The Changing Face of Time:
The Making of the Modern Clock & Watch Dial
1550-1770

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Abstract

This thesis provides a reinterpretation of early modern clock and watch dials on the basis of use, in response to an immense gap left in horological historiography where dial designs have been dismissed as insignificant beyond aesthetic concerns.

By 1770 a standard design had emerged, which represented hours, minutes and seconds. Yet, between 1550 and 1770 dials represented combinations of calendrical, lunar and astronomical information using multiple concentric rings, subsidiary dials and apertures. Change was gradual, but significant. I have developed a unique methodology for unlocking the meaning embedded within these early combinations and the significance of dial change, by closely comparing a selection of clock and watch dials from different museum collections with printed paper sources such as almanacs, astronomical, astrological and mnemonic diagrams, craft books, and art works.

Multiple concentric rings and subsidiary dials bore similarity to circular and tree diagrams and were conducive to perceptions of stepped knowledge acquisition. Both media became plainer in appearance from the mid-late seventeenth century as these perceptions declined. Some makers utilised different formats to generate trust in their work, from alternative hour schemes during the late-sixteenth century to imitation of precision timepieces from the early-eighteenth century. Others utilised touch-pins, during the mid-late sixteenth century, and illumination of numerals, from the late-seventeenth to the early-eighteenth century, to enable users who were otherwise excluded. The calendar, lunar and astronomical functions were useful as a prompt for recalling astrological advice up until its decline during the mid-late seventeenth century. After which, the three functions enjoyed different lifespans, while they continued to be useful for other purposes, but none survived to be part of the standard format.

It is only through the lens of use and comparison with the wider context that the significance of early modern clock and watch dials can be fully appreciated.

Table of Contents

List of Figures

Chapter 1

Introduction

Figure 1.1[1]©Science Museum
Nicholas Vallin, London, 1600, owner unknown

Figure 1.2[2] ©British Museum
John Arnold, London, c.1778, owner unknown

The late-eighteenth century user of the watch in figure 1.2 would have had very little use for the dial of the clock in figure 1.1. It did not tell them the minutes or seconds. Conversely, the late-sixteenth century user of the clock in figure 1.1 would have found the watch dial in figure 1.2 extremely limiting. It did not tell them the age of the Moon, or the date in terms of the civil or zodiac calendar. For this reason it was not useful for astrological or mnemonic purposes and nor was it a device representative of higher knowledge. Such was the difference between clock and watch dials in the two hundred years that separated the production of these two examples. Nevertheless, I will argue that the dial in figure 1.2, which exemplifies a version of the standard format that emerged around 1770, primarily owed its design to dials such as that in figure 1.1. Another version displayed centre seconds, where the second hand was concentric with the minute and hour hands. However, the version seen in figure 1.2 was more prevalent during the late-eighteenth century and will be the version referred to in this thesis. While the availability of materials and the capacity to reproduce this form would also have played a role, these factors do not sufficiently explain the longer-term influences which led to this design. The standard format was as much a product of hitherto declined theories and practices as it was of those prevalent around 1770 when it rose to popularity.

[1] Science Museum 1938-429. Reproduced by kind permission of the Trustees of the Science Museum Group.
[2] British Museum CAI.1839. Reproduced by kind permission of the Trustees of the British Museum.

The journey of dial development from the type seen in figure 1.1 to the type seen in figure 1.2 is a rich and fascinating one and forms the overarching narrative of this thesis. It is not known who the original owners or users of the dials in figures 1.1 or 1.2 were. We know who made them, approximately when, and that they were made in London, but their dials were not unique to London. They are tantalising evidence of past use and connections to the wider context of knowledge transmission, but the challenge remains of how to unlock their meaning. I will argue over the course of the thesis that the best way to improve our understanding of dial use is through a close comparison with printed paper sources. It is only through these comparisons that we can identify which traditions of communication and knowledge clock and watch-makers drew upon when designing dials. I will argue that the decisions made in terms of what to include on dials, such as the civil calendar, and later decisions as to what to leave out, such as the period of the day by the early-seventeenth century, were the results of changing user needs. These changing needs are evident in printed paper sources, such as almanacs, where the decline of astrology during the mid-late seventeenth century was noticeable by the reduction of predictions based explicitly on parts of the day thought to be ruled by particular planets. Similarly, comparison of dials with printed paper sources enables us to identify changing uses of indications on dials that may at first seem to have changed very little throughout the period. One example is the pictorial representation of the changing lunar phase. Almanacs up until the mid-late seventeenth century provided weather, health and farming advice based explicitly on the lunar phase, which made the indication of the changing phase on dials very useful for astrological purposes. However, people throughout the period, but particularly in more rural areas from the early-eighteenth century, planned night-time journeys according to the dates of the full Moon. This meant that even after the decline of astrology, the indication of the lunar phase on dials remained useful, but these changes are undetectable without comparing dials to printed paper sources.

Thus, I will ask four over-arching questions of dials, itemised at the beginning of section 1.2, but before I can introduce them I will outline the reasons why these particular questions need asking in light of what has been written about dials and early modern knowledge transmission so far.

1.1 Critique of the secondary literature

Clock and watch dials have received very little attention from historians. Loomes' trio,[3] which only map changes in numeral size and dial decoration in a catalogue-style approach rather than commenting on the significance of these changes, and Tennant's account of dial conservation[4] are the only book-length works which concentrate on dials. Due to their alternative focus, these works and the wider horological historiography have left an immense gap in the historical record. Clock and watch dials are a mechanical form of knowledge communication and yet have not been considered from the angle of use before. This omission from the historical record has left a substantial gap mainly in the horological literature, but also elsewhere as I will demonstrate. An important part of my unique methodology, outlined in section 1.2, is to bring three bodies of historical literature together for the first time. Each chapter and my unique set of chapters as a combination contribute to three overarching areas of historiography. These are: histories of horology and social histories of time; histories of early modern knowledge transmission, namely histories of printing and reading; and histories of early modern epistemology, namely natural magic and nascent science, which I will discuss in turn.

Through my unique methodology and the answers I provide to the research questions, I overhaul the current literature on the history of horology and social histories of time. Historians of horology such as Thompson[5], Bruton[6], Loomes[7], and others[8] approach the history of clocks and watches in the same manner, which is an inheritance from the late-nineteenth century writer, Britten[9], and mid-twentieth century writers, Baillie[10] and Clutton.[11] These authors provided a catalogue-style approach to clock and watch history, mapping and describing every detail of a clock or watch, but with extremely little contextualization and no comment on the significance of the elements they described. Their focus was on the development of precision timekeeping and consequently they wrote in

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[3] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club; Loomes, B. 1994. *Painted Dial Clocks.* Woodbridge: Antique Collectors' Club; Loomes, B. 1981. *White Dial Clocks: the Complete Guide.* Newton Abbot: David & Charles.

[4] Tennant, M.F. 1995. *Longcase Painted Dials.* London: N.A.G. Press.

[5] Thompson, D. 2004. *Clocks.* London: British Museum Press; Thompson, D. 2007. *Watches.* London: British Museum Press.

[6] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.

[7] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club.

[8] Christianson, D. 2002. *Timepieces: Masterpieces of Chronometry.* Newton Abbot: David & Charles.

[9] Britten, F.J. 1982. *Britten's Old Clocks and Watches and their Makers.* 8th ed. edited by Baillie, G. H. Ilbert, C. A, Clutton, C. 9th ed. revised by Clutton, C. ed. London: Methuen.

[10] Baillie, G.H. 1929. *Watches: their History, Decoration and Mechanism.* London: N.A.G. Press.

[11] Britten, F.J. 1982. *Britten's Old Clocks and Watches and their Makers.* 8th ed. edited by Baillie, G. H. Ilbert, C. A, Clutton, C. 9th ed. revised by Clutton, C.. ed. London: Methuen.

terms of a pre-pendulum and post-pendulum context, where everything in the former era was designed as a stop-gap until the pendulum was developed. This approach has been continued in the horological literature until now. For this reason throughout the thesis I refer to 'historians of horology' and name one or two, whose names recur throughout the thesis, but they stand for a wider school of thought which has remained unchanged for over a hundred and twenty years.

