Weston Barger

Dr. John Stewart

Honors University Physics II

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The Life and Work of Michael Faraday

The life of the 19th century British scientist Michael Faraday was among the most mystifying and interesting in human history. One truly cannot help but be fascinated by the rags to intellectual riches story of the self-educated Faraday. Michael Faraday's scientific discoveries led to not only some of the most beautiful mathematical generalizations in modern electromagnetic theory, but also form the theoretical backbone for the modern world as we know it. Modern electricity generation and transportation depend on the work done by this exceptional scientist. Not only was Faraday devoted to making and publishing his scientific discoveries, he was also a tireless educator and famous science lecturer. He helped to establish several still remaining lecturing traditions. This paper will focus not only on a very small, but profoundly important, number of his scientific and educational contributions, but on some of the factors that contributed to the uniqueness of Michael Faraday.

Faraday was born the son of a blacksmith in 1791 on the outskirts of London. Michael Faraday was formally educated until he reached twelve years of age. His family was excruciatingly poor and his father, in poor health, worked sporadically. He left school to become an errand boy for a book binder. After a year of work he was able to become an apprentice book binder. This was a crucial event in the life of Faraday. He was able to read the books that he was asked by his employer, Mr. Riebau, to bind. It was while working under Mr. Riebau that young Faraday first encountered scientific text. For example, he was able to read the 3rd edition of the

Encyclopedia Britannica which included articles about chemistry and electricity. During this period of his life Faraday developed the habit of keeping a diary and writing down his thoughts. This habit followed him into the laboratory and served him very well. Faraday is known for keeping extremely accurate notes in the laboratory. (Burns 2005)

Faraday was encouraged by his employer to carry out scientific experiments of his own. After experimenting for himself and reading several books about science he joined the City Philosophical Society, where he gave his first lecture (James 1991).

Working as a book binding apprentice had a profound and lasting effect that was ultimately of great benefit to him. Inspired by the book, “The Improvement of the Mind” by hymn author Isaac Watts, he began to keep a ‘common place book’. This book was a diary of sorts where Faraday jotted down facts, thoughts, ideas and other musings (Thomas 1991). He continued this almost compulsive note taking throughout his career as a scientist. Academia possesses a clearer picture of the methodology of Faraday than almost any other scientist in history. His laboratory notebooks from the years 1820-1860 were published in the early 20th century. The entries of his notebook are labeled sequentially, starting at 1 in 1831 and ending in 1860 with number 16,041 (Tweeny 1986).

Faraday detested the book binding business and thought it to be “vicious and selfish”. He longed dearly to leave his trade and devote his life to science and the pursuit of knowledge. In 1812, Faraday was given the opportunity, by someone who his employer introduced him to, to attend a series of lectures given by Humphrey Davy. Davy was a brilliant scientist, responsible for the discovery of sodium, potassium, calcium and magnesium, and a renowned lecturer. Faraday excitedly attended the lecture, taking extremely accurate and detailed notes. He rewrote them several times. He eventually wrote a letter to Davy, with his notes enclosed, expressing his

desire to become a natural philosopher and requested that he be given a position at the Royal Institution when one was available. Davy was impressed with Faraday's notes, his energy and his idealism. After a few months, Faraday was hired by Davy as an assistant at the Royal Institution. Faraday would stay associated with the Royal Institution for his entire scientific career (Jones 1870).

The Royal Institution is an independent research and educational body in Great Britain founded by the American born Count Rumford. He founded the Royal Institution with the support of the President of the Royal Society, Sir Joseph Banks, in 1799 with hopes of, “diffusing and facilitation the general introduction of useful mechanical inventions and improvements and for teaching by courses of philosophical lectures and experiments, the application of science to the common purposes of life.” In 1801 he recruited the bright scientist, lecturer and poet Humphrey Davy (Thomas 1991).

Faraday's relationship with Davy would prove to be beneficial at the beginning of his scientific career. Davy was the springboard off of which Faraday jumped into the scientific community. In the autumn of the year that Faraday was hired, Davy and he embarked on a trip to France, Italy and Switzerland. During this trip Faraday had the opportunity to meet various prominent scientists and preform many important experiments (Thomas 1991).

