CHARLES PROTEUS STEINMETZ[1]

THE whole world, through its orators and writers, has expressed so beautifully and so well its appreciation of Charles Proteus Steinmetz that if I attempted to express what is in my heart, it would be but to repeat what has already been said much better by others. However, as his devoted friend and intimate associate for one third of a century, as one who recognized his great talents when he was unknown, and surrounded him with a favorable environment for the development of his genius, I regard it as a privilege to publicly endorse all that has been said of his usefulness, his commanding genius, his inspiring personality. This cheerful, patient, kindly spirit, this zealous student of nature and lover of humanity was your friend and my friend.

I have been asked to speak of his scientific attainments and their meaning to the world. To do this properly would be to cover much of the history of the electrical industry during the past 30 years. I must confine myself to sketching such features as seem of most importanec and possibly of greatest interest.

Thirty years ago I first met Steinmetz. The occasion was as follows: The General Electric Company had been recently formed by the union of the Edison Company and the Thomson-Houston Company, which brought into one enterprise the results of the work of Edison, Elihu Thomson and many other early pioneers in the fields of arc and incandescent lighting, electric traction and industrial motor application.

Rudolph Eichmeyer, of Yonkers, had developed some interesting designs for electric traction purposes, and certain novel and economical forms of windings for armatures of electrical machines. I was then in charge of the manufacturing and engineering of our company and my views were sought as to the desirability of acquiring Eichmeyer's work. I remember giving hearty approval, with the understanding that we should thereby secure the services for our company of a young engineer named Steinmetz. I had read articles by him which impressed me with his originality and intellectual power, and believed that he would prove a valuable addition to our engineering force.

I shall never forget our first meeting at Eichmeyer's workshop in Yonkers. I was startled, and somewhat disappointed by the strange sight of a small, frail body surmounted by a large head, with long hair hanging to the shoulders, clothed in an old cardigan jacket, cigar in mouth, sitting crosslegged on a laboratory work table. My disappointment was but momentary and completely disappeared the moment he began to talk. I instantly felt the strange power of his piercing but kindly eyes, and as he continued, his enthusiasm, his earnestness, his clear conceptions and marvelous grasp of engineering problems convinced me that we had made a great find. It needed no prophetic insight to realize that here was a great man, one who spoke with the authority of accurate and profound knowledge and one who, if given the opportunity, was destined to render great service to our industry.

I was delighted when, without a moment's hesitation, he accepted my suggestion that he come with us.

Steinmetz had already made his first important contribution to electrical science in investigations of magnetism, and especially in formulating and determining the laws governing the losses in iron subjected to varying magnetic induction. He showed that the hysteresis varied as the 1.6 power of the density of magnetic flux. This made possible for the first time the exact predetermination of the so-called iron losses in the armatures of electric motors and generators and in the transformers and other electrical apparatus employing iron. As a result, the quality of our electrical machinery was improved, and the weight and costs reduced. It is difficult at this date to realize the fundamental importance of this one contribution to the orderly and definite progress of the electrical industry.

During the first decade of the commercial application of electricity to light and power which may be said to cover the period between 1880 and 1890, direct current only was used. This was the basis of the Edison system, the Thomson-Houston arc system, the Vanderpool and Sprague railway motor systems. The laws governing the flow of direct current were simple and easily understood, and could be treated by mathematics of the most elementary character.

About the time Steinmetz came with the General Electric Company in 1893, the use of alternating current for lighting, power and other purposes was just beginning to be of demonstrated commercial value. Advance in the commercial use of alternating current was hindered by the extreme difficulty of understanding the technical nature of its action and of the various phenomena connected therewith. The engineer who had been working with direct current found it difficult to understand and therefore to correctly design alternating current apparatus. While the problems of the direct current apparatus and electric circuits could be treated by the simplest mathematics such as ordinary arithmetic, the alternating current, involving such phenomena as reactance, capacity, leading and lagging currents, phase displacements, etc., could apparently only be solved by higher mathematics involving the use of calculus methods which were not generally familiar to the engineers of those days. Even skilled mathematicians familiar with such

[1] Address delivered at the Memorial Meeting in Schenectady, October 31, 1923.

methods made slow and difficult progress in the solution of the problems which arose daily.

