RADIO MAGiC

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The Road to Radio—Part 2

Introduction

"Magnetism is the polarity of time; electricity is the polarity of space. The conflict of both yields the chemical process."—Johann Wilhelm Ritter.

I though this part of our trip was going to be an easy drive through time, however, it became apparent I needed to explain the two battling philosophies we will encounter over the next few decades. You ask, "What does philosophy have to do with this story?" Well, buckle up and read on!

Philosophical Road

In the early 19th century, Immanuel Kant's philosophy, which dominated the latter part of the Enlightenment (late 18th century), collided with Friedrich Schelling's Naturphilosophie and the emergence of Romanticism, which rejected the rigid social conventions of the old century, favouring individualism, passion and intuition over conformity, passivity and logic. With a fascination for both the natural and supernatural worlds, it was represented by the romantic poetry of Byron and Shelley, the gothic horror of Shelley and Poe plus the use of mind-expanding hallucinogenic drugs and/or absinthe. Kant rigidly defined science as being based only on reproducible empirical evidence and mathematical proofs. He believed that matter was not composed of atoms (chemist John Dalton's new theory) but two opposing forces: attraction and repulsion. In his mind, water was water—ad infinitum.

In contrast, Naturphilosophie sought to understand the interconnectedness of nature, whether through forces, atoms or both, often relying on metaphysical ideas. It promoted a comprehensive understanding of nature based on a few interconnected universal principles. Dalton's atomism was deeply rooted in the metaphysics of the ancient Greek philosopher Democritus who proposed the concept of "atomos"—small, invisible and indivisible particles that are the building blocks of everything, going hand-in-glove with Naturphilosophie and openly defying Kantianism.

Technological Road

Alessandro Volta's invention of the voltaic pile in 1800, resulted from his disagreement with Luigi Galvani's theory of "animal electricity" or galvanism. But because Volta described his invention as working much like galvanism, the terms "voltaic" and "galvanic" soon became interchangeable. Static electricity, generated by friction, was still referred to as electricity while the new dynamic form generated by the pile or "battery" (from Benjamin Franklin's term for many connected together Leyden jars) was called galvanism.

Modern concepts such as "current", "voltage" or "resistance" did not exist. Instead, we have terms like "intensity", "quality" and "strain" to describe the effects of the electricity and galvanism. Without modern metering devices, it was only possible to quantify experimental effects based on observations of the heating or incandescence of metals, electrochemical reactions or by physiological effects on the anatomy of animals or humans (dead or alive!). Detailed descriptions of experiments along with the rather artistic diagrams often used local units of measurements while most equipment and supplies had to be locally sourced and/or custom-made, making experimentation an expensive endeavour. This posed challenges for others living in different countries or sometimes even in different cities in the same countries to build equipment to scale and reproduce experiments exactly. Consequently, confusion, conflicting conclusions and missed opportunities were far too common, as a result, there were many missed and/or overlooked discoveries. Latin was the still the common language of academia so any new theories or discoveries published only in regional languages and non-academic periodicals also went unnoticed.

In 1802, André-Marie Ampère declared, according to close friend François Arago, *"I will demonstrate that electrical and magnetic phenomena are due to two different fluids that act independently."* His statement reflected the influence of towering figures of Franklin—the "American Prometheus"—and the revered Charles-Augustin de Coulomb, famously known for his electric and magnetic force laws. There were also two conflicting fluid models of electricity along with Coulomb's theory that a magnetic fluid, separate from the electric fluid, also flowed within matter. These Aristotelian-like principles, similar to Aristotle's dictate "heavier objects always fall faster", were set like concrete in the minds of physicists:

- Galvanism and magnetism are two separate and distinct fluids.
- Magnetic fluid flows similarly to electric current in a galvanic circuit.
- The two open wires terminating a battery attract one another and adhere like magnets after connecting.

There was no need for further investigation or questioning—the "gods" have spoken.

