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The 16th-century Astronomical Clock of the National Maritime Museum of Greenwich

Cultural and Sensorial Analysis

The National Maritime Museum in Greenwich keeps a Renaissance table clock that was made in Augsburg around 1586. Although signed by Caspar Buschman, its authorship remains a topic of discussion because of the existence of an almost identical clock signed by Johann Reinhold. The Greenwich clock is in a square, gilded case with four legs in the form of seated bears (fig. 1). The dial of the clock shows several astronomical readings in addition to the hours of the day in both twelve- and twenty-four-hour increments.

The aim of this article is to present the history of this particular object by analysing both the object itself and a recently discovered early 18th century instructional booklet, kept in the Caird Library of the National Maritime Museum, that describes the clock in detail and explains how to operate it.[1] We know that documents of this kind were sometimes made to accompany complicated Renaissance clocks and scientific instruments, but most are lost. This booklet provides invaluable information with which to track the history of the object and to understand how and why the clock was valued more than a century after it was made.

The Buschman Clock in Greenwich

The astrolabe dial on the top of the table clock is the main and the most visible indicator (fig. 2). It shows the minute and the hour of the day, the phase and the age of the

* This paper presents some of the results from a research project about a 16th-century astronomical table clock kept at the National Maritime Museum in Greenwich. That project has been made possible only thanks to a Sackler Fellowship granted to me by the museum. The research was carried out between March and May of 2017 and its aim was to investigate the history of this particular object, not only from written sources (if any could be found) but also by examining the clock itself. So that the maximum information could be obtained from the object, it was taken apart by Rory McEvoy, Curator of Horology at the museum, to whom I am very grateful. In addition, he took the advantage of the dismantling to do some cleaning and to bring the going train back to running order.

1 Description d'une piece horlogerie tres rare & tres remarquable, Geneva 1704, kept at the National Maritime Museum, Greenwich, Caird Library, PBC1310.

1 Caspar Buschman / Johann Reinhold, table clock, ca. 1586, London, National Maritime Museum Greenwich, Caird Collection

moon as well as its position on the zodiac, the position of the sun and the positions of the moon ascendant and descendent nodes. This allows the clock to show the moments when lunar and solar eclipses are more likely to occur. In addition, the rete of the astrolabe indicates the position and the magnitude of a selection of prominent stars in the sky. Around this dial there is an outer ring corresponding to the annual calendar, making one turn each year and registering the date and saintly feast for each calendar day.

The clock was made a few years after the institution of the Gregorian calendar in 1582. Prior to this, the Julian calendar had run for a millennium and a half, and a difference of ten days had accumulated between the real position of the sun with respect to

2 Cf. fig. 1, main dial

the zodiac and the calendar date. In order to reestablish the correct dating for the equinoxes and the solstices, ten days were eliminated in 1582 and the leap year was introduced in order to avoid this issue in the future.[2] The Gregorian calendar was promoted by the Catholic Church but for political reasons was not adopted in every European territory at the same time. The Greenwich clock evidences this phenomenon in its calen-

2 For further information on the Gregorian reform of the calendar see Coyne, George V./Hoskin, Michael A./Pedersen, Olaf (eds.): Gregorian Reform of the Calendar. Proceedings of the Vatican Conference to Commemorate its 400th Anniversary, 1582–1982, Città del Vaticano 1983.

3 Cf. fig. 1, calendar ring

dar, as it originally had two hands, one showing the new Gregorian and the other the old Julian calendar (fig. 3). This paper explores this aspect further.

A total of six smaller dials on the side panels of the case provide further data. Two of the side panels feature two dials each, and the two other side panels feature one dial each along with a circle in openwork tracery, through which the sound of the bell passes. On one of the four sides, two dials show cycles of the sun and moon as well as their combinations, which can be used to make calendar calculations. On this side, the left dial offers the epact and the golden number for the years between 1586 and 1699 (fig. 4). On the next side, the single dial gives the planetary hours, that is to say, which planet rules over each hour of the day (fig. 5). On the third side, the right dial indicates the length of the day depending on the latitude, which can be set manually on the left dial (fig. 6). The single dial on the fourth side is used to set up the alarm mechanism. The bell itself is positioned behind the openwork tracery circle on this side of the clock (fig. 7). In addition to these mechanically driven dials, the clock features four sundials on its underside, which can be detached from the case and used. Three of these correspond to different latitudes and the other has a variable angle gnomon to be used in latitudes from 42° to 54° (fig. 8).

