Exploring biographical possibilities of a late 19th century electromagnetic rotation apparatus

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This essay discusses possible interpretations about the existence, meaning and importance of an artifact (Inv. Num. 1036) from the Deutsches Museum in Munich identified as a version of Faraday's electro-magnetic rotation apparatus. Gessner's model was used to obtain as much information about the object as possible, which was contrasted with the experience of building and handling a replica designed to be as close as possible to the original instrument in structure. The results show how a material culture approach to the history of science can offer ways of elucidating aspects of the life of a given object even when its written documentation is scarce or inacessible, proving to be complementary to other traditional approaches in the field.

Keywords: Michael Faraday, Deutsches Museum, Electromagnetism, Material Culture

Introduction

From the second half of the 20th century onwards, new ways of understanding material culture emerged, which had previously been relegated to a position of lesser relevance than what written sources could offer to the study of history (Furtado 2017). The premise of this perspective is based on the idea that artifacts, as human constructions, capture elements of the cultural panorama that allowed them to emerge just as much as texts do (Prown 1982). For the history of science in particular, instruments and all kinds of objects associated with scientific practice are not only connected to the state of science at the time of their conception, but they also present an epistemological nature that have often been responsible for directing the course of its transformations (Baird 2004).

Since then, new methodologies have been developed to encompass the complexity of artifacts, among which Fleming's model, also known as the Winterthur model, stands out (Fleming 1982). With a focus on history of art, this model aimed to offer four stages of analysis that would consider a variety of aspects surrounding the existence of a given artifact: (1) identification, (2) evaluation, (3) cultural analysis and (4) interpretation. The analysis begins with identification, which consists of a pure and objective description of the artifact and continues with information obtained from similar objects and the cultural context of origin, as well as the researcher's own perception based on present values.

Scientific artifacts, however, have specific characteristics that distinguish them from other types of artifacts. Gessner's model, based on Fleming's, emerged to offer a specific way of looking at them (Lourenço & Gessner 2014). Since scientific artefacts are interrelated with past and present theories and their functioning is a central part of their existence, the author reorganizes the stages proposed by Fleming into four categories: singular aspects, generic aspects, synchronic and diachronic vision. These categories intersect and complement each other.

According to this model, an artifact can be viewed from a synchronic view, referring to the current state of the object, such as its pure description and the current explanation for its functioning, or through a diachronic view, referring to its historical use, its role and the contemporaneous explanation for its functioning. Information obtained from the object itself is what is known as singular aspects, while information obtained in comparison with similar objects and from the scientific context surrounding the object, whether contemporary or current, makes up generic aspects. As Lourenço and Gessner argue, the model provides clear guidelines for the study of scientific objects whose documentation is scarce, as is the case with the object discussed throughout this text.

The aim of this essay is to present the stages of a material culture approach to one of the objects belonging to the founding collection of the Deutsches Museum in Munich, donated in 1905 by the Bavarian Academy of Sciences (Fehlhammer & Rathjen 1999). It consists of an apparatus designed to demonstrate a current-carrying wire revolving around a magnet, catalogued as Inv. Num. 1036. Its origin is briefly documented and further information about what it was, how it worked, its meaning and purpose during its life at the Academy was at first unknown. The results were obtained using a mixed methodology that combined Gessner's model mentioned above and the construction and use of a replica, which helped to elucidate the main elements of its history as a scientific artifact.

This essay combines the results of a group assignment carried out at the Deutsches Museum as part of the International Seminar on Material Culture in the History of Physics, which took place in March 2024, followed by individual research. The steps of material description and its identification as a version of an apparatus developed by Faraday resulted from joint work during the activity and are compiled in the first section and partially in second section. As a subsequent development, I concluded that one of the versions of Faraday's apparatus was very similar to the object being dealt with and I used the documentation available about it to understand how it worked, the main results of which are in second section. Some of the questions that arose from this analysis were answered by building the replica mentioned above. A brief description of the replica and the results I obtained from it are in the third section. The fourth section discusses previous results to answer what the purpose and meaning of this object might be, considering that it is catalogued in the Deutsches Museum as an educational instrument, revealing a possible narrative for its biography.