Perception is Everything

This is classic "groupthink", a subconscious psychological mind effect that causes cognitive blindness (tunnel vision) and/or confirmation bias whereby people only favour information supporting their existing beliefs while ignoring all contradictory evidence. The human mind is very susceptible to manipulation due to our innate need for social connection and belonging. This explains why peer pressure and mass/social media shapes a subjective reality of the world that people within the same group blindly accept as true while ignoring the outside-the-group objective reality of the world as it is. This can be complicated by "functional fixedness", which is the inability to see alternative applications for commonly used items beyond their traditional roles. The magnetic compass, a commonly used navigational tool for centuries, was not seen as having any other purpose despite the fact that mariners reported strange compass behaviours during lightning storms and Franklin proving that lightning is electricity, everyone was oblivious to the obvious. Our eyes have a physical blind spot and our minds have a psychological blind spot. While we can shift our eyes' blind spots simply by turning our heads, to shift our minds' blind spots requires something more dramatic or traumatic to happen.

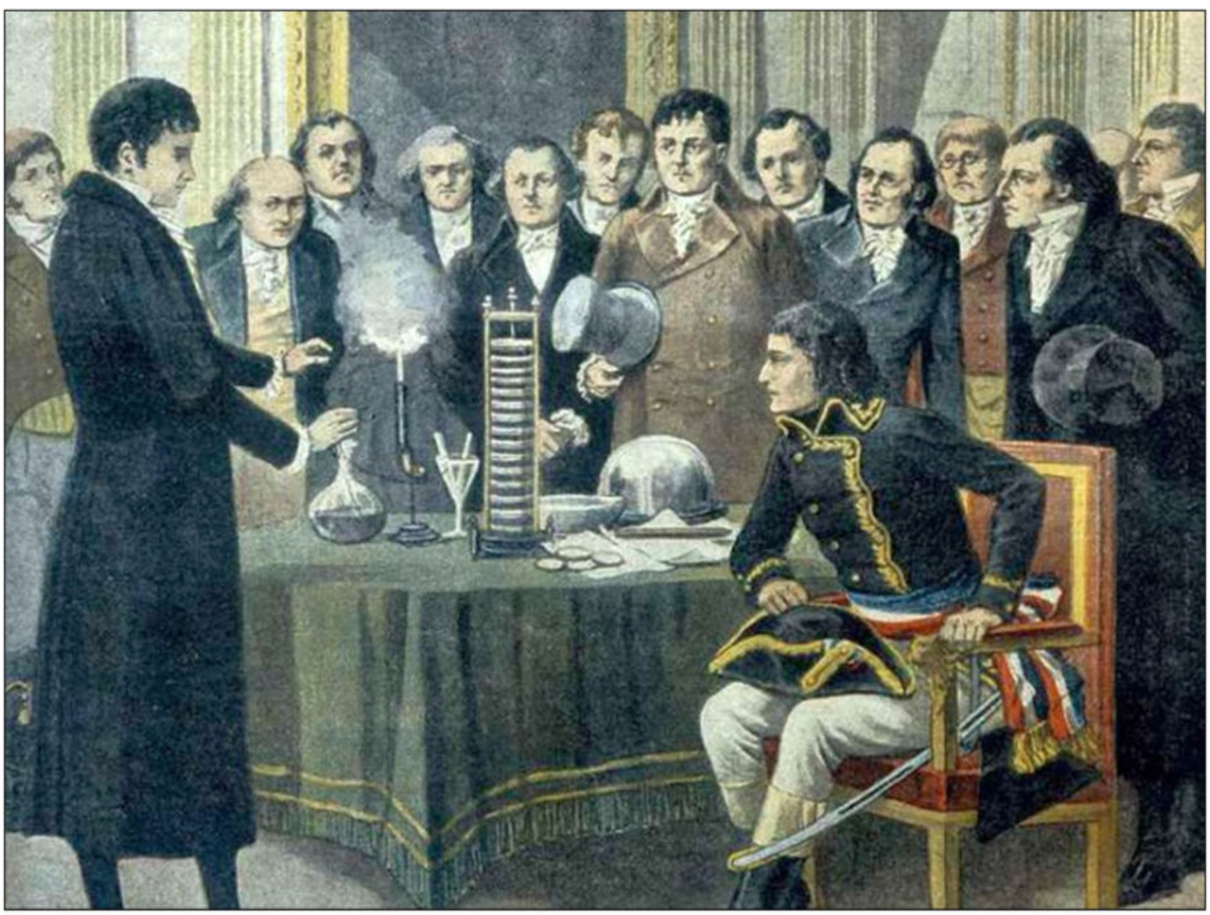
Revolutionary Road

"Electricity and galvanism—what discoveries in just a few years!"—Napoleon.

