Asmussen explained to the officers that Steinmetz and he were together. He stoutly declared they would stick together after landing and that he would personally see that Steinmetz did not become destitute in a strange land.

Asmussen spoke English fluently.

Moreover, he showed a fairly substantial sum of money, which, he declared, belonged to them both.

He was willing to make himself responsible for the welfare of his friend; and, upon his representation, Charles P. Steinmetz was finally admitted to America, which was to be for him the land of friends, fame, and fortune.

Yet, as already revealed, Steinmetz himself had not a penny in his pocket when he first set foot upon American

soil. His traveling companion was his financier. He owed his friend money for paying his way over from Europe; he owed him also for any expenses that came up from day to day. He himself was destitute.

Thus it was that the two young friends found themselves in New York with both funds and prospects uncertain. Yet those few weeks were weeks of happiness for them. Asmussen had relatives in Brooklyn, and there they obtained lodgings until they could hunt up work.

The Brooklyn people received Steinmetz with as much hospitality as they did their own kinsman. They made it pleasant for him while he boarded there, and helped him to learn English better. And soon he began hopefully to visit the places of which he had been told, or to which he had letters of introduction, looking for a chance to work.

The first person whom he approached, seeking a position, was the engineer of the Edison machine works, to whom he bore a letter of introduction, written by Mr. Uppenborn. But there was no opening here; the engineer made that quite plain.

"It seems to me," he remarked, as he dismissed his caller, "as if there was a regular epidemic of electricians coming to America."

The next day Steinmetz went to Yonkers and called upon Rudolf Eickemeyer, who conducted a prominent manufacturing establishment near the railroad station, having succeeded the original firm of Eickemeyer and Osterheld. What happened when he entered the office is told by Walter S. Emerson, a nephew of Eickemeyer's, who was at that time an office clerk, in addition to other duties.

"He had come directly from the railroad station," Mr. Emerson relates. "He wore plain, rather rough clothes and a cap. I got the idea, from looking at him, that he was some chap who had knocked his way from place to place, looking for a job.

"I asked him whom he wanted to see. He replied: 'Mr. Eickemeyer,' speaking in a quick manner.

"I went upstairs and found Mr. Eickemeyer. 'Uncle,' I said 'there's a man to see you down in the office. I don't know his name; he might be a fellow who has come off a freight-train. I'll follow you down.'

"I went down behind Mr. Eickemeyer and stood in the door as the two met. Then I heard the visitor's name. I heard him say: 'I'm Mr. Steinmetz'; and then they began to talk German and sat down together at Mr. Eickemeyer's desk.

"I stayed a little while, then left. A little later I glanced into the office. They were still talking together, Mr. Eickemeyer sitting at his desk and Steinmetz in a chair alongside. They talked for a couple of hours."

It seems that when Eickemeyer made his appearance, Steinmetz arose and said, mustering his best English:

"Have I the honour to speak to Mr. R. Eickemeyer?"

Eickemeyer, who was a good judge of men, looked the

young fellow over with a quick, keen eye, nodded understandingly, and said, with a smile:

"Sprechen Sie Deutsch?"

And then all went well. Feeling more and more at home, Steinmetz talked eagerly with Eickemeyer in German. They enjoyed a stimulating conversation, in the course of which all the latest news in electricity and electrical matters, as well as the most recent technical developments, were fully discussed.

Steinmetz himself pictures this notable meeting as an opportunity for both to engage in an enjoyable technical discussion about various electrical subjects.

"I inquired if I had the honour to be addressing Mr. Eickemeyer, whereupon he said, 'Sprechen Sie Deutsch,' uttering it as a command, or a request, rather than a question. I then presented my letter of introduction from Mr. Uppenborn. After that we talked for an hour or more, our chief subjects of conversation being transformers, storage-batteries, and apparatus having to do with magnetism. He was much interested in the subject of transformers and storage-batteries, inquiring from me the latest developments in Europe concerning these machines. He was doing but little real electrical work at that time, his business consisting chiefly of the manufacture of hat machines."

This interesting interview did not produce a position for Steinmetz, however. All that Eickemeyer could do was to take the young man's name and address, promising to inform him if an opening occurred.

But Carl Steinmetz was not the sort of fellow to sit down and wait for opportunity to seek him out.

A week later he again presented himself at Eickemeyer's plant, to see if there was a chance for him.

His persistence was rewarded. He was told to report for work the following Monday morning.

His job was to be that of a draftsman at two dollars a day, or twelve dollars a week. And that was his start in America, secured principally by his persistent effort, within two weeks after he landed at Castle Garden.

A profitable commentary on the turn of events which made Steinmetz an employe of Rudolf Eickemeyer is to be found in the "General Electric Review" for September, 1912. Writing under the title of "Steinmetz and His Discovery of the Hysteresis Law," Douglas S. Martin says:

"Two weeks later [after landing at Castle Garden], Steinmetz presented his letter of introduction to Rudolf Eickemeyer at Yonkers. The element of chance probably was at work here, as there were other nebulous plans then in his head; but it may also be in the belief that here would at least be work and opportunity for a man with some knowledge of electrical matters. Actually his knowledge was somewhat limited, at least so far as practice was concerned. He had never handled—hardly ever seen—even a direct current motor; and, although he had published in Switzerland an able paper on the design of transformers,

the sight of one of them ('converters' as they were then called) had never been vouchsafed to him."

Promptly upon finding employment, Steinmetz took steps to establish himself in the western republic in another respect. Unwavering in his decision that America would be his home and his country thenceforth, he had speedily appeared before a naturalization court and had taken out his first papers. He wanted to be made a citizen of the new land to which he had come. This purpose was consummated in due time, for five years later he returned to Yonkers and received his second papers, which raised him to the status of a fully naturalized citizen of the United States.

LESSON 10.

STEINMETZ MAKES FRIENDS WITH LIGHTNING

JOHN WINTHROP HAMMOND

As the man who tamed the lightning, Dr. Steinmetz was endowed by an extravagant press and a mildly awed public with attributes akin to those supposed to have been possessed by the gods of mythology.

Indeed, some of his admirers among the newspapers have habitually alluded to him as the Jove of Schenectaday. Enthusiastic cartoonists have pictured him snatching the lightning-bolt from the hand of Jupiter Fulgur and converting it to the use of science.

Perhaps the idea actually prevails, in some minds, that he amused himself, when time hung heavy in his laboratory (which it never did), by hurling thunderbolts about the room as easily as boys throw a base ball around the bases.

This wonder-struck attitude of astonishment, with its inevitable exaggeration, grew out of a series of prosaic electrical experiments conducted by Steinmetz and his co-workers, which culminated in the early part of 1922.

It was all in the day's work with Steinmetz. It came up and was carried through in the course of his every-day experimentation at the Ceneral Electric Company. He believed it would prove to have a practical side that would

be of value to his employers. And such turned out to be the case.

Dr. Steinmetz was a student of lightning for the greater part of his life, chiefly because an investigation of lightning logically followed upon his study of hysteresis and of alternating current calculations. His earlier work made it possible, first, for efficient electrical machines to be designed, and, second, for electric energy in its most general application—alternating current—to be developed into immense electric power systems, whose far-stretching transmission-cables and ramifying distribution-lines carried the services of this tireless giant hither and thither, anywhere and everywhere.

But coincident with such tremendous development there appeared new problems, growing out of this very expansion to which Steinmetz contributed so much. He sums up the chief of these new problems in his own simple, pithy words when he says:

"When alternating currents had finally been conquered, and alternating-current transmission-lines began to spread all over the country, an old enemy became more and more formidable—lightning.

"And for many years the great problem upon which depended the further successful development of electrical engineering was that of protection from lightning.

"But before this could be undertaken with reasonable hope of success, we had to know a great deal more about lightning, and the phenomena which are centered in lightning."