On the sundial plate is engraved the pineapple punch of the city of Augsburg, where the clock was made. In addition, the epact dial dates the clock to around 1586, the earliest year shown on the dial. The authorship may seem obvious at first glance, as the clock is signed on the astrolabe's tympanum by Caspar Buschman, a member of a family of clockmakers whose workshop in Augsburg remained active at least until the 18th century.

4 Cf. fig. 1, back side

5 Cf. fig. 1, left side

6 Cf. fig. 1, front side

7 Cf. fig. 1, right side

8 Cf. fig. 1, bottom side

Three 16th-century Buschmans from Augsburg were named Caspar: Caspar I (1512–1589), Caspar II (1536–1613) and Caspar III (1563–1629).[3] Given that the clock was made around 1586, the signature could correspond to any of these three. According to Klaus Maurice, the Greenwich clock was made by Caspar I or II, as Caspar III inherited the workshop from his father only in 1591.[4]

Although the clock is signed by one of the Buschmans, there is strong evidence to suggest that Johann Reinhold 'The Elder' (1550–1596), a celebrated scientific instrument maker working in Augsburg in the final third of the 16th century,[5] made the Greenwich

3 Bobinger, Maximilian: Kunstuhrmacher in Alt-Augsburg, Augsburg 1969, pp. 79–82.
4 Maurice, Klaus: Die Deutsche Räderuhr, 2 vol., Munich 1976, vol. 1, Munich 1976, p. 176.
5 Bobinger 1969 (see footnote 3), p. 14.

clock or some of its parts. An almost identical clock is found in the Landesmuseum Württemberg in Stuttgart, signed by Reinhold and made in 1582 or 1583.[6] A close study of select symbols from the sundial plates of both clocks demonstrates that they were made with the same punches.[7]

If we accept that the Greenwich clock was made in large part by Reinhold, another question arises: Why and when did Buschman (Caspar I or Caspar II, or perhaps the two together) sign it? It is very difficult to answer this question with the currently available evidence, however, it is possible that Buschman and Reinhold may have collaborated and exchanged technical knowledge and skills. Both worked and probably lived in the Schmiedgasse, in Augsburg, and they knew each other. Evidence of their familiarity with one another is the fact that Caspar Buschman III became guardian of Reinhold's ten-year-old son after Reinhold's death in 1596.[8]

Reinhold was not only a clockmaker but also a renowned scientific instrument maker of his time who worked with Georg Roll (1546–1592), another instrument maker and dealer in Augsburg.[9] Today various terrestrial globes and other instruments still exist that are signed by one or both of them. Particularly interesting are the globes in Dresden[10] and Vienna,[11] signed by Roll and Reinhold and by Roll, respectively. The two are almost technically and artistically identical and feature on their bases sundials very similar to those of the Greenwich and Stuttgart clocks. Also bearing a close similarity to the Greenwich and Stuttgart examples is the rete of an astrolabe by Reinhold now in the collection of the American Museum of Natural History, New York.[12] Because retes of similar shape were produced by various craftsmen within the region of Augsburg, their shapes cannot aid in establishing the authorship of an anonymous instrument. However, in the future, analysis of the punches from several instruments known to have been made by the Reinholds and/or Roll and by the Buschmans may yield a better understanding of the relationships between their workshops.

For whom was it made?

The Greenwich clock is an outstanding object whose manufacture would have required a specialized knowledge and technical skill that not every clockmaker possessed. There must have been a good reason to make an object like this one, so what was that reason?