The French Revolution brought significant changes to European society, promoting rationality, secularism and equality regardless of social status. It rejected established religion and traditional political and philosophical doctrines. One of its lasting contributions was the revolutionary "le système métrique" (metric system). Napoleon Bonaparte spread the Revolution's social reforms including the metric system usually by force (during the Napoleonic Wars) to impose these changes throughout the regions occupied by France (half of Europe by 1810). Paradoxically, he was also an intellectual and patron of the arts and sciences. After meeting Alessandro Volta in 1801 (Figure 1), and being impressed by his invention, Napoleon established the annual Prix du galvanisme.

Figure 1: Volta and Napoleon

In 1801, Volta demonstrated to Napoleon that his pile and galvanism could decompose water into oxygen and hydrogen (depicted igniting the hydrogen). Credit: Sciencesetavenir.fr (artist unknown).



A grand prize of 60,000 gold francs (about 10,000 USD in gold bullion then or 1,000,000 USD today) rewarded achievements comparable to those of Franklin and Volta, with a secondary prize of 3,000 gold francs for lesser achievements (the grand prize was never awarded). Napoleon provided safe travel passes and invited all intellectuals to come to Paris and showcase their talents, creating an environment where a successful presentation could significantly impact a young academic's career. This attracted the best and brightest minds of the age to Paris, transforming it into a major cultural and intellectual hub in Europe.

The "Electrochemists"

In the early 19th century, significant advancements in galvanism mostly occurred in a new field called "electrochemistry", which was driven by young chemists such as Humphry Davy (later assisted by Michael Faraday), Johann Wilhelm Ritter, William Wollaston, William Nicholson and Adolf Ferdinand Gehlen. Ritter resolved the "galvanic dispute" by proving Volta's pile generated electric current through chemical reactions between dissimilar metals separated by an aqueous solution (acid, base or neutral), and it was this current that caused non-spontaneous reactions ("decomposition") in chemical compounds.

Ritter also discovered what he called "chemical rays" existing beyond violet light (ultraviolet) and investigated how different wavelengths of light influenced chemical reactions, including the amazing “photosensitive” property of silver chloride. His pioneering and wide-ranging electrochemistry work would eventually become "photochemistry", "spectroscopy" and "photography". Today, Ritter is recognized as the father of electrochemistry.

Electrochemists used galvanism with abandon to decompose hundreds of chemical compounds, rapidly discovering new elements. The first chemical compound decomposed was water; Wollaston, Nicholson and Ritter found that it decomposed into hydrogen and oxygen in the ratio of 2 to 1 or H_2O (Figure 2, next page). This began the shift in chemistry away from dynamism towards atomism. And unlike physicists, who often engaged in endless theoretical and philosophical debates with minimal experimentation, the electrochemists were very results-oriented.