This is how Dr. Steinmetz came to study lightning, in relation to its effect upon electric light and power systems. Perceiving that permanent progress was now contingent upon the mastery of this situation, he did not deem it unduly presumptuous to ask questions of the terror of the skies, which has overawed all generations of men through the long sweep of the ages.

Man and nature had already come into inevitable collision when Steinmetz began his investigation of "transient phenomena," under which technical term electrical engineers place all types of electrical discharges that occur only periodically and exhibit erratic behavior. The greater the electrical systems became, the surer they were to encounter interference from the electrical manifestations of a thunderstorm.

Ambitious man found that he had assured himself a battle royal with one of the most spectacular elements in existence.

This colossal combat did not, for a while, assume formidable proportions. But that was merely because electric light and power systems had only just begun to spread out their marvellous networks of wires and to produce great machines for sending currents at great voltages over those wires. The provocation, so to speak, was lacking.

As these systems grew larger, however, and the menace from lightning increased accordingly, Steinmetz, as well as other electrical engineers, gave serious consideration to means of safeguarding electrical apparatus from its ravages. He first began making investigations of any extent during the closing years of the nineteenth century and by 1898 was giving a great deal of attention to it.

Steinmetz very soon observed in his investigation of transient phenomena, that while lightning may have been the criminal which started the trouble in an electrical system, the actual damage and destruction was not done by the lightning but by the normal power of the electric circuit produced by the electric generators. This normal power of the system broke loose and got out of control as a result of the disturbance originally created by the lightning.

With the increasing advance of the electrical transmission systems, from thousands of horse-power to tens of thousands and from tens of thousands to hundreds of thousands, this danger increased also, in proportion.

The lightning-arrester is the particular guardian of electric light and power lines which has been affected by the work of Steinmetz and others who have studied the peculiarities of transient phenomena.

This is by no means the same sort of contrivance as Franklin's lightning-rod, designed for the protection of buildings and houses, and still efficient to-day, nearly two hundred years after its invention. The lightning-arrester protects electrical apparatus and electric transmission-lines.

Probably the lightning-arrester has never, outside the electrical-engineering profession, been given the credit it deserves. If millions of busy people throughout the land understood the way this quick-working device guards them from annoyance by warding off interruptions to the electrical service that is so much a part of their lives, they would look up to it as not the least of the inanimate, ever-vigilant friends of man.

For the lightning-arrester is the sentinel of the transmission system. It is the watch-dog of the electric generating station, the guardian of the power-house. It operates with a swiftness equaled only by lightning itself, and its grand function is to ward off lightning disturbances whenever these outbursts menace the line.

It does this by automatically opening a path by which the vast voltage of a lightning-bolt can jump harmlessly to the ground, instead of coaxing the electric current of the service lines out of all bounds and thereby throwing the whole system into chaos. And after it has shunted off the lightning's energy, by taking advantage of lightning's one inherent weakness—a tendency to follow the line of least resistance—the lightning-arrester prevents the normal voltage of the transmission-line from following after the lightning. It induces the transmission current to stay where it belongs and proceed on its way to serve the needs of man.

This whole little drama of the clash and counter-clash of mysterious forces occurs so instantaneously and is over so swiftly that the people in homes, stores, offices and factories who are using the electric current that very moment never know that anything out of the ordinary has happened.

The lightning-arrester has done its work with silent, unerring efficiency; without being told what to do or when to do it; more dependable than any man could be.

Steinmetz assisted materially in the evolution of the lightning-arrester. He conducted for several years important tests of lightning-arresters, for this was the practical contribution which his lightning-generator brought about. The way this unique apparatus helped in this work will be related further on, but let it be emphasized here that Steinmetz was a decided influence in this, as in other fundamental aspects of electrical development.

LESSON 11.

STEINMETZ AND TRANSPORTATION

JOHN WINTHROP HAMMOND

Railroad electrification was one of the transformations of the rapidly developing electrical age in which Dr. Steinmetz displayed a tremendous interest. Repeatedly he had predicted the inevitable approach of the electrified railway system, which would supersede steam railroads. He looked upon it as one of the next great forward steps toward utilizing the full possibilities of electrical energy.

In 1920 he mentioned electrification at the step which would do more than any other one thing to overcome the vast operating problems of American railroads. In 1922 he said: "I believe the railroads of the United States will soon be operated by electricity. The change from steam may come any day. One of the big systems will start, and the rest will be compelled to follow."

Then he added a truism that is known to all electrical engineers and accepted in theory by nearly every one who has closely studied the subject:

"Steam cannot compete with electricity. It costs more and does less. A steam-engine must slacken speed on upgrades. Electric locomotives, with unlimited power behind them, can go at top speed all the while."

Steinmetz never played a prominent part in railroad electrification work. He was called in consultation on problems connected with such developments, as he was whenever a difficult problem presented itself. But it was not a field to which he made any direct contributions, as he did to the field of street-lighting, or to the basic question of economical current distribution.

Being a student of every phase of electrical engineering, however, he studied the application of electricity to railroading in a thorough manner; and the inherent wastefulness of the steam-engine centered his attention immediately. For Steinmetz was a foe of economic waste, wherever it showed its head. And he considered railroad electrification as merely one aspect of an era soon to come when wasteful methods will vanish before the advance of electricity, the economizer and efficiency builder.

He pointed out, also, that so far as electrical science was concerned, America's railroads might all be electrified to-day. "Electricity," he said, "has been ready. The railway managers were the ones who were not prepared to move. Their finances were not in a favorable condition. They could not borrow the money to make the change. Moreover, they were not sure that they wanted to adopt electricity as their motive-power."

This attitude appeared to a mind like that of Steinmetz as rather over-conservative.

To his view, judging the matter simply as a question of ultimate efficiency, and convinced that electric energy would provide such ultimate efficiency, this attitude seemed like living in a rut.

Steinmetz had gathered a few towering statistics on this question of railroad electrification and what it would mean. He presented them, as part of the case in favor of railroad electrification, in "Heart's International Magazine" for May, 1923.

"Railroads" he said, "burn in their locomotives about 160 million tons of the coal they carry. If the railroads were electrified and coal for manufacturing purposes were burned at the mines, it would be approximately equivalent to doubling the freight-carrying capacity of our railroads for other kinds of freight. About half of the freight now carried is coal.

"It should mean a good deal to this country to get rid of the steam locomotive and the coal train. They are both wasters. Whatever is wasted anywhere is a burden upon the country. It is lost motion to devote approximately half of the freight-carrying capacity of our railroads to the transportation of coal that should be burned where it is mined whenever conditions make this possible, and converted into electricity."

These views were only a part of the story, as frequently related by Dr. Steinmetz in vigorous, vivid phrases. In this instance he was picturing electricity as the giant of the ages, capable and ready to do anything under the sun that might be required of it.

"What will electricity do for us yet?" he asked. And

then, answering this pertinent question: "It will do whatever energy can do for us. Nobody, to-day or ever, can fix the limits to which the use of electricity may go. We can say only that it will go as far as human need for energy goes. Electricity is energy, and energy is the basis of civilization.

"We call this the age of electricity, but it is n't. The age of electricity has n't begun. All that we have yet done is but preparatory to the ushering in of the electrical age. When the age of electricity comes—as it will—electricity will do for everybody all that it can do for everybody. It will do all this in addition to doing a multitude of things of which we have not yet dreamed.

"I came to America in 1889. It seems a long way back to think where the development of electricity was at that time. It seems a long way ahead to think where it will yet be. For the age of electricity is yet to come. And it will be a great age."

A day when the familiar steam-locomotive will no longer puff and chug its way from town to town, and thunder over the great highways of steel, half hidden in wind-blown streamers of white vapor, is not easy to imagine. Steinmetz could imagine it because he was accustomed to "viewing the whole physical world as a unit" —exactly what he once declared every student of electrical engineering must learn how to do.