6 Leopold, John H.: Die große astronomische Tischuhr des Johann Reinhold, Luzern 1974, p. 77; Stuttgart, Landesmuseum Württemberg, inv. no. 1975–23.
7 Pérez-Álvarez, Víctor: The Universe on the Table. The Buschman Astronomical Clock from the National Maritime Museum, in: Antiquarian Horology 39/3, 2018, pp. 342–360, p. 355.
8 Bobinger 1969 (see footnote 3), p. 82.
9 Maurice 1976 (see footnote 4), p. 68; Bobinger 1969 (see footnote 3), p. 29.
10 Dresden State Art Collections, Mathematisch-Physikalischer Salon, inv. no. E II 2.
11 Vienna, Kunsthistorisches Museum, inv. no. Kunstkammer, 854.
12 New York, American Museum of Natural History, inv. no. Hayden Planetarium, 2048.

Was it commissioned by an individual or was it made to be sold on the market? It is not easy to answer this question, but some clues point to the second option. When a sumptuous object is commissioned by an individual, the finished product often shows his emblem or coat of arms or a related inscription. The Greenwich clock has no such personal marker. The most prominent figurative elements are the four seated bears, however, no particular meaning can be attributed to these.[13] In Renaissance clocks and other objects from this period, it is very common to find feet in the shape of dogs, lions, dragons and other animals, but not bears.

The calendar on the top of the clock might help to establish whether it was made for a Lutheran or a Catholic customer. The clock was constructed around 1586, approximately four years after the Gregorian reform. The Julian calendar was still in use in Lutheran regions well into the 17th century, while in Catholic territories the Gregorian calendar was adopted between late 1582 and 1583.[14] The outer ring of the dial of the Greenwich clock corresponds to the new Gregorian calendar, with the solstices and equinoxes as well as the Catholic feasts falling on the correct dates. The Conception, Birth and Assumption of the Virgin are also featured on the clock. Here Mary's feasts are particularly meaningful, as during the 16th century they were gradually eliminated from the Protestant liturgical calendar because they do not appear in the Bible. However, as these festivities were strongly rooted in popular culture, in 1520 Luther advised that they be maintained for a while in order to avoid shocking the people.[15] The calendar is Catholic but had two identical, radial hands that respectively showed the date according to the 'new' and the 'old' calendar. Although one of them is now missing, in 1704 both were still attached to the clock, according to the instructional booklet. This could be interpreted in different ways. The clock could have been made primarily for a Catholic market, however, with the second hand (corresponding to the old calendar) still allowing for future marketability to Protestant consumers who opposed the adoption of the reformed calendar.

The particular political circumstances of Augsburg during the 1580s must also be considered in order to understand the clock. Following the 1555 Peace, Lutherans and Catholics coexisted in Augsburg, but not without tension. The Gregorian calendar was launched by the Catholic Church in 1582 and in January 1583 was approved by the Augsburg city council despite the opposition of its Lutheran members, who considered this a violation of the 1555 Peace and publicly expressed their displeasure. This contributed to the spread of several rumours among the people, who saw the Jesuits as the pope's fifth column and perceived the adoption of the new calendar as an act of interfer-

13 Pérez-Álvarez 2018 (see footnote 7).

14 Gingerich, Owen: The Civil Reception of the Gregorian Calendar, in: Coyne/Hoskin/Pedersen 1983 (see footnote 2), pp. 265–267.

15 Kreitzer, Betz: Reforming Mary. Changing Images of the Virgin Mary in Lutheran Sermons of the Sixteenth Century, Oxford 2004, p. 122; Heming, Carol Piper: Protestants and the Cult of the Saints in German-speaking Europe, 1517–1531, Kirksville 2003, p. 104.

ence by the Catholic Church in the lives of Lutherans. In October Emperor Rudolph II ordered the implementation of the new calendar in all his territories, but that did not prevent opposition in Augsburg, and in 1584 the detention of a Lutheran leader triggered a revolt. The riots ended on June 14 after the emperor issued a general pardon and the Lutherans accepted the Gregorian calendar, but public shows of opposition continued during the following years.[16] It is in this context that the maker of the Greenwich clock decided to include both calendar hands on his clock to highlight the new calendar, however, without forgetting the old one (fig. 3).