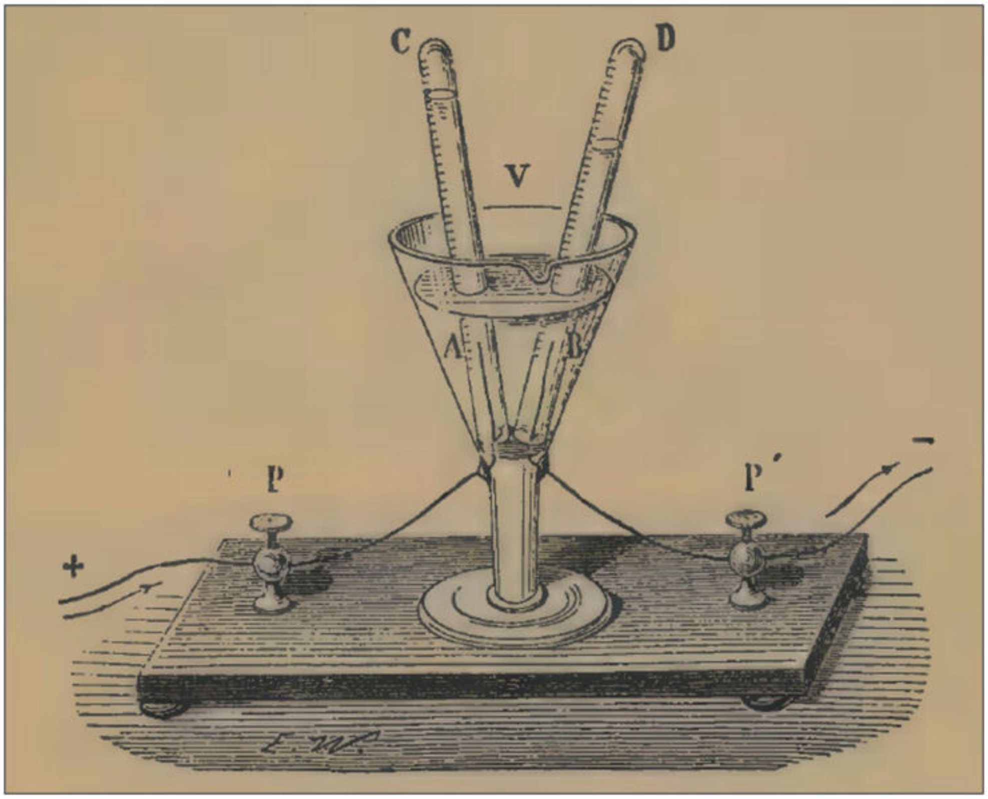


Figure 2: Decomposition of Water using Galvanism
A low voltage (V), constant current through water (A) converts electrical energy to chemical energy, producing hydrogen (D) at the negative terminal (P') and oxygen (C) at the positive (P) terminal in a 2:1 ratio. Credit: William Nicholson, *British Encyclopaedia*, 1809.

When Hans Met Johann

From late summer 1801 to the end of 1803, the brilliant young chemist, poet and Kantian-educated Hans Christian Ørsted embarked on his first grand tour of Europe—a rite of passage for all university graduates—funded by a travel grant from the University of Copenhagen—to deepen his understanding of technical chemistry, particularly in porcelain manufacturing and beer brewing. The most serendipitous and significant event of the tour was his meeting Johann Wilhelm Ritter (Figure 3), a self-taught genius who introduced Ørsted to electrochemistry, magnetic chemistry, experimental physics and hardcore Naturphilosophie. Only eight months older, Ritter had already achieved international fame albeit not fortune. He lived in perpetual debt, which forced him to leave the University of Jena without any degree. Nevertheless, his pioneering research and recognized genius made him a star attraction, and Ørsted was very eager to meet and learn from him.

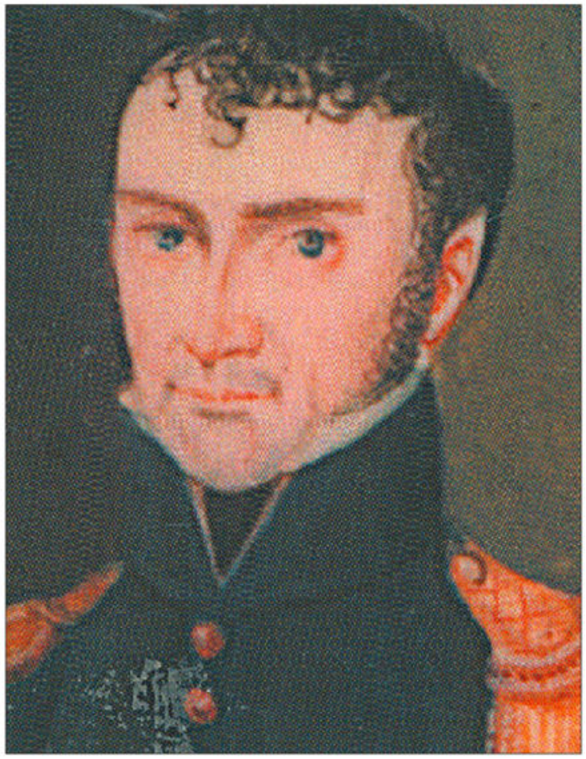


Figure 3: Portrait of Johann Wilhelm Ritter
A coloured version of an 1804 woodcut image based on contemporary descriptions of Ritter, dressed in the Bavarian Academy of Sciences uniform. Credit: *Das Leben des Physikers Johann Wilhelm Ritter*, Klaus Richter, 2003.