The object

When first looking at the object, two main separable parts can be identified (fig. 1). One consists of a glass tube 17.0 centimeters long and 2.7 centimeters in diameter with cylindrical wooden caps at its lower and upper ends, measuring approximately 2.0 and 3.0 centimeters in length respectively, in which metal parts can be identified that traverse it from the outside to the inside (fig. 2). The other consists of a 21.6 centimeter long metal rod attached to a circular metal base with a diameter of 9.0 centimeters and three approximately spherical pieces act as a tripod at the bottom.

Fig. 1 Inv. Num. 1036 with and without the mount. Source: Deutsches Museum. Photographs taken by the author.

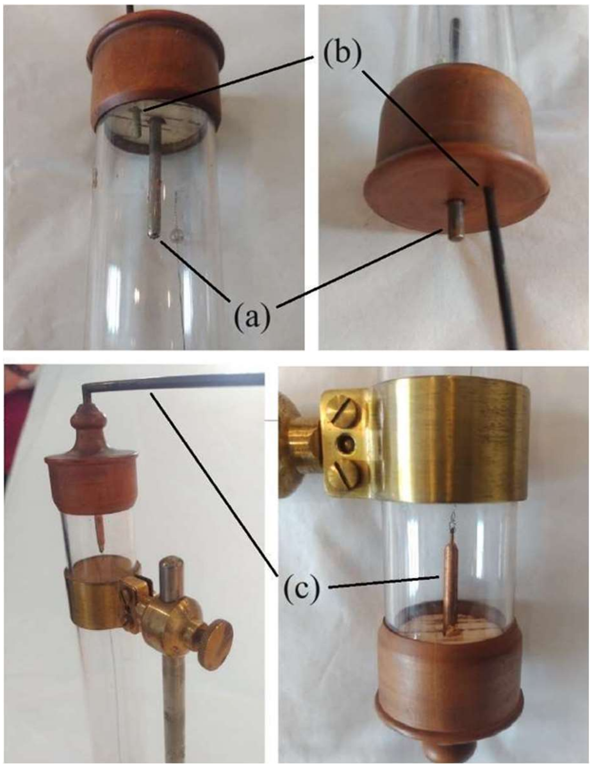

Fig. 2 Caps and metal pieces in both ends of the tube. Source: Deutsches Museum. Photographs taken by the author

The rod supports the glass tube by means of a brass-colored metal piece that holds one to the other. At one end, the part takes the form of a cylindrical shell that embraces the glass tube and holds it in place with two screws. At the other end, there's a cylindrical hole through which the metal rod passes and is held in place by a screw. With the help of an experienced curator from the Deutsches Museum, this screw could be loosened, and the two main parts separated, allowing the tube to be handled individually.

The lower cap has two circular holes through which cylindrical metal pieces traverse, one, the piece (a), with a silvery color, has a diameter of approximately 3 millimeters and is located exactly on the axis of symmetry of the cap. It extends about 3.0 centimeters into the tube. The other, piece (b), which is dark and matt on the outside and dark and greenish on the inside, is located almost at the mid-point of the cap's outer radius, has a diameter of slightly less than 2 millimeters and extends less than 1.0 centimeter into the inside of the tube.

In addition to the cylindrical body and a circular hole also on the axis of symmetry, the upper cap has a rounded adornment. The metal piece (c) that runs through it looks dark and matt on the outside of the tube, but coppery on the inside, with a diameter of approximately 3 millimeters. This same piece, which has a shape like the Greek letter capital gamma (Γ), has a nearly horizontal portion measuring 10.5 centimeters, an external vertical portion that is away from the glass tube measuring 13.3 centimeters, and a vertical portion that crosses the cap measuring around 5.5 centimeters. Both caps have a piece of cork inside the tube that covers the entire base.

