RADIO MAGiC


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# The Road to Radio—Part 3

## Introduction

*“The application of galvanism is still in its infancy, and perhaps we will still be reduced to groping for a long time.”*—Giovanni Aldini.

Our Humvee’s quantum time-jump drive backfired, sending us to Paris in 1802. While we wait for the drive to slowly solar recharge, here are two lesser-known backroad stories you may find interesting.

## Mojon and Romagnosi

Giovanni Aldini (writing as “Jean” in French) is in Paris working on his *Essai théorique et expérimental sur le galvanisme* (Theoretical and Experimental Essay on Galvanism). Concurrently, in Genoa, Italy, chemist Jean-Baptiste Mojon is exploring the physiological effects of Alessandro Volta’s new invention (the voltaic or galvanic pile/battery) and its magical dynamic electricity (galvanism) à la Aldini. He has also seemingly validated Charles-Augustin de Coulomb's magnetic fluid theory that magnetism, generated by magnetic molecules, is an intrinsic property of matter. Mojon wired steel sewing needles together across the terminals of his batteries and discovered that they slowly became magnetized and polarized, challenging the prevailing belief that magnetic poles formed only between the open wire ends.

***Note 1:*** *Early batteries had, unknown at the time, high internal resistances (several to hundreds of ohms) and could be safely short-circuited although this accelerated zinc electrode oxidation.*

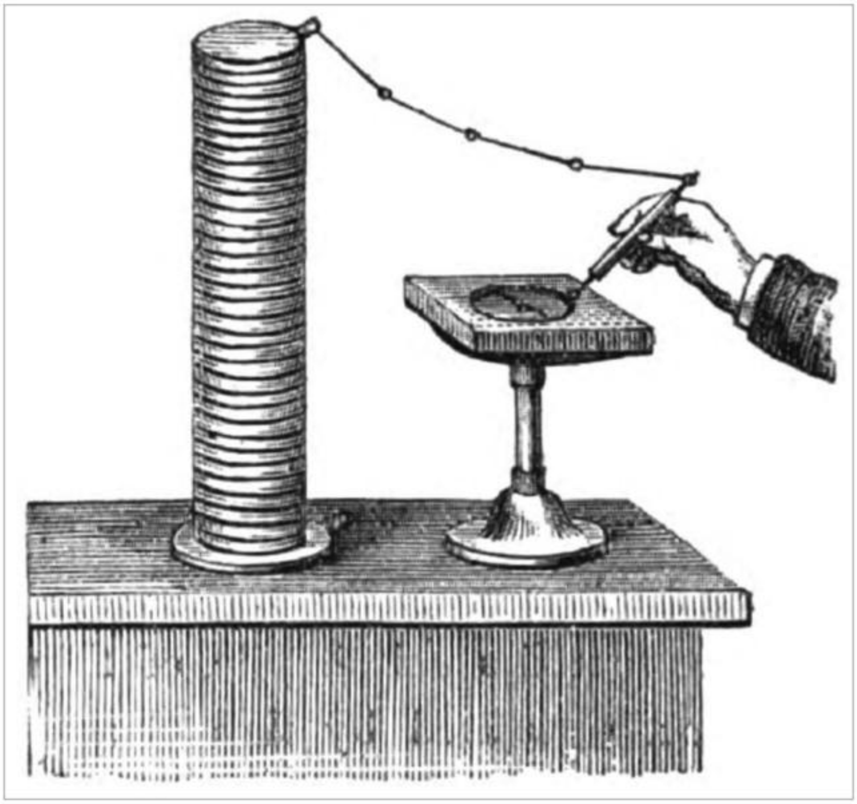


**Figure 1: Romagnosi's Experiment**
Credit: Contemporary drawing by Gilberto Govi, 1869.

Meanwhile, in Trento, Italy, consigliere (lawyer) Gian Domenico de Romagnosi, like many amateur electricians—the term for those engaged in the study or speculative use of electrical phenomena—was also captivated by Volta's invention and galvanism. Breaking free from "functional fixedness", he wondered whether a magnetic compass, used to detect the Earth's magnetic field, could also detect Coulomb's magnetic fluid. Romagnosi built his battery using thin stacked discs of copper and zinc, separated by flannel soaked in sal ammoniac (ammonium chloride). He connected a silver chain to one battery pole, through a short glass tub, which he held in his hand, terminating the other end of the chain in a silver knob. He took a compass, placed it on a glass stand, removed its cover, and touched one end of the needle with the silver knob (Figure 1). After a few seconds of contact, the compass needle declined (deviated) to a new position, where it remained "stuck" even after removing the knob.