Ritter’s thought processes, bold ideas and methods transcended acceptable conventions of natural philosophy (science) in his time, and he suffered for his art in true Romantic fashion. His many admirers and patrons included Goethe and Napoleon's powerful political and military ally, the Duke of Gotha. A German pun on his Johann’s last name reflected their admiration: *"Ritter ist Ritter und wir sind nur Knappen"* ("Ritter is a knight and we are just squires"). However, he had many caustic critics patiently waiting for “the knight” to fall from his high and mighty horse.

A deep friendship blossomed between the two young men, despite Ritter’s self-admitted uneven temperament, use of opium, excessive alcohol consumption, and overspending on equipment and experiments. He was in perpetual debt, always borrowing money and rarely paying it back plus frequently alternated between despair and euphoria, from self-pity and doubt, to arrogance and rudeness.

Plagued by lifelong poor health, Ritter conducted high-voltage galvanic experiments on his body as a counterintuitive method to manage pain. Inspired by Dr. Giovanni Aldini (Galvani's nephew), it was discovered that when two equally painful stimuli occur together, the central nervous system is overloaded, reducing its perception of pain and providing temporary relief both physically and mentally.

Ørsted, in contrast, was sober, cautious, financially and emotionally stable, yet he felt an inexplicable attraction to Ritter, and vice-versa, like opposite poles of two magnets. Over the course of a year, they spent forty days together, engaging in deep-thinking discussions walking in the forests around Jena, visiting its many beer gardens. The two conducted experiments together, with Ørsted documenting Ritter's techniques, promising to always keep them confidential.

Hans in Paris

In December 1802, Ørsted arrived in Paris, where he passively attended lectures, and immersed himself in the artistic and social opportunities the city offered. He hired a tutor, quickly improved his French, which he enthusiastically—perhaps recklessly—used to promote Ritter's work as his unpaid agent among Parisian intellectuals. Hearing about this, Jean-Baptiste Biot, the secretary of the Académie des sciences, asked Ørsted to nominate Ritter for a Prix du galvanisme. Thrilled by this opportunity, Ritter penned a lengthy treatise, writing in his often very difficult-to-follow, stream-of-consciousness Romantic style. He introduced his invention called an "accumulator" (Figure 4, next page) or charging column, along with his discovery that the Earth had electric poles that generated an electric field capable of charging the accumulator. He then described his experiments with magnetic batteries and magnetic chemistry along with his discovery of chemical rays and their photochemical effects.

Unfortunately for Ørsted, he not only had to translate the treatise from German to French, he had to rewrite large portions to make it cohesive and coherent enough for the non-abstract Kantian thinking Académie jury. So he produced four shorter presentations that were published in *Journal de physique, de chimie, etc., Brumaire a. 12 and Frimaire a. 12* (Journal of Physics, Chemistry, etc., Winter 1803).

