Emil Stöhrer and the development of electrical motor technology in the 1840s

Dr. Frank Dittmann, Dr. Johannes-Geert Hagmann

Deutsches Museum, Museumsinsel 1, 80538 Munich, Germany

***Abstract* — After the discovery of the basic laws of electrophysics, many scientists, inventors, and mechanics ventured their work in this new field of physics. Among them was a Leipzig based mechanic Emil Stöhrer who is widely unknown today. However, in particular through a series of articles in prominent scientific journals, his work became known in the scientific community during his lifetime. This paper gives an introduction to his life and work in electrophysics.**

***Index Terms* — Emil Stöhrer, biography, electrophysics, electromotor, electromagnetic machines**.

I. Stöhrer's First Publication on Electromagnetic Machines

In spring 1841 a short article on electromagnetic machines was published in the Polytechnisches Centralblatt, a scientific journal edited in Leipzig. The author was the mechanic Emil Stöhrer (1813-1890). In the introduction to his article, Stöhrer started by emphasizing the novelty of the subject: "Everybody seems to consider the construction of electromagnetic machines as a secret or mystery… However, since by laboriously experiments Mr. Jacobi and Mr. Lenz in St. Petersburg [1] could discover the rules on how the power of electromagnets increases, everybody who has skills in mechanics and knowledge in galvanism and electromagnetism is able to construct electromagnetic machines with good effects" [2, p. 225].[1] Stöhrer referred to Jacobi's boat driven by electricity on the river Newa in St. Petersburg and cited an electric rapid printing press in Philadelphia. In his article Stöhrer highlighted that he had himself started research on the subject only one year prior to his publication, and that he was planning to construct a larger machine. The stimulus for pursuing this aim was the idea of Moritz Hermann von Jacobi (1801-1874) and Heinrich Friedrich Emil Lenz (1804-1865), according to which the efficiency increases in quadratic manner with the numbers of battery cells. Viewed from this perspective large and powerful machines seem to be much more efficient than smaller ones—even more so as the material delivered by the battery cells, in particular copper and zinc, could be sold to recover the investment partially.

In November 1841, Stöhrer's second report appeared in the Polytechnisches Centralblatt [2]. However, things obviously had not progressed as well as he had hoped, as reflected through his criticism public newspapers which drove up the expectations on the outcomes of research electromagnetism: "There is a hope to see miraculous things while it is still in infancy. It is believed that this power generation could be developed only in a few years to the highest level, although centuries passed before e. g. the steam engine reached its present degree of perfection" [2, pp. 1023-1024].[2] Stöhrer reported in his paper that he had constructed a larger electric motor which even could drive a lathe. This success encouraged him to construct "a really technically useful electromagnetic machine" [2, p. 1027]. Indeed, already in December 1841 Stöhrer's third paper was published [2]. Considering the succession of his articles and the results he reported one can assume that Stöhrer worked hard on his ideas. His third paper discussed the problem of commutator sparking on the machine, and the question which battery is the most practical one—Stöhrer primarily used carbon zinc elements. He then outlined the construction of his motor. It seems that the Leipzig mechanic indeed had constructed an electrical motor and tested its use. There is a report claiming that Stöhrer drove with an electric car to Connewitz, a suburb of Leipzig but precise information and supporting evidence for the event are missing [3].

II. The Life of Emil Stöhrer

Emil Stöhrer was born on September 25, 1813 in the small town Delitzsch near Leipzig as the only son of a physician [3], [4], [5]. He received his education at the well-know school in Pforta and accomplished an apprenticeship at the workshop of Johann Gottlieb Wießner in Leipzig. After completing his training Stöhrer went on travelling, which eventually also lead him to Paris. After his return to Leipzig Stöhrer married and started to work in the workshop of his father-in-law which produced special instruments for electrotherapy and teaching equipment for demonstrations in physics lessons. After the

[1] "Von allen Seiten her scheint die Construction elektromagnetischer Maschinen als ein Geheimnis betrachtet zu werden… Seitdem aber durch die mühevollen Versuche der Herren Jacobi und Lenz in Petersburg die Gesetze, nach welchen die Kraft der Elektromagnete wächst, zu grossem Vortheil für die elektromagnetischen Maschinen bestimmt und öffentlich bekannt gemacht worden sind (…) ist Jeder, der in der Maschinenkunde Kenntnisse besitzt und die Theorie des Galvanismus und Elektromagnetismus inne hat, im Stande, elektromagnetische Maschinen von guter Wirkung zu construiren."