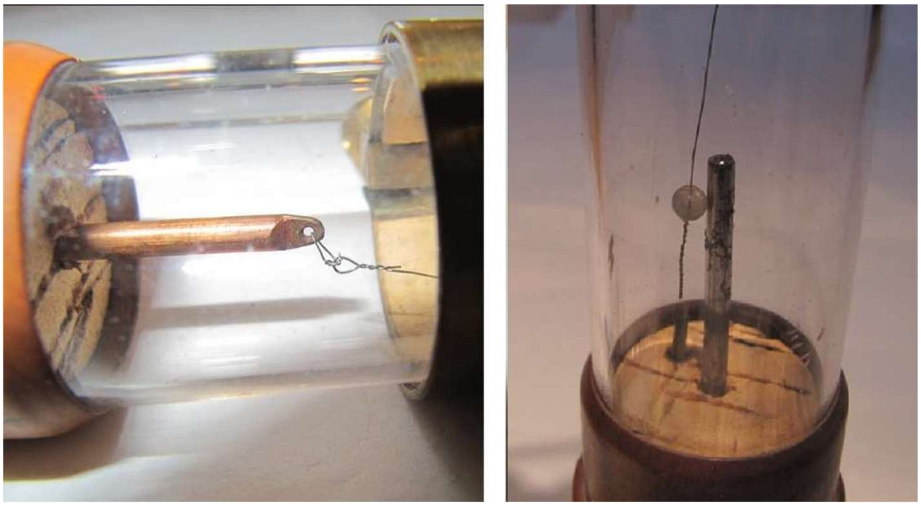

Fig. 3 A closer look at the upper and lower part of the hanging wire. Source: Deutsches Museum. Photographs taken by Łukasz Kowalski.

Piece (c) has a flattened part on the inside of the tube where there is a small hole from which a filament with a small thickness (less than a millimeter) and a silvery appearance hangs via two small loops (fig. 3), extending almost the entire length of the tube and ending just above piece b at the bottom. A spherical bead of transparent material is surrounding the filament near its lower end. Below it, the filament is wrapped around itself in short loops. The loops at its upper end leave the filament considerably free to move like a pendulum, which is noticeable as soon as you gently manipulate the tube. All the other parts seem firmly attached to each other and show no signs of being movable.

The only inscription that could be identified on the object was the number 1036 at the top of the base of the glass tube support and the guess was that this was a number associated with the object's registration in the museum catalog, information that was confirmed from the documentation available on the object. There is no mention of the instrument's maker. A notable detail that doesn't seem to have been included intentionally, but rather as a mark of use, is an almost imperceptible horizontal circular marking on the glass tube located at the same height as the bead, best seen against a white background (fig. 4). Another equally important feature is that (a) appears to contain residues of some orange-colored material on its surface, the same as those present on adjacent parts of the tube. None of the parts of the object could be precisely determined in terms of composition, as we didn't use any method of analysis in this matter.

Fig. 4 Circular marking on the glass. Source: Deutsches Museum. Photograph taken by Łukasz Kowalski.

Working principle and similar objects

Looking at the documentation available on the history of the object in the museum, we find that it is a teaching instrument from before 1870 and, as previously mentioned, was donated by the Bavarian Academy of Sciences in 1905, a year before the Deutsches Museum opened. The object is registered under the name, "Apparatus for demonstrating the rotation of a current carrying wire around a magnet"[1] (Deutsches Museum 2024).

It is meant to reproduce a basic electromagnetic phenomenon. The action of the magnetic field produced by the magnet causes a force upon the electric current passing through the hanging wire that is perpendicular both to the direction of the wire and to that of the magnetic field vector, resulting in an accelerated circular movement around the magnet. Today, devices with this type of operation are known as homopolar motors, or in other words, motors that produce rotations without alternating magnetic or current poles (Stewart 2007). Motors of this nature are currently used in physics teaching as demonstration experiments and are famous for their simplicity and low cost, requiring only wires, an ordinary battery and a magnet (Stewart 2007; Assis & Chaib 2012; Doff & Szmoski 2016) (fig. 5).

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[1] *Apparat zur Demonstration der Rotation eines stromdurchflossenen Drahtes um einen Magneten.*

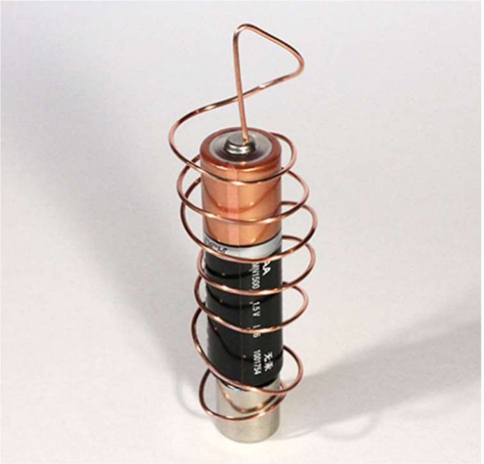

Fig. 5 Example of a simple homemade homopolar motor. Source: National Science Week (2023).

