

Observing the Weather around 1800 – Biographies of a Hair Hygrometer

Stefan Walberer

s-walberer@mailbox.org

In this essay potential biographies of a de Saussure hair hygrometer made by the instrument maker Paul in Geneva are investigated. The object is part of the Deutsches Museum's collection and was gifted in 1905 by the Bavarian Academy of Sciences. Following Fleming's approach, this essay first describes the object's design, material and construction, and then investigates the history of its invention and making as well as its working principle. Through an exploration of the history of meteorology around 1800, the instrument's broader historical context will be presented. This will lead to the object's potential places of origin, shedding some light on its use and role as part of weather observation practices at Bavarian monasteries as well as at the Academy of Sciences in Munich. Even though there is a lot more research to be done than could be conducted within the limitations of this essay, some new insights into the object's history can be presented on the following pages.

Keywords: Deutsches Museum, hair hygrometer, Horace-Bénédict de Saussure, Jacques Paul, object biography, meteorology

A framework for material culture studies: the Winterthur protocol

Every object has its history. Objects are strongly connected to and deeply embedded in their cultural and social context and thus obviously part of human life and activity. This holds for every kind of object, thus also for scientific instruments. For history of science studies these objects can provide evidence about scientific cultures of the past in general as well as about scientific practices and institutions in particular. Hence, the study of scientific instruments as material culture has become a highly estimated field in the history of science. This essay is supposed to provide such a material culture research example and it will be guided by the so-called Winterthur protocol that was developed by Edward McClung Fleming as a model for studying artifacts (Fleming 1982). Since Fleming's model is not intended to be a rigid scheme that constrains the study of objects, but instead provides the flexibility needed for the examination of various different objects, it seems to be a viable approach to this essay's objective.

Fleming focuses on the five properties design, material, history, construction and function and suggests four operations to be conducted. The first one is to identify the object by describing and classifying it. A detailed description and classification of the instrument will

consequently be the first objective of this essay. The second step is the evaluation of the object which can include more or less subjective judgments about the artifact's design. Since the object discussed in this essay is not a piece of art, but a rather functional object, I will restrict this step mainly to the comparison of the object with others of its kind. A cultural analysis of the object should be step three according to Fleming's model in order to shed light on the cultural embeddedness of the object. This step will send the investigations of this essay into a new direction: away from the object itself into the broader history of meteorology around 1800 and the scientific-cultural practices and contexts in which hygrometers were used. The fourth step in Fleming's model is the interpretation of the artifact in relation to our culture. This point is obviously of special interest for pieces of art and will not take too much room in this essay.¹

First approach: Description of the object

When we first approached our object, we saw a seemingly fragile instrument of a brass-looking² material (Fig. 1). It consists of a rectangular bottom frame, three thin vertical bars, a rectangular upper frame and a circular scale with a black pointer. The instrument is about 35 centimetres high; the upper and bottom frames are about ten times eight centimetres in dimension.³ The whole instrument weighs 0,605 kilograms (DMS, Grunddatenausdruck). There are four big hand screws in the bottom frame's corners and two smaller hand screws with decorative, acorn-like screw heads on the upper frame. Four hand screws of different sizes can be found on the back of the instrument. We were able to turn all these screws without applying force. The object is in overall good condition. There is no obvious damage apart from some slight signs of use and oxidation as well as some scratches (Fig. 8). Some of the screws are slightly damaged (DMS, Grunddaten-Ausdruck).



Fig. 1: Hair hygrometer, front side, in lying position (which is not the intended one for using the instrument). Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

¹ Parts of this essay, specifically the description of the object as well as first insights about the instrument maker, are the outcome of collaborative work conducted at the VII. International Seminar "Material Culture in the History of Physics" in February 2025 (funded by the Wilhelm and Else Heraeus Foundation) at the Deutsches Museum in Munich.

² In the museum's database it is simply called "Metall" (metal) without being further specified (DMS, Grunddaten-Ausdruck). Similar objects that are developed by the same scientist and made by the same instrument maker are in fact made out of brass (Turner 1987: 257–259).

³ The museum's database provides more exact measurements of 117 millimetres times 86 millimetres for the frames' dimensions, but it also contains the obviously wrong number of only 136 millimetres for the height of the object, so the accuracy of these measurements is questionable (DMS, Grunddaten-Ausdruck).



Fig. 2: Hair hygrometer, close-up of the back side of the scale and the two hand screws to adjust its height. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

The circular scale (Fig. 3) is an annulus with three spokes that connect it to the centre of the scale's circular plain. It is attached to two sliders through four small slotted-head screws (two on the left and right edge of the scale respectively). These sliders are connected to the two outer vertical bars and are (in theory) movable in order to allow the scale's height to be adjusted by loosening two hand screws on the backside of

the sliders (Fig. 2). In practice, when we examined the instrument at the seminar, the sliders were stuck and we didn't want to apply too much force to prevent breaking the mechanism, so we were not able to change the scale's height. The scale is equidistantly partitioned into 360 degrees. Multiples of 10 are engraved in black. Instead of the midpoint between two engraved numbers we found little black arrows pointing towards the centre of the scale's circular plain. Between the numbers 160 and 170, near the inner boundary



Fig. 3: Hair hygrometer, close-up of the circular scale, from the front. In the background the (non-original) metal spring. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

of the annulus we found a little circular hole. There are other similar holes, for instance between 230 and 240 as well as between 240 and 250 degrees, but they contain little pins

that connect the scale to the rear parts of the instrument. We were not able to find any explanation for this empty hole.

The black pointer is attached to an axis at the centre of the circular scale and seems to be



Fig. 4: Hair hygrometer, left side, in lying position (which is not the intended one for using the instrument). Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

made out of a different material than the rest of the object. On the right and left sides of the scale we found the engravings “PAUL” and “A GENEVE” respectively, both decorated with two arrow-like curved ornaments. When looking closely, we could see a black dot following the letter A in the second engraving, but it turned out soon that this dot is not part of the inscription, but rather a sign of oxidation or damage.⁴

Three vertical bars connect the bottom frame to the upper one (Fig. 4). The rear vertical bar is flattened on one side along its upper third part (Fig. 8). Unlike the outer vertical bars, the rear one doesn't end in a decorative acorn-looking hand screw, but in a pivot that fits into a little circular hole on the upper frame. A tiny metal pin secures the bar's attachment to the upper frame (Fig. 9). A grey metal spring is attached to a black string that is wrapped

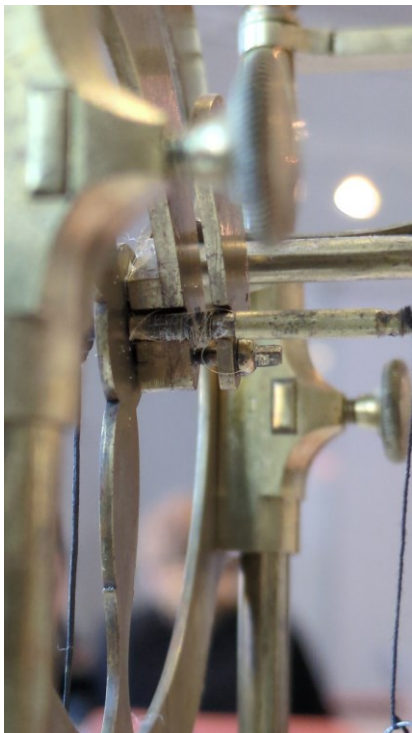


Fig. 5: Hair hygrometer, close-up of the pointer's axis and the pieces of hair we found wrapped around it. On the right image edge the non-original black string. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