One of the problems with the traditional horological literature is that, as it is based solely on museum objects, the authors have been distracted by the modern identity given to the objects as 'museum objects' once acquired by the institution. Gauvin, who I discuss below, is sceptical about the power of objects once they appear in a museum.[12] For him once in that context they become functionless. I argue below that his appraisal of Dudley's comments is not quite accurate, but with regard to the approach made by historians of horology I agree with him. Clocks and watches must be contextualised to be fully understood. Similarly, as Preziosi and Farago argue, museum objects are staged and framed to be interpreted in certain ways or in ways that privilege their aesthetic significance.[13] Indeed, there is often a concern in museums to display the objects with the most pleasing appearance. However, in order to understand the significance of dial change the objects must be interpreted according to the wider context of which they were a part.

In each chapter of my thesis I challenge the traditional horological literature on the basis of methodology. Traditionally, historians of horology have focussed on technical developments and interpreting clocks and watches in this context has led them to conclude that ever-increasing precision was a historical inevitability. They have rarely considered clocks as examples of material culture within a wider network of ideas and practices with the one exception of navigation and longitude. It is context that is missing from the horological historiography. Most of the authors approach their work in a highly prescriptive fashion. In true catalogue formation they begin with the casing, move past the dial, and go through each component of the movement.[14] Historians of horology such as, Bruton and Loomes, merge all indications other than the hour of the day into one group of 'other'.[15] These works provide important background information for my inquiry in terms of the mechanical context in which my research area rests and I aim to contribute to their work by introducing a discussion of dials.

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[12] Gauvin, J.F. 2016. Functionless: Science Museums and the Display of 'Pure Objects'. *Science Museum Group eJournal.* Spring (5). http://journal.sciencemuseum.org.uk/browse/issue-05/functionless/.
[13] Preziosi, D. and Farago, C. 2004. *Grasping the World: the Idea of the Museum.* Aldershot: Ashgate.p.4.
[14] See appendix two for a definition of this horological term.
[15] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.p.104-119; Loomes, B. 1994. *Painted Dial Clocks.* Woodbridge: Antique Collectors' Club.p.223.

The weakness of some social histories of time, such as those by Adam,[16] Landes[17] and Birth[18] is a result of their reliance upon the historians of horology mentioned above for their facts about clocks and watches. They accept the marginalisation of the functions other than the hour initiated by this group of historians and base their own arguments solely on the clock as communicator of the hour and clock as a device reflective of the march towards precision timekeeping. Birth even referred to Yates and the art of memory, but did not make the link that I do between dials and this tradition.[19] His focus is on the human mind and its construction of the concept of time, rather than instrument use. I argue that if these historians allowed for the full potential of dials as conveyors of a wide range of knowledge, as I argue in this thesis, their arguments would be less constrained. While other historians such as Dohrn-van Rossum, [20] and Glennie and Thrift[21] similarly do not question historians of horology, their work on the proliferation of clocks from the thirteenth century onwards provides some valuable context. I contribute to these works by expanding the scope beyond attitudes to the hour and focus on the dial. While Mayr[22] has made a promising start in thinking about clocks in a different way, I argue that he has not gone far enough. His claim that the clock metaphor was important in terms of the clock as a representation of the universe in miniature and later in terms of the mechanical philosophy focusses on an overview of the clock and what it signified. On the other hand I focus on the components of the dial and how this related to knowledge and how both changed.

The next two bodies of literature that I discuss, histories of early modern knowledge transmission and histories of early modern epistemology, serve a dual purpose for my thesis. On the one hand I contribute clock and watch dials to their discussions. On the other hand by doing so I overhaul the existing horological historiography discussed above. Until now clock and watch dials have not been discussed in relation to these issues. My thesis contributes to the historiography of early modern knowledge transmission. Most of the authors who engage with this topic, such as Lefevre[23] and others,[24] base their claims on

[16] Adam, B. 2004. *Time.* Oxford: Polity.
[17] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[18] Birth, K.K. 2012. *Objects of Time: How Things Shape Temporality.* New York: Palgrave Macmillan.
[19] Ibid.p.10.
[20] Dohrn-van Rossum, G. 1996. *History of the Hour: Clocks and Modern Temporal Orders.* Chicago: University of Chicago Press.
[21] Glennie, P. and Thrift, N.J. 2009. *Shaping the Day: a History of Timekeeping in England and Wales 1300-1800.* Oxford: Oxford University Press.
[22] Mayr, O. 1986. *Authority, Liberty & Automatic Machinery in Early Modern Europe.* Baltimore: Johns Hopkins University Press.
[23] Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.

printed paper sources. While this is perfectly reasonable and informs my work, it leaves a gap with respect to the role played by technology which was intended to be read. I will argue that clock and watch dials were a form of mechanised diagram, sharing both content and format with their printed paper counterparts and were used by some of the same people. They must not be overlooked as they played an important role as the earliest forms of mechanisations of knowledge. I will argue that dials were influenced by printed paper sources and influenced them in their turn.

Historians of printing such as Eisenstein rightly emphasised the changes brought about through printing in terms of new knowledge being disseminated across Europe and the influence of the printers over what would be read.[25] However, she did not include technology such as dials as a form of text as it is beyond her scope. Again, this leaves a gap in our understanding of the reach of printing. I will argue that dial designs transcended national boundaries in the early modern period, similarly to printed paper sources. Clock and watch-makers were heavily influenced by printing which is evident in their dial designs.

Historians of reading practices such as Finkelstein and McCleery discuss the roles of author and reader in the reading experience.[26] They emphasise the significance of the annotated book and claim that this was evidence of a dialogue between reader and author.[27] However, I will argue, with reference to dials, that it was not a dialogue because the author could not respond. As with dials the author of the text, like the clock or watch-maker, forms the content and the format of the piece and then sends it out into the world. It is then used by the reader or user who in the case of the reader can annotate it, but in the case of the clock or watch user must hold on to their thoughts instead. Finkelstein and McCleery's focus on printed paper sources, though perfectly correct for their aims, has limited their discussions of the exchange between author and reader via the book. In these two scenarios the book and instrument communicate information to the user beyond the reach of the author or maker. This is an important similarity between them and helps us to understand dial use. Almanacs, which as will be discussed below are a key primary source that I compare with dials, were often annotated.

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[24] Kemp, M. 2000. *Visualizations: the Nature Book of Art and Science.* Oxford: Oxford University Press; Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press.

[25] Eisenstein, E.L. 1983. *The Printing Revolution in Early Modern Europe.* Cambridge: Cambridge University Press.p.63-64.

[26] Finkelstein, D. and McCleery, A. 2005. *An Introduction to Book History.* New York, NY: Routledge.

[27] Ibid.p.109.

Historians of the book such as Robert Darnton argue that there was a communication circuit of influence in printed books.[28] I argue that this was also true of the influence of printed paper sources on dials, but also expand the idea by adding mechanical instruments to the circuit. By doing so, I add clock-makers in to two stages of the circuit. I argue that whereas Darnton's circuit ends with the reader,[29] the dial circuit ends with the user, who is also a reader and so located in two stages, before which is the clock or watch-maker. The maker is also represented in two places in the circuit. They are readers like any other, but they are also makers of mechanical objects and situated one stage before the user. In a later article, Darnton refers to Adams and Baker's addition of 'survival' to the circuit, which they have redefined in event terms.[30] He says this is important, which it also is for dials. However, I add non-survival or decline to the circuit, which neither of these authors discusses. Throughout the thesis I argue that this was an important part of dial development.