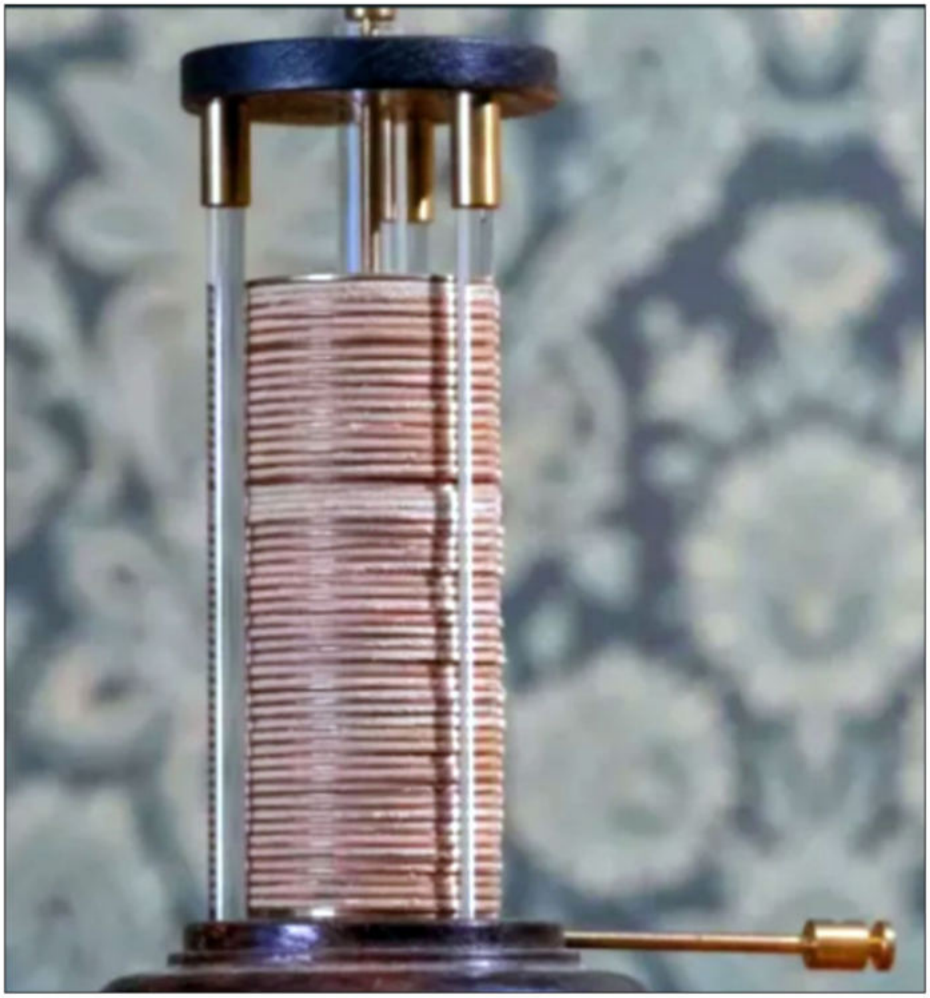


Figure 4: Ritter’s Accumulator
Inspired by Volta, Ritter stacked copper plates separated by cardboard soaked in hydrochloric acid. When connected to a conventional galvanic battery, he discovered it slowly accumulated energy (like a Leyden jar condenser). Then when connected to an electric circuit, the accumulated energy was released slowly like a conventional galvanic battery. Credit: Modern replica; University of Jena.

However, the jury could not agree on any winning presentation for any awards. They ruled that while Ritter's accumulator (the first rechargeable battery) was innovative, it required charging by another galvanic battery. Ørsted, working with Biot and Coulomb, could not prove the existence of terrestrial electric poles and generating an electric that could recharge the accumulator as Ritter claimed. They also struggled to demonstrate his magnetic chemical experiments consistently. The presentation on chemical rays was disqualified because there was no category for “light”. Ørsted was praised for his outstanding efforts in translation and presentation, but also warned he was very foolish for having done so (taking Ritter at his word) considering the outcome.

But Johann had amazing powers of persuasion, especially when manic, and he convinced Hans to throw caution to the wind: *"The grand prize is a sure thing; perhaps even one or two 3000 gold franc awards!"* Then reality came crashing down around them. Ritter was bitterly disappointed because he needed the money plus any award would have validated and elevated his work. And when Ørsted returned home in January 1804, the University of Copenhagen was well aware of his association with Ritter, his apparent "conversion" to Naturphilosophie and the events in Paris. As a result, he was denied a prestigious professorship chair in chemistry or physics for ostensibly violating the terms of his travel grant and being "too much of a philosopher".

The Poison Pen or Quill

Paul Erman was a conservative Kantian physicist, one of only four men to win the secondary Prix du galvanisme. He and his colleague Johann Friedrich Pfaff were well-known opponents of Naturphilosophie and its “knight”, Ritter. In March 1806, Ritter recklessly called them out in his treatise *Die Physik als Kunst* (Physics as Art), which he presented at the annual foundation celebration of the Bavarian Academy of Sciences. He criticized the narrow-minded aspects of Kantian philosophy and his equally narrow-minded contemporaries. Ritter challenged the notion that knowledge could only be derived from empirical evidence and rational deduction, and argued for a more integrated and holistic scientific approach that encompassed artistic, emotional and philosophical dimensions. He encouraged a re-examination of how science is perceived and studied, and called for a richer engagement with the natural world that transcended dissection and analysis of its bits and pieces. It was pure Romanticism.

Then, in 1807, Erman and Pfaff struck back hard in *Annalen der Physik* (Annals of Physics), the highly influential German physics journal then and now, ridiculing Naturphilosophie, metaphysics, pseudoscience and Ritter. They argued that there was no place for his artsy, abstract thinking in the unemotional and analytical world of science, which was focused on the facts not fictions. Having won that prestigious prix and money made Erman a superheavyweight giant, and when he walked and talked the world of physics shook and listened.