Repeating this process produced more deviation in the needle but it always stayed stuck in the new position. Romagnosi suspected that the needle's magnetism was affected by galvanism so he brought various ferrous objects close to the compass needle (without touching it) and found it no longer reacted! He writes:

> "In order to restore the polarity, Romagnosi took the compass box between his fingers and thumbs, and held it steadily for some seconds. The needle then returned to its original position, not all at once, but little by little, advancing like the minute or second hand of a clock."

**Note 2:** Ammonium chloride is a white crystalline salt and highly soluble in water becoming acidic. A very versatile chemical compound, used in textiles, pottery, medicine, as a fertilizer nitrogen source, to remove oxide coatings from metals and as an electrolyte paste in modern carbon-zinc dry cells.

As any astute lawyer would, he demonstrated this effect before several witnesses, and to establish his priority of discovery, published a short account in the *Gazzetta di Trento* (August 3rd, 1802), followed by a detailed version in the *Gazzetta di Rovereto* (August 13th). One of the witnesses is believed to be Pietro Configliachi, editor of the *Giornale di Fisica, Chimica, Storia Naturale, Medicina ed Arti* (Journal of Physics, Chemistry, Natural History, Medicine and Arts). Although Configliachi may have assisted with drafting the gazetted accounts, he did not include either version in *Giornale.* But we do know that he knew the details of the experiment because he will tell the academic world about it—down the road.

The first sentence of both gazetted accounts simply states:

> "The Counsellor, Giandomenico de Romagnosi, living in Trento, known to the republic of letters by his learned productions, hastens to communicate to the physicists of Europe an experiment showing the action of the galvanic fluid on magnetism."

He was the first to use the terms “galvanic flux” and “magnetic action”, and he understood that only the galvanic flux generated by his battery could temporarily desensitize the magnetic compass needle. He also differentiated magnetic action from the effects of static electricity because in the *Rovereto* version, he writes (in the third person):

> “He then put the needle under the action of Electricity, both vitreous and resinous, using a tube of rubbed glass or sealing-wax. The needle was strongly attracted and at some distance from the tube.”

“Electricity” (vitreous and resinous) means static electricity and refers to Charles du Fay’s theory of positive and negative electric fluids, which Coulomb championed. This created a formidable groupthink among young European physicists, such as André-Marie Ampère, creating a roadblock in their minds.

**The Fork in the Road Not Taken**

In early October 1802, Romagnosi submitted his discovery (written in Italian) to the French Académie des sciences for consideration for Napoleon’s new Prix du galvanisme. Upon receipt, his paper was immediately mistranslated and misinterpreted: “Romagnosi” became “Romanesi”, “counsellor” changed to “physicist” and an external “magnetic compass needle” and “open galvanic circuit” morphed into “a magnetic needle closing the galvanic circuit.” Of course, without a magnetic compass being involved no fixed in-circuit needle could possible decline! To be fair, the novelty of the Volta’s pile/battery and dynamic electricity, multiple fluid models and theories, the lack of standard terminologies, experimental procedures, metering equipment or a common measurement system was very problematic in these early years of "groping".