Objects of this type appeared at the beginning of the 19th century following the popularization of Oersted's experiment and soon after their advent multiplied into many versions. The first were idealized by Michael Faraday (1791–1867) in 1821 and created by instrument maker John Newman (1783–1860), who worked for the Royal Society during the first half of the early 19th century (Gee 1991). In Faraday's time, this instrument, which was not yet recognized as a motor in today's standards, served as a demonstration of a newly discovered phenomenon that challenged existing conceptions of the interaction between currents and magnetic fields.

The theory that was in vogue was proposed by André-Marie Ampère (1775-1836), who set out to explain electrical and magnetic phenomena in terms of the forces between electrical currents. According to Ampère, the currents could produce attractive or repulsive forces between them, depending on the spatial arrangement of the conductors. The effect of magnets on currents and vice versa could be explained in the same way by admitting the existence of microscopic current loops inside a magnet (Steinle 2005; Assis & Chaib 2012).

Faraday, on the other hand, was suspicious of Ampère's approach. He argued that the forces of attraction and repulsion described by the French physicist should be seen as complex results rather than fundamental principles. In a sequence of experiments recorded in his diaries, Faraday affirms that

> Every thing tends to prove that there is no attraction between the poles of the magnet and the wire, but only motion in a circular direction, and all the motions of the magnet or its poles about the wires may be deduced from this. When the single pole was floating upon the mercury it shewed it both by revolving round single wires and passing through double ones. (Faraday 1933: 51)

His 'Electro-magnetic Rotation Apparatus' was thus produced with the clear intention of not only demonstrating the phenomenon he had observed for the first time, but also defending his own theory of electricity and magnetism. The instrument was produced in two versions presented in a publication entitled On some new Electro-Magnetical Motions, and on the Theory of Magnetism in the Quaterly Journal of Science in 1822.

Fig. 6 Faraday's original rotation apparatus. Source: Royal Institute.

The first version of the instrument, and perhaps the most famous, brings together in the same instrument two related demonstrations, a current carrying wire revolving around a magnet, and its inverse, a magnet revolving around a current carrying wire. The instrument is divided into two main parts in the form of glass cups containing mercury, allowing current to pass through a fixed conductor around which the magnet in one of the cups revolves, or through the hanging wire that revolves around the fixed magnet in the center of the other cup. One of the originals used by the British scientist is currently kept by the Royal Institution on display in what was once his magnetism laboratory (fig. 6).

What brings us to Faraday's work, however, is the second version of the instrument presented in the same article, which is very similar to the object in the Deutsches Museum (fig. 7). It was intended to be sent to scientists in England and other European countries, such as France and Germany, as a strategy to promote the acceptance of his experimental results (Baird 2004):

> It consists of a piece of glass tube, the bottom part of which is closed by a cork, through which a small piece of soft iron passes, so as to project above and below the cork. A little mercury is then poured in, to form a channel between the iron wire and the glass tube. The upper orifice is also closed by a cork, through which a piece of platinum wire passes which is terminated within by a loop; another piece of wire hangs from this by a loop, and its lower end, which dips a very little way into the mercury, being amalgamated, it is preserved from adhering either to the iron wire or the glass. When a very minute voltaic combination is connected with the upper and lower ends of this apparatus, and the pole of a magnet is placed in contact with the external end of the iron wire, the moveable wire within rapidly rotates round the magnet thus formed at the moment; and by changing either the connexion, or the pole of the magnet in contact with the iron, the direction of the motion itself is changed. (Faraday 1844: 150–151)

Although some of the materials found in the object of the Deutsches Museum were not mentioned or even used, such as the wooden caps and the apparent absence of (b), both instruments have many similarities in structure and function. The movement of the wire in Faraday's apparatus is compatible with the circular markings observed on the tube, which are exactly at the height of the spherical bead attached to the wire, probably caused by friction. The use of mercury not only explains how the circuit closes inside the instrument but would also explain the residues identified on (a) and on neighboring parts of the tube.