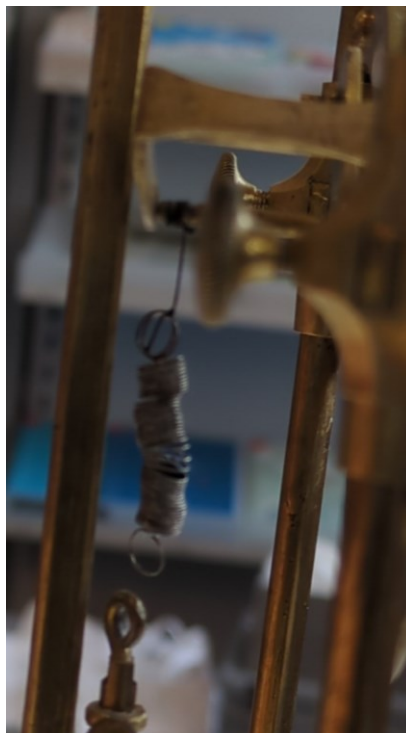


Fig. 6: Hair hygrometer, close-up of the non-original metal spring. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

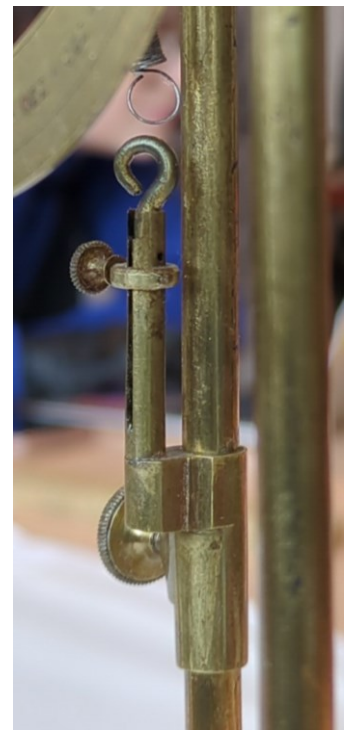


Fig. 7: Hair hygrometer, close-up of the movable slider on the middle vertical bar with the hook. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

⁴ See the section about the instrument maker below for further explanation of the inscriptions.

around the pointer's axis (Fig. 6). The spring seems to have been overstretched and twisted, since it is slightly deformed. The black string looks like a sewing thread and seems to be a later addition or replacement (DMS, Grunddaten-Ausdruck). Axis and pointer are in fact still movable and react highly sensitive. Around the axis of the pointer, we found some little pieces of grey or blonde hair (Fig. 5) that is most likely human (DMS, Grunddaten-Ausdruck). A slider is attached to the middle vertical bar that can be moved by loosening a little hand screw on the left side of this slider (Fig. 7). Moving it was in fact possible when we worked with the object in the seminar, but we had to apply some force and could only move it upwards, probably due to the fact that only the upper part of the bar is flattened on the left side. A vertical cylindrical clamp is connected to this slider and contains a little hook. This hook can be fastened by another hand screw (smaller than the other one) that tightens the clamp and thus secures the hook in its position (Fig. 7).

The upper frame consists of three edges of a rectangle (Fig. 9). On its rear side, right behind the circular hole the rear vertical bar is connected to, there is a rectangular hole.⁵ The two outer vertical bars are connected to the upper frame by two decorative, acorn-looking hand screws that we could turn and remove easily without applying force. The rectangular bottom frame consists of four edges of a rectangle, a fifth bar dividing the rectangle along its length into two congruent rectangles and another bar that connects the centre of the frame with its rear longer edge (Fig. 10).



Fig. 8: Hair hygrometer, from the back, close-up of two vertical bars. One with hook and flattened part. Signs of damage and oxidation on the other bar. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

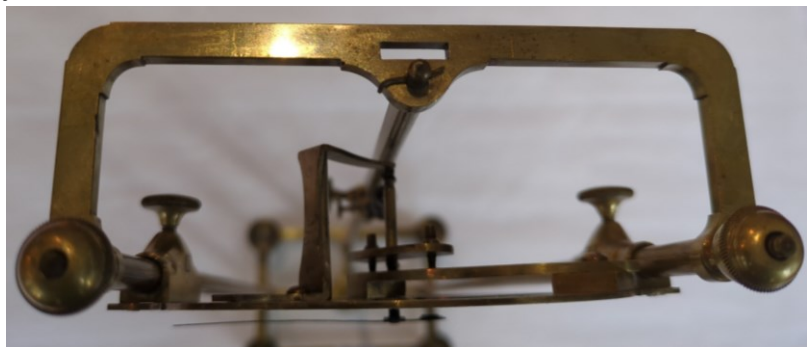


Fig. 9: Hair hygrometer, close-up of the upper frame. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.



Fig. 10: Hair hygrometer, close-up of the bottom frame with the flat gear in its centre. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

⁵ The function of this hole was at first unclear. We speculated that its purpose may have been to hang up the instrument. See the section on de Saussure's description below for clarification.

On the upside of the front bar there is a rectangular notch to fit a light grey metal plate containing the inscription “05/128”. The number 128 appears again on the left bar of the bottom frame, this time stamped or printed in black. The frame’s corners are marked with the engraved numbers one to four on the frame’s upside (Fig. 11). On the frame’s bottom side, the numbers one and two mark the positions of the two outer vertical bars (Fig. 12). There is no such label for the third vertical bar. In the centre of the bottom frame, we found a little gear-like circular metal object (Fig. 10). A little vertical pin- or screw-like part with a screw thread and a little hole on its upper side connects this gear to the frame. Additionally, it is held in its position by a band-shaped angled metal plate that partially covers the upper side of the gear and is attached to the frame via two little slotted-head screws. The museums database entry states that this gear is (in the current state of the object) functionless (“ohne Funktion”) and suggests there might be something missing (“hier fehlt wohl etwas”), but it makes no further assumptions on what the function of this gear might have been or what parts might be missing (DMS, Grunddaten-Ausdruck).⁶ At the seminar, the gear was movable, but this had in fact no observable effects.

