

RADIO MAGIC

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The Road to Radio—Part 5

Introduction

After some badly needed repairs to our Humvee's quantum drive, we are back on the road and have jumped to the 1820s. Hans Christian Ørsted's discovery of "electromagnetism" (or rediscovery, Part 4 refers) in July 1820, rocked and shocked the world of classical (Newtonian) physics. Only two months later, Johann Schweigger invented the first practical application of electromagnetism: the "multiplier" or multiplier, which eventually evolved into the "galvanometer" (named in honour of Luigi Galvani). This was quickly followed by André-Marie Ampère's invention of the "solenoid" (derived from the ancient Greek word for "hollow tube"). Figure 1.

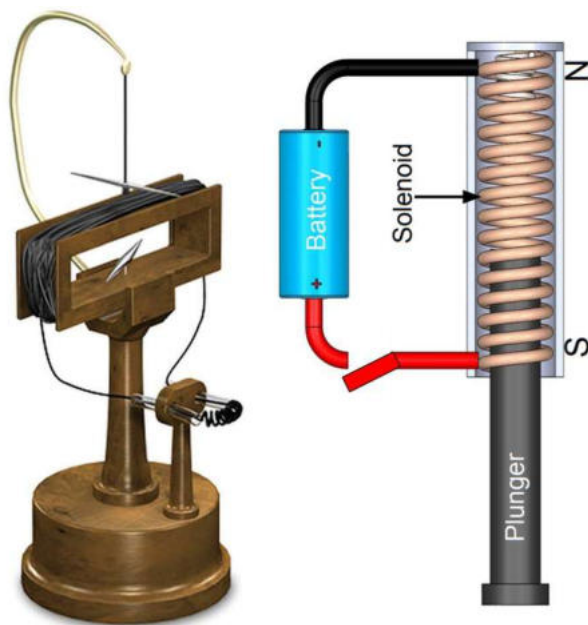


Figure 1

Image left: Multiplier. Multiple turns of wire "multiplied" the electromagnetic effect and increase sensitivity to electric current, allowing comparative measurements (current strength and direction) to be made for the first time. Credit: National MagLab, Magnetic Academy.

Image right: The solenoid becomes an on/off electromagnet and used to control or regulate (remotely) other mechanical or electrical devices through very long lengths of electrical wire. Credit: HowStuffWorks.com.

Faraday: “He Smells the Truth”

Experimental physicist Friedrich Kohlrausch's statement about Michael Faraday (Figure 2) metaphorically suggests he possessed an uncanny ability to sense underlying scientific truths that others could not. Faraday was renowned for his intuitive genius, deep insight and imaginative, self-taught approach to experimentation. His groundbreaking discoveries in electrochemistry and electromagnetism shaped much of today's science and technology.



Figure 2: Portrait of Mr. Michael Faraday

Credit: Thomas Phillips, 1842. Wikipedia.

Born to a poor working-poor class family belonging to a now-extinct Christian sect that practised “bare faith” (Biblical literalism), Michael’s formal education ended at age 14 when he began a seven-year bookbinder apprenticeship at a local bookstore that serendipitously provided him with unlimited access to read the books he could never afford, soaking in their contents like a sponge. That is, except for any on advanced mathematics — his lifetime Achilles heel.

“There were plenty of books there, and I read them. I could believe in the Arabian Nights as easily as in the Encyclopaedia. But facts were important to me and saved me. I could trust a fact but always cross-examined an assertion.”

I will let him tell you the story of how he became the assistant to Sir Humphry Davy, one of the greatest of British chemists and a pioneering electrochemist of the early 19th century:

“When I was a bookseller's apprentice, I was very fond of experiment, and very adverse to trade. It happened that a gentleman, a member of the Royal Institution, took me to hear some of Sir H. Davy's last lectures. I took notes, and afterwards wrote them out more fairly in a quarto volume. My desire to escape from trade, which I thought vicious and selfish, and to enter into the service of Science, which I imagined made its pursuers amiable and liberal, induced me at last to take the bold and simple step of writing to Sir H. Davy, expressing my wishes, and a hope that, if an opportunity came in his way, he would favour my views.