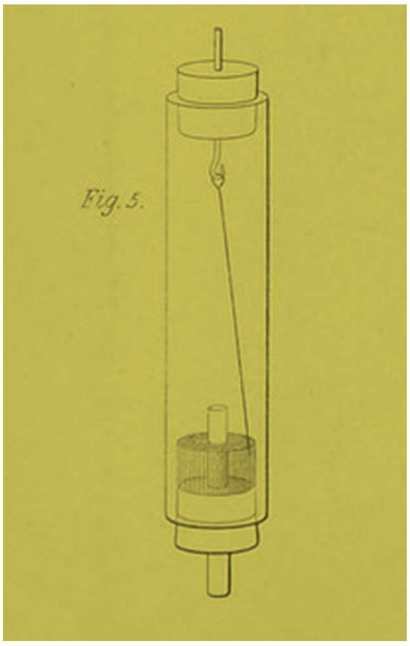

Fig. 7 Second version of Faraday's rotation apparatus. Source: Faraday (1844).

Regarding its dimensions, Faraday's apparatus is of uncertain size. In a letter he wrote to Ludwig Wilhelm Gilbert (1769–1824) (James 1991), the length and diameter of the tube are said to be approximately 3.8 cm and 0.8 cm, which is significantly smaller than the instrument in the Deutsches Museum. Another copy of the instrument sent to Jean Nicolas Pierre Hachette (1769–1834) and Ampère was described in a *mémoire* published in the *Annales de Chimie et Physique* as 8.0 cm long, with no information on its diameter (Ampère 1821: 330).

Faraday himself seemed to be more interested in delivering the phenomenon to his peers than in producing an apparatus of fixed dimensions, as it would not interfere significantly in its function. It is also possible that the instruments had the same dimensions and that the authors adopted different measurement standards, including or excluding the part of the upper and lower conductors that extends outside the tube, but no other historiographical source confirms or denies this hypothesis.

The fact is that the instrument in the Deutsches Museum does not appear to be one of these original versions of Faraday's apparatus, based on its dimensions and structure. The description in the museum also disagrees with the working mechanism. Most aspects match, but there is no mention about mercury. On the contrary, it is suggested that the instrument works through direct contact between the hanging wire and (b):

> [...] A long, rod-shaped magnet is therefore located in the lower piece of cork. Eccentrically to this, a similarly shaped piece of metal is passed through the cork, which was originally in contact with the hanging wire. The wire could touch the piece of metal. The bead on the wire only served to electrically insulate it from the

> magnet. Another wire, which came out of the top of the glass tube, formed the second electrical connection. When current flows through the wire, which is freely hanging inside, a magnetic field forms around it. This deflects it from the permanent magnet in the lower part of the tube and causes it to perform a circular pendulum motion around the magnet. Every time the wire touched the lower electrical contact, this motion was amplified. (Deutsches Museum 2024)

Working with a replica

I decided to investigate the questions about how it worked by reconstructing the experiment as close as possible to the original. Working with a replica can help reveal hidden aspects about the use and functioning of a scientific instrument that are not easily found in written sources. More than just confirming the description in the Deutsches Museum, I wanted to use the replica to access the tacit knowledge and skills required to make and use the instrument. These implicit but fundamental details, when accessed, give the user an experience that indirectly connects to the history of the instrument itself and the scientific culture that allowed it to exist (Heering 2008).

Through some replicas of Faraday's original instrument made previously by other authors, it is possible to get an idea of the obstacles commonly faced (Bradley 1991; Höttecke 2000). Mercury is the first and perhaps most important of these. For safety reasons, I replaced it with a solution of table salt when necessary, as it gives similar results even with significantly higher electrical resistance. Other materials such as the wood of the caps and the glass of the tube were also replaced by 3D printed parts made of PLA[2] and acrylic, respectively. Relying on nowadays explanation of its working principle, the difference in materials should not prevent it from working like the original.

The diameter of the tube and the metal conductors were chosen to be as close as possible to the original but were subject to the manufacturing standards available in the region where I live. The acrylic tube measures 26mm in inner diameter and 30mm in outer diameter and (b) has a slightly smaller diameter than the original piece. All the conductors, including the hanging wire, were made from copper, while (a) was made from an iron nail. Instead of cork, a layer of silicone was applied between the lower cap and the acrylic tube to prevent leaks. The upper cap was made removable to add or remove the salty water when necessary.