The four vertical hand screws in the corners of the bottom frame are much bigger and look different than all the other screws mentioned above. Their screw heads are flat and remarkably big and their screw threads are made out of a light grey metal that does not seem to fit to the rest of the instrument (Fig. 10 and 11). When we looked from underneath, we noticed that the ends of these screws are rounded (Fig. 12). Further investigation of the screw threads could possibly give deeper insights into the origin of these screws and the time of their production, but this could obviously not be conducted as part of the seminar nor of this essay.⁷

After our work with the object at the seminar, there remained lots of unanswered questions some of which are the following:



Fig. 11: Hair hygrometer, close-up of the black inventory number on the bottom frame. In the foreground one of the four probably non-original hand screws. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

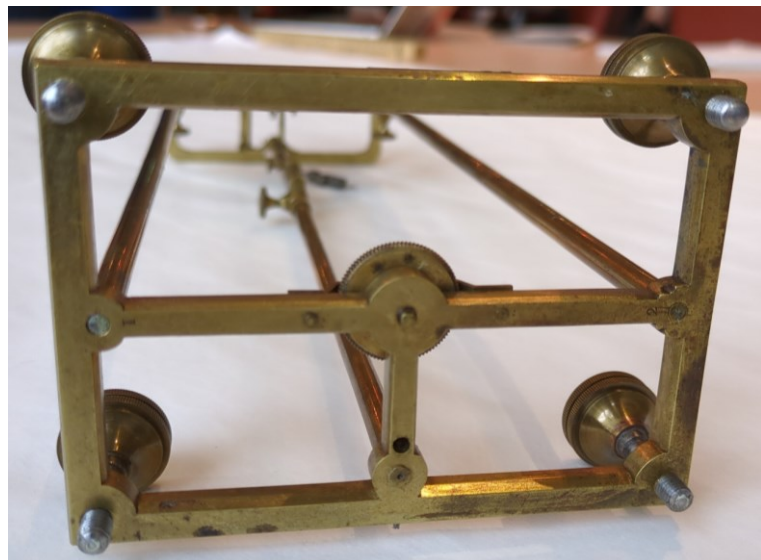


Fig. 12: Hair hygrometer, close-up of the bottom frame, from the bottom side. Source: Deutsches Museum (inventory number 128). Photograph taken by the author.

⁶ See the section on de Saussure's description below for information about this gear's function and the missing parts.

⁷ As for the function of these screws we had two speculative ideas: First, we thought there might be something like a wooden pedestal missing and that the instrument is supposed to be fixed to it with these screws. The second idea was that the screws were only for balancing the object on uneven ground. See the section on de Saussure's description below for clarification.

- Where exactly and how was the hair attached to the instrument?
- Was there a spring in the original object? If so, what was its purpose?
- What was the function of the gear on the bottom frame?
- What was the function of the four screws on the bottom frame?
- Was the instrument supposed to stand or was it hung up to a wall?
- What parts are missing?
- How exactly could humidity be measured with this instrument?
- How did the instrument end up at the museum and where did it come from?

The following sections are an attempt to answer these questions. Although there will be some limitations, dead ends and open questions during this endeavour, it will turn out that the object's biography prior to its time at the museum can be reconstructed to quite some extent by investigating its inventor and its maker as well as unpublished inventories of the Deutsches Museum and the Bavarian Academy of Sciences. Furthermore, a discussion of the history of meteorology and the role of instruments as tools for weather observations in Bavarian monasteries will clarify this object's most probable cultural embedding and scientific use.

The Instrument Maker: Paul from Geneva

When we attempted to investigate the origin of the instrument at the seminar, the most useful hint to start our research with was the inscription "PAUL A GENEVE", since it led us to the instrument maker. Browsing through Webster's Instrument Makers Database, we found two relevant entries (Adler Planetarium & Astronomy Museum 2007). Both instrument makers are based in Geneva in Switzerland and both have Paul as their last name. But only for one of them there is a first name listed: Jacques.⁸ The other one, whose first name is missing, is described as "son of Jacques Paul". In general, there seems to be less information available about this son. He is categorized as a philosophical instrument maker, who made barometers and thermometers, but also "other philosophical apparatus" and it seems to be "difficult to tell the father's work from the son's". No known objects are listed and there is only the very vague mention "c. 1800" about his potential life dates (Adler Planetarium & Astronomy Museum 2007).

Jacques Paul had two sons, Théodore-Marc Paul (1760-1832) and Nicolas Paul (1763-1805), but Nicolas is also the name of Jacques Paul's father (Schulé 1981: 139). Jacques' son Nicolas joined him from 1788 on in his Geneva workshop, and they built instruments together, now using the engraving "Paul" without a first name (Loude 2010: 13). This suggests that there might have been another engraving that Jacques Paul had used before. However, I was not able to find any object with a first name engraved, neither "Jacques" nor "Nicolas". Either way it seems obvious that the letter A in the signature is not part of a name, given the known first names Jacques, Nicolas and Théodore-Marc, which means that the black dot mentioned above is not part of the inscription.⁹ Instead it should be transcribed as "Paul à Genève" (Loude 2010: 12) and translated as "Paul from Geneva". Assuming that the instrument was not made before 1795 (DMS, Grunddaten-Ausdruck), it is most likely that it was not Jacques Paul, but rather his son Nicolas, who made it, since Jacques died in 1798 latest, probably already in 1796, and had been in bad health

⁸ This name is sometimes spelled without the letter c: Jaques (Loude 2010: 12).

⁹ Wrongly, the museum's database includes the dot into the signature: „PAUL / A. GENEVE“ (DMS, Grunddaten-Ausdruck).

condition since 1788 (Loude 2010: 13). However, the literature about the Paul family is in part contradictory, especially when it comes to Jacques Paul's date of death. Some sources name the year 1796 (Schulé 1981: 139; Museo Galileo 2015; Archinard 1979: 28), while others claim that he died in 1798 (Adler Planetarium & Astronomy Museum 2007; Deutsches Museum 2016). I even found the exact date 01.10.1796 as Jacques Paul's date of death (Marti-Weissenbach 2010), but according to another source, "he died in December 1796" (Loude 2010: 13). Based on these contradictory pieces of information and without knowing the exact year of its making, it was not possible to determine any details about the time of the instrument's "birth". What can be stated however, is the place of "birth: the Paul family's workshop in Geneva.

Invention and Description of the Instrument by De Saussure

While in the forgoing paragraphs the instrument maker has been identified, some further research at the seminar led us to the instrument's identification as a hair hygrometer. It was initially developed by Horace-Bénédict de Saussure (1740-1799), a scientist from Geneva.¹⁰ De Saussure has been called "the father of hygrometry" (Freshfield 1920: 460) and is described as a passionate mountaineer that developed different scientific instruments because they were not yet available and he needed them for his mountain excursions (Middleton 1942: 253; Barry 1978: 702). In 1783, he described two types of hair hygrometers including schematic figures for both of them in his *Essais Sur L'Hygrométrie*. The first type is obviously our object's model, the second one is a smaller, portable version with a different scale. Considering that Paul and de Saussure were both of the same age and from Geneva, both working on hair hygrometers and both dealing with the exact same model, it is obvious that they knew each other and collaborated in one way or the other (Loude 2010: 12). In de Saussure's *Essais* there is even a proof for this collaboration: In a footnote, he mentions a person named "M. Paul" (where M. is an abbreviation for Monsieur), whom he calls one of the most distinguished artists in Geneva (De Saussure 1783: 13–14). Considering that de Saussure published his *Essais* in 1783 and that Nicolas Paul came to work in his father's workshop not earlier than 1788, de Saussure must refer to Jacques Paul.¹¹ He describes the instrument maker as a craftsman who was not only capable of executing de Saussure's instruments, but even of perfecting the scientist's model. Furthermore, he explicitly says that Paul had made for him one hair hygrometer of the first type (similar to our instrument) and multiple ones of the portable type (De Saussure 1783: 13–14). So, when Nicolas Paul constructed our instrument, it was definitely not the first one of this kind made in the Paul family's workshop and the son could make use of his father's longtime expertise with making de Saussure's hair hygrometers, since the invention of this object already took place in 1775 (Carozzi 2005: 215). De Saussure's starting point for developing hair hygrometers was the observation that human hair gets longer when getting wet and shorter under dry conditions. But he realized that the difference in length is too little to be observed directly, which is why he wanted to develop measuring devices that made this change in length visible (De Saussure 1783: 1–2). In the following, de Saussure's description of the instrument as well as his schematic figure (Fig. 14) will be analysed in order to explain the working principle of "our" hair hygrometer from the Deutsches Museum. By doing so, I will be able to answer some of the questions that came up during our investigations at the seminar.

