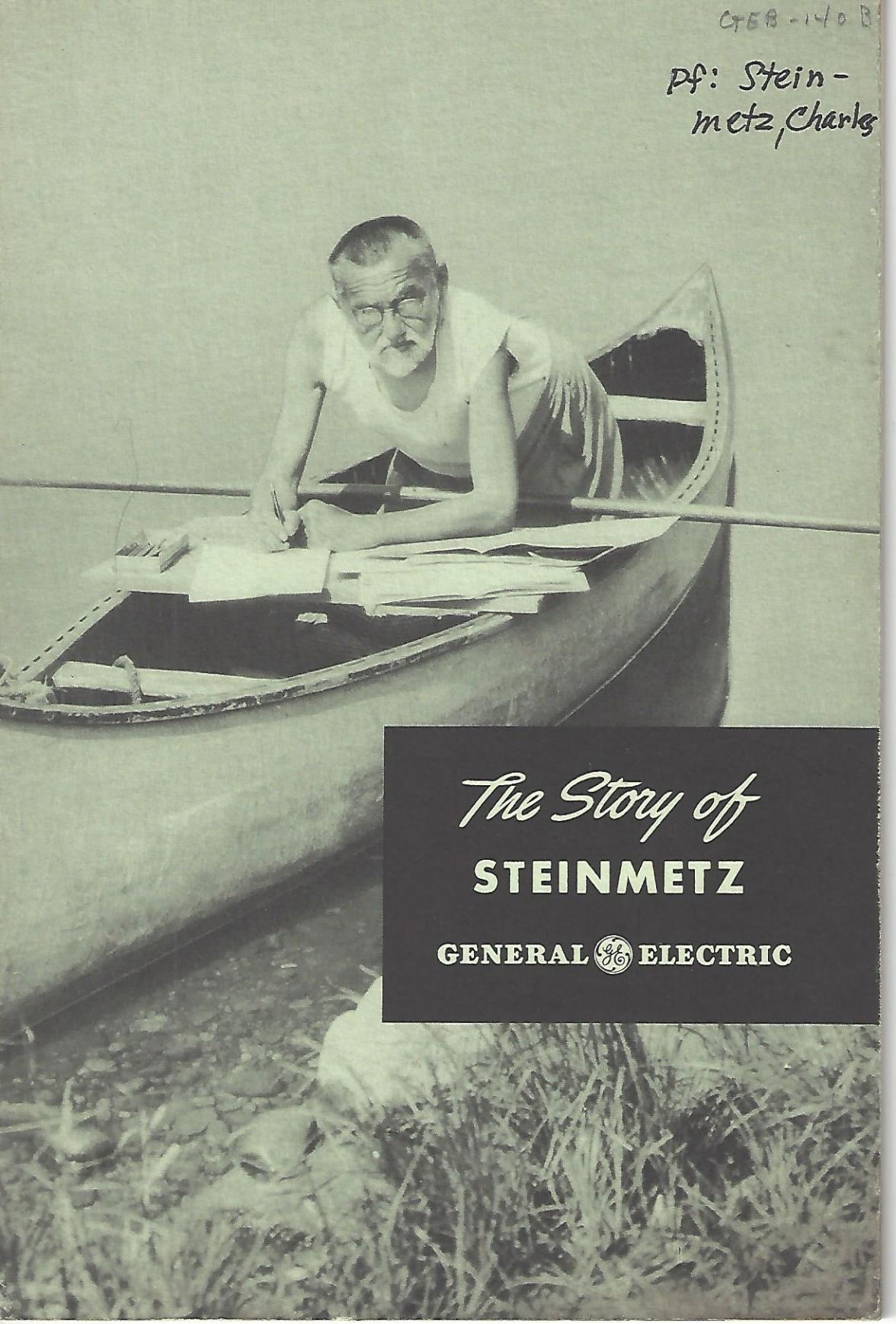


The Story of STEINMETZ

GENERAL ELECTRIC

THE STORY OF
STEINMETZ

This is an age of wonders. Dreams of skyscrapers, airplanes, and steamships have all become realities since the turn of the century. The mysterious force of electricity has been harnessed, its behavior analyzed, its services offered to the entire world. Like an infinitely versatile servant, it drives the wheels of industry, washes the dishes of the housewife, and brings the entertainment of masters into the very privacy of a living room.

Naturally, many men have made signal contributions to the development of the present field of electricity—men like Franklin, Faraday, Maxwell, Edison, and Thomson. And in the first rank of that group stands Charles Proteus Steinmetz, the mathematical wizard of electrical engineering, a man whose work helped to make possible a great industry of today.