Davy was an extremely talented lecturer. Davy was not only a scientist, but also a poet. His lectures captivated every audience to which he presented. This made a large impression on Faraday. Spending time under Davy shaped Faraday's views of lecturing. He remarked in his diary, “A lecturer should appear easy and collected, undaunted and unconcerned, his thoughts about him and his mind clear for the contemplation and description of his subject. His action should be slow, easy and natural consisting principally in changes of the posture of the body, in

order to avoid the air of stiffness or sameness that would be otherwise unavoidable." (Thomas 1991) He was able to hone his skills as a lecturer and this helped him to be successful in popularizing the subject with which he felt so much passion.

Faraday went on to establish the Friday Evening Discourses and the Christmas Lectures, both of which are still important traditions to the Royal Institution that are carried on today. The Christmas Lectures, geared towards young audiences, are broadcast by the BBC into the homes of millions every year. The first Christmas Lecture, The Chemical History of a Candle, was wildly successful and is still given to school children in Japan with the hopes of teaching the foundation of scientific thinking (Burns 2005).

Faraday had a unique approach to conducting science. He knew almost no mathematics and was generally skeptical of the study. Faraday believed that the study of mathematics led to over complicated thinking that, overall, drew focus away from the science done in the laboratory. Although one might not expect this sort of views from a physicist or chemist (and certainly not of someone who is simultaneously both), it certainly supports the fact that he was one of the greatest experimentalists of all time. This distaste for mathematics might have also been a contributing factor to his popularity as a lecturer. Faraday was able to describe his findings to those in a visual and linguistic way rather than relying on mathematical expressions (Thomas 1991).

Michael Faraday was piously religious. Faraday's parents belonged to a group of Christians known as the Sandemanians. His parents were devout Sandemanians and he joined the church shortly after his marriage. Followers of this small sect held the bible to be the literal truth and are opposed to the acquisition of personal wealth. Faraday turned down several prominent positions and titles, including knighthood, because of his religious conviction. Faraday claimed

to have kept his scientific work and his religious life separate, and has been championed for it, yet some underlining connections may be observed. He was also a firm believer that nature is unified. He sought a connection between electric, magnetic and gravitational forces. Faraday would have required prophetic insight in order to achieve this task. Some scholars believe his views about unification may have been related to his religious views. (Seeger 1983).

Faraday was not only a great experimental scientist, but also a talented lab technician and craftsman. Hermann Helmholtz once commented, “A few wires and some old bits of wood and iron seem to serve him for the greatest discoveries” (Hirshfeld 2006). His limited funding did not impede him from making some extremely important advances Chemistry. In 1827, Faraday published a book entitled “Chemical Manipulation” in which he walks aspiring chemists through a large number of lab procedures. The book is constructed in a manner that is as unique as it is indicative of his procedural method of thinking. The book is constructed from 1399 numbered paragraphs. Every new phrase introduced, such as “Determine specific gravity”, is defined in terms of more simple expressions. He built a large number of new phrases, but was very clear in their meaning. Faraday also employed the used of conditional statements. Many of the procedures outlined in the book involved phrases of the form: If X holds, then proceed with Y. It was rather uncommon for procedural methods of the day to be stated so explicitly in terms such as these. This sort of thought is indicative of Faraday’s very logical and methodical approach to lab work and highlights his unique approach to lab work; it is especially interesting when contrasted with his view of mathematics (Tweeny 1983).

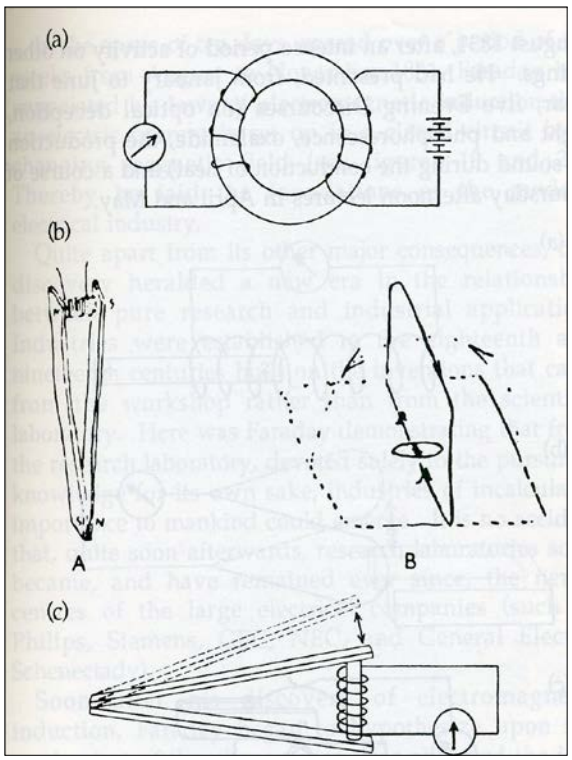
One facet of Faraday's personality that cannot go without mentioning was his work ethic. Faraday never slowed down. Through a large part of his career he lived in close proximity of his laboratory, over it as a matter of fact. He often gave into the temptation to work late into the