[2] "Man hofft von dieser Sache schon Wunderdinge zu sehen, während sie noch in der ersten Kindheit liegt; man glaubt, dass sich diese Krafterzeugung in ein paar Jahren bis zu den höchsten Potenzen ausbilden lasse, während es Jahrhunderte dauerte, ehe z. B. die Dampfmaschinen ihren heutigen Grad an Vollkommenheit erreichten."

father-in-law's death Stöhrer became owner of the small company. In 1859, honoring the high quality of his products, he received a honorary doctor's degree from the University of Jena. Stöhrer conveyed the workshop in 1863 to his son Emil Stöhrer jr. which was born in 1840. One year before, 1862, Stöhrer sen. had founded a small company in Dresden producing electrotherapy equipment and soon he moved to the capital of Saxony. About 15 years later, 1880, Stöhrer sen. was at the age of 67, he conveyed his Dresden company his son, too. However, owing to the early death of his son two years later [6] the old man had to return as head of both companies. Emil Stöhrer died on August, 15, 1890 at the age of 77 years in Leipzig.

Figure 1. Emil Stöhrer as young man.
Credit: Stadtgeschichtliches Museum Leipzig, C. Kaufmann.

III. THE DEVELOPMENT OF EARLY ELECTRICAL MACHINES

At the beginning of the 19th century, the principle of the nowadays well known rotating electromotor was not an obvious idea. Most of the electromagnetic machines, following the terminology for electromotors at the time, used the linear motion of an iron bar which was pulled into a coil if current flowed through it.

Yet as early as 1821 Michael Faraday (1791-1867) constructed a test setup showing a rotating magnet around a wire or a wire rotating around a magnet (Fig. 2). His idea was to demonstrate that the magnetic field forms circles around the wire. Additionally Faraday demonstrated that the driving force declined with increasing distance. This arrangement can be considered as first electromotor. In 1822 Peter Barlow (1776-1862) demonstrated that a cupper disk with jagged brim rotates between the poles of a horseshoe magnet. One year later William Sturgeons (1783-1850) invented an electromagnet which multiplies the magnetic force of a current through a wire. In the following years more and more inventers paid attention to the study of electromagnetic machines. It was probably the Hungarian physician Anyos Jedlik (1800-1885) the first inventor who constructed a rotating apparatus with electromagnets around 1830 [7].

A prominent role among this group of inventors was assumed by Moritz Hermann von Jacobi, a German serving the Russian tsar in St. Petersburg. In 1834 Jacobi presented his first electrical motor of a rotating type consisting of eight iron horseshoes with one coil on each. Four coils were mounted on a movable disc and four others on a solid disc in such a way that the ends of the horseshoes passes very closely near them. In addition Jacobi installed a commutator in order to achieve a continuous rotation. The weight of the motor was 25 kg, it produced about 0.02 h.p. [8, pp. 2-19]. Jacobi added improvements to the machine and presented a larger and more powerful version in 1838 (Fig. 3). This motor of about a 1 h.p. was brought to work as power unit in an electrically driven boat. 64 platinum zinc elements provided the required electrical energy. Using this machine Jacobi demonstrated that electromotors in principal were able to produce power for real-life applications and, secondly, that the use of rotating machines was the best technical solution. Moreover, he highlighted the inefficiency of producing mechanic energy from electricity provided by galvanic cells.

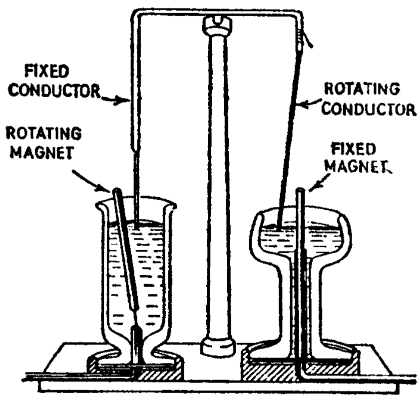

Figure 2. Faraday's apparatus demonstrating that the magnetic field forms circles around a wire.