Steinmetz took hold of this situation with characteristic energy, and soon brought order out of chaos. He abolished the mystery and obscurity surrounding A. C. apparatus and soon taught our engineers how to design such machines with as much ease and certainty as those employing the old familiar direct current.

He had already made the discovery that alternating current problems could be attacked and solved with success by the use of what was known as complex quantities. By the use of this system he not only was able to solve these problems himself, but to teach our engineers to do the same work by methods almost as simple as ordinary arithmetic and algebra. Steinmetz himself regarded this as one of his greatest contributions and called it the development of the "symbolic method of alternating current calculations." This method was found to be so powerful, accurate and rapid that its use was not confined to the engineers of our company, but rapidly spread throughout the world. He preferred to use this mathematical method in the treatment of all problems of alternating current engineering which arose and advocated its use before the American Society of Electrical Engineers in numerous papers, and embodied it in the text-books of which he was author.

Not only did the adoption of these mathematical methods open the door to many to do useful design work who otherwise could not have done so, but it enormously increased the speed with which definite and accurate calculations and designs could be made. It furnished the engineer with a powerful tool which multiplied his power with just as much certainty as the machine tool improves and multiplies the usefulness of the ordinary workman.

It was fortunate indeed for our company and for the electrical industry that Steinmetz became associated with us at the critical time when the alternating current development had just started. It is not too much to say that his genius and creative ability, not only in his own personal work, but in advocating and obtaining the general use of a simple mathematical system for treatment of A. C. problems, were largely responsible for the rapid progress made in the commercial introduction of alternating current apparatus.

Steinmetz's practical inventions literally cover the entire field of electrical applications: Generators, motors, transformers, lightning arresters, lighting, heating and electrochemical operations. Of these many inventions, which were set forth in some 200 patents, perhaps the most important are the induction regulator, the method of place traisformation, as from two phase to three phase, and the metallic electrode arc lamp.

His experimental work in arc lighting led to the production of the magnetite arc. The practical advantage of this type of lamp is found in the extreme length of time which the metallic electrode will burn without recharging—these electrodes burning 200 hours contrasted with a life of 70 hours in the carbon arc used before his time. The efficiency also of this type of lamp, especially in small units of illumination, was of great commercial value.

He devoted much time to the development of the mercury arc and by his masterly methods did much to improve this interesting and important type of illumination. These and many other of his inventions have found permanent and extensive use in the industry.

During the last ten years, when alternating current power transmission lines of great length, carrying large amounts of energy, have spread all over the country, to use his own words, "an old enemy became more and more formidable—lightning," and for many years the great problem which pertained to the successful development of electrical engineering was that of protection from lightning. Before this could be undertaken with reasonable hope of success we must know a great deal more about lightning and centered phenomena. This led to the investigation of transient phenomena. It was soon found that while lightning might have been the criminal which started the trouble in the electrical system, the damage and destruction was not done by lightning, but by the electric machine power back of the circuit which was let loose and got out of control by the disturbance initiated by lightning. He goes on to say that the study of the phenomena produced by lightning effects could in general be grouped under the name of "transients" because, unlike the direct and alternating currents which flow continuously, these disturbances last a limited time only. The study of this problem led him to produce his famous "lightning" generator of which so much has been told in the public press. In the hands of Steinmetz and his assistants such progress has been made that the nature of the phenomenon has been so elucidated that as a result it is possible to proceed with confidence in the further development of the large high-powered transmission systems, making possible Steinmetz's vision that the day was rapidly approaching when the electrical engineer would supply the world's requirements of energy over transmission lines which would cover the country with a network similar to that of the railways, the one taking care of the distribution and supply of energy, and the other carrying the materials.