As previously observed, he realized that railway electrification was but one side of a future all-electrical world.

But to the people of this generation, who listened to his predictions with sometimes more indifference than the situation justified, this seemed to be the most astounding statement that he uttered, the most astonishing single metamorphosis which the affirmed electricity might be expected to achieve.

It was a prediction that Steinmetz not only never hesitated to pronounce, but on which he even applied, upon occasion, to localized districts, as if welcoming an opportunity to impress people by describing how it would affect their home environment. Thus, he told an interviewer who hailed from New England that in the New England of the future "every steam-engine will be scrapped."

"The time will come, and in a very few years," he reiterated, "when electricity will completely take the place of coal. Power will flow through a network of wires to every engine and factory in New England, and that power will be generated from the flowing water of the territory."

Steinmetz had already announced that he believed New York State possessed 4,200,000 horse-power of potential water-power energy. He tentatively declared that New England probably had 5,000,000 horse-power in its waterfalls and streams. What 5,000,000 horse-power signified was disclosed in his explanation:

"Every horse-power means some ten tons of coal, for a year. On railroads where steam-locomotives are used, more than ten tons of coal are used annually for one horse-power. This is due to the inefficient system of our steam railroads, where heavy locomotives have to haul their own fuel.

"You will see that with an estimate of five million horse-power available in New England, this would mean a saving of fifty million tons of coal a year—and that would mean shutting down every steam-locomotive in the territory. This is not a dream, but it is a fact that must be faced. This development will come.

"A saving of fifty million tons of coal in New England is hard to realize. Do you know how much coal that is? If it was loaded on coal-cars, placed end to end as they are in a train, it would reach from Boston to Cape Horn, in South America, and there would still be several million tons left over."

To enable his visitor to visualize a future country with electricity as the universal servant of man—noting that thus far it is by no means universal in its service—Dr. Steinmetz then said:

"If you will picture to yourself a map of the Uniedt States showing all of the railway systems, you will get a picture of what must happen to New England. The network of railroads shown on the map can be likened to transmissionl-ines between the hydroelectric plants which will dot New England.

"These lines will be double and treble lines, passing from city to factory, to railroad, to hydroelectric plant. It will all be one vast network, some points taking out power and some points putting in power. That would mean the scrapping of every steam-engine in New England."

Turning again to the railroads, he pointed out, as he usually did when discussing all these possibilities, that the operation of an electric railroad, which used hydroelectric power, would inevitably be cheaper than the operation of a steam railroad, because the primary source of the power—white coal—is furnished by nature and costs nothing after once put to work. The initial costs of the electrification would be high, but after that the expense would be insignificant by comparison. It would mean not only saving half the coal now required, but also an increase of as much as twenty-five per cent in efficiency, through the higher speed and better control of the electric trains.

These observations and recorded comments of Dr. Steinmetz upon electricity as applied to railroad transportation are perfectly typical of the way he talked upon this absorbing subject.

Perhaps it may seem as if he had more to say about railroad electrification than about the electrification of almost any other one industry. But this may be accounted for by the probability that the steam-locomotive impressed him as the most common and most unmistakable example of economic waste in modern society. He would not have discounted the value of the steam-engine to the world of James Watt, which previously had never known this tremendously significant piece of machinery. His only indictment of the steam-engine was this, that in the presence of the electric

generator and the electric motor the steam-engine represented by comparison an inexcusable inefficiency. In its day he recognized it as a great developer of civilization; but its day, said Steinmetz, has begun to pass.

"Steinmetz," said a writer who summarized his career shortly after his death, "foresaw an era of electricty. To him a ton of coal was not merely a costly and scarce commodity for heating the house or cooking dinner. It was so much potential energy, imprisoned by nature, waiting for man, its master, to release and put it economically to its proper work.

"In a ton of coal, as it is taken from the mines, loaded on the cars, brought to our doors, and burned in our furnaces, he saw appalling inefficiency and waste. He saw in all the processes embraced in mining, marketing, and burning that coal a consumption of time and energy which could be put to a myriad better uses. His dream was of a time when the coal will be taken from the ground expertly, cheaply, mechanically, and burned, as far as possible, with far greater kinetic energy than at present, at the place where it is mined.

"Stenmetz's bold imagination went beyond the era of coal. . . He looked to 'white coal' to supply the future's needs. Water-power is inexhaustible. It is the refuge of a future generation, which would revert to savagery without means of heat, light, and motion. He wanted to bring the device of that distant to-morrow up to the period of to-day."

LESSON 12.

STORY OF SKINNER

MAURICE HOLLAND

There is an element of similarity in the stories of most of these scientists whose skill, industry, and mental fertility have won them posts as directors of research in modern industry. It is no exaggeration to say, for instance, that a large majority of them attended Massachusetts Institute of Technology. Nearly all of them, having achieved a measure of distinction in their work, graduated to become instructors and then professors of chemistry, physics or engineering. In many cases they taught for years, trained young men in the principles of pure science and then were lured away from the cloistered life of the university laboratory by some far-sighted industrialist who saw that competition made necessary the employment of some genius who could explore new fields.

Having abandoned their caps and gowns, their classrooms and their university laboratories, the ex-professors actually changed their attitude toward their work very little. They remained professors, teachers or instructors. Their students consisted of younger scientists, engaged as assistants. They were still men entirely uninterested in such important (to the industrialist) problems as mass production, dividends, costs, and cheaper operation. They followed elusive scientific

trails and if these chanced to lead to lucrative discoveries, as very often they did, the research director was pleased but not greatly impressed. They resented frequent demands from the management that the laboratory give attention to plant-operating difficulties. They never lost their devotion to the cause of pure science and they longed, from time to time, for the dear, dead days of a university laboratory where profits were unknown and where knowledge for its own sake was the sole objective.

The story of C. E. Skinner, who developed the research laboratories for the vast plants of the Westinghouse Electric and Manufacturing Company, at East Pittsburgh, Pa., would be interesting, if for no other reason, because of its difference. Skinner is, of course, a university graduate. But he did not go to M. I. T. He has never taught. His mind is strictly practical. He believes, and says so, that the duty of industrial research is the creation of greater profits. Skinner is as thoroughly scientific in his viewpoint as any of his fellow directors of research and is constantly called upon by them and by universities throughout the country to give lectures on the most abstract problems which rise to taunt and bother the electrical industry. His attitude, however,—unless I am greatly mistaken,—is that it is his job to make things work. What's wrong with it he has been asking himself for the last forty years? Why doesn't it work? How can I make it work? Let me study this thing, he adds, and in time I think the difficult situation we find ourselves in can be cleared up. And in time, one might add, it is.

One of Skinner's first assignments,—as unique as any in the long history of research,—came during the early days of electric trolleys. Then, as ever since, he was in the employ of the Westinghouse Company and was sent to New York to assist in the electrification of the horse-drawn trolley lines. One morning, after a number of the lines had been equipped with power, a local superintendent named Schmid sent for the young research man.

"Skinner," he said, "I want you should find out the resistance of a horse."

"The resistance of a *what*?" the youthful electrical engineer asked.

"A horse," repeated Schmid. "We keep getting complaints that horses are getting hurt on our line—truck horses that are driven over the tracks. The ground current is too strong, or something. Or the horses are too weak. Anyhow —go down to our stables and find out about it."

Fortunately, Skinner had been brought up on a farm and had no terror of horses. So he went to the stable and began his work.

"Electrification," he recalls, "was taking the place of the former horse-drawn cars and frequently the tracks were not in much better shape than before the motive power was changed. Rail joints were not bonded and complaints had come in that horses were injured or even killed by

stepping on these rails, particularly when a horse happened to span the joints between the two rails.