If an experiment cannot be accurately reproduced by others and produce the same claimed results, it is usually dismissed. According to the Académie’s records, no formal report was submitted, but Volta, a jury member at the time, was verbally informed, and he must have mentioned “Romanesi” to Aldini, who conflated it with Mojon’s experiment because, in *Essai*, page 191, he writes:

> "Mr. Mojon kindly shared his experiment with me recently. Having placed very fine sewing needles horizontally, each two inches long, he connected both ends to the two poles of a device with a hundred glass cups. After twenty days, he removed the needles, which were slightly oxidized but at the same time magnetic, with very noticeable polarity. This new property of galvanism has been observed by other researchers, and recently by Mr. Romanesi, a physicist from Trento, who found that galvanism caused the magnetic needle to decline."

If Volta or Aldini had read their countryman's gazetted accounts or the original Prix submission before it was "lost in translation" they would have recognized the significant difference from Mojon's experiment. But it was not to be. Soon after, Romagnosi accepted a professorship chair at the University of Parma leaving him little spare time for his hobby. And that was that. In my view, he rightfully deserves historical acknowledgment for having priority of discover for what I call the "Romagnosi effect". He the first to use a magnetic compass to investigate interactions between galvanism and magnetism. Mojon and Romagnosi had unknowingly found two critical corner pieces required to solve a much larger puzzle.

**When Hans Met Jean**

A short test time-jump to a year forward keeps us in Paris but now it is summer, 1803. Aldini hears high praise for a 25-year-old natural philosopher named Hans Christian Ørsted who is making the rounds in Parisian academia acting as German physicist Johann Ritter's unpaid agent (Part 2 refers). He met with Ørsted several times and must have been impressed because Aldini asked him to contribute an article for *Essai*. However, instead of being flattered, Ørsted writes this in his July travel letter:

> "Aldini, whom I have already mentioned, a rather ignorant Italian professor who travels around and gives himself airs with galvanism because he is the nephew of Galvani, believes himself destined to enlighten all the nations north of Italy. Aldini is to publish a work on galvanism for which he needs some information from me. His greatest merit is that he has the honour of being Galvani's nephew. I do not intend to give him very much. I shall not go farther than a short report on Ritter's discoveries, of which he is ignorant like so many other scholars here."

Ørsted eventually sent his article albeit too late for it to be included in the book. Nevertheless, Aldini included a “Thank you” credit in an addendum and also him sent a courtesy copy of *Essai*. Serendipitously, in the index, right under Ritter’s entry (who previously provided Aldini information about his physiology experiments using galvanism) we find: “Romanesi a fait des tentatives sur l'aiguille aimentée, 191” (Romanesi made attempts with the magnetized needle, [page] 191). And Ritter also referenced Aldini and *Essai* regarding a different matter in a later letter to Ørsted. So Hans cannot claim that he was not aware of Romanesi’s (Romagnosi’s) prior work.

**Romagnosi Rediscovered**

> “To ensure success in the experiment, one needs the following precautions: not all galvanic piles are suitable for the experiment, only those whose discs have at least a thickness of a linea and are two inches in diameter; it is convenient to use an insulated pile and not for an extended duration to avoid rapid oxidation at the surface of the discs; it is advisable to keep the chains suspended so they do not touch any body conducting electricity and to handle them with the glass tube; occasionally, to expedite the experiment’s success, it is beneficial to touch the point of the needle with both knobs and then make it deviate with one of them; and be sure to handle the chains with bare hands to excite the apparatus, as the galvanic flux often experiences interruptions.”—Gian Romagnosi.

***Note 3:*** *The linea (2.25 millimetres) is an archaic unit of linear measurement.*

In his first account, Romagnosi implies that he left the battery in the open-circuit condition and used a singular chain, glass tube and knob. However, the second account uses the plural: silver chains and knobs plus he mentions touching both knobs to the compass needle. Is this a different second experiment with an intentionally (or unintentionally) closed electric circuit? From my research, aside from anecdotes and hearsay, no one who has written about Romagnosi's experiment has even bothered to replicate it! I do not a working reproduction of an 1802 copper-zinc battery, yet (still waiting), but we have modern equivalents albeit much smaller with less stored energy. So can modern carbon-zinc or alkaline AA cells passively generate a static magnetic force that attracts or repels magnetic compass needles? Let us see.