A first look at the schematic figure shows that the hair is going in vertical direction from the bottom frame to the pointer's axis. De Saussure describes that one end of the hair has to

¹⁰ For detailed accounts on de Saussure's life and his role in the history of meteorology, see for instance (Freshfield et al. 1989) and (Carozzi 2005).

¹¹ He mentions "M. Paul" again (De Saussure 1788: 4), but again without his first name.

be attached to the centre of the bottom frame which is a fixed point. But how can this attachment be done considering that our instrument does not have any mechanism for that? By comparing the schematic figure (Fig. 14) with the photograph of the object we worked with (Fig. 13), we can now answer this question. For the hair to be attached there should be a clamp (b/B) that can be opened and closed by a little hand screw. The clamp ends in a screw that is surrounded by the gear on the bottom frame. The function of this gear can now be understood: By turning it, the height of the clamp can be adjusted (De Saussure 1783: 2–3). Thus, the vertical pin or screw that goes through the gear in our instrument has either been added later or is a broken original part, or the little hole was for the clamp to be attached.



Fig. 13: Hair hygrometer, front side, standing. Source: Deutsches Museum (inventory number 128). Photograph taken by Konrad Rainer (CC BY-SA 4.0).

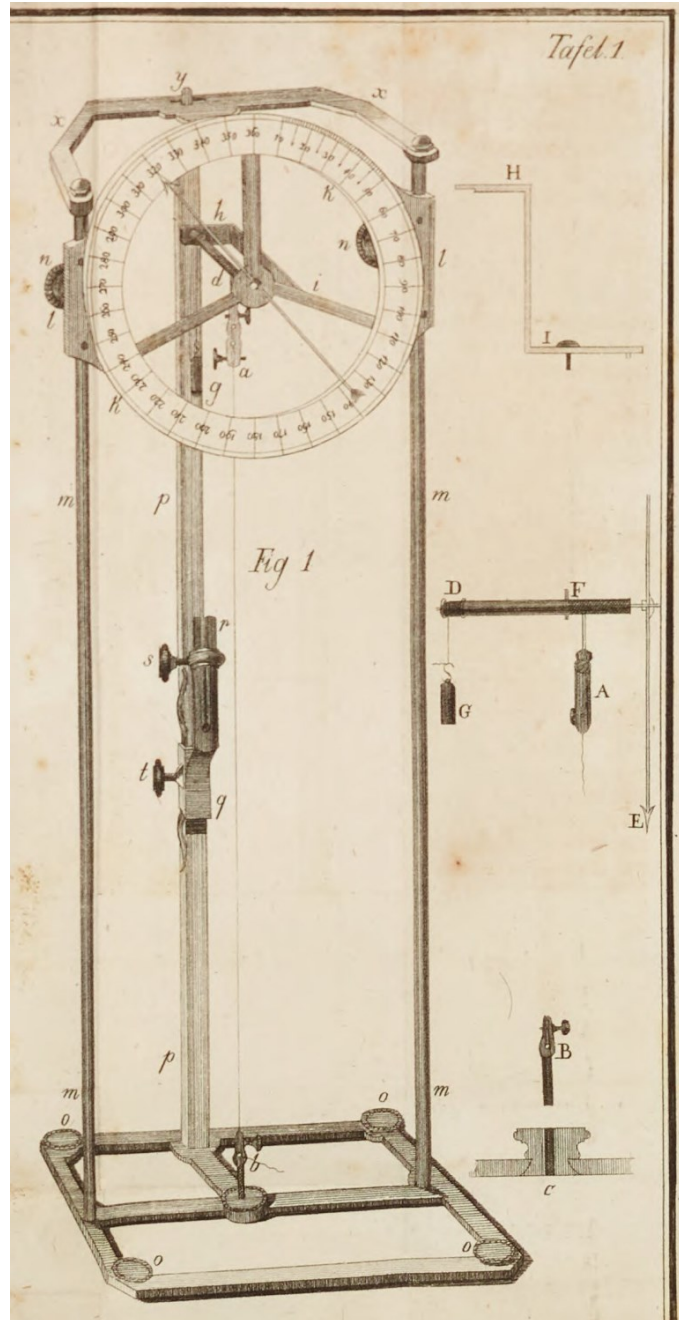


Fig. 14: Schematic figure of a hair hygrometer developed by de Saussure intended to be used in the laboratory. Source: Saussure 1784: Tafel 1. Picture credits: Staatsbibliothek Bamberg, Met.o.37, p. 449, urn:nbn:de:bvb:12-bsb11740933-2 (NoC-NC 1.0).

The second end of the hair should be connected to another clamp (a/A) which can also be adjusted by turning a little hand screw. The upper end of this clamp, according to de Saussure, should hold a little strip of silver foil that is wrapped around the axis near the pointer (but behind the scale), where the axis is incised like a screw thread to make sure that the silver strip fits perfectly and doesn't slip or shift (De Saussure 1783: 3–4). This screw-like incised structure at the axis is visible, but obviously the silver foil and the second clamp to attach it to the hair are missing in the Deutsches Museum's object. De Saussure did not wrap the hair itself around the axis to make sure it won't get rough and thereby prevent the axis from turning despite the counter weight (De Saussure 1783: 3–4). It seems reasonable to assume that the Deutsches Museum's hair hygrometer was at times set up or maybe even used in a way that was never intended, since the pieces of hair we found at the axis suggest that it was in fact wrapped around it, maybe due to the lack of the necessary clamp a/A.

The other end of the axis has a light thin string wrapped around it, which carries the counter weight (g/G). After many experiments, de Saussure decided to limit this weight to three grains, which is about 200 mg (Middleton 1969: 102). Its purpose is to keep the hair under tension. To achieve this, the counterweight must be slightly heavier than the clamp (a/A) that connects the hair to the axis, and wrapped in opposite orientation (De Saussure 1783: 4). Since there is no counter weight and no original string coming with the Deutsches Museum's object, we can extend our list of missing parts by these components.