"The job of measuring the electrical resistance of a horse seemed, when Schmid first told me to do it, something of a baffler. You remember, of course, that this was many years ago. I started down toward the stable with misgivings. The big, stolid truck horses did not seem exactly skittish, though, and I screwed up my nerve to the point of starting the experiments. First, I arranged to measure the resistance from their front feet to their hind feet. I got the horse to stand on pieces of clean sheet iron placed on the dry stable floor and measured the ohmic resistance from the front feet to the hind feet. This was compared—the current was very weak, of course—with measurements made from one hand to the other of my assistant. And to our very great surprise the resistance of the horses was astonishingly low compared with that of human beings. This explained why horses had been hurt and killed when walking on the new electric lines although men and women had crossed the tracks repeatedly without being hurt in the least.

"I never knew exactly what use the superintendent made of the figures I turned in but thorough rail bonding soon became universal. Bonding completely eliminated accidents of this kind, gave higher efficiency to the circuits, of course, and helped to prevent electrolysis through stray currents to water pipes and other conductors." × × ×

LESSON 13.

POWER

H. W. SMITH

Power is one of nature's treasures, latent in treasure chests of wind, water and fuel for man to discover, master and make his servant. On an old piece of pottery made about 3900-2800 B. C., was found what is perhaps the oldest record of the utilization by man of a natural source of power. The design on this piece depicts a sail boat, an application of the force of wind which was one of the first natural sources of power to be applied. Another application of wind power is recorded in the writings of Hero of Alexandria. He describes a windmill of his devising about 110 A. D., which acted through a cam to raise a piston that pumped air to blow an organ.

Early in the records of the 12th century, references are found to windmills as being in common use in western Europe.

The necessity of irrigating the land of the centers of early civilization forced upon man at an early date the problem of pumping water. Many ingenious devices were invented to assist in this work. In his writings, Philo of Byzantium, about 225 B. C., describes treadmills used to raise water, and watermills, similar in construction to bucket-type cistern-pumps operated by paddle wheels, used to pump water. These are the earliest known applications of

water power. Other of its early applications were recorded in Persia: about 640 A. D., sugar cane was crushed with stone rollers, waterwheel driven, and about 750 A.D., pulp for paper was made by a similar process.

By the latter part of the 18th century, water power was in extensive use. But an obvious disadvantage of this source of power was that the power had to be used at water-power site. Several attempts were made to overcome this defect. Denis Papin in 1647, compressed air by means of power derived from a waterwheel and transmitted it a considerable distance through pipes.

At a comparatively early date heat was understood in a small degree as another of nature's sources of power. Its first recorded use for power purpose is described by "Hero the Elder" of Alexandria about 130 B.C. In his writings he clearly describes three methods by which steam might be used directly as a motive power. These were: raising water by its elasticity; elevating a weight by the expansive power of steam; and producing a rotary motion by the reaction of jets of steam on the atmosphere.

Later all three of these methods were rediscovered: The first method was found and utilized by Thomas Savery, in 1698; Denis Papin, improved on Savery's device in 1705 and Thomas Newcomen in the same year, 1705, brought out the first practical "fire-engine" as it was called then, and now known as the "atmosphere engine" because its acting force was produced by the vacuum created in the cylinder by condensing steam. Newcomen's atmosphere engine was introduced, in 1711, for the pumping of water from mines. When repairing one of Newcomen's steam pumps, James Watt was impressed with the vast quantities of steam required to operate it and conceived the idea of adding a condensing chamber separate from the steam cylinder. Watt patented his improvements in 1769. In making this change, Watt made use of the expansive force of steam, (Hero's second method). In 1781, Watt patented methods for converting the reciprocating motion of the piston into rotation. This second invention made possible the adaptation of the steam pump to the driving of all kinds of machinery—made of it the steam engine that we know today.

The development of Hero's third method of producing rotary motion by the reaction of jets of steam on the atmosphere, was longer in coming into practical use. Following the achievements of Watt and his contemporaries in the development of the reciprocating engine, many patents were taken out on steam turbines, between the years 1800 and 1850. Almost every modern turbine principle and some others were therein exemplified. These patented plans were abandoned for the time, doubtless, because the imperfect stage of metallurgical and machine-shop development made practically impossible the production of efficiently shaped turbine blades.

In 1884, De Laval and Sir Chas. A. Parsons were the

first to make practical realities of their dreams of a steam turbine. De Laval's turbine was of the impulse type; that is, the steam impinged on the turbine blades and drove them forward by its velocity. The Parson's turbine made use of the reaction principle utilized by Hero for his turbine. The Parson's turbine is the forerunner of the turbine now being built by the Westinghouse Company; patent rights for which were purchased by George Westinghouse in 1895, although Westinghouse now builds impulsion-type turbines as well. In the decade that followed, the Westinghouse Machine Company, for whom the rights were acquired, was practically alone in the manufacture of turbines in North America.

The first internal-combustion engine, of which we have record, operated on gun powder. It was built by Huyghens in 1680. In 1791, an Englishman, John Barber, built what was in effect a gas turbine, using gas distilled from coal as fuel. The essential features of Barber's engine were a mixing chamber wherein air and the produced gas were mixed and ignited, and the employment of a paddle wheel against the blades of which the gases, issuing from the chamber, impinged.

All internal-combustion engines are now commonly referred to as "gas engines" since the liquid or oil fuels are vaporized or gasified before combustion. However, the development of oil and gas engines was more or less distinct.

It was proposed to produce power from oil as early as 1794 by an inventor named Street. A practical petroleum engine was first produced by Julius Hock of Vienna in 1870. This engine operated without compression and like all non-compression engines, was cumbrous and produced little power. The first oil engine to compress the fuel before explosion appears to have been produced in America in 1873 by an English engineer named Brayton.

Dr. Rudolf Diesel, a German engineer, carried the compression to what appears to be the ultimate when in 1892, he obtained a patent for an engine in which the air for the explosive charge was so highly compressed that its temperature was raised above the ignition point of the fuel. His original patent proposed the use of coal dust as fuel, that was injected at the proper instant for proper combustion. A second claim embodied in the same patent covered the use of liquid fuels with the employment of a spraying valve. Developments proceeded slowly until in 1897 a commercial engine was produced—a single cylinder 25 hp. engine of vertical design using a crosshead. From the small 25 hp. engine the Diesel engine gained in favor until in a few years engines of 1000 hp. were in commercial use.

The Diesel engine is particularly adaptable for marine service. The first marine Diesel was constructed in 1903 by French engineers for use on a canal boat.

The first completed Diesel electric propulsion installation

was the Schooner Yacht Elfay, which was electrically equipped by the Westinghouse Electric Company.

The gas engine is another type of internal-combustion engine. In 1820, Rev. W. Cecil read a paper before the Cambridge Philosophical Society, describing an engine invented by himself, which ran with perfect regularity at 60 revolutions per minute, consuming 17.6 cubic feet of hydrogen gas per hour. Mr. E. Lenoir was the inventor of the first gas engine that was brought into general use. His patent was dated 1860; the engine was double acting; i. e. explosions occurred on both sides of the piston. The better known Otto engine was brought out shortly afterward. It was of the single-acting four-cycle type of gas engine.

Mr. Westinghouse was interested in this type of engine, as a natural result of his previous experience with natural gas. In 1883, a gas-producing well was drilled at "Solitude", the Pittsburgh home of Mr. Westinghouse, and the commercial exploitation and utilization of this gas became for a time one of the main interests of Mr. Westinghouse. In the late nineties, he believed that the gas engine, because of its high thermal efficiency as compared with the best performances of the steam engine, would supplant the use of steam. He, therefore, directed his efforts to the production of relatively large units. The development of steam turbine efficiencies and the demand for larger power units than could be satisfied by gas engines, soon convinced him, however, that the field for the gas engine was more limited than he had at first supposed.

About the same time Mr. Westinghouse was experimenting with gas and considering means of distributing it to the public, he chanced to read an account in an English paper of the development of an alternating-current electric transmission system by Gaulard.