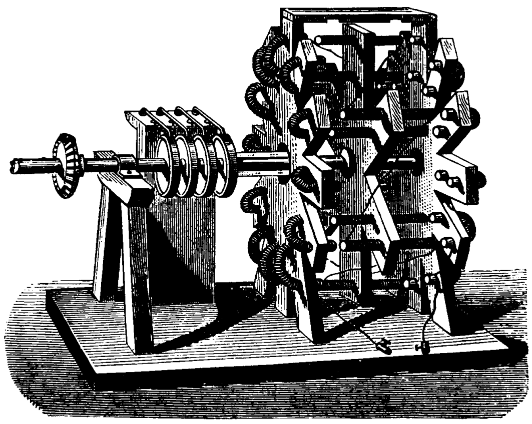

Figure 3. Jacobi's improved electromotor of 1838

Despite the negative judgment of the professor in St. Petersburg, other inventors—in Germany often called "electromagnetic heroes"—tried to develop practical electromagnetic drives. The most important among them was Johann Philipp Wagner (1799-1879). He worked—similar to the experiments of the American inventor Thomas Davenport (1802-1851) 1835 in New York and the Scotchman Robert Davidson (1804-1894), who presented after 1842 his electric locomotive "Galvani"—on an electric driven car. Wagner's research was supported through different channels, among others from the German Federal Assembly (Deutsche Bundesversammlung). Politicians hoped that Germany, using national zinc and copper ore reserves and producing electricity from galvanic elements, could break Britain's economical dominance which was grounded on the energy reserves in English coal. Additionally there was a strong hope to find an easy-to-handle energy source for small handcraft companies as alternative to elaborate and expensive steam engines. In this situation electricity seemed to be the appropriate solution since electric power was considered to be easy and safe, and the operation of the machines did not require highly skilled workers in contrast to steam engines. Furthermore people did not see any risks of explosions or unhealthy gases. In summary, the advantages of electric motors would be the large flexibility, less space requirement, the easy opportunity of speed control and robustness in cases of load changes and inversion of direction. However, soon particularly the idea of pretended low cost reached by selling the remaining material of galvanic cells proved false. 1844 Wagner had to concede that his experiments went wrong. The cost of electromagnetic power was at best five times expensive than power of a horse and twice than manpower [9, p. 106].

In result all this problems let the hope of electromotor as "savior of handcraft" disappear and it seemed to be unbelievable that the electromotor could become a useful drive in any time. In this sense even 1873 Julius Dub wrote in his known book on applications of electromagnetism, that "magnetism and electricity have less chance, to become a moving force in industry." [10, p. 857] Seven years after discovering and using the dynamo electric principle by Werner Siemens (1816-1892) Dub hoped to find a new source of electrical power.

Those technical and economical problems led to the situation, that the electromotor, whose prototype already had been presented by Michael Faraday in 1834 and which in the 1830s and 1840s was urgently requested as alternative energy source for small handcraft companies, could not be developed to a practically useful drive. Whereas the electric generators, whose physical foundation with the Faraday's induction law had not been discovered until 1831, already since the 1840 had been used for illumination and galvanic purposes. This implies that the first wave of development of early electromagnetic machines (electromotor) did not succeed and that the modern electromotor had its roots in the dynamoelectric machines, developed since the 1860s.

IV. Stöhrer's Contributions to Early Electrotechnology

Emil Stöhrer was obviously not a central figure in the development of early electrotechnology. Still, his machines received quite some attention in the community of scientist and inventors at his time. Being a mechanic living in Leipzig, the city of fairs, he was not really an inventor. His main interest was focused on the *improvement* of machines and apparatuses. With his machine dating from 1844, he improved the efficiency of the motor by increasing the number of electromagnetic poles and hence followed an idea that was also used with the later Alliance machine. It should be stressed that Stöhrer's also performed experiments on short-cutting the field coil through which he demonstrated the principle of an eddy current brake [11]. This work shows that Stöhrer dealt with power efficiency even though the law of conservation of energy had been discovered only a few years ago, and was not at all part of the common knowledge of the average physicist of that time.

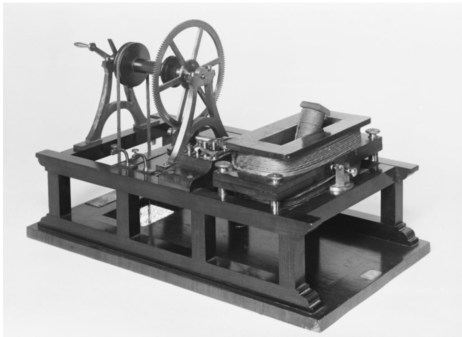

Figure 4. Two Stöhrer's machines in the collection of the Deutsches Museum. See: [11], [13]

In a similar manner, we have to consider Stöhrer's efforts to improve galvanic cells. These elements were the main source of electricity until the beginning of the 1870s. Stöhrer developed an element which could be easily operated and adapted. In order to protect the electrodes it was usually necessary to observe acid level every time and to activate the device in order to remove gas pearls from the electrodes. All these activities could lead to poisonous gases, burned skin and other dangers and accidents. Stöhrer mostly employed carbon zinc elements. His batteries for medical purposes were equipped with a mechanism for rising and lowering the electrodes. For telegraphy lines, he built long life elements (about 2 years life span) which could be tilted without losing acid [12].