The axis is connected to the centre of the scale where there is a little hole to fit in the pivot of the axis. Its rear end is sitting in a hole on an angular part of the instrument that is connected to the scale with a slotted-head screw. This construction enables the height adjustment of the scale, the axis, the clamp (a/A) and the counter weight via the two hand screws described above (De Saussure 1783: 4–5). This can be necessary for different hair lengths, although it is not clear how the length of the used hair influences the accuracy of the measurement. The same holds for the counter weight: If it is too heavy, the hair might break or contract less, if it is too light, it might not keep the hair under tension and thus make high humidity values unmeasurable.

The function of the four hand screws in the corners of the bottom frame is, according to de Saussure's description, to keep the hygrometer in balanced position on uneven ground. In de Saussure's schematic figure, these screws look very different and much smaller than the ones in the museum's object. Considering this, it seems even more likely that these screws were added later, while the original screws went missing at some point in the instrument's biography. Maybe the original screws were not needed for a long time and thus removed. This assumption is reasonable, since the rectangular hole on the back side of the upper frame is in fact intended to be used to hang up the instrument, as Saussure mentions (Saussure 1783: 6). But obviously all this remains highly speculative and I was not able to reconstruct the history of these missing parts.

While working with our object in the seminar at the Deutsches Museum, we implicitly assumed, that this instrument is made for standing on a table to be used for more or less regular measurement of humidity at one certain place. Especially the highly damageable hair let us assume that this object was never made for being transported. When reading de Saussure's description, I realized that this assumption is not necessarily justified. Although de Saussure states that carrying hair hygrometers of this model from one place to another is not to be recommended and may cause it to break (De Saussure 1783: 6–8), he nevertheless describes a mechanism of this hygrometer that was specifically designed for the instrument being transported. The middle vertical bar has a cylindrical clamp attached. Instead of holding a hook like in the Deutsches Museum's object, this clamp can be moved upwards to reach the counter weight and fix it in place to protect damage to the construction due to a possible pendulum movement of the counter weight in case of

transportation of the object (De Saussure 1783: 5–6). This justifies the assumption that the hook as well as the grey spring are non-original additions of later times instead of just substitutions for original parts that went missing. This seems obvious for the spring due to its material, but the hook does at first sight not at all look like a later addition since it seems to be made of the same material and designed in the same style as the rest of the object. Only the uselessness of the clamp could have indicated that something is wrong with this part, since as far as I can see, there is no need for the hook to be removed. De Saussure's description also explains why in case of our object the vertical bar is flattened only at its upper third part. There is no reason for the clamp to be moved down. Instead, it should be moved as far up as necessary to reach the counter weight. Considering the spring and the hook of our object it seems reasonable to assume that it was set up and used in a way that was not intended by its developer de Saussure. As mentioned above this assumption is underpinned by the hair that we found wrapped around the pointer's axis.

However, the use of a spring is not too far-fetched and de Saussure himself mentions this option. In a footnote, he writes that Jean-André de Luc (1727-1817)¹² had applied a minimal change to this kind of hygrometer: He substituted the counter weight by a spring. De Saussure does not mention a hook inserted in the clamp, but this seems to be an obvious choice for the spring's attachment. However, de Saussure was not able to find or build a spring that was soft enough to imitate the only minimal counter weight needed to keep the hair under tension without breaking it, while at the same time making its length changes visible. Furthermore, he was worried about potential changes in the spring's sensitivity over time and due to exposure to different temperatures. That is why Saussure himself didn't want to use a spring and chose the counter weight instead (De Saussure 1783: 7–8).

De Saussure mentions some advantages and disadvantages of this type of hair hygrometer. He recommends not to move the instrument too much, as this can cause less accurate measurements or damage. It should best be used in an observatory or laboratory standing on a table. Consequently, I will from now on call this type of de Saussure hair hygrometer the "laboratory type" in order to distinguish it from the "portable type". The laboratory type was the first and original model de Saussure developed, but the portable one was superior under most circumstances (Middleton 1969: 102). Thus, Paul made about 150 hygrometers of this kind (Loude 2010: 13; De Saussure 1788: 4; Turner 1987: 258).

Compared to the schematic figure the scale of the original object is more decorative since the three spokes of the scale are of more ornamental shape instead of straight sticks. The scale is attached top down compared to de Saussure's schematic figure. This can be seen from the position of the numbers on the scale and the three spokes. Due to the scratches on the screws on the right and left side of the scale this can (but need not) mean that the instrument has once been disassembled and reassembled later. The difference in orientation is not problematic for the use of the object, since the hair and the counter weight can be adjusted and calibrated accordingly.

The exploration of de Saussure's description in this chapter was the key to answer most of the open questions that had come up during our work with the object at the seminar. Missing parts have been identified and the instrument's functionality and working principle for measuring humidity has been described based on the inventor's own work. A direct comparison between de Saussure's schematic figure and the Deutsches Museum's hair hygrometer further indicated that some parts (especially the four bottom screws) might have been replaced or added later – including parts like the hook that we had not expected

¹² For more information about de Luc and his role in the history of meteorology see for instance (Frisinger 1977: 75–77) and (Middleton 1942).

to be non-original. Furthermore, the arrangement of its parts suggests a specific use of the instrument that deviates from the intended one.

Human hair as a hygrometric substance

De Saussure made a lot of experiments to investigate moisture in the atmosphere. He noticed that humidity and temperature are connected to each other and that the amount of possible moisture in the air is higher the warmer the air is. To conduct his experiments, he obviously needed instruments to measure humidity.¹³ De Saussure's hair hygrometers and his way of calibrating them were almost universally accepted. However, he had a prominent adversary: Jean-André de Luc. The main subject of their controversy was the question of how to calibrate hygrometers. This question was crucial since measurements made with two different hygrometers were only comparable if the minimum and maximum points were set by the same procedure. De Luc had developed a hygrometer that used a whalebone as the hygroscopic substance and set the highest level of humidity (100 on his scale) by "immersing the whalebone into water" (Middleton 1969: 103), while Saussure just exposed it to water vapor (Middleton 1969: 103–106; Middleton 1942).

Before developing this kind of instrument and using hair as the hygroscopic substance, de Saussure made a high number of experiments with lots of different substances none of which produced acceptable results (Middleton 1969: 101–102). Human hair is in fact superior to other hygroscopic substances and is still widely used in meteorological instruments (Häckel 2016: 319). Today's meteorologists state that human hair reacts to an increased humidity of ten percent with a length extension of about 0,25%, but even modern hair hygrometers can only be accurate up to an error margin of three to five percent. Under certain circumstances the inaccuracy can increase to up to ten percent. Furthermore, hair is quite sensitive to contamination with dirt and some chemical substances, and additionally the sun's radiation reduces the sensitivity of human hair, especially under very warm conditions. Thus, a hair hygrometer should be set up at a clean place without too much sun radiation and protected against substances like ammoniac. Additionally, human hair's sensitivity to changes in humidity can be increased by rolling and flattening it (Häckel 2016, p. 319). Today's hair hygrometers are mostly so-called hydrographs, which constantly draw a graph on a piece of paper to record the humidity development over time. Due to the resistance of the mechanical parts and the pen on the paper, these instruments can't work with only one single hair. Instead, they contain a bush of parallel hairs. In most of these instruments a second mechanism measures and records the temperature. In this case, the instrument is called a thermo-hygrograph (Häckel 2016: 319–320).