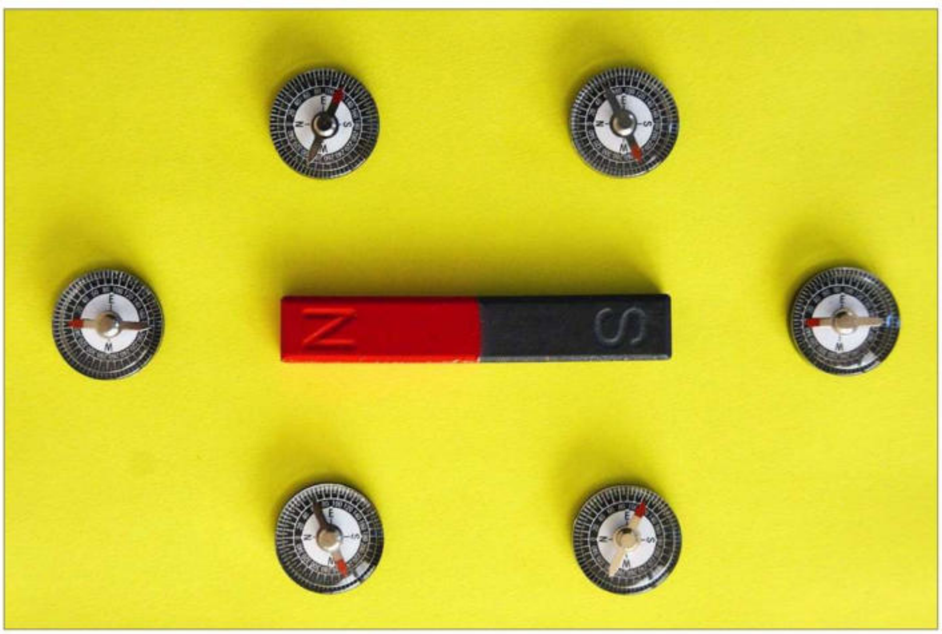
***Note 4:*** *A cell is a single unit device that converts electrical energy to chemical energy while a battery is a group of cells connected together.*

**Experiment 1**

Six inexpensive air-damped magnetic compasses are oriented to magnetic north and arranged to form a cavity. As a control reference, a bar magnet is placed inside the cavity, and the declinations of the compass needles from magnetic north were noted (Figure 2A).

**Figure 2A: Magnetic Field around a Bar Magnet**

Demonstrating the orientation of the magnetic field surrounding a bar magnet.




**Experiment 2**

The bar magnet was replaced with a fresh carbon-zinc AA cell and then an alkaline cell (Figures 2B and 2C, next page).


**Figure 2B: Magnetic Field around an AA Carbon-Zinc Cell**
The compass spacing is reduced because the cell's generated magnetic field strength is much weaker, yet the compass needles still deviate from magnetic north albeit they appear "uncertain".


**Figure 2C: Magnetic Field around an Alkaline AA Cell**
The Duracell brand produced the strongest and most reliable deviations in the compass needles similar to those caused by the bar magnet.

## Experiment 3

The tangent law of magnetism allows us to measure the interaction between two magnetic fields that are 90 degrees (orthogonal) to each other. The understanding of how magnetic fields influence compass behaviour and the required corrections was known and applied by mariners for centuries based on generations of observation and experience. For this experiment, the compass was oriented to magnetic north and an AA cell's positive terminal was moved from the side toward the compass until the compass needle deflected 45 degrees (Figure 3A). When this occurs both magnetic fields are equal in strength because the tangent of 45 degrees equals one. Measuring the distance at this point allows for comparative tests with other cells and magnetic fields. I also conducted the experiment using a bar magnet (Figure 3B, next page).

**Figure 3A: Tangent Law of Magnetism Demonstration Using AA cell**

The compass (orientated to magnetic north beforehand) needle is deflected 45 degrees at a distance of 33 millimetres from the compass' centerline by the alkaline cell's static magnetic field. At this angle, both magnetic field strengths are equal (55.7 µT at the time of the experiment at my location). But Earth's magnetic field is slightly decreasing daily. See https://www.magnetic-declination.com.