The heart of the system was a "secondary generator" or transformer. Mr. Westinghouse was greatly interested and purchased the Gaulard-and-Gibbs patent right in 1885. From this small beginning has developed the manifold electrical activities of the Westinghouse Electric Company.

No man can tell of what electricity consists. We know it to be closely related to light and we believe it to be a part of all matter, but its identity can hardly be said to be established. It has been but 97 years (1831) since Michael Faraday read a paper before the Royal Society of Great Britain, entitled "A New Electrical Machine" describing the first dynamo. It is but 129 years since Alexander Volta devised the first Voltaic Pile (1799). A current of electricity was discovered by Galvani in 1790, and static-electricity phenomena were largely explored by Dr. William Gilbert about 1600. The date of the genesis of electrical discovery is generally taken by historians to be about 600 B.C., when Thales, a Greek philosopher, related his observations that a piece of amber when rubbed with a cloth, will first attract and then repel light objects brought close to it. Space does not permit the enumeration

of the many electrical discoveries made by other great investigators, but electricity for commercial use became feasible with the invention of the electric dynamo. Its first use was to generate current for lighting. By 1878 the electric arc-light had established itself as a satisfactory street illuminant—at least in the United States of North America. And the forerunners of the modern incandescent lamp was brought out by Sawyer and Mann, and Edison in 1878 and 1879.

Practically the first considerable use of electric power, as power, was for the propulsion of street cars. Thomas Davenport, in 1834, built and operated a toy motor on a small railway exhibited at Springfield, Mass., U. S. A., and at Boston, U.S.A., in 1835. This was perhaps the first real suggestion for the practical use of electricity for railway operation. Experiments were conducted utilizing the storage battery as the electric source, but with indifferent success. The first practical railway ever built was installed in Germany by the Siemens firm for exhibition at the Berlin exposition, in 1879. The first commercial electric railway was also in Germany at Lichtefelde, near Berlin in 1881. Only one car was used and it was operated over a track one and a half miles long. The motor was carried by a frame beneath the car body and the power was transmitted to the axles by steel cables. This car had a capacity of 26 passengers and had a maximum speed of 30 miles an hour.

In North America experiments were closely paralleling those made in Germany and England. Numerous experimental roads were built at about the same time all over the United States, including a well-known installation by Leo Daft on the Hampton Road, Baltimore, U. S. A., in 1885. Commercial installation made soon after were by Sprague and by Bentley and Knight in 1888-1889. These years marked the beginning of a new era in street railroading and the construction of electrically operated railways spread rapidly through the United States of North America.

Early in the days of the development of electricity, there was a demand for a means of transmitting power over a distance. Vast hydraulic resources were going to waste because there was no known agency to transmit the power to a point where it could be utilized. It was not feasible to use for this purpose the continuous or direct current largely used for electric lights and electric railways, because excessively large copper conductors were required to keep down high transmission losses.

Mr. Westinghouse recognized, in the alternating current electricity, an agency particularly fitted to this service since its potential could be easily stepped up and down by the transformer, thus eliminating the necessity for large conductors.

The first hydro-electric installation in the United States transmitted electrical energy 13 miles to Portland, Oregon, from Oregon City, Oregon. This installation, made in the

summer of 1890, used single-phase alternating current generated at 4000 volts, and stepped down at the terminus to a potential suitable for lighting; it was used solely for that purpose.

The second hydro-electric plant in Colorado near Telluride transmitted power somewhat more than three miles to a mine. It utilized single-phase alternating-current and began regular operation in June, 1892. Power was generated at 3000 volts to be used in driving an alternating-current split-phase motor and for lighting; no step-down transformers were used. Both these plants were Westinghouse installations; the last one being particularly influential in convincing engineers, then planning the development of Niagara Falls, U. S. A., that alternating current should be adopted for that development. An equally important factor, was the timely development of the Rotary Converter by B. G. Lamme, the late Chief Engineer of the Westinghouse Company. This machine conveniently and efficiently changed alternating current to direct current. From this beginning the use of alternating current expanded until it surpassed any other power agency.

Although we cannot definitely foresee the future possibilities of power, electrically transmitted, we can at least recognize tendencies.

More automatic equipment is being used, large transmission systems are being interconnected and power is being transmitted over longer distances at higher and higher voltages with greater economy and efficiency.

In practically every country around the world there has been an expansion in the use of electrical power; whether the power be derived from air, water, steam, gas or direct chemical action, electricity is being generated and distributed over wires into our industries, into our homes, into our offices, along the streets and railways, onto our farms. As a result, we may look forward to higher values of horsepower per capita than were ever before tabulated. Man has become less a slave to manual labor. He has, by the use of electrical devices, enlarged his capacity for accomplishment and production, with a corresponding increase in individual leisure and wealth. The effect is not confined to industrial activities but is being felt in agricultural pursuits as well. Wherever power has been enlisted in the service of man it has made his work easier, more interesting and more profitable.

LESSON 14.

FRANKLIN THE BOY

Benjamin Franklin was a product of Boston in every sense of the word. He was born here, January 17 (N. S.), 1706, in a little wooden house on Milk Street. Just across the way stood the Old Cedar Meeting House, replaced a few years after Franklin left Boston by the present "Old South." Here, on the day of his birth, he was baptized. It was in the Puritan Boston of the early eighteenth century that Franklin spent his boyhood; then, happily, too, late to feel the bitter intolerance of that earlier Boston which had banished non-conformists and executed Quakers and witches. His home was a happy one and wisely ordered. Of luxury there was none, but Franklin assures us that of the needful things there was always a plenty.

Attention was paid to the head as well as to the heart; there was good cheer at all times. As Franklin was the fifteenth child in the family (with two yet to come), he was no novelty and ran small chance of being spoiled. It is an interesting thing to note, since Franklin is often spoken of as one of the best educated men of the time, that his school education began at the Boston Grammar School, when he was eight years of age, and that Master George Brownell put the finishing touches on it when he was ten. Short as was his school career, it was fresh in

Franklin's mind when he made his will many years later, for he says therein: "I was born in Boston, New England, and owe my first instructions in Literature to the free Grammar School established there: I have therefore considered these Schoods in my Will." Thousands of the "best scholars" of the Boston schools have received the much coveted silver medals which Franklin's generosity provided. These medals still serve with each generation to keep green the memory of one of the most famous of Boston schoolboys.

After leaving school, where he made a pitiable showing in mathematics, he worked as his father's assistant in the tallow-candle business for about two years. Then, at the mature age of twelve, he signed apprentice indentures with his brother James, who was editor and publisher of The New England Courant, America's fourth newspapers. James showed himself jealous and thrifty rather than brotherly in his relations with, perhaps, the most valuable apprentice that master printer ever had; while the boy, on his part, was impertinent, wise beyond his years, and thoroughly convinced of his own importance. It was not an enviable situation for either brother. Finally, when he had served his brother about two-thirds of the specified time, the apprentice in no very dignified manner brought the affair to an abrupt end by running away.

Although Boston had had her son Franklin in her keeping less than eighteen years, she nourished him and made

him what he was. She was, indeed, his *alma mater*, and when he left her the formative period of his life was past, and he went forth, with all his virtues and his faults, a mature man in everything but years.

This was in 1723, a decade before Washington was born. Thus, while the first sovereign of the House of Brunswick was struggling to pronounce in English the name of his new possessions, a runaway 'prentice boy of His Majesty's colony of Massachusetts Bay was already developing into a leader of the men who were to wrest from the King's great-grandson a large share of the royal dominion.