The role of people within the networks of knowledge distribution is important and is something I consider throughout the thesis in terms of the relationship between clock and watch-makers and their users on the one hand and makers and printers on the other. Topham explores the role of authority in publishing networks by using the case study of Deighton in Cambridge.[31] While writing about a different period, Topham's work is useful for thinking about the role of authority in terms of influences on dials. In the case of Deighton, through his network he was able to influence the texts made available to students at the university.[32] Topham concludes his article by saying that publishing practices played an important role in constructing the history of the sciences. I will argue along similar lines that they also did in influencing the development of the clock and watch dial. This influence occurred through reproduction of likenesses and perceptions of effective knowledge transmission, ideas and practices, and emotional influences.

Clark informs us that before the eighteenth century books and objects were not separated; they were all kept together in the libraries of wealthy individuals.[33] While Clark's focus is on the role of the books within the library, he leaves a gap in terms of exploring the role of the instruments. I interpret their shared storage and location of use as a sign of

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[28] Darnton, R. 1982. What is the History of Books? *Daedalus.* 111(3).pp.65-83.
[29] Ibid.p.67.
[30] Darnton, R. 2007. What is the History of Books? Revisited. *Modern Intellectual History.* 4(3).p.504.
[31] Topham, J. 2000. A Textbook Revolution. In Frasca-Spada, M. and Jardine, N. eds. *Books and the Sciences in History*. Cambridge: Cambridge University Press.pp.317-337.
[32] Ibid.p.323.
[33] Clark, W. 2000. On the Bureaucratic Plots of the Research Library. In Frasca-Spada, M. and Jardine, N. eds. *Books and the Sciences in History*. Cambridge: Cambridge University Press, p.190.

complete knowledge, as perceived by the owner of the library. This is important for thinking about the relationship between dials and printed paper sources; they must not be viewed separately.

Historians who have written about the diagram, such as Franklin, correctly claim that diagrammatic forms of representation were created as a form of language that would be easily interpreted by the reader.[34] Again, his focus on printed paper sources has meant that he is unable to cover the whole picture, which has left a gap in terms of the role played by technology in this period. With reference to clock and watch dials and printed paper sources, I will argue that they were also embedded with signs of early modern perceptions of what constituted an effective method of communication. Franklin also hints at the importance of layered information when he discusses tree diagrams.[35] However, he does not go far enough. Again, I refer to dials together with printed paper sources to argue that loci and proportional sizes of typeface or symbols were indicative of hierarchies of knowledge and pathways for the eye. This expands the work of historians who refer to early modern perceptions of knowledge transfer as being a three-stage process. I will argue that clock and watch dials were conceivably designed according to these principles.

The third body of historiography which my thesis contributes to is that of early modern epistemology. Gunpowder, the printing press and the magnetic compass were cited by Francis Bacon as the three great inventions of the Renaissance. John Henry says they thoroughly changed ways of life.[36] While I agree with his statement, I argue that clocks and watches were a fourth invention of similar importance. They were a mechanised form of knowledge tool, which adapted to changing use throughout the period 1550-1770.

Throughout the thesis I argue that clock and watch dials were useful for astrological and mnemonic purposes, given that they shared much of their content and format with printed paper sources related to these two elements of the natural magic tradition. I agree with historians of nascent science and magic, such as Henry[37] and Eamon,[38] who argue that technology was perceived as a form of mathematical magic in the sixteenth- and early-mid seventeenth century. While clocks and watches were beyond their scope, no other historians have considered them from the perspective of the natural magic tradition. This is

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[34] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.pp.53-97.
[35] Ibid. p.56-58.
[36] Henry, J. 2012. *A Short History of Scientific Thought.* Basingstoke: Palgrave Macmillan.p.51.
[37] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.58.
[38] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.172.

surprising given that Eamon discusses the role of the artisan closely guarding his trade secrets and the wider perception of the artisan as a magician for that reason.[39] This is perhaps one reason why there is a lack of archival sources left behind by clock-makers of the early period. I will argue in several chapters that dials acted as an aid to natural magic up to the late-seventeenth century when clock and watch-makers, similarly to others, began to distance themselves from the tradition by revealing more, but not all, of their trade secrets and distancing themselves from astrological theory which was one part of the tradition.

Historians of astrology, such as Curry[40] and Webster,[41] agree that prophecy was an important part of early modern life. However, for them also technology is beyond their scope. I will argue that clock and watch dials, which shared the requisite information used by almanacs to discuss predictions, acted as a prompt for users to recall astrological advice, up until the mid-late seventeenth century. As dials have not been considered in a sufficient level of detail before, the subtle differences between the calendar, lunar and astronomical functions have not been identified in terms of the different roles they played as an astrological prompting device until now. I am in agreement with Curry that astrology began to decline during the mid-late seventeenth century. Whereas Perkins[42] provides some evidence of continued astrological practices during the eighteenth and nineteenth centuries, clock and watch dials certainly began to lose their signs of astrology during the mid-late seventeenth century. As dials have not been fully contextualized before, these patterns of change have not been linked.

As mentioned above, I will argue that dials were used as a mnemonic prompt for astrological information up to the mid-late seventeenth century. I will also argue that in the late-sixteenth and early-seventeenth centuries multi-function dials served as a mechanical aid to the art of memory, providing a range of different combinations of numerals, symbols and pictures which could be assigned to any concepts or ideas the user wanted to remember. This contributes to the work which Yates began fifty years ago.[43] Those who have criticised her work for the extent of her arguments about the hermetic nature[44] of the art of memory in the early modern period have missed the value of her other findings. Her discussions of image construction, that the mnemonic method was a search for signs and

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[39] Ibid.p.178.
[40] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.7.
[41] Webster, C. 1982. *From Paracelsus to Newton: Magic and the Making of Modern Science.* Cambridge: Cambridge University Press.p.17.
[42] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.34-35.
[43] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.
[44] Ibid.p.127.

symbols to use,[45] and loci,[46] allocating those symbols to a constructed place such as a building, are extremely useful for thinking about the influence of the mnemonic tradition on perceptions of knowledge ordering. Dials have not been considered in terms of the art of memory before, but the function of formats and content on dials should be thought of in this way. The multi-function dials with sets of concentric rings or subsidiary dials provided numerous loci for users to remember, as I will demonstrate in several chapters.

I am in agreement with historians such as Henry,[47] and Clark[48] who argue that nascent science drew different aspects from older traditions such as natural magic and discarded others and then distanced itself from them. Where clocks and watches have been considered within the debate about the nature of the scientific revolution, social historians of time such as Landes have referenced the invention of the pendulum in 1657 and the increased accuracy it enabled to claim that a 'horological revolution' also took place in the period.[49] However, his focus on the development of the mechanism meant that dials were beyond his scope. Dials, on the other hand, show that in some respects the story of horological development was one of incremental change as a response to changing user needs, rather than over-night change.

Throughout the thesis I also discuss the influence of religion on dials and draw out several examples of when dials were used as an aid to religious contemplation. I agree with Henry that religion was not at odds with nascent science.[50] It was also not at odds with the branches of astrology concerning the weather, health matters or agriculture, as it was believed that God had assigned signatures to the planets which influenced these things.

New issues will emerge from the thesis because I am bringing these three bodies of historiography together for the first time. This includes the duality of mechanical objects and printed paper sources within the narrative of epistemological and associated practice change in the early modern period. I provide a new method for researching instruments by focussing on use and challenging the traditional catalogue-based approach, which to an extent can be applied to other types of instrument.

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[45] Ibid.p.378.
[46] Ibid.p.84-93.
[47] Henry, J. 2012. *A Short History of Scientific Thought.* Basingstoke: Palgrave Macmillan.p.77.
[48] Clark, S. 1997. *Thinking with Demons: the Idea of Witchcraft in Early Modern Europe.* Oxford: Clarendon Press.p.221.
[49] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[50] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.85-86.