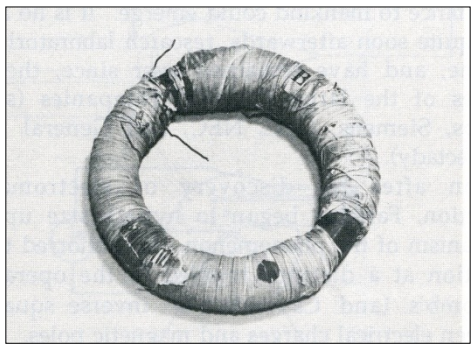
night. For example, just between 1832 and 1834 he accomplished what would have been acceptable for a decade of work for most people. Faraday published twenty original papers, gave over fifteen Friday Evening Discourses, gave the six Christmas Lectures in 1832-1833, over forty daytime lectures, seventy-five lectures at the Military Academy at Woolwich and was in correspondence with a multitude of prominent scientists. In the mid 1830's his health started to deteriorate as a result. He suffered from headaches and lapses in memory. He tried very hard not to let this slow down his progress. In 1840 however his health suffered greatly. Some commentators suggest that he rested completely but this is more than likely an understatement. He continued to publish papers and give lectures, but at a pace that was more manageable. Faraday applied this devotion in all aspects of his life (Thomas 1991).

In 1821, after reading a paper by Ørsted about the effects a current carrying wire had on a compass needle, and a paper by Ampere about the force of attraction experienced by two parallel current carrying wires Faraday begin to ponder the mysterious relationship between magnetism and electricity. Faraday wrote a paper on the history of magnetism until 1821. Faraday then showed that one could rotate a wire by wrapping it around a magnet and running a current through the wire. He had succeeded in creating the world's first electric motor. This discovery earned him international fame, but at a price. Faraday, excited about his discovery, was a bit hasty to publish. He published his paper without consulting his mentor Davy. Davy and another scientist had discussed electromagnetic rotation in the presence of Faraday and Davy felt that Faraday should have consulted him before proceeding to publish. This incident damaged the relationship between Faraday and Davy. Because Davy had been promoted in the Royal Institution, he had direct control over the projects that Faraday undertook. He assigned him to a project concerning optical glass. Bad blood between Faraday and Davy was one factor leading to

Faraday's ten year gap in work with electricity. It was not until Davy's death in 1829 that Faraday was able to pursue his own interests freely (Thomas 1991).

On August 29, 1831, Michael Faraday made his most important discovery, electromagnetic induction. This event marked the beginning of the electric industry as we know it today. Faraday demonstrated electromagnetic induction by wrapping a wire around a soft-iron ring and connecting it to a battery. He then wrapped a second wire around the other side of the ring and connected it to a device to measure current. This was the world's first electric transformer. In a second set of experiments, Faraday showed that a continuous current could be achieved by spinning a magnet through a coil of wire. He had successfully built the first electric generator. He also demonstrated that a single wrap of wire rotated through the earth's magnetic field also generated a current. Included below are a few of Faraday's drawings of the devices described and a picture of the soft-iron ring he used in his experiments (Thomas 1991).

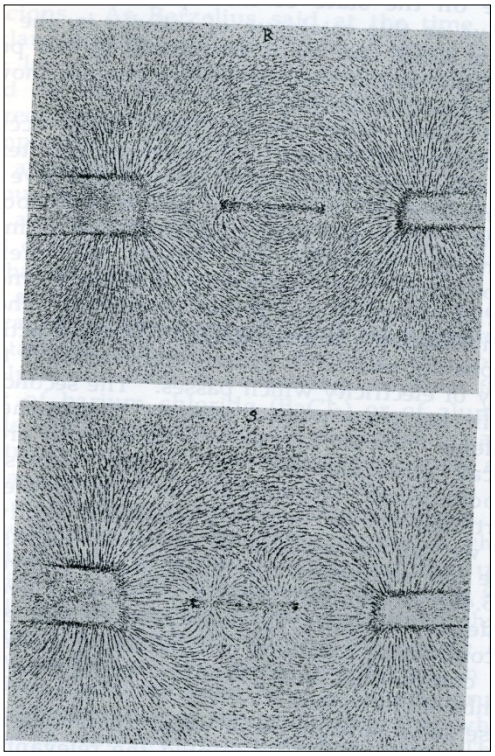




By the end of November of that same year, he had essentially expressed the laws of

electromagnetic induction. He stated that current in a closed loop is created by a changing magnetic field through the loop. It is Faraday who is responsible for the idea of magnetic flux (Thomas 1991).