Steinmetz was an ardent believer in the value of education. He not only found time to aid the educational work of Schenectady, but became president of the national association of corporation schools and

lecturer at Union College. In a masterly address, upon retiring as President of the American Institute of Electrical Engineers in 1902, he stated that all future progress in science and engineering depends upon the young generation, and to insure unbroken advance it is of preeminent importance that the coming generation enters the field properly fitted for the work.

His personal example, his spoken words and his writings have had a powerful and beneficial influence upon the development of education, especially technical education in this country.

That I have not overstated the value of Steinmetz's work in this early period is indicated by the message of an eminent electrical engineer, Professor Harris J. Ryan, president of the American Institute of Electrical Engineers, who says: "Through a period of years Dr. Steinmetz stood almost alone as the one electrical engineer in the world capable of defining and solving the many perplexing problems encountered for the understanding and improvement of the transformer, induction motor, alternator and polyphase high voltage system, the modern fundamental implements of the electrical engineer."

That the value of Steinmetz's services were not limited to the General Electric organization is well known, but it is satisfactory to have the testimony to that effect by the president of a great electrical manufacturing company who states: "He has been such an outstanding figure in engineering work for so many years and is so well known to the public that his death will be a great loss not only to the profession but to people generally."

One of our largest customers offers the following tribute: "He was untiring in his devotion to the development of the electrical industry and in his passing the industry has suffered an irreparable loss."

From far Japan comes the following comprehensive and beautiful encomium: "He spent his life serving humanity."

A representative of the greatest electrical manufacturing company in Germany offers the following tribute: "It will always remain one of the highest merits of your company that he found here the congenial environment and support necessary for a genius like his to develop to the fullest benefit of mankind."

Professor Elihu Thomson, one of our country's greatest scientists and electrical engineers, a man whom all the world delights to honor, sends this tribute: "In the death of Dr. Steinmetz the science of electrical engineering has lost a great leader, whose talents were most exceptional. Nearly a third of a century has passed since he displayed a faculty amounting to genius in the application of mathematical methods to the solution of difficult problems in electrical work, and throughout the subsequent period this special work of his has been followed up unremittingly. His numerous books and papers, his lectures and discussions will in themselves constitute an imperishable monument for all time. His long connection with the General Electric Company gave him the needed opportunity to put into extensive practice his ideas, and the resulting value to the industry itself can not be measured or estimated. The whole science of transient phenomena in electric circuits is virtually his, and he had the qualities of the patient teacher and expositor to those seeking information as students or listeners to his discourses. Only those who have followed his career, so full and so fruitful, can know the vacancy created by his absence from among us."

I must now bring to a close this inadequate sketch of the contributions of this remarkable man to the development of the electrical science and industry. During his short life he rendered services of the most conspicuous character and inestimable value.

He was the author of many original scientific papers and of a large number of electrical books which have been the accepted standards in colleges, laboratories and workshops everywhere.

He was a prolific inventor, a skilled mathematician, a trained engineer and an inspiring teacher. Our generation has produced men who have equalled or excelled him in some one of these fields, but no one has arisen who, to such a superlative degree, combined the qualities of inventor, mathematician, engineer and teacher.

He possessed a marvelous insight into scientific phenomena and unequalled ability to explain in simple language the most difficult and abstruse problems.

Countless electrical engineers now occupying positions of great importance in our company and elsewhere in the world gladly give testimony of their debt to him.

He was patient, sympathetic, cheerful and ever willing to share his great gifts with all those who sought his counsel.

He loved children and they loved him. A neighbor and his wife were mourning his loss in the presence of their children, when the father exclaimed with deep emotion, "and he was my friend." His little son of seven years looked up from his play and said: "He was my friend, too, daddy."

We, his fellow citizens, friends and associates, join the great world in mourning his loss, but may our grief be tempered by the memory of his great achievements which make his name the synonym of high service to humanity.

E. W. RICE, JR.

HONORARY CHAIRMAN OF THE BOARD,
GENERAL ELECTRIC COMPANY