GENERAL ELECTRIC

GEB-104B

THE STORY OF STEINMETZ

THE EARLY LIFE of Charles Proteus Steinmetz was typical of that of Prussian folk at the time when Bismarck was welding together the German Empire. He was born in Breslau, Germany, on April 9, 1865, the third child of a small family consisting of his parents and his half sisters, Marie and Clara. As was the custom at the time, he was christened with a name designed to preserve the memories of his father and two uncles: Carl August Rudolph Steinmetz, later Americanized to the name by which he became so widely known. His mother died when he was a year old, so his grandmother took over the care of the household. Because Carl had been born deformed, his grandmother was especially kind to him, and his childhood was spent in a happy, middle-class environment.

In spite of his physical handicap the boy grew up healthy and strong. Although he did not distinguish himself at first in school (he had some difficulty with multiplication tables), he soon grew to like his studies, and by the time he was graduated from high school he had become the leader of his class. When he entered the University of Breslau, in 1882, he had already turned his attention toward science and had set up a small laboratory in his home, where he carried on original experiments.

But Carl had other interests—interests which were to alter profoundly the current of his life. At this time Bismarck was trying to stamp out socialism in Germany; but, with the enthusiasm of youth, a small company of students held secret meetings and discussed social problems. Carl joined this group. A feeling of excitement and watchfulness was in the air at the meetings, as the police had orders to arrest all persons who would dare to question Bismarck's course.

In spite of their precautions, they were discovered. They went to a photographer and had a picture taken of themselves standing around a statue of Lassalle, a noted German socialist.

This is the photograph which revealed the student socialist group. Steinmetz is standing on the right.

Only enough prints were ordered to provide one for each member, but the photographer, proud of his work, made another print and exhibited it in his window. The secret was out—the statue of Lassalle was clear evidence that these young men were socialists. The police confiscated the photograph and began rounding up the students.

Knowing that the police were on his trail, Carl decided to leave Germany. To arouse as little suspicion as possible, he bought a round-trip ticket to a small town just across the German border. And so, on a May day in 1888, after six years at the University of Breslau, where he had become a candidate for the degree of Doctor of Philosophy, he crossed into Switzerland and continued to Zurich, where he entered the Zurich Polytechnic School. It was there that he met and struck up a warm friendship with Oscar Asmussen, a young American who was attending the Polytechnic.

The Immigrant

In the spring of 1889, Asmussen's family suggested that he return home, and Asmussen, who had grown fond of Carl, asked his friend to accompany him. Carl had no money—he had been tutoring and writing for the papers to keep himself at

the Polytechnic—but Asmussen agreed to pay for his passage and to lend him what he would need until he found work in America. From the editor of a German electrical publication for whom he had written various articles, Carl obtained a letter of introduction to Rudolf Eickemeyer, who had an electrical establishment in the United States.

Almost exactly a year after Carl had left Germany, the two friends traveled across France and embarked on the steamer *La Champagne*, bound for New York. Although they traveled in the steerage, Steinmetz always remembered that voyage. "It was the most pleasant trip I ever made," he said. "I was not once seasick, and we made a very jolly excursion of it all the way over."

The voyage took eight days. During most of that time Carl did his best to pick up a little English. Asmussen gave him what instruction he could, but the time was so brief that when they finally reached America, Carl could speak hardly any English

Steinmetz in Yonkers in 1890.

beyond a few phrases. When he stood before the immigration officer at Ellis Island, on June 1, his reply to the question, "Can you speak English?" was simply "A few." His appearance did not impress the officer. He had caught cold on the ship, his face was badly swollen, and he looked generally forlorn. After some minutes of searching questions and puzzled answers the immigration official shook his head. Carl was without funds; he might become a public charge. He must go back to Europe.

At this crucial moment Asmussen came to the rescue. Pulling a roll of bills from his pocket, he told the officer that the money belonged to both of them, and that he would accompany his friend. Slowly the official relented, and finally Carl was permitted to step ashore in the United States.

The American

THE DAYS following his arrival in New York were filled with job hunting. Having his letter of introduction, however, Carl called on Rudolf Eickemeyer, who operated a manufacturing plant in Yonkers, New York. Eickemeyer, who was a good judge

Steinmetz and friends on an outing in the 1890's. He is second from left in the front row.