This took place at the end of the year 1812, and early in 1813 he requested to see me, and told me of the situation of assistant in the laboratory of the Royal Institution, then just vacant. At the same time that he thus gratified my desires as to scientific employment, he still advised me not to give up the prospects I had before me, telling me that Science was a harsh mistress; and, in a pecuniary point of view, but poorly rewarding those who devoted themselves to her service. He smiled at my notion of the superior moral feelings of philosophic men, and said he would leave me to the experience of a few years to set me right on that matter.

Finally, through his good efforts I went to the Royal Institution early in March of 1813, as assistant in the Laboratory; and in October of the same year, went with him abroad as his assistant in experiment and in writing. I returned with him in April 1815, resumed my station in the Royal Institution, and have ever since remained there.”

Note 1: The Royal Institution of Great Britain was founded in 1799 by leading British scientists to introduce new technologies and educate the general public about science through lectures and demonstrations. It is famous for its Christmas Lectures, which were started in 1825 by Faraday, so that working-class British children, as he once was, could be exposed to the sciences at no cost.

The Search for Electromagnetic Rotation: Converting Electrical Energy to Mechanical Motion

Before 1820, there were only three known universal forces in physics: gravity, electricity and magnetism. Physicists believed that these forces acted between one body and another instantaneously, no matter the distance, in a straight line (linear) fashion. But this new force (electromagnetism) was at right angles — and it apparently formed spiral loops around conducting wires (according to Ørsted)! In the fall of 1820, Sir Humphry Davy and his assistant Michael Faraday carefully confirmed Ørsted's unbelievable findings. On November 16, 1820, Davy writes this to his colleague chemist/physicist Dr. William Hyde Wollaston, MD:

“As bodies magnetized by electricity put a needle in motion, it was natural to infer that a magnet would put bodies magnetized by electricity in motion; and this I found was the case. Some pieces of wire of platinum, silver and copper were placed separately upon two knife edges of platinum connected with two ends of a powerful voltaic battery, and a magnet presented to them; they were all made to roll along the knife edges, being attracted when the north pole of the magnet was presented, the positive side of the battery being on the right hand, and repelled when it was on the left hand; and vice versa, changing the pole of the magnet.”

He then opines that Earth's magnetism might even originate from similar electrical phenomena; that auroras could be manifestations of electrical currents at the poles, and that the Sun may somehow be involved!

Because Faraday was reassigned to assist metallurgist James Stodart, Davy invited Wollaston to help carry on with additional experiments. He had been investigating electromagnetism for several months and suggested to Davy that an external magnet, when brought near an electric current-carrying wire, might interact with the electromagnetism generated by the wire and force it to rotate around its axis, which resulted in their “rolling wires” experiment. Now they attempted to produce continuous electromagnetic rotation; however, by the spring of 1821, they still had no success. Even though Faraday was working on another project, he had full access to Davy's atrocious laboratory notes, which he rewrote for official reports, and was well aware of the experiments and any progress or lack thereof.

The "Faraday Incident"

On September 3rd, 1821, in his basement laboratory at the Royal Institution, Michael Faraday constructed an apparatus using quicksilver (mercury) floating a piece of cork with a magnetized needle stuck vertically into it (later replaced by a fixed-in-place, then a free-to-swivel vertical bar magnet). Suspended above was a free-to-swivel bare wire touching the mercury. With his wife's 14-year-old brother George as the only witness, Faraday held his breath, connected a battery, and the wire magically sprang to life, continuously rotating around the magnet (Figure 4)!