"Franklin upon the whole," says his biographer, James Parton, "spent a very happy boyhood, and his heart yearned toward Boston as long as he lived. When he was eighty-two years old, he spoke of it as 'that beloved place.' He said in the same letter that he would dearly like to ramble again over the scenes of so many innocent pleasures; and as that could not be, he had a singular pleasure in the company and conversation of its inhabitants. 'The Boston manner,' he touchingly adds, 'the turn of phrase, and even the tone of voice and accent in pronunciation, all please and seem to revive and refresh me.'" The Franklin Institute, the gift of a greatful son to his native place, bears eloquent testimony to the sincerity of these words of Franklin. He returned to Boston in 1724 to consult with his father, and again visited his native place in 1733, 1743, 1753, 1763. He saw it for the last time from Cambridge in 1775.

When Franklin was about fifteen and had been an apprentice some three years, his brother James saw a chance to use the lad in a way not nominated in the bond, but agreeable to both parties. It promised to feed their vanity and fill their pockets. This was that the boy should indulge the family fondness for rhyming, of which he had given evidence some seven years before, and write ballads upon current events.

There was abundant precedent for this, if Franklin even in his youth ever felt the need of such support. At that time in America and England ballad writing and selling was a lucrative adjunct of the printer's trade. The products of the pen of a Bostonian named Fleet were so popular in Franklin's day that he derived from them alone sufficient remuneration to support his family. Franklin's grandfather, Peter Folger, and his Uncle Benjamin used very frequently to dispense wisdom in sugar-coated pill of pious rhyme. Their young kinsman may have felt that from both sides of the house he inherited the ability to produce acceptable ballads. In any case he summoned the tragic muse and wrote two ballads. A verse from one of these, recounting the capture of the famous pirate, Edward Teach (Blackbeard), is given in Weems's "Franklin." It reads:

"Come all you jolly sailors,
You all so stout and brave;

Come hearken and I'll tell you
What happen'd on the wave.
Oh! 'tis of that bloody Blackbeard
I'm going now for to tell;
And as how by gallant Maynard
He soon was sent to hell—
With a down, down, down, derry down."

The other was entitled "The Light-house Tragedy." Of it we unfortunately have not so much as a line, but even without this doubtless conclusive evidence we are prepared to accept Franklin's own statement that both ballads were "wretched stuff."

Parton says that Franklin inherited the family propensity for rhyming but that he also inherited "the family inability to rhyme well."

Although the Blackbeard ballad was not a "best seller," the other one went off rapidly. Naturally the boy was delighted. But his father pointed out that "verse-makers were generally beggars," and he showed him that in the long run he would be better off in mastering a good prose style rather than in writing doggerel ballads. To the credit of the youth be it said that he looked the matter squarely in the face and followed his father's advice. The world owes Josiah Franklin a thousand thanks for what it gained in Franklin's prose—and for what it was spared of Franklin's verse.

LESSON 15.

FRANKLIN THE PATRIOT: AT HOME

Every properly brought up individual in the United States knows the resolution of Richard Henry Lee, introduced at the meeting of the Continental Congress, June 7, 1776.

"That these united colonies are, and of right ought to be, free and independent States: that they are absolved from all allegiance to the British crown; and that all political connection between them and the State of Great Britain is and ought to be totally dissolved.

"That it is expedient forthwith to take the most effectual measures for forming foreign alliances.

"That a plan of confederation be prepared, and transmitted to the respective colonies for their consideration and approbation."

While the delegates were awaiting instructions from their various colonies as to what they should do concerning these resolutions, it was deemed advisable to set a committee to work drafting a paper declaring the colonies independent, in case such a declaration should need to be used. On this committee were Thomas Jefferson, Benjamin Franklin, John Adams, Robert R. Livingston and Roger Sherman.

Shortly before this time Franklin's health had suffered greatly, partly at the result of an exhausting journey he had made to Canada, the fatigues of which would have

wearied a younger man. To make it mory trying still, the perilous pilgrimage had after all been fruitless, for Canada declined to join the colonies against Great Britain. Rest at home had to a great extent restored Franklin's health, and he was able again to carry on his thousand activities on behalf of Pennsylvania and the other colonies. His firm belief in independence he expressed emphatically and in his own characteristic fashion. Formerly he had franked his litters: "Free, B. Franklin"; he now enjoyed inscribing them, "B. free Franklin." One of his memorable sayings was: "Those who would give up essential liberty for a little temporary safety deserve neither liberty nor safety."

As is well known, the Declaration of Independence was drafted by Jefferson. Franklin and John Adams made a few verbal changes, which may be seen in their writing on the document. Franklin himself, though abler with his pen than any of his fellow-countrymen, never drafted a state paper which was really famous. His biographer, Parton, says:

"He would have put a joke into the Declaration of Independence if it had fallen to him to write it. At this time, he was a humorist of fifty years' standing. Franklin had become fixed in the habit of illustrating great truths by grotesque and familiar similes. His jokes, the circulating medium of Congress were as helpful to the cause as Jay's conscience or Adam's fire; they restored good humor, and relieved the tedium of delay, but were out of place in formal, exact, and authoritative papers." One famous occasion when his humor relieved the tension was the time during the debate in Congress when Jefferson sat beside him, "writing under the mutilations" being perpetrated by the delegates, as he felt, on his paper. "I have made it a rule," said Franklin to Jefferson, "whenever in my power, to avoid becoming the draftman of papers to be reviewed by a public body."

Then he told him the well-known story of his friend who started out with the sign, "John Thompson, Hatter, makes and sells Hats for ready money," with a figure of a hat subjoined. By taking the advice of his friends, he ultimately had nothing left of his sign but "John Thompson," with the figure of the hat.

Franklin was wont to relieve the weariness of long drawn-out discussions by introducing a little fun. One of his jokes, when a public matter had grown tedious, was as follows:

"I begin to be a little of the sailor's mind when they were handing a cable out of a store into a ship, and one of 'em said: ''Tis a long, heavy cable. I wish we could see the end of it.' '——,' says another, 'if I believe it has any end; somebody has cut it off!'"

Americans of a later date, to whom the fortunate outcome of the planning of the Continental Congress is an old story, can hardly realize what a serious moment it was

when the time arrived for signing the Declaration. The arguments of John Dickinson and others were too numerous and strong to be entirely forgotten. As the members were about to sign, tradition tells us that Hancock said, "We must be unanimous; there must be no pulling different ways; we must all hang together," and that Franklin seized this excellent opportunity to make the grimly witty response, "Yes; we must indeed hang together, or most assuredly we shall all hang separately!"

Franklin signed his name with that gay flourish with which he commonly decorated his autograph. The signature is very well written. It stands third in the fourth column of names, but the arrangement is such as to throw no light on the question of who signed first after Hancock.

The real date of the signing of the famous instrument has been the subject of much discussion. Passages from the writings of Adams, Franklin and Jefferson can be quoted, which point to July 4 as the date. McKean is equally definite in saying that nobody signed that day. John H. Hazelton the author of *The Declaration of Independence, Its History,* and other authorities who have weighed the evidence on this point, have shown that on July 4 the declaration was adopted, that on July 19 Congress resolved "that the declaration passed on the 4th be fairly engrossed on parchment," and that on August 2 it was signed by most of the members. The Journal of Congress records for August 2.

"The declaration of independence being enerossed & compared at the table was signed." (The spelling follows the original.)

Some of the names to be seen on the parchment document in the State Department at Washington were added after August 2; McKean, Thornton, Gerry, Wolcott and a number of others were not present at the formal signing.

("Scenes from the life of Benjamin Franklin")

LESSON 16.

THE ENGINEER, PRACTICAL IDEALIST

BY R. F. SCHUCHARDT

THE Institute, meeting here in convention on the "stern and rock-bound coast" of New England, finds itself on historic ground. In this region are located many battle fields, of arms and of intellect, that have left their deep impress on our civilization. The battle fields of arms are marked by monuments that are now shrines of an appreciative people. The battles of the intellect, though often accompanied by bloodshed, are not so well remembered. Bunker Hill is fresher in our minds than are Salem and Roger Williams, yet Williams' heroic struggle for freedom of thought paved the way for that later struggle marked by the shaft on Bunker Hill.