Coordinated attacks against Naturphilosophie also appeared in *Annalen*, written by its editor Ludwig Wilhelm Gilbert, who asserted that the "vogue" of galvanism had passed. He condemned Naturphilosophie's "abuse" of duality and polarity along with its metaphysical assumptions and methodologies, calling them "repugnant." Adding, *"The effect of Naturphilosophie was worse than ten defeats by Napoleon!"*

Requiem for a Heavyweight

Ørsted distanced himself because he was back in good standing with the University of Copenhagen with a professorship chair in physics (1806) and career to protect. The two men never met again, although they corresponded covertly through intermediaries. In January 1807, Ritter was upbeat and optimistic:

> *"I cannot deny that magnetism appears to me as the very cause of electricity. The connections between electricity, magnetism, and the phenomena we observe continue to intrigue me, and I am excited about the potential discoveries that lie ahead. Please keep me informed of any relevant findings or thoughts you may have; my interest in our shared inquiries is unwavering. It is through our correspondence and collaboration that I believe we can make significant strides in these fields."*

However by February 1808, his tone had changed:

> *"There are indeed several sides attacking me, and, which I would never presume Pfaff to do, quite maliciously; (Gilbert, Erman, etc.). It is seen as a general defeat. But I will truly show them that I am 'the Knight'. Gilbert will likely be dealt with quite briefly by Tieck's Old Frank, but Erman should keep the struggle in mind. He has already been announced to him. It is despicable to refute as he does; I mean the metal charges and the electrical polarity of the magnet. I stand now on firmer ground with my little knowledge than ever before. I remained silent for a year and more, but I studied. However, Pfaff still does not have what I call electrical calculus in his possession. I particularly refer to a very palpable work that he has just sent to Gehlen against my electrical system. There are many and nice experiments in it; only the reasoning is worthless."*

Ritter's "electrical system" proposed a theoretical framework connecting galvanism, magnetism and chemical processes for which he faced harsh criticism from others because of his lack of any empirical evidence, but Ørsted believed.

Note: Ludwig Tieck's 1804 comedic play, *Der Alte Fränkin* (Old Frank), highlighted Romantic ideals that valued imagination and emotion over rationalism and empiricism. Tieck uses humour and satire to challenge various people "Old Frank" encounters on his travels, pointing out the absurdities and contradictions in their perspectives, highlighting the foolishness of fanatical adherence to societal expectations and conventions.

Ritter's last letter to Ørsted was dictated to Gehlen on December 27, 1809. He was destitute and unable to support his family. Bedridden for months, in chronic pain, with failing eyesight and hearing, barely able to speak, he still ended on an optimistic note:

> *"Now we must conclude, good friend! Do take care of this letter and answer it as well as you can, and as soon as it is possible; you will have contributed significantly to my recovery. I will view life as a completely new gift afterward and will manage it according to stricter, more measured laws than before.*
>
> *J. W. Ritter*
> *I embrace you warmly.*
>
> *PS For security reasons, please send your response to Herr Gehlen."*

Ørsted's reply letter was received and read by Gehlen to Ritter on January 22, 1810. He died the next day, at age 33, a physically and mentally broken man.

Note: Adolf Ferdinand Gehlen played a vital intermediary role during a period of intense political, philosophical and ideological conflict. His support and connections enabled covert communications among academics. Throughout Ritter's final years of professional and personal struggles, Gehlen did not abandon him as others had. Because his meagre estate was sold piecemeal over the years to support his widow and four children, less than one-third of Ritter's personal written material (letters, lab notes, journals, etc.), not published elsewhere, has been recovered and archived.

Epilogue

In his 1818 *Account of the History and Present State of Galvanism*, Dr. John Bostock writes:

> *"Although it may be somewhat hazardous to form predictions regarding the progress of science, I may remark that the impulse, which was given by Galvani's original experiments, was revived by Volta's discovery of the pile, and was carried to the highest pitch by Sir Humphry Davy's application of it to chemical decomposition, seems to have, in some measure, subsided. It may be conjectured that we have carried the power of the instrument to the utmost extent of which it admits, and it does not appear that we are at present in the way of making any important additions to our knowledge of its effects, or of obtaining any new light upon the theory of its action."*

My Final

The world of physics would so not be ready for the head-on collision and pileup to be caused by Ritter's protégé. But first, we have to take a little side trip in part 3.—73

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