Milestones in Physics

Electricity Began with Magnets

By Ruth A. Sparrow

With "Milestones in Physics," Hobbies presents the fifth in the series which Ruth A. Sparrow, Librarian, has written on the Museum's rare book collection of "Milestones of Science." While electricity covers only one of the important fields included in physics, it is a field of special interest because of its deep significance in our daily living.—Editor's Note.

● ● ● Electricity perhaps has given the world more comfort and pleasure and has exerted indirectly the greatest influence in modern times, surpassing anything that has been invented or discovered. The practical application of electricity has been of fairly recent date and that of its offspring, radio, even a later development. Yet its roots go deep into the past.

It seems that electricity began with the lodestone or magnet. Pliny reports the magnet in *Historia Naturalis* (Venice, 1476). Pliny was born in 23 A.D. and in his encyclopaedic work reports from the works of the great writers of the past. The magnet, according to Pliny, received its name from Magnes who discovered it upon Ida. Magnes found when taking his herds to pasture that the nails of his shoes and the iron ferrel of his staff adhered to the ground. Pliny marvels at this rock: "What is there in existence more inert than a piece of rigid stone? And yet, behold! Nature has here endowed stone with both sense and hands. What is there more stubborn than hard iron? Nature has, in this instance, bestowed upon it both feet and intelligence."

From the earliest times it has been common knowledge that if a lodestone is hung up and allowed to swing freely it always turns towards the earth. Artificial magnets are made by rubbing a piece of steel with a piece of lodestone. There are two forms of electricity, static and current. The former, which involved these various experiments, was the only form known up until the end of the eighteenth century. The word electricity comes from the Greek word "elektron," meaning amber, and is derived from the early Greeks who demonstrated static electricity by rubbing amber with fur.

However, with all the interest manifested in this subject, it was not until 1600 that we find any real experimentation. In that year William Gilbert (1540-1603), physician to Queen Elizabeth, announced the results of his experiments on magnets, magnetic bodies, and electrical attractions. In this work he also announced his conception that the earth is nothing but a large magnet, and he goes on to explain that this is the reason for the direction of the magnetic needle, north and south, as well as the dipping of the needle. He showed that there are other substances, in addition to amber, that are capable of being electrically excited and attracting other objects. Among them are gems, resin, fossils, jets, and glass. Gilbert was probably the first in the field of electricity and magnetism to point out the necessity of experiment in preference to speculation. His *De Magnete* (London, 1600) was the first truly important scientific book to be published in England. It is one of the great contributions in applied physics and has long been considered a classic.

Otto von Guericke (1602-1696), a German natural philosopher, was the next to take up investigations in this new field of science. He invented the first electrical machine in which he showed the existence of electrical repulsions as well as electrical attractions. Von Guericke is best known for his researches on the pressure of the atmosphere and the creation of a vacuum. He took two hemispherical cups of copper and carefully fitted them together to form a spherical vessel; exhausting the air from the vessel he demonstrated that sixteen horses pulling in opposite directions could not separate it. This first edition of *Experimenta Nova (ut Vovantur) Madgeburgica de Vacuo Spatio* (Amsterdam, 1672) is one of the most famous books in the history of physics and ranks next to Gilbert's in the number and importance of the electrical discoveries described.

In 1786 Luigi Galvani (1737-1798), an Italian physician, first discovered the application of electricity to medicine and the reaction of muscles to electricity. One day while working in his laboratory he accidently touched the leg of a frog with an instrument he had been using while turning an electrical friction machine. The leg of the dead frog moved and Galvani began at once to investigate this phenomenon. "Who," says Helmholtz, "when Galvani touched the muscles of a frog with different metals and noticed their contraction, could have dreamt that all Europe would be traversed with wires, flashing intelligence from Madrid to St. Petersburg with the speed of lightning? In the hands of Galvani, and at first even in Volta's, electric currents were phenomena capable of exerting only the feeblest forces and could not be detected except by the most delicate apparatus. Had they been neglected on the ground that the investigation of them promised no immediate results, we should now be ignorant of the most important and interesting of the limits between the various forces of nature." And had Helmholtz lived at a later period how amazed he would have been to see how easily communications are made without a maze of wires. As a result of Galvani's investigations we have his great work on animal magnetism, *De Viribus Electricitatis in Motu Musculari* (Modena, 1792), the keystone to the literature on the subject.