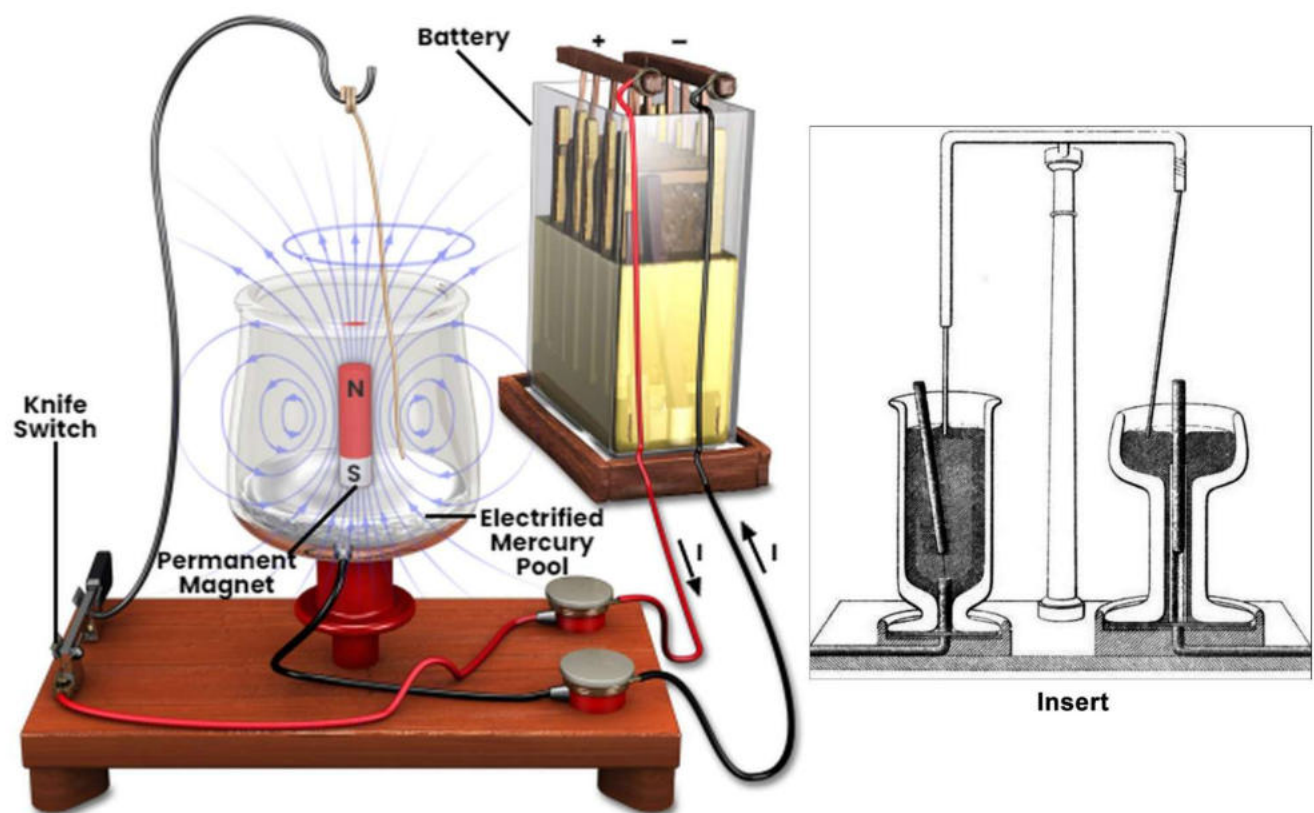


Figure 4: Converting Electrical Energy to Mechanical Motion

Faraday proved electromagnetic rotation was reciprocal, either when a bar magnet was fixed and the current-carrying wire free to rotate and vice versa (insert), either clockwise or counterclockwise depending on battery polarity. Credit: National MagLab, Magnetic Academy. Insert: *Experimental Researches in Electricity, Volume 2*—M. Faraday, 1844.

From his stream of consciousness, original laboratory notes:

“To establish the motion of the wire a connecting piece was placed upright in a cork on water; its lower end dipped into a little basin of mercury in the water and its upper entered into a little inverted silver cup containing a globule of mercury; the arrangement of battery poles always as at first. Magnets of different power brought perpendicularly to this wire did not make it revolve as Dr. Wollaston expected, but thrust it from side to side.

Arranged a magnet needle in a glass tube with mercury about it and by a cork, water, etc. supported a connecting wire so that the upper end should go into the silver cup and its mercury and the lower move in the channel of mercury round the pole of the needle. The battery arranged with the wire as before. In this way got the revolution of the wire round the pole of the magnet.

Very satisfactory, but make a more sensible apparatus.”

Years later, George recalled:

“We danced around the table then went off to the circus to celebrate. I shall never forget the enthusiasm expressed in his face and the sparkling in his eyes.”

