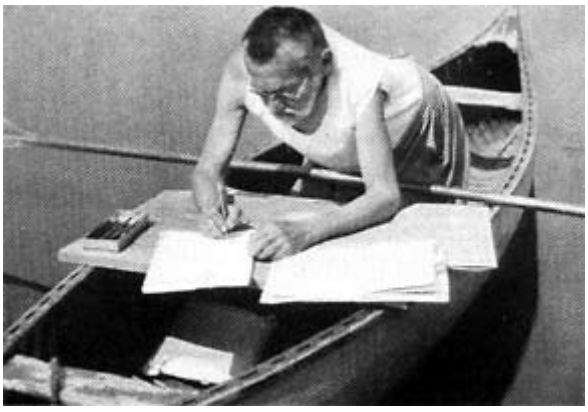
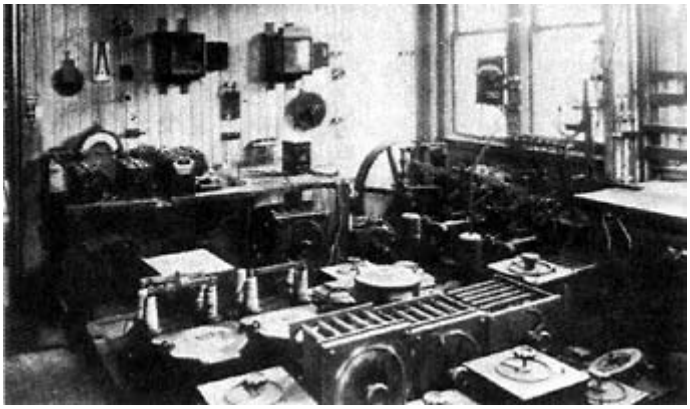
Charles Proteus Steinmetz and the Magic of Electricity
Franz Pichler





The development of electrical engineering, a century ago, can be considered as one of the most interesting chapters of the history of technology in Europe and North America. The inventors of this time, such as Edison, Tesla, Siemens, Marconi, Morse, Bell, Heaviside, Gramme, and others, are still of strong biographical interest for us .

The ideal profile of an inventor would be the union of a rational thinking scientist with an artist, who brings the subject to the right human dimensions and relations. Leonardo da Vinci and Albrecht Duerer might be mentioned here to represent the ideal combination of a scientist with an artist.

This essay should bring the scientific work and the artistic life of a man to our rememberings, a man which is known in Europe only in special scientific circles: Charles Proteus Steinmetz, as he called himself with his americanized first name. Just as the famous Austrian-American inventor Nikola Tesla, Steinmetz also received his fundamental scientific education in old Europe. However, the American continent gave him the chance to apply his talents in full breadth, not forcing him to a certain personal lifestyle. In contrary, he could fully keep his most interesting individuality.

Alternating current against direct current

Similar to the second half of this century being dominated by the computer as the "realization engine for Information Technology", electrical machines (in a very general sense) caused great excitement in the second half of the last century. An important step for the practical application of electricity was the invention of the "dynamo-electric principle" by Werner Siemens (1866) — and independently by the British scientist Wheatstone — which made possible the generation of electrical power by dynamos without the use of permanent magnets. Dynamos of this kind replaced voltaic batteries to power galvanisation processes and carbon lights. They were built as D.C. machines.

As soon as the invention of the multiphase generator by Tesla (1888) and the invention of the high power transformer (Zipernowsky 1885, Stanley 1886), the generation of electrical power and its transportation across long distances became simpler and more efficient. The installation of a high voltage power line in Germany from Lauffen to Frankfurt (1891) by Oscar von Miller and the construction of the Niagara powerplant (1895) by the Westinghouse Company — with Tesla as the designer for the A.C. generators — established milestones in the practical use of alternating current. In North America, however, the replacement of D.C. technology by A.C. technology was not a simple task. The competing firms, the Edison General Electric Company (in support of D.C. technology) and the Westinghouse Company (which favoured A.C. technology), got into a long fight. It has been reported, that the Edison Company even supported the installation of the electrical chair (New York 1889) to demonstrate the danger of the alternating current.

The electrical exhibition in Frankfurt (1891) and the electrical exhibition at the world fair in Chicago (1893) brought a decision in favour of A.C. technology. In North America, this result was mainly achieved by the pioneering works of Nikola Tesla and Charles Proteus Steinmetz. In his important lecture on the "Application of Complex Numbers in Electrical Engineering" (which was published in German in the "Elektrotechnische Zeitschrift" at the same time [Stein 93]) Steinmetz was able to show that for alternating current phenomena the laws of Ohm and Kirchoff were valid just in the form as for direct current phenomena. By the "symbolic method" of Steinmetz it was possible to represent alternating currents by simple algebraic expressions. The computation of alternating current phenomena became just as easy as for direct current phenomena.

Steinmetz the scientist

Of what kind were the important scientific contributions of Charles P. Steinmetz? How did it happen?

Charles Proteus Steinmetz was born on April 9, 1865 in Breslau as Karl Rudolf Steinmetz. He was physically handicapped from childhood on, seemingly having too big a head for his short body and legs. He attended with great success the grammar school and the University of

Breslau. There he studied mathematics and astronomy, showing also great interest in physics, philosophy, and the newly up-coming subject of electrical engineering.