The freedom we enjoy today, freedom of thought and of political action, we owe to those who fought and suffered and bled in generations past. We are worthy possessors of our heritages only if we in turn give thought to the morrow, and in our work today plan so that the morrow will offer a richer life for our children.

Are we of the engineering kinship, who are presumably well trained to determine facts and to reason from them, giving sufficient thought to the morrow? It is well on this occasion, in the atmosphere of these significant historical surroundings, to pause a few moments before taking up the technical part of our work, to consider briefly some problems of this interesting workaday world of ours, to try to glean from the study some of the trends in our civilization and our relation to them.

If it is true, as Professor East has written, that man stands today at the parting of the ways, with the choice of controlling his own destiny or of being tossed about by the blind forces of his environment, then it will be well for the engineer to concern himself more with the environment. He should take a larger part in the leadership seeking solution for the human problems that vitally influence the trends. Surely the bewildering complexities of today require clear thinking, and who is better fitted for a thoughtful analysis of the factors on which development and progress depend?

With this as a background, I should like to suggest some thoughts that appear worthy of your careful consideration.

The history of mankind shows a successive rise and decay of great civilizations. Reflection on this leads to the frequent questions: Is our civilization headed for decay? Are we also, like former ages, unable to bear up under prosperity and power? I shall not venture an answer, but let us consider some facts. Earlier civilizations existed on relatively small areas. Today the entire world is a neighborhood—made so largely by the work of the engineer.

Not only is it a neighborhood world but also a much more densely populated world, and the great increase in population, we are told, started with the industrial revolution in the eighteenth century—also based on the engineer's work. The engineer, responsible for so much that *is*, cannot shirk his rerponsibility for correct guidance of what *shall be*.

Our civilization has come to be known as the Machine Age and as such it is both lauded and condemned. President Glenn Frank in a splendidly balanced analysis of the machine age and its trends, offers this comment:

". . . the masses have more to hope for from great engineers, great inventors and great captains of industry than from the social reformers who woo them with their panaceas. The greatest social progress of the next fifty years is likely to come as a by-product of technical progress."

Even in the Orient, where the materialism of the Occident is thought to sound the death knell of the spiritual, we find the famous Chinese philosopher, Dr. Hu Shih, in agreement, for he sees science and the new technology as the forces which restored to man a sense of self-confidence and thus created the modern civilization of the West. He concludes that inventors, scientists and producers of goods deserve the blessings of their fellows as spiritual leaders.

Others of the interesting group that contributed to the symposium, "Whither Mankind," inspired and edited by Charles A. Beard, seem to concur. As Dr. Beard summarized in part; "They are not oblivious to the evils of the modern order, but they do not concede that any other system, could it be freely chosen in place of machine civilization, would confer more dignity upon human nature, make life on the whole richer in satisfaction, widen the opportunity for exercising our noblest faculties, or give a sublimer meaning to the universe in which we labor."

With these encouragements let us try to see some of the things about us as they are. Let each of us compare this world of our experience with the dream world of our ideals. Let us see if as engineers we have not an exceptional opportunity to gain in our individual lives that true satisfactfon which comes from an attempt to leave the world a better place than we found it. But first let us recognize that an engineer today is far more than Treadgold defined him nearly a century ago. In addition to "directing the powers of nature for the service of man" he now adds to the common welfare also in fields more human. He finds himself occupied at times in social guidance so that the tools he has provided shall be properly used.

One of the most significant and important trends of this day is the continuing movements of population from the rural regions to the urban, which, with the great increase in the world's population, is thus rapidly accelerating the growth of cities. The engineer's machinery makes it possible to provide the necessary food with the expenditure of a

lesser manpower than formerly and his transportation developments readily bring the food to the urban population. But with rapidly increasing population the problem becomes more and more difficult.

Professor East cites figures to prove that the maximum food supply that can be produced on the land area of this globe available for that purpose will support a population of fifty-two hundred millions, a figure which at the present rate of increase, he says, will be reached in about a century. Long before that time it will become necessary to bring into production land which is now largely arid and difficult of access, and even then occasional crop failures will result in widespread starvation.

We can leave to the medical profession and to the biologists the task of checking population increase, but let us engineers face some of the attendant problems. We are not directly concerned with the exact decade when world saturation will be reached but we are vitally concerned with the provisions for living and for advancing civilization while man's neighbors are crowding closer and closer. The marvels of science have lulled the layman into a falsesense of security. They have given him faith to believe that with the scientist and the engineer on the job the future will take care of itself. Perhaps it will, but only if the thinkers and the doers of this generation and those who follow put themselves earnestly to the task. Intelligent thinking usually leads to intelligent action. No engineer worthy of the names can take a laissez-faire attitude on problems that deeply affect human welfare and progress.

How does the engineer picture the future city? Is it to be a mechanical Colossus full of ingenious provisions for commerce and industry, for housing and for getting about, or will it be a place where man still has some contact with nature? The growth of our cities is both upward and outward. The upward limit is moving higher and higher, for both business houses and multiple dwellings, and all of the ground area that was formerly devoted to low buildings is being covered by the higher structures. The engineering problems of transportation, of light and air and health for the highly congested population are not impossible of solution but we must admit that they are being taken care of only in part. Multiple-decked streets above and below ground, huge ventilators, air-conditioning devices, artificial light and other necessary contrivances are relatively easy to plan, though some of them are very expensive to provide; but is the sort of civilization that is likely to develop in a city of that character the kind that makes for a richer and nobler living? Are we building the City and forgetting the Man, as Grosvenor Atterbury suggests, and are we not fast losing our sense of values?

You remember the Greek legend of Hercules and his encounter with Antaeus, the giant whom Hercules met when on his trip to get the golden apples. Antaeus was a son of Mother Earth and each time he touched the

ground his strength grew tenfold. Hercules wrestling with the gaint noticed this increased strength so he finally caught him up and held him in the air. Then, no longer having contact with Mother Earth, the giant's strength sank and life ebbed away with it. Is this not symbolic of man's experience when contact with nature is lost? Can a life develop properly when shuttling in crowded cars, through crowded streets or supercrowded subways, between an office which sees the sun for twenty or forty minutes a day and an apartment home in a high building closely touching elbows with neighboring high buildings? Is there a social problem involved in such city building and has the engineer no concern in it?

Our physical surroundings, things we can change if we will, offer a fertile field for the interest of engineers with their vision and with their desire for lifting life to higher levels. I suggest that we give more study to this and similar city problems and that we occasionally discuss them at Institute meetings, especially in our metropolitan sections.

Let us consider some of the problems that are, as it were, at our elbow. One is that of automobile-engine exhaust in our cities, which has received all too little attention. This presents a serious health problem in the deep canyon-like streets. Investigators of carbon-monoxide poisoning declare that this deadly poison is often found in city streets in sufficient quantities to impair health, and in some instances to be the proximate cause of death. And with the traffic jams on country highways, the holiday outing is now far from a health trip.

While on the subject of air pollution let us in passing note the factory and the apartment-house chimneys that still frequently belch forth dense clouds, often robbing man of beauty and of health. The engineer has provided a partial cure, but even our giant power stations, which receive the most expert engineering attention, still leave something to be desired.

There is another handicap to which little thought is given, —the deleterious effect of noise on the nervous system. Scientific tests have shown a marked reduction in labor efficiency due to noise, and British physicians have even advocated an act of Parliament prohibiting needless noise in the interests of the nation's health. Certain it is that our present-day business and professional life draws heavily on our nerves, and all too many men collapse under the strain. Relief from noise as one contributor to the strain is thus a direct public benefit.