Steinmetz's home on Wendell Avenue in Schenectady, showing the large conservatory where he kept his plants. Behind the house is the laboratory.

of men, looked the applicant over with a keen eye and said, with a smile, "Sprechen Sie Deutsch?" Carl was immediately at home, and after he and Eickemeyer had chatted in German for more than two hours, he was hired as a draftsman at two dollars a day. Asmussen found work the same day, and the two set up housekeeping in a rented room in Harlem. After a few months Asmussen married, and Carl moved to Yonkers to be nearer to his work.

One of Carl's first acts after obtaining a job was typical of his attitude toward his new country: he applied for citizenship papers, and he Americanized his name to Charles Proteus Steinmetz. "Proteus," the name of a mythological character having the same deformity as Steinmetz, was a nickname which had been given to him years before when at college in Germany. In the first year Steinmetz also joined the New York Mathematical Society (now the American Mathematical Society), and the American Institute of Electrical Engineers.

It was not long before the engineering profession began to hear of young Steinmetz. At the age of 26—three years after he had landed in the United States—he announced a discovery

Many hours were passed pleasantly among the strange collection of desert plants in his conservatory.

in the field of magnetism which established his reputation. Prior to that time designers of electric machines knew that iron in the magnetic circuit of alternating-current machines becomes hot when the machines are operated. This is a loss of useful energy, but no simple way of calculating the amount of the loss was available. Steinmetz, after examining data of other experimenters and performing tests of his own, found that a law could be written which would give the information desired. This law he demonstrated and explained in a paper published in the *Electrical Engineer* of December 9, 1891.

The article was greeted with instant acclaim. It was hailed as a great help in the design of electric machinery, and experience has justified the opinion. The original law of Steinmetz (called the "law of hysteresis loss") is used today in designing all electric machines, from sewing-machine motors to hydroelectric generators, and it makes possible an easy and accurate calculation of energy loss in the iron. With a knowledge of this factor, such a loss can be decreased, and more efficient machines can be built.

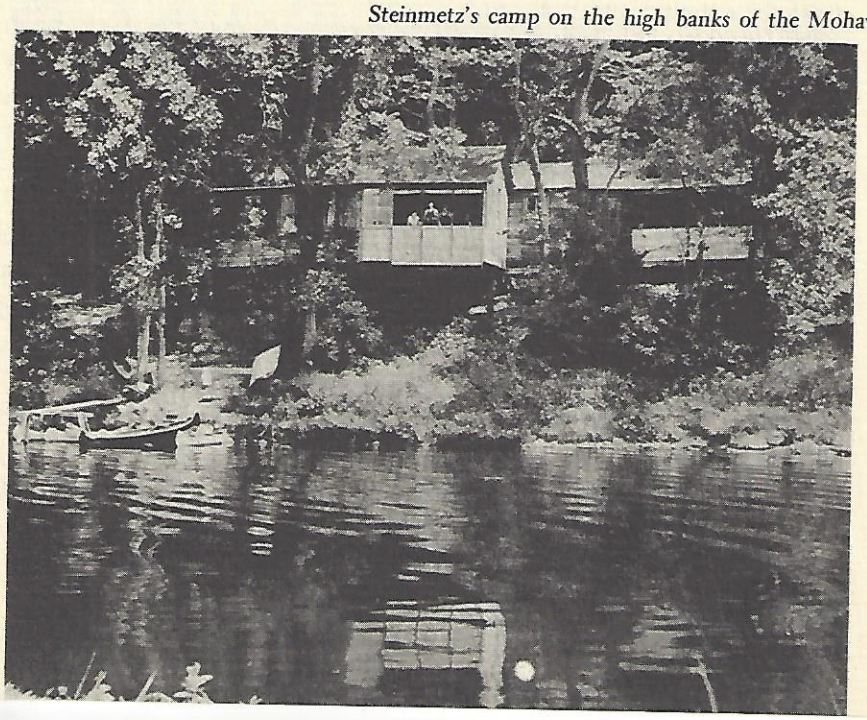
Steinmetz and General Electric

SHORTLY AFTER this time the Eickemeyer and Osterheld Company passed out of existence. The interests of the company were purchased by the then new General Electric Company, formed on April 12, 1892, by the union of the Edison General Electric Company of Schenectady, New York, and the Thomson-Houston Company of Lynn, Massachusetts.

E. W. Rice, Jr., of General Electric, went to Yonkers to ask Steinmetz to join the company. Mr. Rice said later, in describing the interview: "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, and clothed in an old cardigan jacket, cigar in mouth, sitting cross-legged on a laboratory work table.

"My disappointment was but momentary and completely disappeared the moment he began to speak. 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 indeed made a great find. It needed no prophetic insight to realize that here was a great man, 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."