1.2 New interpretations of the changing face of time

As discussed in section 1.1, until now clock and watch dials have received very little scholarly attention concerning their historical comparative development. The dial is the user-facing part of a timepiece and its role is to communicate information from the mechanism to the user. Any form of communication necessarily involves choices about what to communicate and how to communicate it. As Foucault reminded us, every culture has a schema of perception, which instils in each of its citizens ways of perceiving, ordering and communicating things.[51] Therefore early modern dials were, and still are, laden with meaning about the knowledge which people in the period wanted to communicate and the methods which they thought were the most effective for communicating that information. I will argue that the best way of getting closer to this information is through a focus on the use of these horological devices.

Dials underwent change in the period under investigation here, both in terms of content and format. The hour was a constant feature, but throughout the period other functions were represented such as calendrical and lunar indications for example. Multi-function dials, which represented complex combinations of information, were popular up until the mid-late seventeenth century, but then went in to decline. The calendrical and lunar indications initially survived this decline, but began to disappear during the mid-eighteenth century and were not part of the standard format by 1770. Dials were the face of the kind of time that users wanted, whether that was multi-layered or singular. This changing appearance of the dial was influenced by a wide variety of factors which were also changing over the period such as astrology, mnemonics, religion, trust and the increasing need for more accurate timekeeping. Each of these, I will argue, contributed to the making of the standard format which emerged by 1770 and enjoyed a long life throughout the nineteenth century.

There are four main research questions which arise from the gaps left in the existing secondary literature, discussed above. Given the extent of the surviving objects left to us by past makers and users, it is both frustrating that these questions have not been posed of clock and watch dials before, but also a refreshing invitation to me to undertake this very fruitful area of research. In answering each of these questions over the course of my chapters, an outline of which can be seen in section 1.3, I will offer a complete reinterpretation of clock and watch dials in the period 1550-1770.

[51] Foucault, M. 2001. *The Order of Things: an Archaeology of the Human Sciences.* London: Routledge.p.xxii.

1) What were the relationships between dials and printed paper sources?

   Clock and watch dials were not made or used in horological isolation. Both makers and users were part of a wider intellectual culture, which manifested itself through its printed paper sources such as almanacs, astrological, mnemonic, and mathematical works. Both dials and printed paper sources shared content and formats for layering information, so there must have been a relationship between the two media. The extent to which dials mirrored printed paper sources and vice versa will be examined in each of my chapters.

2) To what extent was there a relationship between dials and astrology? To what extent did the decline of astrology and the mnemonic method influence dials from the mid-late seventeenth century?

   The wealthy users of clocks and watches had access to a wide range of printed materials. Before the mid-late seventeenth century many of these were astrological and mnemonic works. These works shared content and format with dials and so it is conceivable that dials were used for similar purposes. Mnemonic works declined during the early-seventeenth century and astrology declined during the mid-late seventeenth century. This was evident in printed paper sources and over the course of my chapters I will explore the extent of the influence on dials.

3) To what extent was there a relationship between dials and perceptions of effective knowledge transmission?

   Dials in the period featured a variety of different formats such as concentric rings and multiple apertures and content which changed as the years went by. Over the course of my chapters I will explore the extent to which dials changed as ideas about the way in which knowledge was acquired changed.

4) To what extent did users' emotions influence dial development?

   Some users throughout the period preferred dial format or content which had mainly gone in to decline, such as quarters of the hour rather than minutes. In several chapters I will explore the extent to which users that were reluctant to change influenced dial development through the responses of makers.

In order to answer these research questions I have developed a unique methodology for approaching clock and watch dial research. Unlike many horological scholars such as Loomes[52] and Thompson,[53] I consider both clock and watch dials simultaneously. This is important because they cannot be viewed separately from each other. They were often made by the same makers and were certainly purchased and used by the same types of people, so there is no reason to separate them in the way that historians of horology have traditionally. I will note differences between clocks and watches where appropriate within my discussion of use. This will include the difference between portable devices and static examples. For the purposes of this thesis I will not be including a discussion of turret clocks,[54] although I do make occasional references to them.

My temporal parameters are relatively large, beginning in 1550 and ending in 1770, which is necessary for discussions of dial change, given that modifications occurred approximately every fifty years. Dials, similarly to ideas, did not change overnight; it was a gradual process. People maintained their timepieces and did not replace them frequently as people do today. In order to fully answer the research questions, for example the effect of the decline of astrology on dials, I need to be able to discuss the period in which these ideas and practices were at their height and after their decline. To only examine the period in which they went into decline would be insufficient for answering the research questions. Therefore, throughout the thesis I discuss dial change in terms of the period in which change occurred for example the 'early-seventeenth century' or the 'late-sixteenth century' as it is not possible to be more precise. The exception being a few isolated cases such as those associated with the introduction of the pendulum for clocks in 1657. The focus of my thesis are the clock and watch dials of Britain, but with extended comparison with European dials from Germany, France, Italy, and the Netherlands. As I will explain throughout the chapters, the issues which I discuss were not nation-specific; both ideas and dials transcended national boundaries during this period. Again, there were only one or two exceptions to this. The types of people who could afford to buy the clocks and watches discussed were also the types of people who travelled widely throughout Europe.

As previously noted, clock and watch dials have received very little attention in the secondary literature. Any minor references to them have been highly descriptive and lacked any in-depth contextualisation. One of the most probable reasons for this, and one of the major challenges to this thesis, is the lack of direct archival evidence of clock and watch dial

[52] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club.
[53] Thompson, D. 2004. *Clocks.* London: British Museum Press; Thompson, D. 2007. *Watches.* London: British Museum Press.
[54] See appendix two for a definition of this horological term.

use for the period under investigation. There are few, if any, first-hand accounts of clock and watch use and very few clockmakers' notebooks or order books. This makes it very difficult to establish who the users of these dials were, how and where the dials were used, and what influenced makers in the design of dials. Nevertheless, the clocks and watches exist as evidence of both past making and past use. Consequently, they demand interpretation as primary sources in their own right. Where Topham asks new questions about the original readers of specific publications,[55] I argue that new questions must also be asked of clock and watch dials. Taking the period 1550 – 1770, dials changed a great deal both in terms of the different types of information conveyed and the ways in which that information was arranged and indicated. By 1770 clock and watch-makers across Europe had adopted a standard format for dials. Historians of horology, such as Thompson,[56] Bruton[57] and Loomes,[58] traditionally describe dials in terms of artistic and aesthetic influence or in terms of the development of precision timekeeping. However, as historic objects they are inherently meaningful.

The museologist, Dudley, describes encountering a Chinese horse statue and recalls being: "…utterly spellbound…" by it.[59] Despite there being no label and thus not knowing anything about it other than it was a horse, she says that its three dimensionality, tactility and sheer power literally moved her to tears. [60] What she does not mention is that the location of the horse at eye line, which is very different from other museum displays, aids this emotional experience. As noted above, Gauvin is sceptical about visitors being able to share common ground with objects on display in museums as they have been removed from their original context.[61] However, what is important about Dudley's experience is that objects are powerful because they were made for a specific reason and were used by people in the past. Contemplating them gives us a sense of this, however small. It is very likely that if they elicit an emotional response from us now, they also did in the period in which they were made, but perhaps for a different reason. It is our duty to unlock as much as we can about their past, which will hopefully help us to understand the reasons why they were

[55] Topham, J. 2010. Science, Religion, and the History of the Book. In Dixon, Thomas, Cantor, Geoffrey, and Punfrey, Stephan. eds. 2010. Science and Religion: New Historical Perspectives. Cambridge: Cambridge University Press.p.221.
[56] Thompson, D. 2004. *Clocks.* London: British Museum Press; Thompson, D. 2007. *Watches.* London: British Museum Press.
[57] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.
[58] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club, Loomes, B. 1981. *White Dial Clocks: the Complete Guide.* Newton Abbot: David & Charles.
[59] Dudley, S.H. 2012. *Museum Objects: Experiencing the Properties of Things.* London: Routledge.p.1.
[60] Ibid.p.1.
[61] Gauvin, J..F. 2016. Functionless: Science Museums and the Display of 'Pure Objects'. *Science Museum Group eJournal.* Spring (5). http://journal.sciencemuseum.org.uk/browse/issue-05/functionless/.

made in the first place. On the other hand it is not all about the emotion-evoking objects. This is where historians of horology have missed the significance of dials previously. However, by using the evocative examples as a gateway we can start to compare the rest and improve our understanding of the whole.