It is striking that the clock also gives the hour according to several time-telling systems used in various areas of Europe. Together with the two parallel calendrical indications, this may lead us to interpret it as a travel clock intended to be used in different places. Spring-driven clocks with balance escapement from this period can run while being transported but, for technical reasons, they are not reliable timekeepers in such a context. They are therefore usable only during stops on the trip, after being settled on a proper surface and set to the correct time using the sundials on the bottom plate. If conceived as a travel clock, the Greenwich clock would almost surely have had a protective leather or wooden case. Contrary to this possible use is the fact that setting this clock to time is a complex task, as will be elaborated upon later. The inclusion of the double calendar reading and the multiple time-telling systems as well as the many other dials may also be explained as an intention on the part of the maker to create a compendium-like clock, an amusement object, with as many complicated features as possible.

These pieces of evidence indicate that the clock was made not for a particular customer but to be sold on the art and scientific instrument market, and perhaps for ready export to any European country. The fact that a nearly identical clock still survives today suggests that several similar or identical units were made for the same purpose.

How was the clock handled?

Close study of a surviving original instrument can reveal information unaccounted for in written sources. In this section the clock is examined to demonstrate the extent to which it is reliable, easy to operate and thus practical as a time-keeping instrument.

16 Städtische Kunstsammlungen Augsburg/Zentralinstitut für Kunstgeschichte (eds.): Welt im Umbruch. Augsburg zwischen Renaissance und Barock, exh.-cat. Augsburg, Zeughaus, 3 vol., Augsburg 1980–1981, vol. 1, Augsburg 1980, pp. 379–380; Roeck, Bernd: Eine Stadt in Krieg und Frieden. Studien zur Geschichte der Reichsstadt Augsburg zwischen Kalenderstreit und Parität, 2 vol., Göttingen 1989, vol. 1, Göttingen 1989, p. 125; see also Creasman, Allyson F.: Censorship and Civic Order in Reformation Germany, 1517–1648, Farnham et al. 2012, pp. 149–150.

The Greenwich clock was made to be seen, heard and touched.[17] It was designed to be installed on a table or a low pedestal to allow the user to reach it easily and to inspect each dial closely. Most of the inscriptions on the clock are very small, for example, the numbers of the days and the names of the saints on the calendar. Even to see the hour shown on the astrolabe, one must be in close proximity to the clock, as it is easy to confuse the alidades of the sun and the moon. Ideally, it should be installed in such a way as to allow for viewing of each the four sides of the case from a short distance.

The sound of the alarm bell is particularly strong. Unfortunately, we are unable to hear the clock strike the hour and the quarter hour because some parts are missing from these striking trains. But it is reasonable to assume that the sound was loud enough to be heard across large rooms and very likely also in adjacent rooms.

The time can be read by touching the face of the clock too. Renaissance clocks and portable watches had exposed dials with a small ball-shaped piece installed directly above each of the hour numbers. Above the hour of 12 would be placed a small conical piece instead of a ball, to mark this as a starting point. The Greenwich clock has the small ball-shaped pieces on the face of its astrolabe, indicating by touch the hours and quarters, and on the alarm dial, indicating the hours. The hands of the minutes and of the moon and sun are also easily distinguishable by touch. These tactile elements facilitate the telling of the time in poor lighting conditions or during the night.

Most of the controls for the clock are accessible through the bottom plate, on which the sundials are featured (fig. 8). This means that one must turn the clock onto its side or onto its face to reach them. This must be done on a daily basis in order to wind the three mainsprings, or all four if one intends to operate the alarm. As there is a hole on the sundial plate for each winding arbour, it is not necessary to detach the plate for this task, although it is necessary for activating other components of the clock. For instance, the alarm itself is easy to set but the lever to stop it is hidden on the underside and cannot be operated without detaching the sundial plate.

Probably the biggest inconvenience in operating the clock is that the hands cannot be moved manually and independently from the clockwork as with modern clocks and watches. This means that, after servicing the clock in the workshop, the clockmaker must be very careful to replace each wheel and hand in the right position. This is particularly important with the astrolabe, which needs to be set to the correct date. The use of the clock also requires certain skills, for example to set the time. The escapement wheel can be released by unscrewing the balance cock and lifting the balance by hand. This allows the user to move the clock forward easily, but makes it extremely difficult to move it backward. A screwdriver as well as basic clockmaking skills are required to remove the balance cock without damaging the delicate balance pivots. Alternatively, to

17 For a good methodological insight on the sensorial analysis of clocks and watches see Desborough, Jane: The Changing Face of Early Modern Time, 1550–1770, Cham 2019.

avoid disassembling the balance, the user could keep the clock running continuously, using only the regulator to compensate for time losses or gains.