While I moved away from the original materials, to some extent losing valuable information about the experience of handling it as it originally was, others aspects could be revealed. Until reaching what can be called the final version (fig. 8), different arrangements, distances, lengths, widths and shapes of each piece could be experimented with, revealing the intentionality behind the structure of the original object. The demonstration was reproduced using the facilities and equipment of the Institute of Physics of the Federal University of Bahia[3]. The DC power source was used to test the operation of the instrument with various currents. A stack of neodymium magnets was used. I did not produce a support like the original and preferred to use

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[2] I thank my dear colleague André Jackson Ramos Simões for offering me his service of modelling and printing the caps.

[3] Special thanks go to Fábio Santos Batista and Rita Maria Silva Pereira of the *Centro de Apoio aos Laboratórios Didáticos e de Pesquisa* (CEALDIP) for providing me the necessary equipments during the tests as well as to Climério Paulo da Silva Neto (Institute of Physics) for the permission to access the laboratories.

the standard supports available in the laboratory, since their function is only to keep the tube vertical during the experiment.

Fig. 8 Testing with the replica. Source: Author.

Several attempts were made to verify whether the instrument could work according to the description of the Deutsches Museum, but no favorable result was obtained. By allowing contact between (b) and the hanging wire in the replica no movement was seen, although it should have been noticeable. With the saline solution inside the tube the wire starts the movement with currents close to 1 ampere. When connected to the power source, the motion of the wire does not start immediately, a small shake was sometimes necessary to make it overcome the friction against internal parts of the tube. Once the wire is sufficiently free to move, the apparatus works as described both by Faraday and the Deutsches Museum, even if not as fast as it seemed to be. The movement is almost uniform with a frequency close to 60 rpm, the acceleration is low enough to be imperceptible in an interval of about one minute. This was expected to occur due to the higher electrical resistance that the use of salty water implies, while the original instrument in the original conditions of use would work at higher speeds.

This was not the only limitation of the use of the saline solution. With the passage of the current an electrolysis takes place and consumes the positive terminal, where the copper oxidates. The solution slowly turns yellow, probably forming insoluble copper salts[4]. If (c) is connected to this terminal the hanging wire is rapidly consumed, forcing us to replace it after each use. If we want the instrument to work for longer, we are obliged to connect the positive terminal of the power source to (b). In the negative terminal there is production of chlorine gas, which we perceive in the form of bubbles in the solution that to some extent offer small disturbances to the movement of the wire, possibly varying the electrical resistance around it.

There is also significant production of heat as time passes. A current of 1 ampere is enough to rapidly increase the temperature of the solution. I had to stop from time to time to allow the tube to cool and avoid some damage to the instrument, since the PLA from the caps is sensitive to high temperatures. This aspect does not appear to have been documented in historical sources as it should not be a problem with the original materials. The original instrument would not dissipate heat as fast as the replica by working with voltages around 1 ou 2 volts, that seems enough if mercury is used, as I expect.

In the first tests, I made a version without the bead in the lower portion of the hanging wire believing it would not be entirely necessary. The presence of the bead, contrary to what I thought, proved fundamental for the instrument to work. The description of the Deutsches Museum already described its function as an electrical insulator, preventing the current from flowing through the magnetized piece in the center to the wire, but the friction between the wire and this piece, or between the wire and the tube is also a problem to its function. When a water solution with salt was used when there was no bead, the wire sticked to the glass walls or to the magnet. A similar effect is supposed to occur with mercury.

Another interesting result that could be obtained from the replica concerns the contact between the wire and (c) on the upper cap. To simulate the same effect as the original piece, I made the connection between (c) and the wire in the shape of a hook. Small imperfections in the loops are enough to make the wire stuck during its movement. After some attempts to solve this problem, I made the connection with two loops as in the original piece and it reduced this effect considerably.

In Faraday’s description he is concerned with the fluidity of the wire’s movement. The adequate mechanism that allows the wire to rotate around the magnet is shown both in text and in engravings (Faraday 1844). As Höttecke (2000) argues, Faraday knew that his phenomenon depended on specific conditions to be reproduced. The idea that its instrument is simple and basic was one of the rhetorical strategies employed seeking the acceptance of the newly discovered phenomenon. It in fact hides rather deliberate choices that favored the demonstration as Faraday intended.