From the Bavarian Academy of Sciences to the Deutsches Museum

Object number 128 is currently part of the physics section at the Deutsches Museum's collection and assigned the subsection "heat". It was gifted to the museum on 15 February 1905 by the Generalkonservatorium der wissenschaftlichen Sammlungen des Staates in Munich as part of the former collection of the Bavarian Academy of Sciences.¹⁴ The museum's documentation book of incoming objects from 1905 lists two hair hygrometers by

¹³ De Saussure made attempts to develop an instrument that measures humidity through the "fall of temperature produced by evaporation", but eventually decided to focus on hygrometers based on length differences (Freshfield 1920: 460–461).

¹⁴ For details about the transfer of the collection from the academy to the museum see (Füßl 2003: 70), (Stange 1906: 6ff.) and (Dienel 1998: 42).

Paul in Geneva with the inventory numbers 127¹⁵ and 128¹⁶ (DMO, Zugangsbuch 1905). Our object has the inventory number 128, as can be seen from the label on the instrument's bottom frame mentioned above. The second hair hygrometer (inventory number 127) lacks an instrument maker's signature and looks obviously different than both of de Saussure's hair hygrometer types. The object with the inventory number 38 is a de Saussure hair hygrometer (portable type).¹⁷

For our object, I was lucky enough to get access to the relevant entries in early inventories of the Bavarian Academy of Sciences thanks to Johannes-Geert Hagmann.¹⁸ Due to the fact that the academy owned more than just one hair hygrometer and that the descriptions of the objects are usually not highly precise, an unambiguous assignment is not always possible. The first known inventory was written by Maximus Imhof (1758-1817) in 1806 and mentions a hair hygrometer ("Haarhygrometer") as item number 104, but does not provide any further information. It is not even clear how many of these hair hygrometers existed, since the German term can be a singular or a plural term and there is no number given (DMA, HS 1954 1). The next inventory from 1827 was most likely written by Thaddäus Siber (1774-1854). It lists four de Saussure type hair hygrometers ("4 Saussuresche Haarhygrometer") as item 13 and associates them with item 104 in the old inventory (DMA, HS 1954 4). In Siber's inventory, there is also a hint about the general use of the instruments in the academy's collection. According to Siber, they were not used at all for 19 years, which made repair and maintenance necessary (Bachmann 1966: 170). This condition of the collection can maybe in part explain the incompleteness of our instrument, although it can't provide any detailed answers for this very object. In 1852, Franz Schleicher and Georg Simon Ohm composed a new inventory that again mentions four hair hygrometers in or with a brass frame ("in messignem Gestell"/"mit messignem Gestell"), this time as items six, seven and eight. They are explicitly assigned to the previous catalogue's item 13 (DMA, HS 1954 6). Two of them are described as made to be hung up ("zum Aufhängen"), one to be freestanding ("zum Freistehen"). The eighth item's description is not properly readable, maybe it characterizes the object as incomplete ("unvollständig") (DMA, HS 1954 6). Since our object can be both freestanding and hung up (as described above) and is obviously incomplete, a clear assignment to one of these items is not possible. But it seems likely that our instrument is the freestanding one, since other common types of hair hygrometers lack this ability (for instance de Saussure's portable type). Obviously, these assumptions are highly speculative and solely aim at showing possibilities based on the little pieces of information and hints I found. In Ludwig Botzmann's inventory from 1894 the assignment of the object to the entry is clear for the first time. Inventory numbers 127 and 128 are combined under item 27 and described as two hair hygrometers by Paul from Geneva ("Haarhygrometer 2 Stück v. Paul à Genève"). Given the fact that the object with the inventory number 127 does not have a signature, it is remarkable that Paul is assumed to be the instrument maker and that on the other hand objects 38 and 39¹⁹, which are both de Saussure portably type hair hygrometers and thus combined under item 15, are simply called hair hygrometers ("Haarhygrometer") without any mentions of their instrument makers, although 38 has Paul's signature and 39 is signed by Brander and Höschel in Augsburg (DMA, HS 1954 8).

¹⁵ "Haarhygrometer (von Paul à Genève)" (black ink) with the addition "Saussure 1783" (red ink). For more information on this instrument as well as photographs see <https://digital.deutsches-museum.de/en/digital-catalogue/collection-object/127/> (04.07.2025).

¹⁶ "Haarhygrometer von Paul in Genf" (red ink).

¹⁷ For further information about this object as well as photographs see <https://digital.deutsches-museum.de/en/digital-catalogue/collection-object/38/> (04.07.2025).

¹⁸ For the history of the academy's inventories, see for instance (Bachmann 1966: 170).

¹⁹ For more information about this object as well as photographs see <https://digital.deutsches-museum.de/en/digital-catalogue/collection-object/39/> (15.07.2025).

Since the inventory lists don't provide any further information about the origin of the objects (that is, how they came to the academy in the first place), this question has to remain unanswered. However, in the following sections I want to discuss the scientific and historical context of our instrument at the time of its "birth" around 1800, which will provide some insights into the object's scientific use for weather observations as well as potential places of origin.

Scientific Use for Weather Observations in Bavaria – Potential Places of Origin

To gain new insights into the earth's atmosphere, scientists in the second half of the eighteenth century began to imagine a geographically wide spread observation network to collect climate data from various different places. This project became feasible from the 1770s onward due to the dramatic enhancement of measuring instruments in experimental physics (Bloemer 2022: 68). The primary interest was to predict the weather as this was imagined to prove beneficial for agriculture. Thus, it was not a special interest in foundational science that convinced the elector Karl Theodor from Palatine²⁰ to spend money on setting up a big observation project (Winkler 2023: 94). In 1780 the *Societas Meteorologica Palatina*²¹ was founded as part of the Academy of Sciences in Mannheim and set up an observation network of 39 Stations, reaching from the Urals to North America and from Greenland to the Mediterranean Sea.²² In Bavaria, seven stations were part of the observational network. All Bavarian observers of the Mannheim network were members of monastic orders (Bloemer 2022: 74).

Apart from the organizational and communicational effort of setting up 39 observation points all over the world, it was of high importance to collect accurate and comparable measurement data. Since at that time measurements usually depended on the different scales and instruments as well as their calibration and use, it was crucial to standardize these factors. The instruments needed for the observations were made and calibrated by an instrument maker from Strasbourg²³ under the supervision of one of the leading scientists of the project (Winkler 2023: 98). Identical sets of instruments were sent to the stations and hygrometers were obviously part of this equipment. In addition to the instruments, detailed descriptions of how and when to read the instruments were handed to the stations to keep the observer's influence on the data as little as possible.