With respect to interpreting objects, Baird says that we read books, but 'examine' instruments.[62] However, in my chapters I argue that clock and watch dials were designed to be 'read' in a similar way to printed paper sources. I do agree however, when he says that in reading, interpreting and writing about texts we call on a vast array of interpretive techniques and that we need an equally powerful array of techniques to understand instruments and their place in past culture.[63] Meaning can indeed be drawn from clock and watch dials and in order to do so I have developed a unique methodology. My methodology consists of an inter-disciplinary approach to dials. Given the difficulties presented by a lack of definitive archival evidence relating to clock and watch usage or design decisions, I am compelled to seek this information from alternative sources. I found that no single type of source would yield enough information, but a range of sources would present a fuller picture. Glennie and Thrift experienced a similar difficulty finding archival sources to answer their questions about how the experience of the hour affected large communities and relations between different social groups. They concluded that this was because they were looking at issues that were taken for granted by people in the period and thus not recorded.[64] While this is also applicable to my research, I will argue that the user experience is recorded but not necessarily in the way we expect. The answer is not in one source, but in several different types of source that must be brought together to yield a historical narrative.

In carrying out this research I have examined a total of 256 clock and watch dials from different museum collections. In assessing these dials I have deconstructed their format and content in order to identify patterns of change and continuity. This thesis is object-rich and in order to guide the reader through my arguments I have provided a large number of carefully-selected images throughout each chapter. These are necessary for understanding the subtle changes in different components of dial format and content. While Gooday has made an excellent start asking new questions of gas-meter dials,[65] clock and watch dials have not been considered in this level of detail before. In my chapters I will

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[62] Baird, D. 2004. *Thing Knowledge: a Philosophy of Scientific Instruments.* Berkeley, California: University of California Press.p.xvii.
[63] Ibid.p.xvii.
[64] Glennie and Thrift, p. 101.
[65] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.

interpret the significance of these differences by comparing them with different texts, diagrams, images and other instruments. It would be inappropriate to comment on all of the dials and all of the texts, diagrams and images with which I have compared them in the body of the thesis, so across the six chapters I will refer to key examples which I have identified as representative of the wider groupings. I have not commented on one-off examples and only included types of dial that were made in different countries in Europe and not just one particular place.[66] In fact this does not exclude any as none of the dials I examined were unique to any particular country of region. In an appendix to the thesis I have included a list of all the different dials that I have examined.[67] The printed paper sources used as a form of comparison are captured in the bibliography.

The objects on which this study is based can be said to be representative of the various kinds of clocks and watches, made and used during the period in different countries. I have ensured that they are representative of the different groups of dials available in the period by considering clocks and watches from different museum collections. The majority are held in the collections of the British Museum, this is one of the largest collections in the world, but I have also looked at objects from the Science Museum, the Museum of the History of Science in Oxford, the Fitzwilliam Museum in Cambridge, the Musée du Louvre in Paris, Deutsches Historisches Museum in Berlin, Mathematisch-Physikalischer Salon in Dresden, and the Metropolitan Museum of Art in New York. For authors such as Cipolla, basing research on a museum collection is problematic given that, in his opinion, one should not view museum pieces as representative of those owned by everyone.[68] However, I must gently remind the reader that the overall aim of my thesis is to account for dial change during the early modern period. It is not to establish the type of time measurement device, such as sundials and turret clocks, which the majority of people would have used during the period. This has been covered to a large extent by social historians of time such as Glennie and Thrift who take a narrow geographical area, but a very large selection of people in terms of focussing on the community use of town clocks.[69] Although timepieces became increasingly more affordable as the period progressed, they remained objects owned by the wealthiest sections of European society, as I will discuss in due course

An essential feature of my unique methodology is the combination of primary sources that I draw evidence from. The vast majority of which have not been compared to

[66] Within these types of dials there were two examples of components which appear to be unique to Britain in the period, but the overall type of dials were not unique to Britain.
[67] The full list can be seen in appendix one.
[68] Cipolla, C.M. 1967. *Clocks and Culture 1300-1700.* London: Collins.p.50.
[69] Glennie, P. and Thrift, N.J. 2009. *Shaping the Day: a History of Timekeeping in England and Wales 1300-1800.* Oxford: Oxford University Press.p.100-134.

clocks and watches by historians before and none have been compared with dials specifically. The primary sources I have used can be divided into seven main categories, as I demonstrate below. While some historians would group these sources differently, I have grouped them in terms of their purpose. This was inspired by Wyatt[70] and Lindsay[71] who approach technology from a user, potential user and non-user perspective. An additional influence was Briggs,[72] who divided his work on technology and consumption in to chapters on type of thing in order to discuss users' relationships to it. However, while these authors concentrate on twentieth- and nineteenth-century technology respectively and have more archival sources on which to base their conclusions of use, I have very little in the way of direct archival evidence and must bring many different sources together to make conclusions about the use of early modern clock and watch dials. Nevertheless, their consideration of contexts of use is helpful. This approach helps me compare my unique combination of primary sources with dials. Some sources are useful for one particular chapter or section. Others are useful for multiple chapters where a range of information could be extracted from them. Firstly, one of the main group of texts that I compare with dials are almanacs and calendars. In the period these were an important source of astrological and temporal information. They share a great deal in terms of content and format with dials and underwent change during similar periods, which makes them a key source for each of the chapters, with the exception of chapter three on trust which I approach from a slightly different perspective. I explore the extent to which they were used for the same purposes and by the same kinds of people.

Secondly, another of the main groups of texts that I compare with dials is the range of 'craft books' which were published throughout the period. The sixteenth and seventeenth centuries experienced a proliferation of small pamphlets, which I term 'craft books' which acted as guides or manuals to different crafts and practices.[73] Similarly to almanacs, they are a key source of information on early modern ideas and practices concerning mechanics, mathematics, astrology/astronomy, health, memory and consequently are a key source in each of the chapters. They provide information on the

[70] Wyatt, S. 2003. Non-Users Also Matter: the Construction of Users and Non-Users of the Internet. In Oudshoorn, N. and Pinch, T. eds. *How Users Matter: the Co-Construction of Users and Technology* Cambridge Massachusetts: The MIT Press.pp.67-80.

[71] Lindsay, C. 2003. From the Shadows: Users as Designers, Producers, Marketers, Distributors, and Technical Support. In Oudshoorn, N. and Pinch, T. eds. *How Users Matter: the Co-Construction of Users and Technology.* Cambridge Massachusetts: The MIT Press.pp.29-50.

[72] Briggs, A. 2003. *Victorian Things.* Stroud: Sutton.

[73] For more information see Eisenstein, E.L. 1983. *The Printing Revolution in Early Modern Europe.* Cambridge: Cambridge University Press.p.46-48.

application of some of the content of dials and so provide clues to perceptions of knowledge in the period.

Thirdly, another of the main groups of printed paper sources that I compare with dials are diagrams. These include diagrammatic representations of knowledge such as mathematical, astrological aspect diagrams, schematic diagrams of the heavens, horoscopes, circular volvelles and memory wheels, tree diagrams, and tabulated information. Again, they share content and format with dials in the period, which reveal perceptions about effective knowledge communication in the period. They are a key resource for chapter two on communication methods.

Fourthly, I utilise art works, including prints and paintings, in order to contextualize in several chapters throughout the thesis. Art works provide an additional angle that diagrams and text cannot. This is a visual context for imagining the user and for reconstructing contexts of use. They are a key resource for identifying types of users, for chapter four which focusses on different contexts of enablement, and chapter six which focusses on the lunar function.