Exploring the object’s biography

Based on the documentation about Faraday's instrument and the experience with the simple replica made, some biographical possibilities for the object of the Deutsches Museum emerge more than others. It is important to note that although objects are objective realities, their biographies can be multiple and focus on different sets of cultural relationships that run through their life stories (Kopytoff 1986). With little

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[4] The yellow precipitate mentioned is unknown. A colloidal dispersion of copper (I) oxide might be one of its main constituents. As the electrolysis is not present in the historical version, its by-products are not directly important for understanding the mechanism of the apparatus, but the experience with the replica is indeed limited by this reaction and it is worth taking note of.

documentation found on the original object, we can only interpret it in terms of its value as a teaching tool in the second half of the 19th century.

During the 19th century, many versions of electromagnetic rotation apparatuses were developed after Faraday and Newman's original. Soon after experimenting with the small rotation apparatus with Hachette, Ampère produced his own version for the same demonstration, said to be even more sensitive than Faraday's, replacing mercury with an acid solution (Ampère 1821). Peter Barlow (1776-1862) also produced another version soon after hearing about Faraday's publication and wrote a letter to him describing what came to be known as Barlow's wheel (James 1991; Gee 1991).

When the object first appeared at the Bavarian Academy of Sciences, which probably dates to the 1870s, there already were countless different instruments used to demonstrate the same phenomenon. Looking at historical textbooks in Germany published in the second half of the 19th century, we see that this plurality of instruments is also evident when it involves teaching electromagnetism. The fourth volume of *Lehrbuch der Experimentalphysik* by Adolf Wüllner (1835-1908), devotes a section for the interaction between magnets and currents. He mentions Faraday’s apparatus but prefers to illustrate the phenomenon with an instrument made by the French physicist Jules Célestin Jamin (1818-1886) and presented in a textbook of his own (fig. 9).

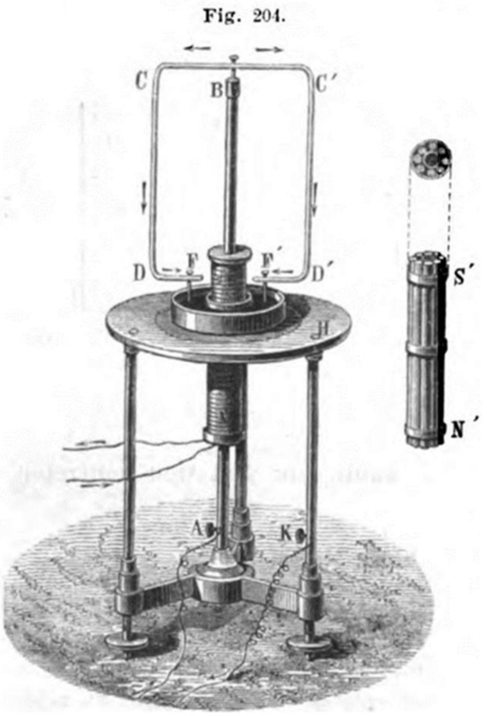

Fig. 9 Jamin's instrument as represented by Wüllner. Source: Wüllner (1872).

Hermann Lordberg (1831-1906) chose another instrument of an unknown author to illustrate the phenomenon in his *Lehrbuch der Physik für höhere Lehranstalten*. This one, however, is restricted to illustrating the analogous phenomenon of a magnet circulating a current (fig. 10). Briefly, the instrument consists of a rigid, cylindrical conductor that is free to rotate around its own axis, attached to a cylindrical magnet. As soon as a power source is connected to the lower end of the conductor and to a point approximately in the middle of its length, the magnet is affected by the current flowing through it and starts to move in a circular motion (Lordberg 1877).

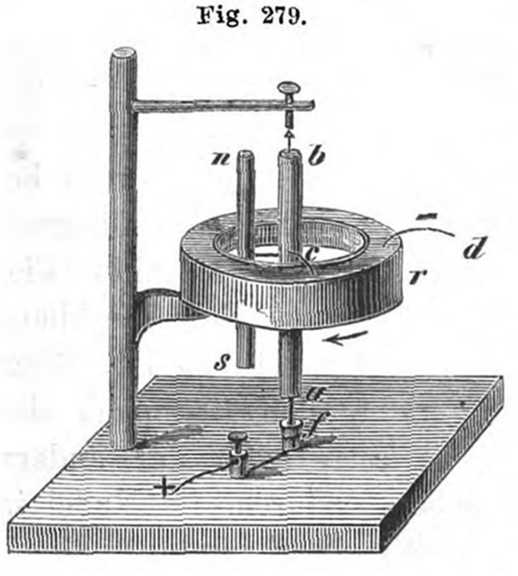

Fig. 10 The apparatus presented in Lordberg's textbook. Source: Lordberg (1877).