First, goose-quill hygrometers were used, which measure length differences of a goose-quill depending on changes in humidity. Because these instruments were not reliable, the *Societas Meteorologica Palatina* offered a prize in 1783 for the development of a hygrometer that was sought to provide better reliability and stability while at the same time allowing easy calibration. Out of eleven submissions, an instrument by Giuseppe Toaldo from Padua was chosen, who, together with his nephew Vincenzo Chiminello, had made a hygrometer that was very similar to an instrument developed by Jean-André de Luc and modified by the French physician Noël Retz. Its working principle was based on measuring the change of volume of a vessel containing mercury (Middleton 1969: 98–99). These hygrometers were eventually used for the Mannheim project despite some comments about their bad stability compared to de Saussure's hair hygrometers (Middleton 1969: 100). For our instrument, this means that it has most likely never been used as an observational

²⁰ For more information about Karl Theodor and the process of founding the *Societas Meteorologica Palatina* see (Winkler 2023: 94–96).

²¹ A similar try in Baden had failed in 1779 due to delays in the production of the measuring instruments needed (Winkler 2023: 95) and/or due to a lack of financial support (Bloemer 2022: 72).

²² (Winkler 2023: 102) provides a map showing all stations of the observation network.

²³ His last name was Artaria, for his first name I found "Carl" (Bloemer 2022: 72), but also "Carlo" (Winkler 2023: 98).

instrument at one of the stations that participated in the Mannheim network, since they used different kinds of hygrometer.

The observational data was collected and published in the so-called *Ephemerides Societatis Meteorologicae Palatinae*. In 1790 the observation network got smaller because some of the stations quit their participation due to the political situation (Bachmann 1966: 207; Middleton 1969: 99; Winkler 2023: 101). The last volume of the *Ephemerides* was published in 1795 (Winkler 2023: 105).

In Bavaria, the idea of a weather observation network came up around the same time. The Bavarian Academy of Sciences in Munich published a request for voluntary weather observations with detailed descriptions and instructions. Other than the Academy of Sciences in Mannheim, the Munich academy could not pay for the instruments, but it recommended to buy them from Brander in Augsburg, which most of the participating stations did (Herrmann 2016: 181; Winkler 2020: 37). Again, we can conclude that most of the stations of this Bavarian network did not use our instrument for their observations since they ordered their equipment (including hygrometers) from Brander instead of from Paul. But since the Bavarian Academy of Sciences did not have strict guidelines for the instrumentation set up, a closer look at the participating stations can at least provide some possible “places of birth” for our object.

The Bavarian observations were mainly conducted by members of monasteries, while priests and doctors were mainly in charge for sending the data to the academy (Bloemer 2022: 77). Other than the Mannheim project, the Munich academy published the meteorological data in compressed and extracted form instead of providing the full information. In 1800, the academy decided not to continue the observational project for two reasons. First, the outcome was seen as nothing more than an accumulation of observational data that had not yet proven beneficial or useful. The second reason was the partial lack of instruments. However, in some monasteries the weather observations were continued until 1803 and in some cases even much longer (Bloemer 2022: 81–85; Winkler 2023: 105).

For the object biography of scientific instruments in the academy’s collection the process of secularization during the years 1802 and 1803 is of special interest because much of what was part of the monasteries’ collections was transferred to public institutions such as the Bavarian Academy of Sciences.²⁴ Thus one possible origin of our instrument is a Bavarian monastery, where it was possibly used as an observational tool. This would imply that it was made and bought before the secularization, probably even before 1800, since many stations quit their observations in 1789 or earlier.²⁵

Since from the publications of the observational data we have some information about certain stations, we can exclude many of them as possible sources for our instrument, since they were either part of the Mannheim network and thus used its dedicated instrument sets or they bought their instruments from Brander and Höschel in Augsburg as recommended by the Academy of Sciences in Munich.²⁶ More stations can be excluded since they used different instruments, but not Paul’s or they did not have hygrometers.²⁷ The following stations did not give enough information about their instruments (or none at all):

²⁴ (Bachmann 1966: 29–33) provides a detailed account on the procedure of picking the instruments for the academy.

²⁵ For detailed information on the stations of the Bavarian observation network see the enormously helpful tables in (Winkler 2020: 39–40).

²⁶ The instruments from Mannheim were used in Andechs, Benediktbeuern, Hohenpeißenberg, Munich, Regensburg (since 1781) and Tegernsee. Brander and Höschel’s instruments were used in Ettal, Fürstenfeld, Niederataich, Prüfening (most likely, see Winkler 2020: 130), Raitenhaslach and Regensburg, see Winkler 2020: 40.

²⁷ Banz (no hygrometer), Mallersdorf (de Luc’s hygrometer) and Weißenstephan (no hygrometer), see (Winkler 2020: 40).

Abensberg, Aufkirchen, Beuerberg, Bogenberg, Dießen, Ettal, Großaiting (probably Brander's instruments), Indersdorf, Neuburg, Oberaltaich, Rott, Scheyern, Schönthal, Straubing and St. Zeno (Winkler 2020: 39–40). If we exclude Großaiting, we still have 14 possible monastic provenances of our instrument.

Unfortunately, there are some more stations left that we cannot yet exclude from our list of possible places of origin, since in principle the instruments used at these places can somehow have ended up at the Academy of Sciences in Munich. These stations are the Lyzeum in Amberg, the Gymnasium St. Anna in Augsburg, Frauenau (where observations were made in a private building), the university of Ingolstadt (probably Brander's instruments), Konstein (private station) and Neumarkt (private station). Since we can probably exclude Ingolstadt, we now have 19 possible places of origin in total.

But there is another problem: The available data about the instruments was published between 1781 and 1783. Especially for stations that continued their observations until 1803 or longer this means that the data is not necessarily correct for the whole period. Maybe instruments broke and needed replacement or additional instruments were bought, possibly from Paul in Geneva. In principle, this can be the case for every observation point in the network. However, tracing back single objects to one of these places seems nearly impossible – and for sure exceeds the limits of this essay. However, in the following paragraph I want to briefly discuss one centre of weather observation where such a reconstruction is at least in part possible.

In the Benedictine monastery St. Emmeram in Regensburg, Frobenius Forster (1709–1791) built up a collection of scientific instruments and started weather observations in 1771.²⁸ During the secularization period the most precious objects ended up at the Academy of Sciences in Munich. However, it is unlikely that our instrument was one of these, since there are hygrometers in the collection to this day, but none of them is made by Paul. Furthermore, our object was probably not to be considered a remarkably precious one. Much later, in 1905, five instruments were transferred to the newly founded Deutsches Museum in Munich (Meinel 1995: 198). In 1962 the collection was transferred to the recently founded University of Regensburg (Meinel 1995: 191).²⁹ Among many other objects it contains various hygrometers, upon which there is a hair hygrometer of de Saussure's portable type made by Brander and Höschel in Augsburg. This instrument has actually been used for weather observations at the Lyzeum in Regensburg and was bought for this purpose in 1820 (Meinel 2017: 358). There is even some evidence that Placidus Heinrich, who compared different types and models of hygrometers, might have owned a hair hygrometer made by Paul, since in a letter from 1822, he writes that he had ordered one from Geneva (Winkler 2020: 166). Much earlier, from 1801 to 1804, the instrument set up at Regensburg had already contained a de Saussure hair hygrometer (Winkler 2020: 162), but it is unclear if it was of the laboratory or the portable type and the instrument maker is unknown.