And how much are we interested in the backyard regions of our industrial cities? Many of these reflect little credit on our advanced civilization. Disorderly dumpheaps and scrap piles are still all too common. They enrich no lives spent among them; rather they are likely to develop that element in our citizenry with which the forces of law and order are in constant conflict. The appalling waste

that this entails affects much more than our taxes. Good housing and neighborhood cleanliness go far toward making life for the lowly conform more nearly to the picture of today's accomplishments that we paint with such pride.

The engineer knows that most of our cities have grown more or less hodge podge during the crude-devolopment years of our country. He knows also that correct growth demands guidance, and this means a city plan. Fortunately many cities, taking the lesson from the important European centers, have seen the wisdom of proper planning and are correcting misfits of earlier decades and are providing better guidance for the future. But the problem is today one of even greater extent—one of regional planning, and engineering enters largely into this also. Here is a field which arouses the enthusiastic interest of every true engineer. He realizes that the suburban regions are rapidly filling with dwellings and to some extent with factories. He knows that if life is to be lifted to better things these newer developments must be coordinated properly so health, convenience, beauty, and the opportunity for wholesome family life may all be properly provided for. In this and similar activities the engineer will seek the greatest dividends in terms of human happiness.

The increasing population, Professor East says, requires that each year forty million acres more must be tilled and harvested than the year before to provide sufficient food, and this clearly makes countries more and more dependent on one another and at times will shift the direction of the dependence. The engineer has brought countries together by rapid transportation, by land, by sea and by air, and has tied them still closer by achievements in communication, and now even by international power lines. What can he do to hold them together as friendly neighbors? The answer here goes to the very bottom of man's relation to man.

The material work of the engineer deals with nature's laws. He knows he must understand these laws and must use truth in his work or it will fail. Engineering analysis applied to human relations similarly seeks to find the underlying laws. A study of past civilizations indicates that they failed because of violation of that basic social law which bids us do unto others as we would have them do unto us. Is it too idealistic to expect improvement in our day to come as a result of more engineering in government, that is, more of the engineering method applied to the solution of questions that tend to bring discord between peoples and between people? There is encouragement in the statement made by Bertrand Russell, "I look, therefore, to the western nations, and more particularly to America, to establish first that more humane, more stable and more truly scientific civilization toward which, as I hope, the world is tending."

Technical achievement has almost eliminated manual drudgery. The habit of technology to be guided by basic

law holds out promise that "man's inhumanity to man" may likewise be banished. Is this also too optimistic? Has human nature remained unchanged through the ages, as is so often stated? May I refer the pessimists, if there be such here, to any story that portrays life during earlier periods, as for instance, "Power" by Leon Feuchtwanger. The reader of this gripping tale of the ruthless standards of the eighteenth century will congratulate himself that he is living in the twentieth.

Our machine civilization is still young and we can attribute to growing pains many of the conditions that today prevent man's best development. However, a look toward the horizon will show many encouraging signs.

Our country, appreciating the keen need of the time for the engineering approach to the important problems of state, has elected an outstanding engineer to the presidency. In other countries the engineer must similarly stand at or near the helm if this civilization is to survive. This does not mean that he alone is to be the savior of mankind, but in this age of cooperation, the engineer, together with the doctor, the lawyer, the economist, the sociologist and other trained minds, must apply himself to a scientific solution of social problems in addition to furthering material development. He must join forces with all those

> ". . whose law is reason; who depend(s)
> Upon that law as on the best of friends,"

with men who can find facts and who can face them boldly and honestly.

The engineer's work has started many trends in the direction of relief from some of the world's growing difficulties. A notable one is the spread of electric power into areas away from congestion, thereby permitting at least a partial decentralization of industries and of population. This spread is greatly advanced by the interconnection of power systems now so common all over the country, while the ease of getting about with automobiles is another important factor. A further material aid is the extension of electric distribution lines into rural regions so that modern methods can be applied increasingly to agriculture, both in the field and in the home, while the telephone and radio are keeping farm operators in touch with the latest in music and education. Great as the progress has been, much still remains to be done in these fields.

Among other items that bring cheer and stimulate optimism may be mentioned the increasing interest now being taken in sane city and regional planning, the efforts of important industries looking toward elimination of waste and the conservation of our resources, the conversion of former wastes into profitable by-products and particularly the growing reclamation of wastes in agriculture.

But here is a bit of pessimism.—The high speed at which life seems to be driven today and the apparent immersion of large numbers in gross materialism has filled some

people with fear and misgivings regarding the future. Thus we have the Bishop of Ripon seriously suggesting a ten-year holiday in science to give the culture of the soul an opportunity to catch up with the rapid material progress. But the fear that the "spirit" cannot grow in an atmosphere of "science" is not a new one. A century ago Edgar Allen Poe in his Sonnet to Science wrote in part

"Hast thou not dragged Diana from her car,
And driven the hamadryad from the wood
To seek shelter in some happier star?
Hast thou not torn the naiad from her food,
. . . ."

The feeling that our present material progress is not really making for a richer life is expressed by many more. Even our own Lorado Taft, with a fine enthusiasm for beauty and an outstanding genius for creating it, is led by his observation to conclude that Americans are practically immune to the arts, have no joy in creating, and are not interested in the most important thing of all, the creation of an ideal civilization.

What answer have we engineer optimists to these critics?—

The good bishop sees but a small part of the picture and that not the bright and inspiring part. When the young Poe wrote his sonnet the Age of Electricity had not dawned. His hamadryads and naiads would today be quite at home with most of our scientists and engineers And our gifted sculptor seems to feel that the progress made through technology expresses itself mainly in jazz. He fails apparently to see the poetry in the work of a Millikan, a Langmuir, a Steinmetz, or an Edison. He should see, as Pupin and others so clearly see, the idealism of the American machine.

The engineer with his enthusiasm over the human purpose of technology's accomplishments is guided by his ideal of a better living for a man, but he keeps his feet on the ground in a practical effort to reach this goal step by step. He appreciates that

"Heaven is not reached by a single bound;
But we build the ladder by which we rise
From the lowly earth to the vaulted skies,
And we mount to its summit round by round."

The important thing is to be mounting the rounds. That we are moving onward and upward I for one firmly believe.

Is not one true indication of the direction in which we are moving found in the growing appreciation of beauty? The advertiser pages of our magazines clearly show the turn of the tide. On every hand commercial competition seems to be along lines of greatest devotion to a beautiful product, and this is not confined to automobiles and bath-room fixtures. Art, which Henry James called "the shadow of humanity," is at last finding its place in industry.

The engineer accepts the line from Keat's famous Ode

"Beauty is truth, truth beauty."

He is conscious of the beauty and the romance in many of the facts he deals with but he does not let his enthusiasm over the beauty, or his dreaming stirred by the romance, blind him to a proper weighing of the facts. Rather he develops from his dreaming a use of the facts for the further enrichment of life.

And what of the engineer of tomorrow? What thought are we giving to him? Engineers appreciate that by their example, as well as by their encouragement and active help given to educators and to the engineering novitiate, they are building the foundations of the profession more firmly and raising it ever higher. They know that education for useful living is not completed in college. It continues throughout life.

Our Institute, representing the electrical section of American engineers offers the fellowship of kindred souls, a broadening of outlook and of knowledge, a blending of humanism with technology. It carries inspiration to its members to be not only technicians of high order but also trained seekers of the needs of mankind, applying their skill and their knowledge to the end that life for the teeming millions of their fellowmen may be made more worth while, less burdensome, more healthful, and more noble.

Thus, my friends, do I conceive the true engineer,—one, who in thought and deed, is and ever will be a practical idealist.

— THE END —

Mottoes from Franklin's Writings.

"He that hath a Trade hath an Eſtate."

"When men are employed they are beſt contented."

"Without Juſtice Courage is Weak."

"I would rather have it said He Lived Uſefully than He Died Rich."

"The Doors of Wiſdom are never ſhut."

"Read much but not too many Books."

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