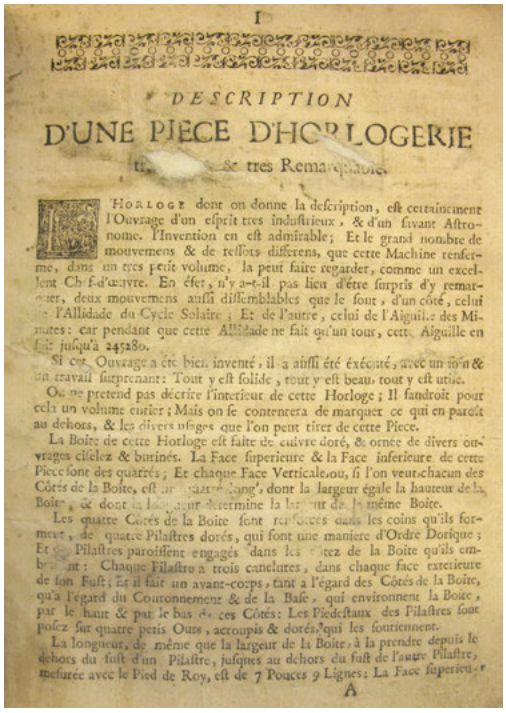
These complicated features, along with the profuse decoration of the gilded case and the high quality of the workmanship, make the clock an ideal amusement object. It is very difficult to establish whether it would have been used on a daily basis to strike and show the hours or would have been set up on special occasions only. At first glance, keeping the clock running may seem unreasonably time consuming and wearisome in terms of maintenance but could be easily accommodated in a luxurious domestic environment. Objects are not only used for their practicality but also for their symbolism and their cultural significance, which changes according to context and use.

The Clock as a Precious Antique in the 18th Century

We know very little about the subsequent history of the clock up to the beginning of the 18th century, when the instructional booklet was printed (fig. 9). This fifteen-page document contains very detailed descriptions and other interesting information about the clock. Its anonymous author praises the skill of the clockmaker, noting the complexity of the movement and the fine decoration of the case. He does not describe the movement – as, according to him, "it would require a full volume" – but he does describe the case in great detail, including its measurements, which match perfectly those of the clock. The seated bears are also mentioned, and the corner pillars are described in full detail: "The four corners of the case are reinforced with four gilded pilasters in the Doric style. […] Each pilaster has three flutings on each of its outer sides. […] The pedestals of the pilasters rest on four small gilded and crouched bears".[18] The use of every dial is then carefully explained. The description of the astrolabe dial is the longest, as it is the most elaborate dial on the clock and gives a variety of indications. A detailed description of each dial is followed by some practical instructions for winding the clock and operating the alarm mechanism.

The 1704 booklet is a rare survival of its genre and, in fact, is very likely the only extant example. Johannes Graf classifies the horological literature into the following groups: books for the user, books for the maker and books that describe complicated astronomical clocks. The 1704 booklet falls into the third category. It was in this type of book that monumental astronomical clocks from cathedrals, often of medieval origin, were described, with Dasypodius's description (1578) of the Strasbourg astronomical clock being the most iconic example. The Greenwich and Dasypodius books have some characteristics in common, for example, they do not describe the movement but only the astronomical indicators. Clockmaking pertained to the domain of the *artes mechanicae*, considered inferior to the *artes liberales* such as astronomy, which encompassed the

18 Description 1704 (see footnote 1), p. 1.



I

DESCRIPTION

D'UNE PIECE D'HORLOGERIE

ti[illegible] & tres Remarquable.

L'Horloge dont on donne la description, est certainement l'Ouvrage d'un esprit tres industrieux, & d'un savant Astronome. L'Invention en est admirable; Et le grand nombre de mouvemens & de ressorts differens, que cette Machine renferme, dans un tres petit volume, la peut faire regarder, comme un excellent Chef-d'œuvre. En effet, n'y a-t-il pas lieu d'être surpris d'y remarquer, deux mouvemens aussi dissemblables que le sont, d'un côté, celui de l'Allidade du Cycle Solaire; Et de l'autre, celui de l'Aiguille des Minutes: car pendant que cette Allidade ne fait qu'un tour, cette Aiguille en fait jusqu'à 24[illegible]280.