His doctoral thesis in pure mathematics titled "Über unwillkürliche selbstreziproke Korrespondenzen im Raum, die bestimmt werden durch ein dreidimensionales Linearsystem von Flächen der n'ten Ordnung" had already been approved by the professors when things changed dramatically! Steinmetz was a member of a group of students which were in favour of socialism, which was not approved by the Prussian government and he also was a co-editor of the newspaper of the socialistic party, the "Volksstimme". From an anonymous friend he learned that his imprisonment was planned by the police. To escape, he fled via Vienna to Zurich in Switzerland. His goal was to live there as a political emigrant and to finish his studies at the "Eidgenössische Technische Hochschule". However things changed again. His Danish friend Oscar Asmussen persuaded him to join him in emigrating to the United States of America. Regardless of his poor knowledge of the English language, with no essential financial means but with a letter of recommendation by Mr F. Uppenborn, the publisher of the internationally recognized scientific journal, the "Elektrotechnische Zeitschrift", he got on board the steamship "La Champagne" in Le Havre to leave for New York. With the help of the recommendation letter, he immediately found employment at the company Eickemeyer and Osterheld in Yonkers, which manufactured electrical machinery.

As he worked in the drawing office, however, his boss very soon discovered his mathematical talent, and more and more he was consulted when difficult problems came up. One of the problems in electrical machinery of that time was the heating up of the electromagnets. Steinmetz took a strict scientific approach to that problem and he developed the theory of magnetic hysteresis, a theory which has kept its validity until today. In his lecture on January 19, 1892 at the meeting of the American Institute of Electrical Engineers (AIEE) in New York City he reported on his important findings. A rather voluminous paper on the subject of hysteresis in the "Elektrotechnische Zeitschrift" has preserved this result until today [Stein 92].

The General Electric Company, which was established in 1892 by the union of several companies of the Edison group, also bought the company of Eickemeyer and Osterheld, and Steinmetz was now an employee of General Electric. He moved to Schenectady, the headquarter of GE, a lovely town on the river Hudson in upstate New York. The General Electric Company supported Steinmetz in his research in the best way, giving him a great deal of independence at the same time. In his own laboratory near his home at Wendell Avenue he could perform any kind of electrical research he wanted. Of special interest to him was artificial lightning to explore the properties of materials when struck by lightning and to analyze lightning arresters. In 1902 he got an appointment as a professor for Electrical Engineering at the Union College and he served there as the chairman of the department until the year 1913. In 1903 Union College awarded him the degree of doctor of philosophy (PhD). The numerous textbooks which he published as result of his lecturing helped a generation of students in electrical engineering in their studies of the fundamental scientific models of electrical systems [Stein 97], [Stein 09], [Stein 14], [Stein 17a], [Stein 17b]. Besides writing books, Steinmetz was ambitious in lecturing at different meetings and in publishing special papers on his research.

Steinmetz In his private life

To have a full picture of Charles Proteus Steinmetz we have to look also into his life from a less scientific point of view. To start with that, let us quote Anton Zischka [Zisch 58]. Zischka

writes: "He was a close friend to Marconi and Edison. To communicate with Edison in his later years he would use the morse-code, knocking it onto Edison's knee. The American press called Steinmetz because of his artificial lightning experiments the "modern Jupiter". Although he was one of the great scientists he lived his entire life as a boy: he ordered an exotic green house for his home and since he himself was a cripple he collected the ugliest animals such as lizards, exotic fishes, and birds. The mirrors in his house were lighted by mercury-arc lamps so that the visitors could see themselves with swollen purple lips and looking like having been drowned in water.

The doors of his house were usually electrified and occasionally he organized "lightning days" destroying in his high-voltage laboratory little houses made of cardboard. He loved to paddle in his canoe, he went regularly to crime-movies (especially he loved to see the actor Douglas Fairbanks) and he read numerous adventure stories. During the night he would develop new mathematical formulas and perform computations which brought General Electric millions of dollars."

Although we must admit that Zischka reports with some fantasy here, he sketches the situation correctly. Steinmetz lived, as we have pointed out earlier, a boy's life. He loved his "camp Mohawk" on Viele's creek and he loved to work on difficult mathematical problems drifting in his canoe. He hated formalities in dressing and he would welcome even eminent visitors at "camp Mohawk" in his red bathing suit and wearing a T-shirt. Since he stayed a bachelor for all his life, to have a family he adopted Mr and Mrs Hayden, and finally he had also three grandchildren. He never gave up being fond of socialism and he engaged himself in different social projects of the city of Schenectady. His passing away on October 16, 1923 after a heart attack was unexpected for everyone.

The major American newspapers would bring reports on him. Herbert Hoover, later president of the United States of America on this occasion gave the following tribute:

"His mathematical reasoning broke the path for many of the advances in electrical engineering in recent years and solved problems that were vital to the progress of the industry. In his writings he has left engineers a heritage of mathematics that will endure, and as a man he has set us all an example of physical courage and of devotion to our life work."

Charles Proteus Steinmetz was certainly one of the important scientists and engineers who, by their research and inventive contributions, helped to design electrical systems and to analyze electrical phenomena by sound scientific methods. Similar to Nikola Tesla, Steinmetz received his scientific education at a European university. Contrary to Tesla, who had to fight all his life long to get support for his research and inventions, Steinmetz was lucky to get permanent and generous support for his research by the General Electric Company. Through his teaching engagement at Union College and through his many text books he shared his knowledge with the younger generation of electrical engineers. Besides his professional scientific interests which we might associate with his first name "Charles" ("Charles the Great") he had many private and rather artistic interests. They fit more to his middle name "Proteus", the name of the multi-faced gnome of Homer's Odyssey, which was his nick-name from students time on. Here we find Steinmetz, although physically handicapped, as the ever-lasting young boy, always ready for a joke, reading adventure stories, going to crime movies, but seriously engaged in public social affairs — in one word — living a full life.

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