It was Alessandro Volta (1745-1827), an Italian physicist, who explained this phenomenon. He showed the method of generating galvanic electricity: in Galvani's experiment the frog was the electrolyte, and the muscular contraction was produced by the flow of electrical current through the frog. The result of this investigation was the construction of the voltaic pile in 1800. In his classic paper *On the Electricity Excited by the Mere Contact of Conducting Substances of Different Kinds,* communicated to the Royal Society of London on March 30, 1800, Volta announced the discovery of the voltaic pile, and on April 30 the first one was constructed in England.

Hans Christian Oersted (1777-1851) in 1820 discovered that an electric current excites a magnetic field and therefore deflects the compass needle. In *Experimenta Circa Effectum Conflictus Electrici in Acum Magnetican* (Nürnberg, 1820) he made this epoch-making announcement of the relations between electricity and magnetism.

The law governing the phenomena announced by Oersted was found, however, by André Marie Ampère (1775-1836), a French mathematician and physicist. The first and most critical of Ampère's series of papers on his discoveries on the electric current appear in *Mémoires sur l'Action Mutuelle de Deux Courans Électriques* (Paris, 1820). Clerk Maxwell called Ampère "the Newton of electrodynamics."

Oersted's discovery and the further investigations of Ampère aroused great interest and activity among the physicists and chemists of the day. In the following year Faraday made his experiments on electromagnetic rotations in which he was able to make a wire carrying a current rotate around the pole of a magnet, thus inventing the first electric motor. These four papers appeared in 1822 in the *Quarterly Journal of Science,* Volume 12.

In 1827 George Simon Ohm (1787-1854), a German physicist, discovered the unit of resistance in an electrical circuit, and his name has been linked with this electrical measurement. *Die Galvanische Kette* (Berlin, 1827) has exerted a great influence on the whole development of the theory and application of current electricity.

In 1839 Michael Faraday, an English physicist, was induced to collect in one volume the fourteen series of *Experimental Researches in Electricity* which had appeared in the *Philosophical Transactions* from 1831-1838. And in 1844 were reprinted those papers from the same source and others which had appeared from 1838-1843, and finally in 1855 was published the last of this series which had appeared from 1846-1852. These appeared in three volumes under the title *Experimental Researches in Electricity* (London, 1839-1855). Among these exceedingly important papers is contained the discovery of induced electricity, the electronic state of matter, the identity of electricity from different sources, and a host of other investigations and inventions.

The work of Michael Faraday was not only extremely important in itself, but it was of the greatest consequence to science for it led James Clerk Maxwell to his wonderful investigations of the dynamics of the electromagnetic field and the electromagnetic theory of light. James Clerk Maxwell (1831-1879), a Scotsman, began his electrical studies in 1855. His greatest contribution was the first full development of his famous electromagnetic theory of light. *A Dynamical Theory of the Electromagnetic Field,* which he read before the Royal Society of London on December 8, 1864, is the most important and original of his three memoirs on his further development of Faraday's and Kelvin's researches on "lines of force" and the nature of the mechanical energy in electromagnetic phenomena. From the equations in which Clerk Maxwell summed up his conclusions emerges not only the electromagnetic nature of light but also the pronouncement verified experimentally by Hertz—the statement that electricity travels through space in waves.

In 1883 Heinrich Hertz (1857-1894), a German physicist, began studies on Maxwell's electromagnetic theory and in 1888 after painstaking experiments produced the electromagnetic waves predicted by Clerk Maxwell. His exposition of his wave theory of electricity appeared under the title *Untersuchungen ueber die Ausbreitung der Electrischen Kraft* (Leipzig, 1892). His discovery of the properties of reflection, refraction, and polarization in electricity, with this wave theory of electrical motion, laid the foundation of radiotelegraphy and radiotelephony.

Guglielmo Marconi (1875-1937), an Italian inventor working along the lines laid down by Hertz, had by 1899 made wireless telegraphy a practical commercial proposition. Marconi's first paper, *Wireless Telegraphy,* was read in England on March 2, 1899 after wireless communication had been established between Osborne House, Isle of Wight, and the Royal Yacht. A few weeks later the first wireless communication between England and France was installed between Dover and Boulogne and successfully worked for the first time on March 27, the first international marine radio service. And from that day dates the opening of the era of wireless telegraphy with its inevitable improvements in world-wide radio communication.