Steinmetz's camp on the high banks of the Mohawk River.



Early in 1893 Steinmetz moved to Lynn, Massachusetts, and entered the Calculating Department of the General Electric Company, with which he was associated for the rest of his life.

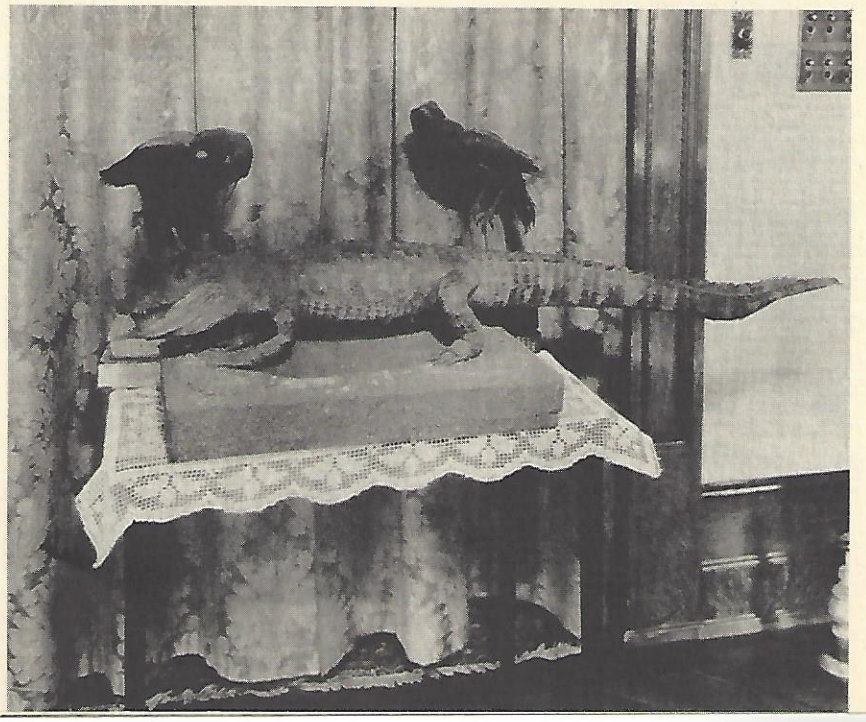
A year later he was transferred to the new headquarters of the Company at Schenectady. He was quickly recognized as one of the greatest engineers engaged in alternating-current work, and became head of the reorganized electrical calculating department. His assistants in the calculating and designing of alternating-current machines were Ernst J. Berg, A. E. Averett, Walter I. Schlichter, and Eskil Berg.

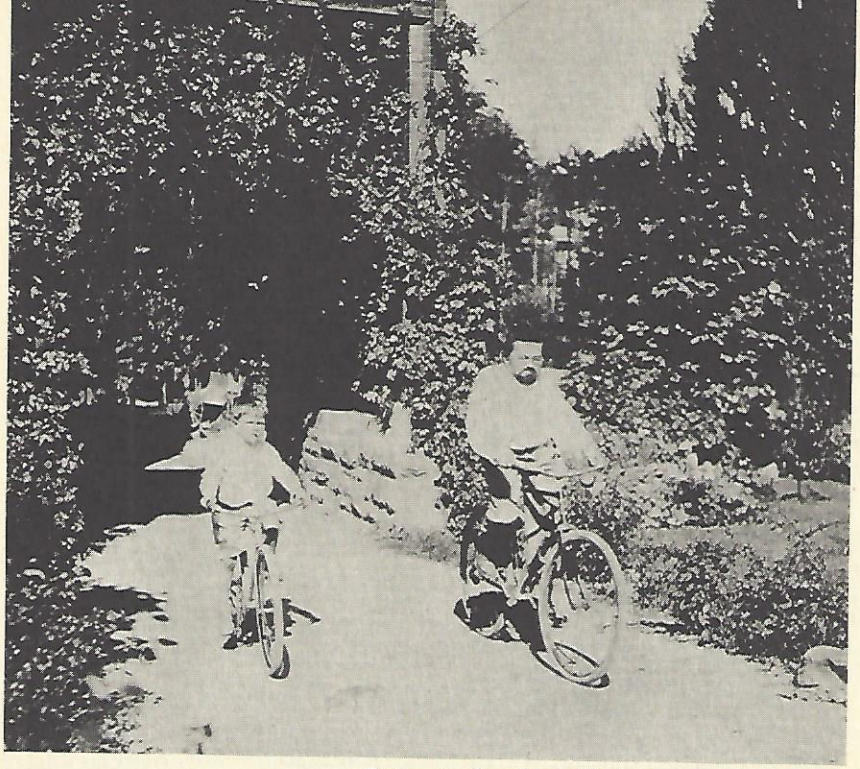
And in the same year Steinmetz became an American citizen, and cast his first vote as a naturalized citizen at the autumn municipal election in Schenectady.