Si cet Ouvrage a été bien inventé, il a aussi été éxécuté, avec un soin & un travail surprenant: Tout y est solide, tout y est beau, tout y est utile.

On ne pretend pas décrire l'interieur de cette Horloge; Il faudroit pour cela un volume entier; Mais on se contentera de marquer ce qui en paroît au dehors, & les divers usages que l'on peut tirer de cette Piece.

La Boite de cette Horloge est faite de cuivre doré, & ornée de divers ouvrages ciselez & burinés. La Face superieure & la Face inferieure de cette Piece sont des quarrés; Et chaque Face Verticale, ou, si l'on veut, chacun des Côtés de la Boite, est un quarré long, dont la largeur égale la hauteur de la Boite, ce dont on la longueur détermine la largeur de la même Boite.

Les quatre Côtés de la Boite sont renfermés dans les coins qu'ils forment, de quatre Pilastres dorés, qui font une maniere d'Ordre Dorique; Et ces Pilastres paroissent engagés dans les côtez de la Boite qu'ils embellissent: Chaque Pilastre a trois canelures, dans chaque face exterieure de son Fust; Et il fait un avant-corps, tant à l'égard des Côtés de la Boite, qu'à l'égard du Couronnement & de la Base, qui environnent la Boite, par le haut & par le bas de ces Côtés: Les Piedestaux des Pilastres sont posez sur quatre petis Ours, accroupis & dorés, qui les soutiennent.

La longueur, de même que la largeur de la Boite, à la prendre depuis le dehors du fust d'un Pilastre, jusques au dehors du fust de l'autre Pilastre, mesurée avec le Pied de Roy, est de 7 Pouces 9 Lignes: La Face superieu[illegible]

A

9 *Description d'une piece d'horlogerie tres rare & tres remarquable*, Geneva 1704

theoretical knowledge required to design scientific instruments. Dasypodius was the mathematician who designed the complicated indicators of the Strasbourg clock (classified under *artes liberales*) and, according to Graf, he emphasizes them in his text in order to distinguish himself from Isaac and Josiah Albrecht, the makers of the movement (classified under *artes mechanicae*). This hierarchy between the liberal and mechanical arts could explain why no mention is made of the movement in the 1704 instructional booklet corresponding to the Greenwich clock.[19]

In addition to explanations of the features of the clock and a few technical and practical points regarding how to use it and keep it running, the booklet includes other information about the history of the clock and the objective of the booklet itself. An italicized portion of the final paragraph reads: "The clock just described is for sale: This piece belonged to Casimir V, King of Poland, who, having abdicated the crown, retired to Paris, where he became abbot of Saint Germain. [The clock] was sold in Paris after this king's death in 1672. Now it is in Geneva with the Master Clockmakers [Guild], whom anyone interested in purchasing it should address".[20]

19 Graf, Johannes: Der kunstreiche Uhrmacher. Kostbarkeiten aus der Bibliothek des Deutschen Uhrenmuseums, Furtwangen 2010, p. 34.

20 Graf 2010 (see footnote 19), p. 13.

John Casimir of Poland (1609–1672) abdicated the Polish Crown in 1668 and spent his final years in Paris. There is no evidence either to confirm or to refute that he owned the clock now in Greenwich, as it cannot be clearly identified among the clocks described in the inventory of the post mortem sale of John Casimir's belongings in 1673.[21] Aspects of the clock suggest that it might have been in or around Paris in the 17th century or maybe earlier. For example, the astrolabe's tympanum is for 48° of latitude, that of several European cities including Paris. The moving plate of the alarm dial, which does not appear to be original, was made with a lower quality silvered metal and bears inscriptions in Latin of the four cardinal points. To indicate the direction in which the plate should be rotated to set up the alarm, the French words "de minuit a midy" were engraved later – maybe after 1704, the printing date of the instructional booklet, which does not mention this inscription. Although in that period French was the *lingua franca* for educated people, the French inscriptions suggest that the clock was at some point in France or Switzerland, and the astrolabe's tympanum points to Paris. Apart from the instructional booklet, there is no evidence to connect the clock with John Casimir of Poland, but we cannot discard this possible connection entirely.[22] The booklet is dated to 1704, only about 40 years after the death of the Polish king – a period short enough for a recent previous owner of the clock to be remembered, particularly if that previous owner had been a distinguished person. The aim of the booklet was to advertise the clock, which was for sale in Geneva at the time. Had the clock previously belonged to a known king, it could be sold more easily and for more money.[23]