Note 2: This simple experiment also proved that the electromagnetic force was totally circular, forming closed loops around the wire. In doing so, he solved a problem (in a day) that had vexed Davy and Wollaston for months!

On October 1st, 1821, his paper *On some new Electro-Magnetical Motions, and on the Theory of Magnetism* was published in *The Quarterly Journal of Science, Literature and the Arts*. However, Wollaston was not properly credited (Faraday truly believed the rotation he discovered was different from the rotation Wollaston had postulated); as a result, his originality and personal character were immediately challenged by the “old guard” scientists and especially Davy, who was deeply wounded by his protégé’s use of “privileged information” for not acknowledging this and not properly crediting Wollaston.

A frantic Faraday realized he was in serious trouble and immediately wrote Stodart, who knew Wollaston well, to arrange for a meeting. This is the start of a long letter:

"I keep hearing more and more whispers about me regarding my work, which, though small to me personally, seem to be spoken openly among scientists. These whispers question my honesty and reputation, and I want to clear things up or at least prove that they are false. You know very well how upset I was when my paper on electromagnetism was published publicly without my expectation, and you will not be surprised that I want to set things straight—even if it causes trouble for you and my friends. If I understand correctly, I am accused of several things:

- 1. Not admitting I received help from Sir H. Davy while working on this.*
- 2. Concealing Dr. Wollaston's ideas and experiments.*
- 3. Starting work on the subject while Dr. Wollaston was already researching it.*
- 4. Dishonestly using Dr. Wollaston's ideas and results without giving him credit."*

Then he goes into a detailed defence of each point! Stodart did not reply, but he must have offered verbal advice, which Faraday ignored because he sent this letter to Wollaston on October 30th, 1821:

"I am urged by strong motives respectfully to request your attention for a few moments. The latter end of last month I wrote a paper on electromagnetism, which I left in the hands of the printer of the "Quarterly Journal", and went into the country. On returning home the beginning of this month, I heard from two or three quarters that it was considered I had not behaved honourably in that paper; and that the wrong I had done was done to you. I immediately wished and endeavoured to see you, but was prevented by the advice of my friends, and am only now at liberty to pursue the plan I intended to have taken at first. If I have done anyone wrong, it was quite unintentional, and the charge of behaving dishonourably is not true.

I am bold enough, Sir, to beg the favour of a few minutes' conversation with you on this subject, simply for these reasons—that I can clear myself — that I owe obligations to you — that I respect you — that I am anxious to escape from unfounded impressions against me — and if I have done any wrong that I may apologise for it. I do not think, Sir, that you would regret allowing me this privilege; for, satisfied in my own mind of the simplicity and purity of my motives in writing that paper. I have very much simplified and diminished in size the rotating apparatus, so as to enclose it in a tube. I should be proud if I may be allowed, as a mark of strong and sincere respect, to present one for your acceptance.”

Wollaston shot back with this famous curt and cold “genteel dismissal”:

“You seem to me to labour under some misapprehension of the strength of my feelings on the subject to which you allude. As to the opinions which others have of our conduct, that is your concern and not mine. If you acquit yourself fully of making any incorrect use of the suggestions of others, it seems to me that you have no occasion to concern yourself much about the matter.”

Fortunately for Faraday, in academia, the mindset is, “*He who publishes first, receives all the glory.*” Pocket versions of his “rotator” were immediately made and sent to eminent European scientists, an expensive but brilliant public relations campaign. A protracted “palace scandal” was not wanted by the Royal Institution because it was bad for business. Faraday et al were performing money-making contract work that kept the candles burning and coal scuttles full. Even Davy, grudgingly, had to admit this. Technically, he was Director of the Laboratory, but it was Faraday who kept it organized and running smoothly. Davy’s lab note-taking was so haphazard and lackadaisical that most reports credited to him were written by Faraday. Perhaps, after years of silence, of servitude but of very little credit, in the intoxication of his first solo discovery, perhaps with support from within the “palace”, the squire lashed out? But when you strike at the king, you had better not miss! Davy had made Michael Faraday; now Davy will break Michael Faraday! But he waited patiently, letting the psychological pressure of never knowing when the axe would fall slowly build. A Shakespearean tragedy is now playing out before our eyes!