At Home

SOON AFTER coming to Schenectady, Steinmetz and two Berg brothers, Ernst and Eskil, rented a house and hired a housekeeper to cook for them. In the back yard of this place they constructed numerous pens and cages for pets which they were collecting. The first of these were two raccoons, obtained by Ernst during a hunting expedition into the near-by woods.

When the crows and alligator died, they were mounted, and are still in Steinmetz's home.





Steinmetz loved to ride into the country on his bicycle, especially when accompanied by one of his grandchildren.

Steinmetz made friends with two crows that used to fly around the yard, feeding them until they became tame enough to eat from his hand. He named them Jim and Mary. When he went into the yard they would alight on his shoulder, and often they would fly to the window ledge of his bedroom and watch him. One day one of the raccoons escaped and killed one of the crows, and the other crow, which died soon after, was popularly considered to have had its death hastened by grief. Steinmetz had the crows stuffed and placed on a high bookcase.

Several young eagles were part of the collection of pets. There were also cranes and owls, squirrels, dogs, and a monkey which Steinmetz called Jenny. Most remarkable of all was a pet alligator, four feet long, which he taught to do tricks. In a short time this collection of animals became famous all over town, and many children went to see them.

With a man like Steinmetz in their midst, the people of Schenectady gradually built a stock of legends about him. One of the better known of these resulted from his habit of smoking a long, thin cigar under almost any circumstance. An office

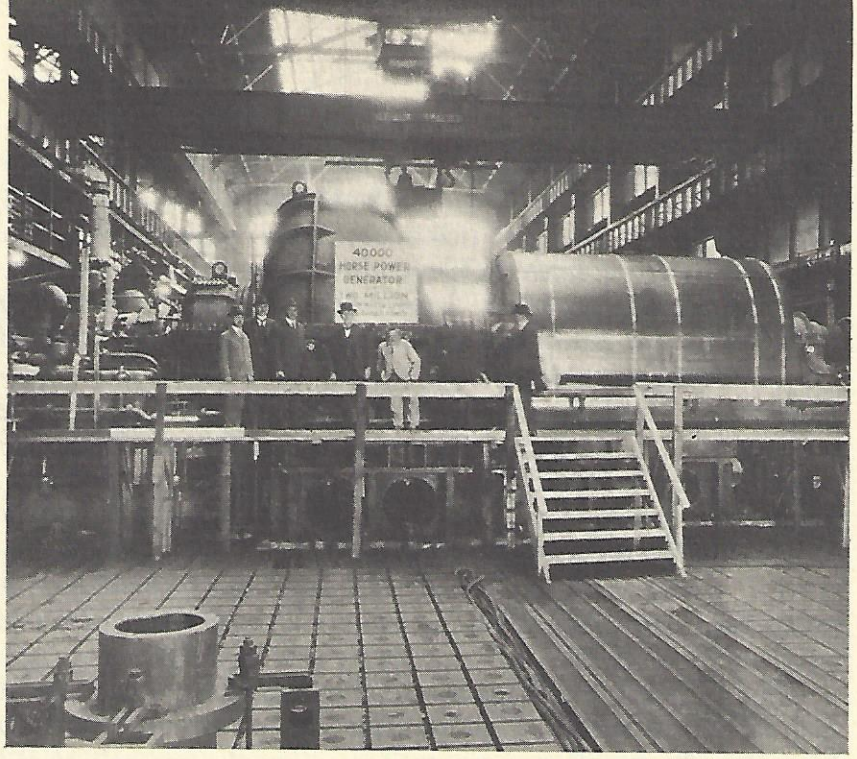
Steinmetz and Marconi, the inventor of radio.

building in which Steinmetz worked was not fireproof, and "No Smoking" signs were posted. Not wishing to break any rules, Steinmetz, on seeing the signs, quietly went home and stayed there, answering all entreaties to return to work with the ultimatum, "No smoking, no Steinmetz."

The solution to this impasse is not known, as the story seems to be mostly fiction; however, the legend indicates the desire of Steinmetz to smoke, come what may.

About this time Steinmetz built a camp for himself on a tributary of the Mohawk River near Schenectady. During the summer months he spent a great deal of time at this camp and entertained his friends there during the week-ends and holidays.