The instructional booklet is anonymous, but La Lande attributes it around 1800 to Nicolas (?) Fatio de Duiller (1664–1753),[24] a prominent Swiss mathematician, who introduced to England a drilling method for extracting jewels with reduced pivot friction and thus greater accuracy.[25] Fatio was elected a fellow of the Royal Society in 1673 and moved to London a few years later.[26] By the 1690s Fatio was looking for patronage and, in 1693, he began a collaboration with the Debaufre brothers (c. 1689–1720),[27] two Parisian

21 Szmydki, Ryszard: Vente du mobilier de Jean-Casimir en 1673. Wyprzedaz mienia po Janie Kazimierzu w roku 1673, Warsaw 1995, pp. 155–157; see also Pérez Álvarez 2018 (see footnote 7), p. 356.

22 For further details on the possible connection of the clock with John Casimir in Paris see Pérez-Álvarez 2018 (see footnote 7).

23 In the 18th century, other brochures were also printed to advertise and sell clocks, for example, the "Hertzanische Uhr" made in Augsburg at the end of the 17th century and sold different times during its history before being dismantled in the 19th century, see Graf 2010 (see footnote 19), p. 37.

24 Jerôme De La Lande: Bibliographie astronomique avec l'histoire de l'astronomie depuis 1781–1802, Paris 1803, p. 350; Baillie also attributes the pamphlet to Fatio without citing to La Lande, Baillie, Granville H.: Clocks and Watches. An Historical Bibliography, London 1951, p. 132.

25 Hilaire-Perez, Liliane: L'invention technique au siècle des Lumières, Paris 2000, p. 110.

26 Speziali, Pierre: La physique, in: Trembley, Jacques (ed.): Les savants genevois dans l'Europe intellectuelle du XVIIe au milieu du XIXe siècle, Geneva 1987, p. 115.

27 Mandelbrote, Scott: The Heterodox Career of Nicolas Fatio de Duillier, in: Brooke, John/Maclean, Ian (eds.): Heterodoxy in Early Modern Science and Religion, Oxford 2005, pp. 282–283 and 289.

clockmakers working in London.[28] Between 1699 and 1701, Fatio travelled to Geneva and other places in Switzerland.[29] The printing year of the instructional booklet for the Greenwich clock, 1704, is consistent with Fatio's stay in Geneva, and his link with the Parisian clockmakers could account for the transfer of the clock from Paris to Geneva. Further research into Fatio's personal archive, at the University of Geneva, might shed light on what connection, if any, he had to the authorship of the booklet and to the clock more generally.

Around 1700 the Greenwich clock was more than one hundred years old, but it was still an attractive object suitable for sale. It was probably at this time that it arrived at a workshop in Geneva to be repaired and updated. Still today the movement is in very good condition, with few of the original 16th-century parts missing, so three centuries ago it must have been in outstanding condition and in need of very few repairs in order to run well, except a deep cleaning and oiling. The escapement was likely refurbished at that time with a balance spring as well as new crown and contrate wheels to compensate for the change of the oscillation period. A new epact year disc for the period spanning 1700 to 1800 was engraved and nailed onto the original one, whose final year was 1699. The disc of the alarm dial may also have been changed on this occasion.

