

THE BIRTH OF ELECTROMAGNETIC ENGINEERING

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EE 155

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September 16, 1998

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THE BIRTH OF ELECTROMAGNETIC ENGINEERING

By the 18th century scientists knew that there was some sort of relationship between electricity and magnetism. They knew that lightning could cause a compass to be weakened or to indicate in the reverse direction. Steel, when struck by lightning, could become magnetized, and electrostatically-charged objects possessed magnetic qualities. But the laws governing the relationship between electricity and magnetism were unknown. [1, p 53] Once these laws were revealed, electromagnetic engineers would quickly develop the technology that would change the way people lived.

OERSTED'S DISCOVERY OF ELECTROMAGNETISM

In the early 19th century, experimenters were able to produce static electricity and store it in Leyden jars and could produce continuous current using batteries. Current flow could only be crudely evidenced by such methods as observing a spark, experiencing a shock, observing the separation of water into its gaseous components, and measuring the temperature rise in a current-carrying conductor. In April of 1820 [4], Hans Christian Oersted, a Danish physicist and chemist, was conducting an electrical experiment for his students. Ironically, he was demonstrating that there was no correlation between electricity and magnetism. When he closed the switch, he was astonished to observe the movement of a compass needle. This needle this time had been oriented parallel to the conductor rather than perpendicular. Oersted used the words "conflict of electricity" to describe the effect. The study of electromagnetism was born. The announcement in 1820 caused much excitement in the scientific community and a flurry of experimental activity began in the new field of electromagnetic engineering. [1, pp 54-55]

One of these experimenters was André Marie Ampère, a French physicist. Upon hearing of Oersted's discovery, Ampère immediately went to work and within a week produced the first of many papers on the subject. He explored and documented many of the characteristics of electromagnetism relating to current direction, the direction of the associated magnetic force, and the repulsive and attractive forces in pairs of current-carrying conductors. He worked out some

of the mathematical formulas of electromagnetism and predicted that a current-carrying coil would behave as a magnet. Johann Schweigger, a German chemist, discovered that the effect was multiplied when additional turns were added to the coil. Thus the galvanometer was developed in the year 1821, giving scientists an instrument for observing and measuring the flow of electricity. [1, pp. 58, 61]

THE DYNAMO

William Sturgeon, an English electrical engineer, demonstrated the first electromagnet in 1825. It consisted of 16 turns of copper wire on a foot-long, horseshoe-shaped iron bar. When connected to a single-cell battery, it could hold a weight of 9 pounds. In 1831, electromagnetic induction was discovered by Michael Faraday, an English chemist, when he moved a bar magnet into a coil which was connected to a galvanometer. That same year, he used this knowledge to build the first constant current generator using a rotating copper disk [1, pp. 61, 97; 2, p. 1033].

From this point it would take almost three decades before the first practical application of the dynamo. While engineers worked to refine the dynamo there was really only one practical use of electrical power—carbon-arc lighting. The carbon-arc light had been invented by Humphry Davy, an English chemist, in 1808. Davy used constant current provided by a battery, a power source which was not practical for commercial use of his invention. In 1858, the dynamo was first put to use to power a carbon-arc light in a lighthouse. The system was more expensive to operate than the oil-fired lamp it replaced, but produced more light. Improvements in efficiency were made, and more lighthouses were converted to electric lamps [1, pp. 24-33, 105, 123].

THE TELEGRAPH

The telegraph predates the discovery of electromagnetism. Models had been demonstrated using static electricity or electrochemical technology. However, the public was slow to see the need for a telegraph and it was not until 1833 that we saw the first limited use of the invention. The public's interest was finally captured by a dramatic event in 1842. A murder suspect had been

seen boarding a train for London. Because of the railroad company's telegraph, it was possible to send a message ahead alerting authorities and giving a description of the suspect. The man was arrested, tried, and executed for the murder. [1, pp. 75-78]

THE ELECTROMECHANICAL RELAY

Improvements to the telegraph were made by Samuel Morse, an American artist turned inventor, which included the Morse code and the electromechanical relay. The purpose of the relay was to operate a printer to record the dots and dashes of the coded signal. Morse felt that the printed output was important but operators soon learned to "read" the code by listening to the sounds the printer made. There was little use for the printed record of dots and dashes, so printers were abandoned in favor of "sounders". The electromechanical relay was also employed to relay the telegraph signal over long distances, overcoming the problem of voltage drop in the lines. The relay, in other applications, continues to be in wide use today. Morse's first commercial telegraph line went into operation in 1845. In 1861, a line was completed from New York to San Francisco, providing instant communication across a distance which took weeks to travel. Only 5 years later, the first successful transatlantic telegraph went into use [1, p. 80; 3].

