Why do we call it a ... Farad?

By: **Lyle D. Feisel, Ph.D., P.E. (Ret.),** *Iowa Alpha '61*

This is the seventh in a series of articles that explore the history of science and engineering. One way in which this history has been preserved is in the names of the scientific units that we commonly use. Those units will serve as starting points for these articles as we explore "Why do we call it a...?"

Clearly, the men and women who populate the history of science and engineering were all very intelligent and talented and they all made significant contributions to our understanding of the physical world. Choosing any one individual who stands out among such an illustrious group is a difficult task, but, if forced to do so, I would choose Michael Faraday, whose long career covered more than half of the 19th century.

To my knowledge, Faraday (1791-1866) is the only person for whom two physical units were named. One, the faraday or faraday constant is — per Encyclopedia Britannica — equal to the amount of electric charge that liberates one gram equivalent of any ion from an electrolytic solution. That is equal to the charge of Avogadro's Number of electrons or roughly 96,485 coulombs. The unit was named the faraday in recognition of Faraday's contributions to the science of electrolysis, which we will explore further in a bit.

The second unit named for Faraday is the farad, his name with the last two letters removed. Interestingly, the farad was proposed as a unit of charge in 1861, but was soon adopted for its current use, a unit of capacitance. By definition, a one farad capacitor charged to one volt will have, on each plate, one coulomb of charge, positive on one plate, negative on the other.

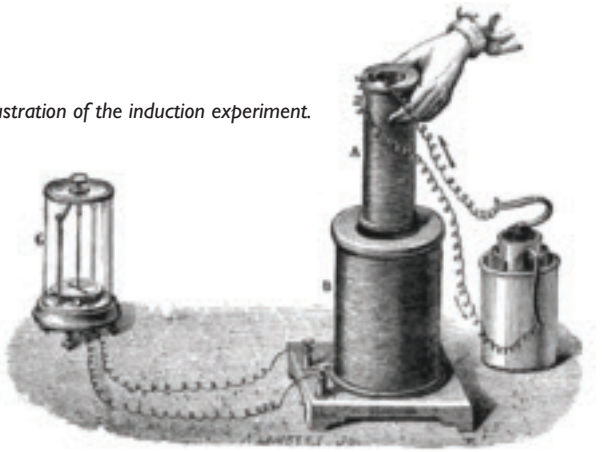
But enough about units. Let's talk about the man. Michael Faraday was born on September 22, 1791, in the village of Newington, which is now a part of London, England. His father was a tradesman with poor health and rather limited income, so there was no money for tutors or private schools. Faraday learned the basics of reading, writing, and mathematics in a church school, but if he learned any science at all, it is likely that it was very basic. At that time, it was much more important to learn a trade so, at the age of 14, he was apprenticed to a bookbinder. This leads us to the first stage of his long and varied career.

The Bookbinder. In the 18th century, books were generally sold "in boards" which meant they were just loose paper or held together in some kind of temporary binding. These pages were then taken to a bookbinder who put them in a more permanent, secure binding. Located in central London, the Ribeau shop, where Faraday worked, received many new manuscripts to be bound as well as some classics for rebinding. Faraday was quick to observe that this river of knowledge flowing through the bindery would not be diminished if he took a few sips.

So, he started to read some of the books that he worked on binding. As he read, he took copious notes, creating his own collection of scientific knowledge and philosophy. He was educating himself.

As his interests expanded, Faraday learned about a series of scientific lectures being offered to the public at the Royal Institution of Great Britain. He attended these lectures by leading scientists including the great chemist, Sir Humphry Davy. Again, Faraday kept careful notes about all that he learned. Eventually, he dared to contact Davy and applied for a job. In 1812, Davy did science a great favor by hiring Faraday as a laboratory assistant, thereby beginning the next phase of Faraday's career.

Michael Faraday, oil on canvas by Thomas Phillips, 1841–42; in the National Portrait Gallery, London.



An illustration of the induction experiment.

The Bottlewasher. As he started his employment with Davy at the Royal Institution, Faraday worked as an ordinary laboratory assistant, cleaning the lab and doing simple tasks such as washing glassware. As he became more proficient, he became more involved in conducting experiments, serving as the eyes of Davy who had been partially blinded in a laboratory accident. In 1815, Sir Humphry Davy invented the Davy lamp, a safety light for use in mines. By this time, Faraday had been sufficiently integrated into Davy's work that he made significant contributions to the development of the lamp, which Davy recognized publicly. With this and other recognitions, Faraday started to work independently and eased into the next phase of his career. As we will find, these next three "phases" overlap considerably.