The Greenwich clock is an outstanding object by one – or maybe two – of the most skilled makers in Augsburg at the end of the 16th century. We are not able to trace back its history without gaps but we do have a concrete picture of what made the object valuable at two representative moments. Although it showed and struck the hours, its astronomical complexities, technical characteristics and the operational difficulties suggest that the clock was conceived of as a magnificent object, perhaps to be exhibited in a *Wunderkammer* or in a lavish room, rather than primarily as a functional object for a domestic environment. Its owner may have been a wealthy individual who could pay someone to wind it every day and to keep it running and showing the correct time. Most likely, he owned other clocks, astronomical instruments and curiosities. The presence of clocks and watches in the goods inventories of European kings from the 14th century onwards has been the subject of previous studies.[30] Still lacking is a detailed study of their presence in the inventories of noblemen and wealthy people from the late 16th and early 17th centuries, which also contained complicated clocks. For example, Octavius Secundus Fugger (1549–1600), a member of a well-known wealthy family of Augsburg, left at his death a collection of sumptuous objects, including complicated astronomical clocks and scientific instruments.[31] In Spain, the Conde de Benavente, Juan Francisco

28 Thompson, David: Huguenot Watchmakers in England. With Examples from the British Museum Horological Collections, in: Proceedings of the Huguenot Society of Great Britain and Ireland 26, 1994–1997, pp. 417–430, p. 427.

29 Mandelbrote 2005 (see footnote 27), p. 291.

30 See, for example, Pérez-Álvarez, Víctor: Mechanical Clocks in the Medieval Castilian Royal Court, in: Antiquarian Horology 34/4, 2013, pp. 489–502.

31 Lieb, Norbert: Octavian Secundus Fugger (1549–1600) und die Kunst, Tübingen 1980, pp. 133–135, "Zeig und Schlag Stundenuhr mit Angabe der Tag und Nachtlänge, seitlich einem Astrolabium,

Pimentel, likewise had, in 1653, a variety of clocks, including one with complex astronomical features.[32] A systematic study of goods inventories from this period and from different sites in Europe would yield a better understanding of who owned these kind of domestic clocks and just how widespread they were.

At the beginning of the 18th century, when it was more than one hundred years old, the Greenwich clock was valued not only as a curiosity but also as a collectable object previously owned by a king.

In the 19th and 20th centuries, the old Renaissance clock surely failed to meet the standards for accurate timekeeping and therefore was no longer usable. By the 1960s, when it was restored, some parts were missing, including the driving pinion for all the astrolabe hands. That part might have been eliminated on purpose in order to render the astrolabe useless, thus limiting the range of functions of the clock to help keep it running and to improve its accuracy as a time-telling instrument. At the beginning of the 20th century, the clock belonged to the Mensing Collection. It arrived in 1937 at the National Maritime Museum in Greenwich and now is exhibited in a reconstructed cabinet of curiosities at the Queen's House.[33]

Renaissance astronomical clocks have been highly attractive and collectable objects since the 16th century. They have been studied by historians of horology, who focus on their technical aspects, yet there are still many research possibilities from the points of view of cultural history and the history of material culture. Strikingly, before the 17th century the historiography of timekeeping largely focused on public clocks and relied almost solely on written sources, neglecting domestic clocks not only as objects of study but also as material evidence about how time was practiced and experienced.

The Greenwich clock is a good example of an object that has had a long life and that contains evidence about its significance for different people at different moments in its history. The issue surrounding its authorship indicates that clockmaking in Augsburg was a complex trade that functioned on the basis of a network of crafts- and tradesmen. Further study of the punches of this and other instruments signed by the Reinholds and the Buschmans might shed light on the connection between these workshops at the making stage. On a different matter, a study of the presence of clocks and other time-telling devices in the goods inventories of people from social groups other than those of kings and rulers, from the 16th to 18th century and from all across Europe, could show how common and valuable they were, who owned them and how they related to other objects.

Sonnen und Mondgang, eingelassen in ein durchbrochenes Metallgehäuse und unter einem Glassturz aufgestellt".

32 Archivo Histórico Provincial of Valladolid (Spain), Leg. 1787 (Valladolid, 1653, julio, 4), see García Chico, Esteban: Documentos para la historia del arte en Castilla. Maestros relojeros, in: Boletín del Seminario de Arte y Arqueología 31, 1966, p. 412: "Otro reloj quadrado a manera de torre chata con movimeintos de luna, sol y planetas, y estralabio, de bronce sobredorado, de campana y quartos, en quarenta y dos ducados".

33 Pérez-Álvarez 2018 (see footnote 7), p. 359.