Fifth, I make selective use of diaries where possible to provide further support to my arguments about particular uses. They provide temporal references which give an indication as to how people thought about time and the temporal units they referred to in the period and how this changed. Unfortunately, there were not many diaries that were relevant, but a few examples help strengthen my arguments in chapter three on trust.

Sixth, I make use of a single clock-maker's notebook. It is significant as the only-known extant specimen containing late-seventeenth century entries. It is not surprising that it is the only surviving example, given the price of paper in this period and that there was no perceived reason to preserve this information once it was no longer current. Evans informs us that even for Thomas Tompion, known today as the 'father of English clock-making', there are virtually no surviving notebooks or archive material relating to his business except a few receipts.[74] The earliest surviving business records of clock and watch-making date from around 1780 onwards. They are normally family business records and entries at the beginning of their sequence often consist of fragmented notes, becoming more of a comprehensive overview of the business during the nineteenth century.[75] Indeed, for these

[74] Evans, J. 2006. *Thomas Tompion at the Dial and Three Crowns: with a Concise Check List of the Clocks, Watches and Instruments from his Workshops.* Ticehurst: Antiquarian Horological Society.p.40. The receipts are not known to be in Tompion's handwriting even.

[75] The archives of the Worshipful Company of Clockmakers holds one work ticket by the maker Benjamin Vulliamy MS3988B/1. 1778. *Ticket by Benjamin Vulliamy*. Worshipful Company of Clockmakers. And the Jump family records MS15189. 1785-1926. *Jump Family Scrapbook*. Worshipful Company of Clockmakers. Tennant

reasons individual clock and watch-makers are not the main focus of the thesis. We don't know enough about the individuals for them to play a major role in this particular inquiry. More importantly, I argue that they were as much a part and a product of the wider culture evident in printed paper sources as anyone else. As previously noted, dials made in different countries followed the same trends except in a very few exceptions.

Lastly, I also consider selected archival material from the Worshipful Company of Clockmakers' guild. This includes material such as a manuscript of the route of a walk to collect quarterly membership fees. This material provides some evidence of the control exercised by the City of London guild over clock and watch-making in London in the period. While I mention the London guild in this context, every major centre of clock-making in Europe was regulated by a similar guild. The experience of London was in this respect typical of centres such as Nuremberg, Paris, and Amsterdam.

Taken together these seven different types of primary source enable me to place clock and watch dials within the wider context of early modern ideas and practice. As a set they enable me to identify similarities and differences in terms of change between dials and printed paper sources. Without such a rich selection it would be impossible to extract meaning from dials other than an obvious description of their indications, but not the significance of them.

The difficulty with identifying specific users of clocks and watches are similar to those with identifying and distinguishing specific dial makers from the clock and watch-makers who made the mechanisms. It would be worthwhile knowing who these people were and the influences on them. In some cases clock and watch-makers would have made dials themselves, but even as early as the mid-sixteenth century different parts of a clock and watch were made by different people, with the master clock or watch-maker doing the final assembly and finishing. This was the same for instrument making and was not unique to clock-making. In this context it would seem likely that clock and watch-makers ordered parts to certain specifications. However, even if this was not the case, dial makers were part of the same context as clock-makers and printers and would have engraved numerals and letters according to the accepted typeface of the period. References to dial-makers are rare, but one example in the archives of the Worshipful Company of Clockmakers refers to two people who were summoned before the Master of the Company for engraving unlawfully in

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refers to the James Wilson family business records of 1777 onwards. Tennant, M.F. 1995. *Longcase Painted Dials.* London: N.A.G. Press.p.30-31.

February 1683.[76] While this is a tantalising clue, there is no further information so all it can offer us is a glimpse of a context in which instrument engraving in one of Europe's large instrument-making centres was controlled by the guilds. Again, the challenge is a lack of supporting primary sources, but can be overcome using the range of primary sources identified above.

As previously noted, clock and watch-makers are not the main focus of this thesis. While they are almost always identifiable, there are exceptions in the case of early clocks and watches of the mid-late sixteenth century. The names of makers normally appear as an engraved signature at the back of the timepiece. In some instances much is known about the biography of a clock and watch-maker such as Thomas Tompion, but in other cases only their active working dates and place of making is known.[77] This is a another reason why I use an extended timeframe in the thesis as extant clocks and watches can often only be dated to an accuracy of within fifty years.[78] Maker information can help to determine the types of customers makers might be selling to. Although client lists have not survived, there are a few armorial engravings on cases which act as an identifier.[79] However, in most cases the ideas embedded within the dial transcend the work of individual makers. The similarities I identify between the products of makers from different countries will show this to be true. I argue that makers were as much a product of their time as anyone else and it is the wider context that will be more revealing about dial use and influence on dials than information about individual makers. Historians of horology such as Thompson[80] imply that the creations of the clock and watch-maker were made in horological isolation, but I will show that this was far from the case.

In terms of who the users of clock and watch dials were it is difficult to define them precisely, given the age of the objects and their historic separation from ownership records.[81] It will be remembered that neither of the original owners or users of the dials featured at the beginning of this chapter in figures 1.1 and 1.2 are known. However, to compensate for this I have identified the different types of user, who would have owned and

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[76] MS3975. 1632-1816. *Index of and Abstracts to Journals and Ordinanaces*. Worshipful Company of Clockmakers.

[77] Historians have thoroughly researched the names, active dates and locations of many different clock and watch-makers and published extensive lists.

[78] Many clocks and watches in every museum are dated as 'mid-sixteenth century' or 'early-eighteenth century'.

[79] Such as British Museum watch 1856,0429.1.

[80] Thompson, D. 2004. *Clocks.* London: British Museum Press; Thompson, D. 2007. *Watches.* London: British Museum Press.

[81] Museum records rarely hold information on early modern owners of clocks and watches. The vast majority were either donated by wealthy collectors during the late-nineteenth century or have been acquired since then. This means that the details of ownership of the object at the point of entry into the museum are known, but not the original owners.

used the dials I discuss in this thesis. I have based these identifications on a body of work conducted by historians of consumption and the economy of early modern Europe and London such as Weatherill,[82] Earle,[83] Brenner,[84] Brewer and Porter.[85] There is a consensus in this literature about who the people with money were throughout this period and it is these people that would have been the users of clocks and watches. They included royalty, the aristocracy, merchants, bankers, guildsmen, successful craftsmen, and professional people such as lawyers, doctors, and leaders of civil and military life. This is supported by adverts in the *London Gazette* and records of the Old Bailey to losses and thefts of watches. These records refer only to watch ownership, as watches were easily portable, but the same kinds of users owned clocks and watches. Examples of adverts in the *London Gazette* from the late-seventeenth century refer to a small gold watch being stolen from a Countess in Brussels;[86] a French watch made of gold lost by a Major General near Whitehall;[87] and an attorney's clerk stealing a gold watch from his master's premises near the Strand.[88] The Old Bailey records of the same era describe various cases of people who experienced theft of their watches. Most accounts describe the victims as 'Gentlemen', which throughout the period under investigation here meant a wealthy individual such as those described above.[89] These references are helpful for thinking about the types of people that owned timepieces, but are frustratingly brief in their descriptions. All of these references were to lost or stolen watches, rather than clocks, because of their ease of portability. While I have included late-seventeenth century examples, they were typical of the period under discussion here.[90]

This information enabled me to select the kinds of printed paper sources, outlined above, which I compared with dials. Users were literate people. Many of their libraries have been recorded in probate records and are known to have included astrological, mnemonic, technical and mathematical works, in addition to the great works of literature and art. Sir Henry Billingsley was one example of a wealthy merchant with an interest in the latest