In early 1823, desperately wanting and needing to make peace with Wollaston (now impossible with Davy), Faraday wrote an addendum to his paper about their respective roles in the discovery of electromagnetic rotation, which Wollaston approved for publication. Wollaston's scientific ethos leaned toward quiet contribution over public acclaim. Known for being very reserved and private, he sometimes published anonymously, especially when introducing new scientific ideas or discoveries. Wollaston had laid the conceptual roadwork for Faraday to follow, then gracefully stepped aside:

"It may have been about August 1820, that Dr. Wollaston first conceived the possibility of making a wire in the voltaic circuit revolve on its own axis and it was at the beginning of the following year that Dr. Wollaston came to the Institution with Sir Humphry Davy, to make an experiment of this kind. I was not present at the experiment, nor did I see the apparatus, but I heard Dr. Wollaston's conversation at the time, and his expectation of making a wire revolve on its own axis.

It has been said I took my views from Dr. Wollaston. That I deny."

Wollaston's implicit blessing suddenly shifted support of the "old guard" within the Royal Society and Royal Institution toward Faraday as the heir apparent. Everyone realized this fact — except Davy!

Note 3: Priority disputes in academia are common—it is a "publish or perish" culture. Michael Faraday's famous maxim was, *"Work. Finish. Publish."*

Note 4: William Brande was editor of Institution's *The Quarterly Journal of Science* and Chair of Chemistry. He was close in age and an ally of Faraday, who was now his laboratory/lecture assistant. Brande was more methodical and reserved than Davy, which suited Faraday's growing independence and scientific maturity. I believe this publication was chosen to bypass the Royal Society's *Philosophical Transactions* (the Royal Institution had no journal, at the time) because it would have required Davy's editorial approval (he was president of the Royal Society)—and that was never going to happen!

Note 5: The Royal Society (of London for Improving Natural Knowledge) was established in November 1660 as an elected member body. It is the oldest national academy of science. Two (or more) Fellows of the Royal Society (FRS) are required to nominate a candidate who “has made a substantial contribution to the improvement of natural knowledge” (science). Secret ballot voting is held at the “Annual Meeting for the Election of Fellows”, where candidates must receive at least two-thirds of the ballots cast.

Requiem Regis

Faraday made a tactical retreat and refocused on chemistry. He never made “*a more sensible apparatus*”, but he presented a copy of his rotator to the Royal Institution (Figure 5). His three very informative and entertaining *Annals of Philosophy* articles, titled *Historical Sketch of Electromagnetism*, simply signed “M”, appealed to both academics and the general public. However, “M” was not fooling anyone! Rumours quickly spread, and he was forced to acknowledge authorship, which elevated him to the scientific stratosphere. Sir Humphry was not amused (Figure 7, next page).