In 1900 he purchased a plot of land on Wendell Avenue, Schenectady, and began to build a house, while at the same time the General Electric Company built him a two-story laboratory on the rear of the lot. During the time the house was being



Steinmetz and Edison inspecting a large turbine-generator at the Schenectady plant of General Electric.

built, Steinmetz lived upstairs over the laboratory, and there came to live with him a young engineer, Joseph LeRoy Hayden, who was helping with his experiments. A very warm friendship sprang up between these two, and when Hayden married, in the spring of 1903, and moved into a home of his own, Steinmetz missed his younger companion. So when the new house was finished, in the fall of that year, he invited Mr. and Mrs. Hayden to live with him. The arrangement was soon followed by the adoption of Hayden as his son and the beginning of many years of happy family life.

The Electrical Engineer

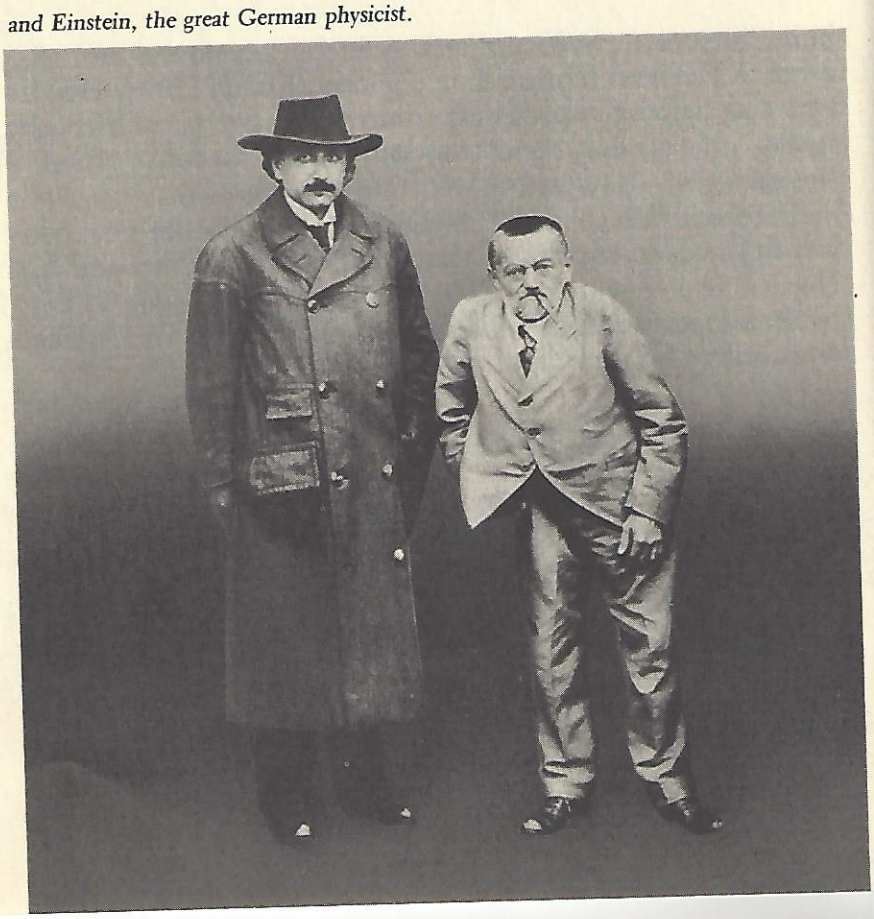
LIKE GREAT MEN in other fields, Steinmetz worked intensely on his problems. In just a few years after the publication of his article on hysteresis loss, in 1891, he soared to his full height, becoming one of the outstanding guides of the electrical engineering profession, and working out entirely new methods for solving electrical problems. The importance of this mathe-

matical work can be realized from the fact that today the principles laid down by Steinmetz are taught in all engineering schools, and are used in practically every application in the field of alternating current. Generation, transmission, and utilization of electric power are largely possible because Steinmetz showed how predictions could be made as to the operation of alternating-current devices.

Previous to this time, involved and cumbersome methods were used in solving alternating-current problems. Such procedures were complicated, inaccurate, and time-consuming. Electrical engineers were faced with an almost insurmountable wall, for while the great possibilities in the field of alternating-current applications were suspected, inventions could not be made because the engineers did not understand the behavior of alternating current.

Then, in 1893, Steinmetz presented the first of his mathematical contributions before the International Electrical Congress. It represented an entirely original approach to the

Steinmetz and Einstein, the great German physicist.



subject, and the method was not at first appreciated. So, realizing that more explanation would be necessary, Steinmetz began writing textbooks.