In some cases the historical versions are still mentioned, with Faraday's apparatus sometimes present but not as a protagonist. Wilhelm Eisenlohr's *Lehrbuch der Physik* presents a version like the one built by Ampère in a section dedicated to the interaction between electricity and magnetism (fig. 11). Karl Peschel's *Lehrbuch der Physik* presents three of the main versions created in the 1820s, by Faraday (the bigger apparatus), Ampère and Barlow (Peschel 1844). Some other textbooks do not approach the subject in the same way and choose not to contextualize the phenomenon with an instrument of this type.

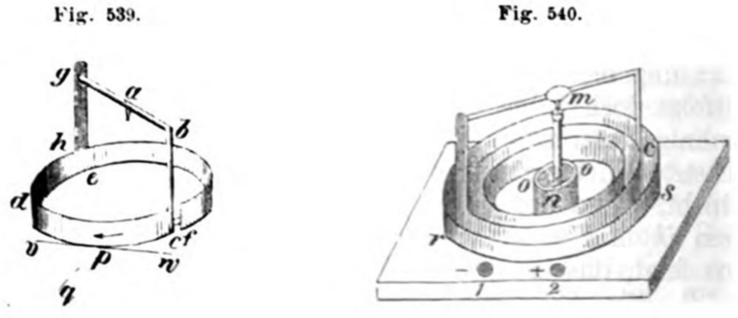

Fig. 11 Electromagnetic rotation apparatus presented in Eisenlohr's textbook. Source: Eisenlohr (1860).

One hypothesis that might explain the choices of the textbook writers is that as the phenomenon became relatively common towards the end of the 19th century, it became disassociated from the form initially elaborated by Faraday. Its original version is closely linked to the state of electromagnetic theory at the time of its creation. Instruments of electricity and magnetism at the beginning of the 19th century were developed to highlight the protagonists of the new interactions discovered in the field, which were current carrying wires in various shapes, magnets and compasses. As time passed and electromagnetic theory became more complex, its materiality also increased in complexity and changed appearance (Gee 1991; Al-Khalili 2015).

When looking at physics textbooks during the 19th century, the adoption of a scientific instrument similar to the second version of Faraday's apparatus may not be entirely related to its functionality, since other different versions were chosen for the same purpose without mentioning or recognizing it. Its function before the Deutsches Museum, while it was held by the Bavarian Academy of Sciences, may have been related to its historical relevance as a precursor to electromagnetic rotations, possibly serving as a demonstration for students.

Conclusion

The results obtained by combining two different methodologies, Gessner's model and the construction and experimentation of a simple replica made from accessible materials, deepen our understanding of Inv. Num. 1036 and highlight some biographical possibilities that justify its existence in the Bavarian Academy of Sciences and its presence in the Deutsches Museum's founding collection. This essay shows how a material culture approach to the historiography of science can complement an analysis based purely on written sources, especially when the documentation of an object is scarce or inaccessible.

The object we are dealing with in this essay is involved in an episode of great relevance to the history of electromagnetism and to studies on the material culture of science. In addition to its involvement with major discoveries in physics, it is one of the examples in which the agency of scientific instruments is evident, corroborating the premise that the materiality of science is just as important as its theoretical aspects. The epistemological relevance of this instrument justifies the fact that this exact version, closely related to the one made by Faraday, was chosen as part of the founding collection and its previous role as an educational instrument at the Academy.

The considerations made about the biography of Inv. Num. 1036 can be enriched by further research into the materiality of electromagnetic rotations in the 19th century, with the aim of identifying the place of this object among the other existing versions in terms of versatility, technical feasibility, cost and other material aspects, as well as aspects of the theoretical nature of the scientific culture regarding electromagnetism in this century. Many other questions could be asked about its absence or low presence in textbooks, but these would need to deal with the characteristics of the other existing versions that served the same purposes.

It would also be relevant to complement the results of this essay with a study based on documents from the Bavarian Academy of Sciences itself, with the aim of understanding the dynamics of teaching instruments in this institution. The instrument maker or the historical users can be more easily identified from this approach, helping to reveal unknown information about it and offering us a better point of reference for making inferences about the biographical possibilities for this object.

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