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[82] Weatherill, L. 1996. *Consumer Behaviour and Material Culture in Britain 1660-1760.* London: Routledge.
[83] Earle, P. 1991. *The Making of the English Middle Class: Business, Society and Family Life in London 1660-1730.* London: Methuen.
[84] Brenner, R. 2003. *Merchants and Revolution: Commercial Change, Political Conflict, and London's Overseas Traders 1550-1653.* London: Verso.
[85] Brewer, J. and Porter, R. eds. 1993. *Consumption and the World of Goods.* London: Routledge.
[86] Anonymous. 13 January 1672. Advertisements. *The London Gazette* p.2. https://www.thegazette.co.uk.
[87] Anonymous. 17th February 1672 Advertisements. *The London Gazette*.
[88] Anonymous. 20th October 1673 Advertisements. *The London Gazette*. p.2.
[89] t16750707-6. 7th July 1675. *Violent Theft: Highway Robbery*. The Proceedings of the Old Bailey. , t16750909-2. 9th September 1675. *Violent Theft: Robbery*. The Proceedings of the Old Bailey. https://www.oldbaileyonline.org
[90] This was probably also true of the previous period, but the records only begin in the late-seventeenth century.

mathematical ideas.[91] He was responsible for the first English edition of Euclid's *Elements* in 1570. It is not known whether he owned clocks and watches, but it is very probable that he did. Many of these people were wealthy enough to travel and had extensive European networks, others had large correspondence networks. While both Weatherill[92] and De Vries[93] point to the importance of probate inventories for learning about consumption, these records are as frustratingly brief as records of the theft and loss of clocks and watches in the period. They tell us that certain individuals owned clocks and watches, which is helpful, but offer no further information about the type of clock or watch concerned, or its indications. Only the wealthy would have been able to afford these types of objects, but this does not lessen their utility. Many objects such as telescopes and microscopes, which were inherently useful, were also extremely expensive. Such was the case with many items of technology and remains so today. They are originally very expensive and owned by only a handful of people and it takes a long time for them to become affordable to more people.

Doubtlessly, the users I discuss in my thesis would have been located at the top and middle of the social hierarchy, but further identification is difficult. Information on the previous owners of the clocks and watches I refer to in the thesis are virtually non-existent. We often know who made clocks and watches in museum collections, but they have historically been divorced from their provenance records. We know who donated them to the museum originally. It was often an antiquarian collector of the late-nineteenth century, but in most cases we don't know who owned them after they were made or where they were up until they were purchased by the collector from a dealer either in Britain or abroad.

My selection comprises clocks and watches that were made in Britain, Germany, France, the Netherlands, Switzerland, and Italy. Those currently held in British collections may have been brought to England in the early modern period or may have been collected in subsequent centuries. The Major General referred to above lost a French watch in 1672, which is evidence of timepieces crossing national boundaries in the period. The precise locations within these six countries were not always known, but where it has been recorded the vast majority were made in either: London, Munich, Nuremberg, Augsburg, Paris, La Rochelle, Blois, Geneva, Bern, Amsterdam, the Hague, and Rotterdam. All of these places were either capital cities or towns with a reputation for trade, publishing craft books and technical treatises, mathematical-instrument making and clock-making. I have not yet come

[91] Barrow-Green, J. 2006. 'Much necessary for all sortes of men': 450 years of Euclid's *Elements* in English. *BSHM Bulletin.* 21.p.5.
[92] Weatherill, L. 1996. *Consumer Behaviour and Material Culture in Britain 1660-1760.* London: Routledge.p.2-4.
[93] De Vries, J.. 1993. Between Purchasing Power and the World of Goods: Understanding the Household Economy in Early Modern Europe. In Brewer, J. and Porter, R. eds. 1993. *Consumption and the World of Goods.* London: Routledge.p.98-99.

across a clock-making centre in the early modern period that was solely clock-making and nothing else. Indeed, it is known that late-sixteenth and early-seventeenth century mathematical-instrument makers such as Humfrey Cole and Augustine Ryther engraved instruments and also supplemented their income engraving maps. While there is no direct evidence that clock and watch-makers did the same, they were very much a part of the wider instrument-making community and therefore part of the wider community of print. These were popular destinations for Europe's princes, aristocrats, merchants and travelling craftsmen who were the buyers and users I refer to throughout the thesis.

Some historians of horology generally pass over the issue of who the users actually were by saying, as Thompson does, that a specific clock or watch was: "…clearly made for a wealthy customer."[94] It more than likely was, but this does not help us to further contextualise, other than make a list of which types of people were wealthy in the period. I can only derive partial evidence about the identity of users from the prefaces of various pamphlets written by clock-makers in the period. The anonymous *An Explanation of the Nature of Equation of Time* identified its audience as 'gentlemen.'[95] Similarly, John Smith in his *Horological Disquisitions* also identified his readers and buyers as 'gentlemen.'[96] I conclude from this that the primary sources here echo the identification in the secondary literature on consumption referred to above.

The subject of clock and watch dial research has the potential to be huge. I cannot include everything here, but this leaves room for future avenues of research. I mentioned at the beginning that the standard format which emerged around 1770 enjoyed a long life in to the nineteenth century. However, the longevity of the standard format is beyond the scope of this thesis. My focus here is using the research questions to explain why it appeared the way that it did. The longitude story is another aspect which is beyond the scope of this research. I refer to it where necessary, but a large amount of recent research has been conducted on the Board and the main protagonists.[97] Clock and watch case decoration is also beyond the scope of this thesis. Much work has been conducted on the allegories depicted on cases and their links to the history of art, literature and religion.[98] Similarly,

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[94] Thompson, D. 2007. *Watches.* London: British Museum Press.p.34.
[95] Clay, F. 1731. *An Explanation of the Nature of Equation of Time.* London.
[96] Smith, J. 1694. *Horological Disquisitions* London.
[97] For more information see Dunn, R. and Higgitt, R. 2014. *Ships, Clocks & Stars: the Quest for Longitude.* London: Collins.
[98] For more information see Priestley, P. T. 1994. *Watch case makers of England: A History and Register of Gold and Silver Watch Case Makers of England 1720-1920*. London: National Association of Watch and Clock Collectors.

allegorical or decorative images on dials, such as ships, windmills, and flowers, are not discussed here.

1.3 Thesis outline

In order to thoroughly answer the research questions and to fully articulate the significance of early modern dials, I have divided the thesis into two parts, each of which consists of three chapters. The first part will consider dial format. This is the way in which information is arranged on the dial and is one of the two basic components of a communication device. I have identified three angles of approaching dial format which each provide different parts of the answer to the main research questions.

I will begin with chapter two where I will consider the different methods of communication used in the period by makers to convey knowledge to users. This chapter sets the scene for the rest of the thesis in terms of establishing the dial as a form of text or diagram. In this chapter I will explore the act of looking and representation of information which enables a discussion of knowledge hierarchy and perceptions of effective knowledge transmission. I will make links between multi-function dials and astrological and mnemonic texts and identify their concurrent decline as taking place in the mid-late seventeenth century. In the era between the mid-late seventeenth century and the emergence of the standard format in 1770, I will identify the solidification of conventions established in the earlier period, some of which became part of the standard format and some did not. This chapter will provide a substantial part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission. It will offer part of the answer as to what the relationships between dials and printed paper sources were, in terms of format influences and convention establishment, and what this says about physical appearance and the intellectual influences behind it. It will reveal the way in which formats, pictures and symbols were used as part of the practice of the art of memory up until the mid-late seventeenth century. It will also look at how the decline of astrology affected dial formats.

In chapter three, I will consider the way in which changing dial formats in the period reveal the trust relationship between clock and watch-makers and their users. I will take a case-study approach and identify four examples across the period where format is used to either generate or maintain trust in a timepiece. These were the alternative hour schemes of the mid-sixteenth to the early-seventeenth century; the co-existence of quarters and

minutes on dials in the late-seventeenth century; the changing relationship of dependence between the sundial and the mechanical timepiece as evidenced through the dial; and the imitation of precision timepieces. Each of the four sections will provide evidence of the extent to which users' emotions influenced dial development at particular moments within the period 1550-1770.