The Chemist. The first decade of the 19th century was a time of great advances in the field of chemistry and Humphry Davy was at the center of the activity. By 1810, he had used the process of electrolysis to isolate several elements, thereby advancing the understanding of matter. After hiring Faraday in 1812, Davy continued his chemical investigations with Faraday's assistance, with Faraday becoming increasingly capable of working independently. Electrolysis was of special interest to Faraday and he advanced both the theory and practice of the process. In 1834, he published a report on electrolysis, giving us the words electrode, electrolyte, cathode, anode, cation, and anion.

In addition to his experiments in basic chemistry, Faraday was also involved in various projects of an applied nature. For instance, a major problem for the Royal Navy was "bottom fouling" wherein marine plants and animals attacked or attached themselves to the hulls of ships, drastically reducing their speed and maneuverability. To combat this, ship's hulls were lined with sheet copper, but the copper soon corroded and made another kind of mess. Davy and Faraday were enlisted to solve this problem. They were partially successful, and the Royal Navy sailed royally on.

Faraday's interests continued to broaden. In 1821, he was asked to review the work of Hans Christian Oersted and he added studies in physics to his considerable accomplishments in chemistry.

The Physicist. Ever since the 1800 invention of the voltaic pile — what we now call a battery — scientists had been looking for a connection between electricity and magnetism. Finally, in 1821, Oersted, a Danish physicist, observed that a current-carrying wire would cause a magnetic compass to deflect. He had discovered electromagnetism. Upon reading Oersted's description of his discovery, Faraday immediately repeated the experiment and, in short order, conducted other experiments that advanced the theory of electromagnetism. I can imagine him asking, "If an electric current can cause a magnet to move, might not a moving magnet cause an electric current?" He answered his question by plunging a magnet into a coil of wire and observing the deflection of a galvanometer. He had discovered electromagnetic induction.

Faraday being Faraday, he didn't stop there. He substituted an electromagnet for the bar magnet and got the same result. He then concluded that what induced the current was a changing magnetic field and recognized that he could change the field either by moving the electromagnet or by changing the current that energized the electromagnet (*see image above*). A further leap of reason and/or intuition led him to put two coils of wire on an iron ring, change the current in one, and observe a changing current in the other. He had invented the transformer. He also built rudimentary generators and motors, foreshadowing the practical use of electromagnetism.

The Public Scientist. I list this as a phase of Faraday's career but really it spanned most of his professional lifetime. As his scientific talents became recognized, his fame grew, not only among fellow scientists but among the general public as well. One of his contributions to the public was his creation in 1825 of the Royal Institution Christmas Lectures. Except for a brief hiatus during World War II, these lectures — actually a series of several related lectures — have been delivered every year since. Faraday himself delivered 19 of these series. His 1848 lectures, "The Chemical History of a Candle," were published as a book in 1861 and have never been out of print. The book can be purchased in either print or electronic format. I recommend it highly, especially for the chemically inept such as yours truly.

There is much more to tell about Michael Faraday, but I hope this gives the reader some sense of how brilliant and creative he was. He contributed to many fields but is especially well known for adding to the understanding that electrolysis involves the transfer of charge. A capacitor — its size measured in farads — stores charge. And that's why we call a farad a farad.

Lyle D. Feisel, Ph.D., P.E. (Ret.) is dean emeritus of the school of engineering and applied science and professor emeritus of electrical engineering at Binghamton University. Following service in the U.S. Navy, he received B.S., M.S., and Ph.D. degrees in electrical engineering from Iowa State University. From 1964-83, he was a faculty member of the South Dakota School of Mines and Technology, serving as head of EE from 1975-83. Feisel was a national visiting professor at Cheng Kung University in Tainan, Taiwan, during 1969-70, and served as the founding dean of engineering at SUNY Binghamton from 1983-2001. He was named Tau Beta Pi Outstanding Alumnus in 2002. Feisel is a life fellow of the IEEE and a fellow of ASEE and NSPE.