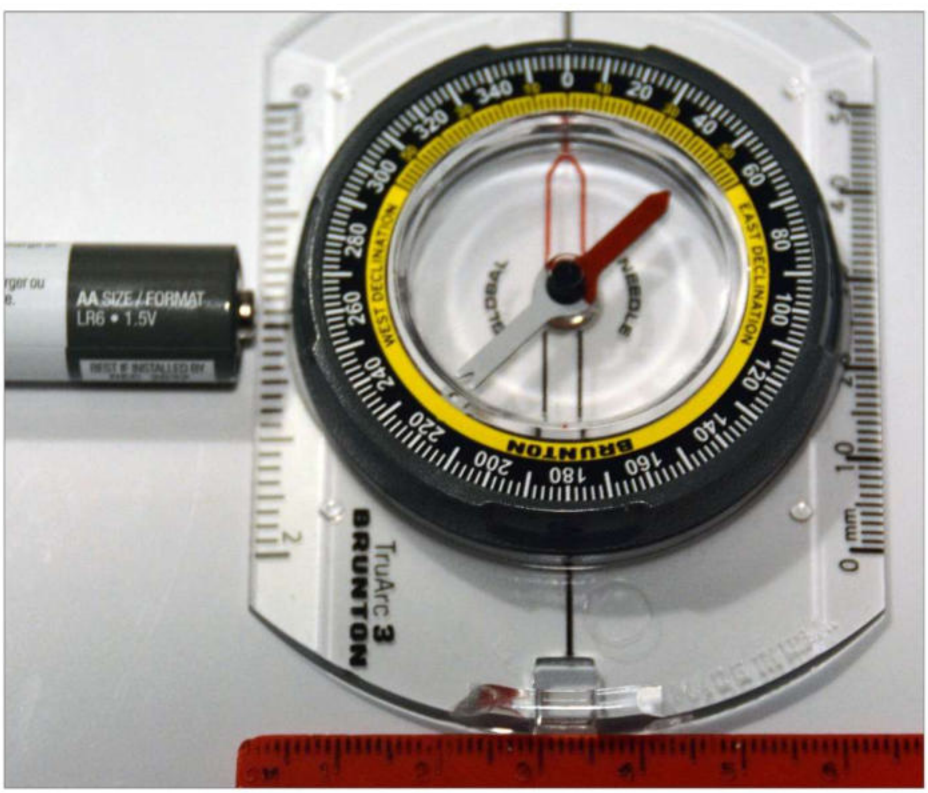


**Figure 3B: Tangent Law of Magnetism Demonstration Using Bar Magnet**
The bar magnet was able to easily deflect the compass needle by 45 degrees at a distance of 174 millimetres, over five times farther away than the AA alkaline cell.

## Conclusion

Modern electrochemical cells have steel or other types of metallic cases; however, if the compass needles were only attracted to the cases or any metallic particles floating in the electrolyte, the six compass needles would all point to the same general direction with no polarity bias. The consistent observed and detected directional polarity generated by the AA cells suggests that an intrinsic link exists between the electrochemical process and magnetism (as Ritter also believed). This raises the possibility that Romagnosi's much larger and much more powerful electrochemical battery could have generated a strong static magnetic field, even open-circuit, and that this caused the compass needle's strange behaviour and also desensitized it. Romagnosi was possibly correct in his conclusion and limited understanding that galvanic fluid can affect external magnetism, and that this was not caused by static electricity or a defective compass (the common historical beliefs). But until I get my working model of an 1802 galvanic battery and repeat the experiment to remove all doubt one way or the other, I must defer to Sir Isaac Newton's famous dictate:

> "I frame no hypotheses [hypotheses non fingo]; for whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy."

**My Final**

Science (natural philosophy to Newton et al) is not about seeing; it is not about believing; it is about understanding and there was no understanding at the time. The obvious will remain oblivious for many more years of “groping” and kilometres to go until someone rediscovers and combines Mojon and Romagnosi’s experiments. —73

## Additional References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