He very soon completed this task, and his first work was published in 1897 under the title, "Theory and Calculations of Alternating-current Phenomena." In its subsequent editions this work was expanded into three volumes, whose titles indicate the wide scope of the work: "Alternating-current Phenomena," "Electric Circuits," and "Electrical Apparatus."

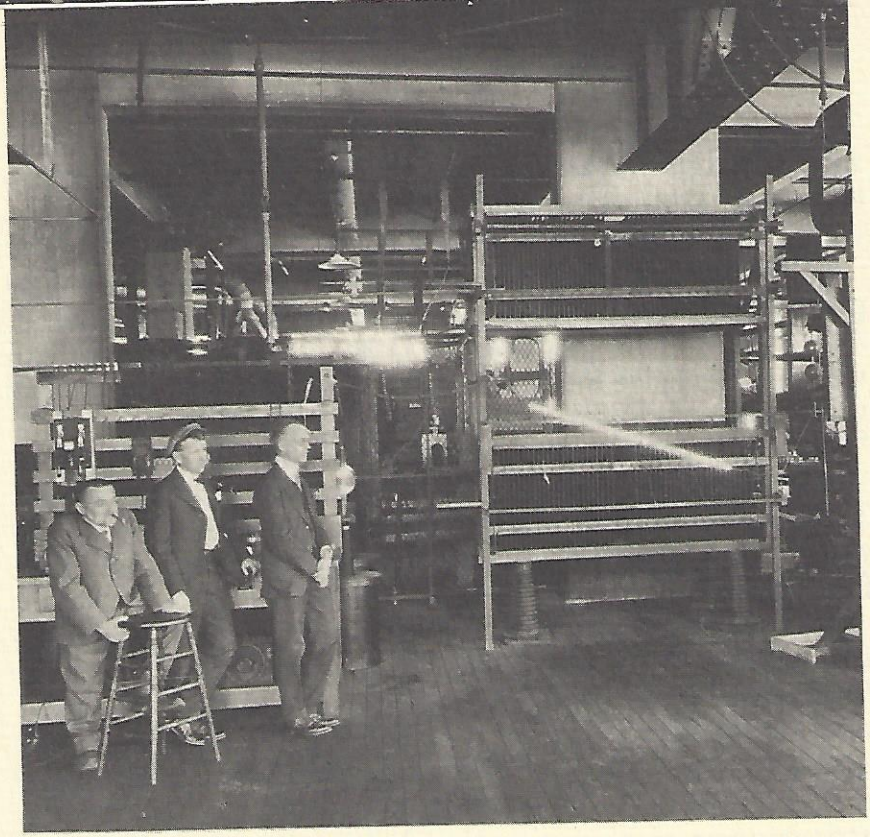
Here was a complete unveiling of what had been mystery! The methods of Steinmetz were new mathematical tools which were badly needed and his analyses served to correlate many fields of electricity.

But Steinmetz did not stop here. Because practicing engineers could not find much time to study the new method, he decided that textbooks for engineering students were necessary. He wrote two of these, entitled "Theoretical Elements of Electrical Engineering" and "Engineering Mathematics," both of which dealt with the fundamental principles essential to an understanding of electricity, thus helping to train prospective engineers for a rapidly growing industry.

Professor and Civic Leader

As a result of his work many honors came to him. In 1901, just ten years after he had presented his epochal paper on magnetism before the American Institute of Electrical Engineers, he was elected President of that society. In 1903, Union College, in Schenectady, conferred upon him the degree of Doctor of Philosophy. Because of his interest in the college, he consented to develop a course in electrical engineering there, and for the next ten years he gave many hours a week to teaching at the college. He would accept no pay for his services, however. When, in 1913, he asked to be relieved of his teaching duties, he had built up at Union an Electrical Engineering Department known and respected the country over—a department which he relinquished to his old friend, Dr. Ernst J. Berg.

Steinmetz's interest in education did not stop with Union College; he took an active interest in civic affairs and, in par-



The artificial lightning generator, developed by Steinmetz to produce lightning so that he could study it.

ticular, in the public school system. In 1911 he was appointed Chairman of the Board of Education of Schenectady, and initiated many desirable innovations. And, not disdaining local party politics, in 1915 he ran for and was elected to the office of President of the Common Council, which gave him further opportunities to serve the schools and to work for other municipal undertakings.