In conclusion, this chapter contextualized the instrument in the history of meteorology and specifically within the Bavarian weather observation practices around 1800. Although detailed answers about the object's exact time and place of origin as well as its actual use could not be derived, the broader scientific context within meteorological observations and the multiple paths following which it might have ended up at the Bavarian Academy of Sciences were demonstrated, which at the same time led to the exclusion of at least some places and time periods.

²⁸ The collected data up to the year 1827, the so-called *Observationes meteorologicae*, is still almost fully available at the university library in Regensburg.

²⁹ The collection is to this day stored at the University of Regensburg and curated by the chair for history of science.

The Object's "Life" at the Bavarian Academy of Sciences

But what about the instrument's life at the Bavarian Academy of Sciences? Was it ever used, and if so, for what purpose? There is a chance that the Bavarian Academy itself bought the object before 1806 from another institution or collector. Also, in 1802, the majority of the Mannheim academy's collections was transferred to the Munich academy (Bachmann 1966: 26). Since the Mannheim observational network used standardized hygrometers of a very different kind, it is unlikely that our instrument was part of this transfer. But even much earlier, the Munich academy had a need for scientific instruments for teaching purposes, since in 1762 public lectures at the academy started and experiments were part of them. But most of these teaching instruments were made by the lecturer himself, while some were ordered from Georg Friedrich Brander in Augsburg, which again makes it unlikely that our instrument was one of these teaching devices. However, the academy's collections also grew through transfer of many different kinds of objects from various other sources. It is obviously highly difficult, if not impossible, to determine any specific provenances (Bachmann 1966: 26).

In 1809, a meteorological commission (Meteorologische Kommission) was founded as a so-called attribute of the Bavarian Academy of Sciences. It was supposed to conduct meteorological research and collect observational data. During the first years however, lots of questions about viable procedures occurred, mostly regarding the best way to gain meteorological data and how to make use of it (Bachmann 1966: 209–210). In 1814 Munich and Hohenpeissenberg were set as main observation points.

Similar to the observation project of Mannheim, comparability and accuracy of the obtained data was intended, so the meteorological commission planned on sending standardized instruments to the stations. Instruments to measure humidity were again part of the intended set up and in 1817/18 Julius von Yelin in fact recommended de Saussure hygrometers (Winkler 2020: 49; Bachmann 1966: 210). In November 1815, at least some of the needed instruments had already been made, but since the tower that was initially intended to be used for making the observations turned out to be unsuitable for this endeavour, the instruments were temporarily set up at the physics institute of the academy (Bachmann 1966: 210). Personal tensions within the meteorological commission and new plans of the government soon led to the commission's factual dissolution, and the search for a suitable observation spot failed many times in the following years (Bachmann 1966: 210–213). Some attempts to revive the meteorological commission failed, but there were some observations done by privately interested members of the academy. It is within the bounds of possibility that our instrument, that was most likely in the academy's possession since 1806, was at some point involved in these irregular weather observations at the academy. But I can neither proof nor falsify this assumption based on the evidence and literature I was able to consult for this study.

Similar objects

During my research, I came across some other collections of scientific instruments that contained de Saussure hair hygrometers. Some of them was already referred to above, but I decided to mention more of them in this section. The following list can obviously only be incomplete, but it aims at giving at least some hints for further investigation.

Obviously, de Saussure's hair hygrometers were not only made by Paul in Geneva, but also by other instrument makers (Middleton 1969: 102). The abovementioned workshop in Augsburg by Brander and Höschel seems to be a good starting point to find more such objects, especially because he made most of the instruments used for the Bavarian observational network (Herrmann 2016: 181; Seeberger 1983: 256–257).

Generally speaking, the laboratory type of de Saussure's hair hygrometers is a quite rare object compared to the portable one, as Middleton states (Middleton 1969: 102). He mentions only one laboratory hygrometer at the Museo di Storia della Scienza at Florence (now: Museo Galileo), but many of the portable type in various museums (Middleton 1969: 102). I could not verify if this object is still in the Museo Galileo's possession, but it owns a "Saussure hair hygrometer" of the portable type without an instrument maker's inscription. The museum attributes it to the Paul in Geneva. The scale (where Paul's inscription usually is) seems to be made of a different material and has maybe been replaced.

The Deutsches Museum owns eight more hair hygrometers beside inventory number 128, but only two of them are developed by Saussure (inventory numbers 38 and 39) and only one of them (38) is signed by Paul; the other one (39) was made by Brander and Höschel in Augsburg (Seeberger 1983: 261). Both de Saussure hair hygrometers are of the portable type. The Deutsches Museum itself lists another hair hygrometer as "Haarhygrometer von Paul" (inventory number 127), but as stated above it is doubtful that this instrument was really made by Paul.

The Musée d'histoire des sciences in Geneva owns (as part of the so-called Saussure collection) five de Saussure hair hygrometers of the portable type and one of the laboratory type, but this one comes with a wooden case.³⁰ The four bottom screws are much smaller compared to the ones we found on our instrument. All these hygrometers are made by Paul and signed with "Paul A Geneve" or "Paul à Genève" (Turner 1987: 257–259). Webster's Instrument Makers Database mentions a hair hygrometer of de Saussure's portable type assigned to Jacques Paul that is in private possession (Adler Planetarium & Astronomy Museum 2007). The Conservatoire National des Arts et Métiers in Paris owns a de Saussure hair hygrometer the portable type.³¹

Answers and open questions

As I conclude, I want to briefly summarize the findings of this essay about the hair hygrometer's most probable origin, context and "life" as a scientific object. Even though it was not possible to determine the exact time of "birth", the object's inventor as well as the instrument making workshop was found. This type of hair hygrometer was invented by de Saussure in 1783 (or earlier) and this specific object was made at the Paul family's workshop (probably by Nicolas Paul) in Geneva (probably around 1800). The reason for its production as well as the institution or person that had ordered this instrument from Paul remains unknown. However, it could be shown that the instrument was most likely used for weather observations in Bavaria, for instance in one of the monasteries or at a private or public observation station. The exact place and duration of this scientific use of the instrument could not be determined, but eventually it ended up at the Bavarian Academy of Sciences (probably before 1806), where it was most likely not used at all for a long time. Probably during this period at the academy, maybe even earlier, some parts of the instrument went missing, were added or replaced and the instrument was being used in a way that was not intended by its inventor. In 1905, the hair hygrometer (together with around 200 other objects) was gifted to the Deutsches Museum and it has since been curated as part of the founding collection (Gründungssammlung).

Most of the questions stated at the end of the second chapter have been answered at least in part in this essay, especially those related to the working principle and to missing parts. However, there remains a lot to discover for future research, for instance potential reasons

³⁰ For photos (black and white) of these instruments see (Archinard 1979: 11–12, 27–28) and (Turner 1987: 257–258).

³¹ For a photo, see (Daumas 1953: PL. 52).

for the small number of instruments of this type compared to de Saussure's portable hair hygrometer. Within the limits of this essay, I was obviously not able to do further archival investigations. This and similar studies about other known objects of the same kind can probably further illuminate the history and material culture of meteorological instruments in the late 18th and early 19th century.

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