THE ELECTRIC MOTOR

The first electric motor was invented by dal Negro in 1830. The fact that a dynamo would function equally well as an electric motor escaped notice until 1838. Still, the idea did not attract much attention until it was demonstrated at the Vienna Electrical Exposition in 1873. The demonstration showed that electricity could do heavy work and engineers began to explore the possibilities. The first commercially successful DC motor was built by Zénobe Théophile Gramme, a Belgian electrical engineer, in the same year [1, pp. 178, 180; 6, pp. 64, rear cover].

In 1888, the AC motor was invented by Nikola Tesla, who also developed the concept of multi-phase power that we use in power distribution today [6, p. 137]. Early uses of the motor included the street car, which replaced the horse-drawn carriage.

INGREDIENTS OF DISCOVERY

In order to advance the field of electromagnetic engineering, there needed to be a way to safely produce electricity and a practical reason for doing so. Static electricity could be produced by rubbing various materials together but was of little use. In 1745, the discovery of the leyden jar permitted static charges to be accumulated over time and released suddenly. Constant (and more easily studied) electrical flow was not available until the invention of the battery in 1800 [1, pp. 27, 31]. With the discovery of the carbon-arc lamp in 1808, we had a purpose for electricity.

Rapid development took place after Oersted's discovery of electromagnetism in 1820; see Figure 1 below. However, refinements in generator technology drug on for 27 years before the first practical installation—a lighthouse using a generator-powered, carbon-arc light. The invention of the incandescent bulb soon made the illumination of homes practical. The power demand that followed led to the birth of the power generation and distribution industry. This, in turn, fueled the imagination of electrical engineers, who continue to develop more uses of electrical power.

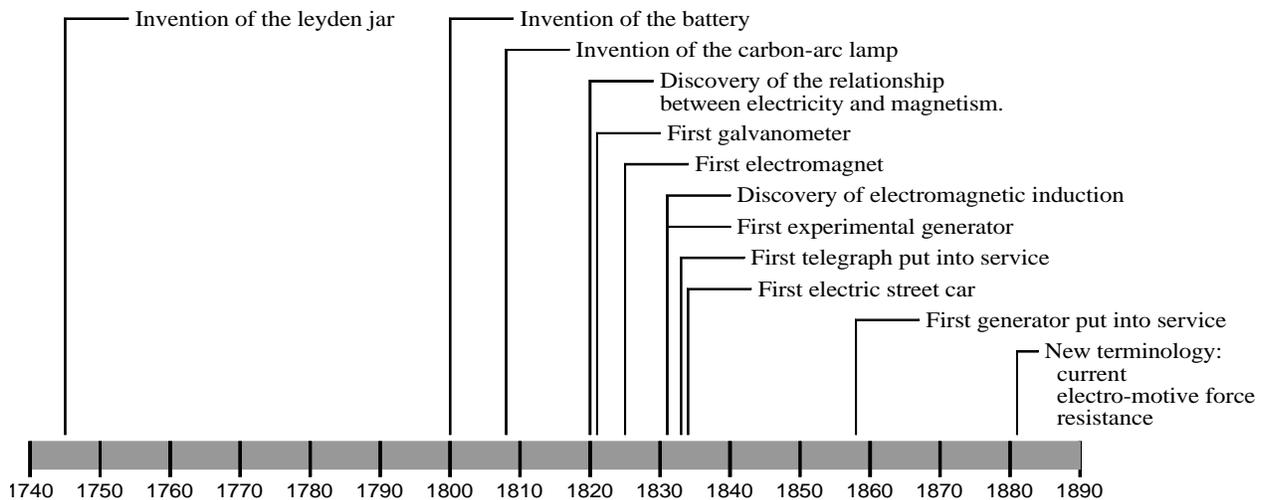


Figure 1. Timeline of Electromagnetic Discovery

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- [5] "Electric Motor," *The World Book Encyclopedia*, 1987 ed.
- [6] Edward Tatnall Canby, *A History of Electricity*, New York: Hawthorn Books, Inc., 1963.

NOTES

Hans Christian Oersted (1777-1851), a Danish physicist and chemist

André Marie Ampère (1775-1836), a French physicist

William Sturgeon (1783-1850), an English electrical engineer

Michael Faraday (1791-1867), an English chemist

Humphry Davy (1778-1829), an English chemist

Alessandro Volta (1745-1827), Italian physicist

Samuel Morse (1791-1872), an American artist

Johann Schweigger (1779-1857), a German chemist

galvanometer