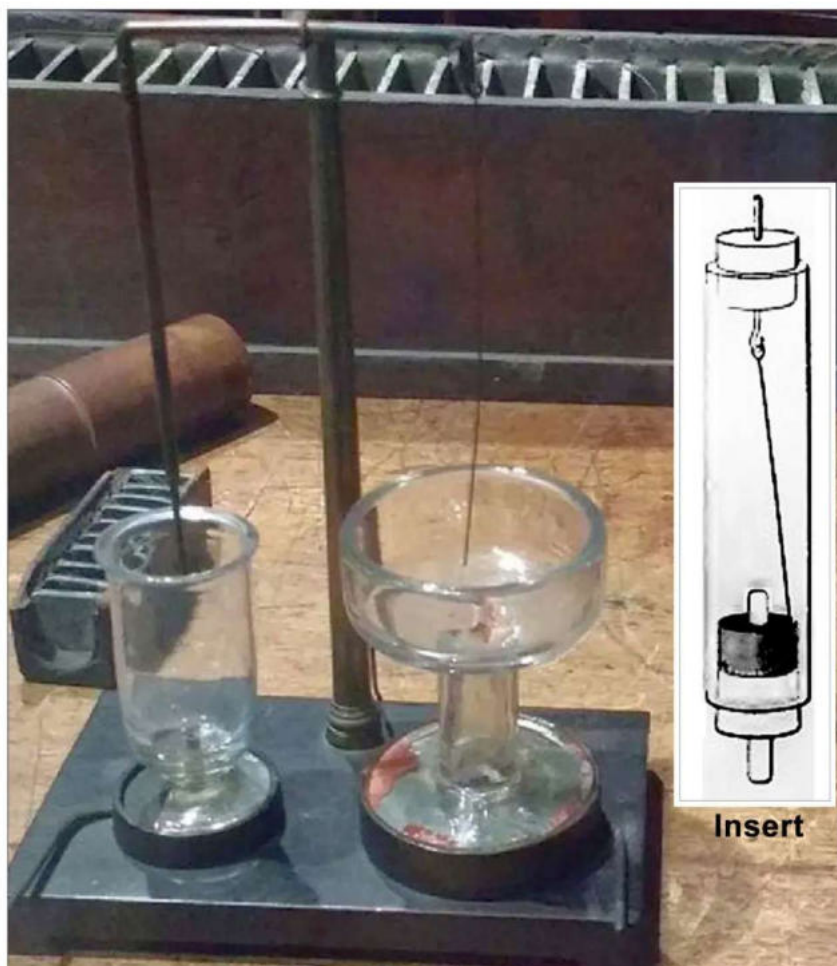


Figure 6: Faraday's Electric Magnetic Rotator

On display in his restored basement laboratory. Credit: The Royal Institution. Insert: Faraday's pocket version — just add mercury! Credit: *Experimental Researches in Electricity, Volume 2*—M. Faraday, 1844.

In mid-1823, when nominated for Royal Society fellowship by Phillips, Wollaston and three others — Davy, very loudly and angrily objected — “You will withdraw it, Mister Faraday!” Michael politely refused. The gauntlet was thrown. President of the Royal Society, Sir Humphry Davy, 1st Baronet, FRS, etc., etc., reared up and used all his might to not only block Faraday’s election but also humiliate him by resurrecting the old accusations of scientific misconduct; calling him “*a mere technician*” and insultingly, in the very class conscious British society, “*not a true gentleman of Science*”.



Figure 6: Portrait of Sir Humphry Davy
Credit: Thomas Phillips, 1821. Wikipedia.

Yet, strangely, Davy did not attend the meeting when the vote was held in early 1824 — only one anonymous “nay” was cast. This was the turning point in Faraday’s career; the newly minted Fellow gained formal recognition from the scientific elite and stepped out from his former mentor’s long shadow and control — all without publicly criticizing him. Davy’s hold on power quickly waned as did his health. In February 1825, a serious stroke left him partially paralyzed. No longer able to manage the day-to-day operations of the laboratory, he abdicated in favour of Faraday — “*The king is dead, long live the king!*”

Sir Humphry resigned as president of the Royal Society in early November 1827, citing poor health, but he also knew he would not win re-election later that month; to avoid the humiliation, he left on his own terms. Many viewed his leadership as ineffective, divisive and heavy-handed, while the younger Fellows agitated for a more merit-based governance; Faraday wisely avoided the “palace politics” and never spoke ill of Davy. Davy’s self-serving scheming to secure the presidency seven years earlier (Wollaston was preferred but Davy outmanoeuvred him) had revealed divisions in the scientific community and fuelled a slowly simmering resentment within the rank and file, which finally came to a raging boil. Davy must go!

Note 6: Faraday’s reserved restraint was a combination of strategic patience, personal ethics, plus his heartfelt gratitude owed to the unhorsed Sir Humphry, regardless of how badly their relationship ended. However, “M” was no longer his subordinate—*“a mere technician”*; he was a rapidly rising scientific force in his own right.

My Final

They had risen separately from humble beginnings with no formal education beyond grade school. Davy’s father died when he was a boy; Faraday’s father was always in ill health. As young teens, they both worked to support their families (Davy as an apprentice apothecary; Faraday as an apprentice bookbinder). They were recognized as towering savants extraordinaire in their lifetimes. They were opposites in nature but siblings in science.

In 1896, the building next to the Royal Institution was purchased to house the Davy-Faraday Laboratory. It provides opportunities for researching pure chemical and physical science through academic partnerships, sponsored fellowships or institutional collaborations.

Well, time to stop and recharge the quantum drive before the next jump.—73

Additional References

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