The Thunderer

As an inventor—that is, as an actual designer of new apparatus and mechanisms—Steinmetz is less well known than many another less-gifted engineer. However, one of his earlier developments had a very wide application. It was the magnetite arc lamp, which gave a brilliant and highly efficient light and was widely used for many years in street lighting. But it is for work in another field of activity that the nonengineering public

best knew Steinmetz and affectionately coined for him the title of "The Thunderer."

He enjoyed boating on the Mohawk River, especially in the vicinity of Viele's Creek, where he had built his camp. One summer day in 1920 a bolt of lightning struck his camp and smashed a large mirror into fragments. He had recently been studying the damage done by lightning to electric systems and he saw in this accident an excellent opportunity to investigate the behavior of lightning. So he pieced together the fragments of the mirror and studied the results of the stroke.

This was the beginning of a long laboratory study of lightning. Steinmetz developed a machine which produced artificial lightning, so that he could study its effects at will. With this machine, artificial lightning bolts were hurled across the laboratory and made to smash model villages. After each crash the damage it produced was studied. During each discharge of artificial lightning one million horsepower of electric power was released for one hundred-thousandth of a second; and because of the spectacular nature of this work, Steinmetz was hailed as "The Modern Jove" and "The Thunderer."

The practical result was that Steinmetz learned a good many things about lightning which no one had known before, and he invented apparatus which would help to protect electric systems from the effects of lightning. Thus a stray bolt striking a summer camp helped to begin the study of how to control one of the greatest enemies to the uninterrupted transmission and distribution of electric power.

The Last Months

IN THE YEAR 1923, while he was still engaged in his investigations of lightning, he began to plan a trip to the West Coast, a part of the United States which he had never seen. On September 1, he and the Hayden family left Schenectady by train. At Denver, Steinmetz gave an evening public address; at Los Angeles, he spoke again. It was a leisurely trip, with stopovers at many interesting spots. On September 23 the party reached San Francisco, where Steinmetz attended his last convention of the American Institute of Electrical Engineers.

The return trip was devoted to sightseeing, and the group arrived in Schenectady on October 12. Steinmetz had enjoyed the trip immensely, but it had seriously sapped his strength. On the advice of his doctor he went to bed to rest for a few days; two weeks later he was still in bed, trying to recover his strength. On the evening of October 25 he felt better, and dressed. Next morning at eight o'clock Hayden found Steinmetz awake and comfortable, and urged him to remain in bed until he had eaten his breakfast. But a few minutes later, when Hayden's son took up his breakfast, Steinmetz had passed away quietly.

Steinmetz and Douglas Fairbanks.

Steinmetz and Edison examine the effects of man-made lightning.

Even after nearly two decades it is impossible adequately to evaluate Steinmetz's contributions to the electrical industry and to humanity. The results of the research that he started, the fundamental principles that he discovered, the mathematical methods that he developed, all will be useful as long as electricity is a factor in our civilization.

Wherever we find electricity reducing the cost of industrial products so that more millions can afford these products, wherever we find it lessening the burden of workmen in factories and housewives in the home, wherever we find it creating new industries which in turn give rise to thousands of new jobs—there we find a part of the fruit of Steinmetz's genius. And so the story of Steinmetz is a significant portion of the story of the growth of electricity from a scientific curiosity to a powerful and beneficent factor in our daily lives.

This publication is one of a series telling of the General Electric Company's history, its research activities, and its contributions to American progress. Among others available are the following:

THINGS I'VE BEEN THINKING ABOUT

A publication which records a few unusual observations by Dr. Willis R. Whitney, first director of the G-E Research Laboratory. (GES-3222)

WHAT'S NEW IN THE WORLD OF SCIENCE, VOL. III

An illustrated booklet describing recent developments and discoveries in the field of science. (GEB-139)

THE STORY OF THE TURBINE

An illustrated booklet on the amazing machine that produces most of America's electric power and drives its ships. (GEB-129)

THEY'RE TURBOSUPERCHARGED

The story of the turbosupercharger and what it means to the men who fly America's high-altitude bombers and fighters. (GEB-132)

THE STORY OF LIGHTNING

An account of how "thunderbolt hunters" study and counterfeit lightning in order to help improve electric service. (GEB-124)

TELEVISION AT WRGB

A fully illustrated booklet telling television's accomplishments to date and what it promises for the future. (GEB-146)

THE ROMANCE OF ELECTRICITY

A 56-page story of electricity, from its origin in sunlight to the services it performs in factory and home. (GEB-131)

Copies of these publications may be obtained by writing to the General Electric Company, Publicity Divisions, Schenectady, N. Y.

7-44 (25M)
Filing No. 211