These findings led Faraday to investigate a few more general properties of magnets. He then put forth the concept of the magnetic field. He used a couple of magnets covered by a sheet of paper. He then sprinkled iron shavings onto the paper and tapped it lightly. What occurred gave the first picture of a magnetic field. He was able to visually show the existence of the invisible 'lines of force', to use his words. Faraday expanded upon this idea in several papers and lectures (Thomas 1991). It was this revolutionary idea that laid the foundation for Maxwell's mathematical models. Maxwell commented, "As I proceeded with the study of Faraday, I perceived that his method of conceiving the phenomenon was also a mathematical one, though not exhibited the in the conventional from of symbols." (Maxwell 1873).

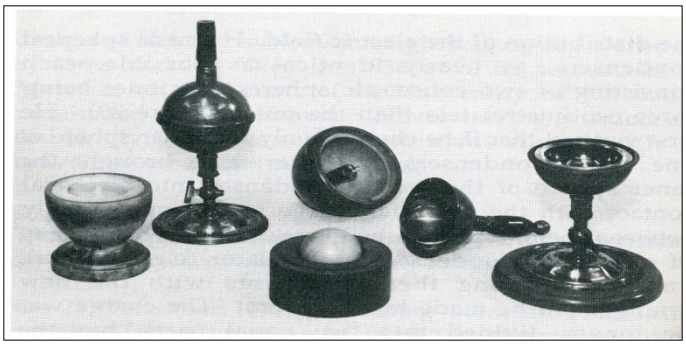


This discovery would prove to be his most influential. The modern world as we know it

depends heavily on electromagnetic induction. One could thank Faraday every time an electric guitar is heard. Electric guitar pickups convert the magnetic flux created by the vibrations of the strings into an electrical current which is then converted, by an amplifier, into sound. The electricity that people use every day was almost certainly the result of induction (Russell).

During the early 1830's, Faraday did some extremely important work in Electro-Chemistry. He published a paper and gave several lectures on what is now known as Faraday's Laws of Electrolysis. He was successful in describing chemical breakdown in terms of the amount of electricity flowing through it, or in his words, “Chemical action or decomposing power is exactly proportional to the quantity of electricity which passes.” The second of Faraday's Laws of Electrolysis states, “Electrochemical equivalents coincide and are the same with ordinary chemical equivalents”. Electrolysis is used in numerous industrial processes including the production of aluminum, lithium and chlorine (Thomas 1991).

It was a popular view in the late 1830s that the medium that separated to electric fields did not affect the distribution of the electric fields. Faraday was not convinced (and rightly not!). He devised and experiment to test the validity of this idea. He built spherical condensers, each containing concentric conducting spheres. He first concluded that when one of the spheres was charged and brought into electrical contact with the other sphere the charge was shared equally between the two conductors. However, when he placed an insulator in the air gap between them he discovered that the condenser containing the insulator held the greater share of the electrical charge. He also noticed that the use of different insulators affected the charge difference experienced. Faraday was then able to characterize each insulator by what he called the “specific inductive capacity”. This is now known as the dielectric constant (Thomas 1991).



In 1845 Faraday made yet another profound discovery. He was the first in the world to show that magnetism and light were related. He found that magnetic fields had a rotational effect on planes of polarized light. This was later named the Faraday Effect. Ironically, Davy's attempt a few decades earlier to distract Faraday from success was helpful to him in the long run. He was able to use work he had done in optical glass to in his research of the inner connectedness of light and magnetism (Thomas 1991).

Throughout his magnificent career, Michael Faraday made scientific advances that led to a greater understanding of nature, but not only that, his inventions led to the modern world as we know it. The electricity that powers the computer that this paper was written on was almost certainly generated via electromagnetic induction and then transported after running through a transformer. Michael Faraday was also a gentle spirit who almost no negative things were written about. He was humble throughout his whole life, even declining knighthood to remain simple Mr. Faraday. His self-education and precise note along with his methodical approach to experimentation helped him to become the greatest experimental scientists of the 19th century, arguably ever. The world we live in would be a dramatically different place if it were not for the work of Michael Faraday.

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