Stöhrer received several requests from professors at the Leipzig University. He wrote in one of his papers: "With the first ... of my constructed and built machines ... Professor Wilhelm Weber of the local physical Cabinet ... had been made some current measurements..." [13, p. 429][3] Stöhrer was probably involved in constructing a needle telegraph in cooperation with Wilhelm Weber (1804-1891). In one of his articles, he described a needle telegraph fed by a mechanically driven inductor such that no batteries were necessary. In 1847 this device was used on the line of the Saxonian Bavarian railway company [12]. Weber taught for a few years in Leipzig. In 1831, the famous physicist became a professor of physics at the University of Göttingen, and soon a friend of Carl Friedrich Gauß. Both constructed the first electromagnetic telegraph in 1833 that connected the observatory with the institute for physics. However, in December 1837, the Hanoverian government dismissed Weber, one of the Göttingen Seven group, for political reasons from his position at the University. Weber then travelled, visiting England among other countries, and became professor of physics in Leipzig from 1843 to 1849 until being reinstated at Göttingen. For this reason, Stöhrer was able to work together with this famous physical scientist in Leipzig.

In summary one can conclude that Emil Stöhrer was a versatile instrument maker in Leipzig with tremendous practical experience. He was well known in his time for manufacturing batteries, telegraphs, electric motors, generators and other scientific equipment. In particular he was interested in improving machines and apparatuses. Additionally, the mechanic Emil Stöhrer learned how to move in the scientific community of his time. This fact is revealed through his scientific papers published e.g. in the prominent Annalen der Physik und Chemie journal. Obviously, these papers helped in spreading his ideas. One can say that Stöhrer's work oscillated between the world of a mechanic and instrument maker on one hand and the world of scientific research on the other.

[3] "Mit der ersten … von mir construirten und ausgeführten Maschine … sind durch Herrn Professor Wilhelm Weber auf dem hiesigen physikalischen Cabinet einige… Strommessungen vorgenommen worden…"

References

[1] E. Lenz and M. Jacobi, "Über die Gesetze der Elektromagnete," *Annalen der Physik und Chemie* vol. 47, no. 6, pp. 225-270, 1839.

[2] E. Stöhrer, "Ueber elektromagnetische Maschinen," *Polytechnisches Central-Blatt* vol. 7, pp. 225-228, 1023-1031, S. 1151-1162, 1841.

[3] Allgemeine Deutsche Biographie (ADB) Vol. 36, pp. 322-323. 1893.

[4] H.-O. Klas, " Der Leipziger Mechaniker Emil Stöhrer, ein früher Anwender von Erkenntnissen der Elektrophysik im 19. Jahrhundert," *Wissenschaftliche Berichte der TH Leipzig* no. 3, pp. 19-29, 1988.

[5] L. Hiersemann (ed.): *Leipziger Techniker-Porträts,* Leipzig: Hochschule für Technik, Wirtschaft und Kultur, 2007, pp. 228-237.

[6] "Emil Stöhrer [jr.] gest." *Allgemeines Journal der Uhrmacherkunst,* vol. 8, no. 3, pp. 21-22, 1883.

[7] Wagemann, "Anyos Jedlik," *Beiträge zur Geschichte der Technik und Industrie* vol. 21, pp. 158-160, 1931/32).

[8] H. Lindner, "Elektromagnetismus als Triebkraft im zweiten Drittel des 19. Jahrhunderts dargestellt am Beispiel der Arbeiten von Moritz Hermann Jacobi (1801-1874) und Johann Philipp Wagner (1799-1879)," Phil. Diss. TU Berlin, 1986.

[9] H. Lindner, "Strom. Erzeugung, Verteilung und Anwendung der Elektrizität," Reinbek: Rowohlt, 1985

[10] J. Dub, "Die Anwendung des Elektromagnetismus mit besonderer Berücksichtigung der neueren Telegraphie und den in der Deutschen Telegraphenverwaltung bestehenden technischen Einrichtungen," 2nd ed. Berlin: Springer, 1873.

[11] E. Stöhrer, "Einige Versuche, diejenige Kraft, welche die elektrische Spirale auf einem in derselben befindlichen Elektromagneten ausübt, zu rotirender Bewegung anzuwenden," *Annalen der Physik u. Chemie* vol. 69, pp. 81-93, 1846.

[12] E. Stöhrer, "Ueber die Anwendung der magneto-elektrischen Maschinen und constanten Säulen zur Elektrotelegraphie," *Annalen der Physik u. Chemie* vol. 77, pp. 485-493, 1849.

[13] E. Stöhrer, "Einige Bemerkungen über die Construktion der magneto-elektrischen Maschinen, und Beschreibung der zusammengesetzten magneto-elektrischen Maschine," *Annalen der Physik u. Chemie* vol. 61, pp. 417-430, 1844.