In chapter four, the last of the format chapters, I will identify two different ways in which makers used dial formats as a method of enabling users who were unable to use traditional dials. This is the first time that dials have been considered from a disability perspective. One example is the touch-pin which was present on dials from the mid-sixteenth to the early-seventeenth century and the other is the illuminated night clock which was used from the mid-late seventeenth to the early-eighteenth century. This chapter will offer part of the answer as to what the relationships between dials and printed paper sources were by arguing that the illuminated night clock was an aid to religious contemplation in a similar way as the older books of hours had been. It will also offer part of the answer as to the extent of the relationship between dials and astrological practice in the period up until the mid-late seventeenth century, given that illuminated night clocks provided the time in the dark for users who needed to know the time at night in order to conduct certain tasks according to astrological practice.

The second part of the thesis will consider dial content. There were three distinct types of knowledge represented on clock and watch dials over the period and as functions on the timepiece they developed differently. Until now they have been grouped together by historians of horology[99] as 'other', but they must be considered separately in order to fully answer the main research questions. I will begin the content part of the thesis with chapter five which will consider the changing uses of calendrical insight provided by dials across the period. In this chapter I will consider the representation made by the calendar function as calendrical locating co-ordinates for users to locate themselves according to advice read in almanacs and elsewhere. I will take a case-study approach and explore the varying layers, or co-ordinates, of calendrical information through a typical multi-function dial of the mid-seventeenth century. I will then consider the survival of some of the layers or co-ordinates, beyond the decline of astrology in the mid-late seventeenth century including for use as a planning tool with respect to key religious and financial dates. It was also a cross-referencing tool during the change from the Julian to Gregorian calendars in 1582 in Catholic Europe, 1700 in Protestant Europe and 1752 in Britain. This chapter will provide part of the

[99] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon, Loomes, B. 1994. *Painted Dial Clocks.* Woodbridge: Antique Collectors' Club.p.104-119.

answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission. I will argue that the calendrical information represented on dials reflected the content of almanacs and mnemonic diagrams. The chapter will offer a substantial part of the answer as to what dials can tell us about astrological and mnemonic practices in the period up until the mid-late seventeenth century. The chapter will also offer a part of the answer as to the extent that users' emotions influenced dial development. I will argue that the rare examples of planetary symbols, used to represent the day of the week on dials in the eighteenth century, were useful for people who were accustomed to thinking of the week in terms of the by-then outdated concept. I will also argue that the change of the calendar and the introduction of the equation-of-time, or reactions to these things, brought about new content on dials and explanations in print.

In chapter six I will move on to consider lunar wisdom provided by clock and watch dials across the period. In this chapter I will consider the representation of the lunar phase as a statement about prevailing ideas such as the inhabited Moon from the mid-seventeenth century onwards. I will then move on to consider the use of the dial as a prompt for the pre-existing lunar wisdom of users as applied to astrology. I will then consider the survival of the lunar function beyond the decline of astrology in the mid-late seventeenth century including for use during the night in areas without street lighting. This will provide part of the answer as to what the relationships between dials and printed paper sources were, through their similarities and difference in representation of the lunar phase. It will also offer part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission, in terms of the subtle differences in the representation of lunar information. This chapter will offer a substantial part of the answer as to the extent of the relationship between dials and astrological and mnemonic practice in the period up until the mid-late seventeenth century. It will also offer a substantial part of the answer as to the extent to which the decline of astrology and the mnemonic method influenced dials from the mid-late seventeenth century. Lunar wisdom was one aspect that reformers of astrology attempted to continue during the decline of astrology.

In chapter seven, my last content chapter, I will consider the changing use of astronomical knowledge in the period. I will identify two different contexts of use for astronomical clocks. The first is the use for astrology and memory in the period from the mid-sixteenth to the early-seventeenth century. I will demonstrate that the astronomical function went into decline slightly earlier than the calendar and lunar functions. The second context of use that I will identify was for teaching astronomy during the late-seventeenth

and early-eighteenth century, as part of the wider context of public demonstration of natural philosophy. The distinction between these two different contexts of use would not have been possible without my novel approach. This chapter will offer part of the answer as to what the relationships between dials and printed paper sources were. It will offer a substantial part of the answer as to the extent of the relationship between dials and astrological and mnemonic practice in the period up until the mid-late seventeenth century. It will also offer a substantial part of the answer as to the extent to which the decline of astrology and the mnemonic method influenced dials from the mid-late seventeenth century.

Each chapter plays a distinct role within the set and together they provide full and rich answers to the main research questions. In chapter eight I will offer my conclusions by returning to my four main research questions. I will answer each of these questions with reference to my findings in chapters two to seven, through which I will provide an explanation as to why the standard format which emerged by 1770 appeared the way that it did, which provides the overall narrative of the thesis. My answers will challenge the traditional horological literature and set the scene for future research in to clocks and watches. I now turn to chapter two where I begin my reinterpretation of clock and watch dials according to the novel approach I outlined above.

Part One:

Format

Chapter 2

Communication Methods

> As thus he was debating with himselfe the Clocke tolde him it was time to goe visite his Host, so that he made himselfe as sumptuous as might be.
> Robert Greene, *Ciceronis Amor*, 1589[1]

> If a Clock tells the Hour and Minute of the Day, it is only by the Motion of the different Hands, pointing successively at the Figures marked on the Hour Plate for that Purpose. We never imagine this to be the Effect of Thought or Intelligence.
> William Duncan, *The Elements of Logick*, 1770[2]

2.1 Introduction

Writing in 1589 and 1770 respectively, although for completely different purposes where timepieces were not the main focus of their writing, both Robert Greene and William Duncan refer to the clock 'telling' someone something. Their joint use of the term 'telling' is crucial because it demonstrates their acknowledgement that timepieces communicated information. However, the context of both the range of information indicated on dials and the perceptions of communication in which they wrote were very different. For the fictional character in Greene's story the clock was telling him to visit someone. How it told him, Greene does not specify, but we cannot automatically assume it was the hour and quarter. Sixteenth- and seventeenth-century clocks and watches 'told' their users a great deal of temporal information from the lunar phase and lunar aspects to the day of the week and period of the day. Until the mid-late seventeenth century such information was used to determine auspicious times to undertake certain tasks according to astrological theory. Greene's character may indeed have been prompted to visit his companion by an indication other than the hour. Through this kind of discussion of dials as memory prompts I contribute to the work of Rossi[3] and others[4] on the early modern art of memory.

One hundred and eighty years later, when Duncan was writing his educational text in 1770, the range of temporal information indicated on clock and watch dials had dramatically decreased. The standard format presented only the hour, minute and second. By the eighteenth century perceptions of effective communication had also altered. In his explanation of material objects, Duncan used the clock as an analogy to say that mechanical devices communicated information but did not interpret it. This contrasted with the

[1] Greene, R. 1589. *Ciceronis Amor.* London.
[2] Duncan, W. 1770. *The Elements of Logick.* London.
[3] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.
[4] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.

sixteenth and early-seventeenth century perception of mechanical devices as magical, according to Eamon's definition of mechanical devices,[5] which I contribute to through a focus on dials as communication devices. Duncan's educational text sits within the context of public teaching of natural philosophy and must also be seen as a deliberate form of distancing from previous theories such as the natural magic tradition. I am in agreement with Henry's view that proponents of nascent science from the late-seventeenth century onwards were keen to separate naturalistic elements from the magic tradition and discard elements they did not want.[6] I contribute to this discussion by introducing clocks and watches. Indeed, Duncan's subsequent assertion using the phrase 'we never imagine', while seeming logical to a modern reader, is indicative of the prior view that some people did believe that the mechanical instrument was an interpreter of information for the user.

Communication by any medium requires certain methods to do so effectively. Perceptions of which depended on the purpose for which information was intended and changed over the course of the period. In books, tables and diagrams this involves a shared language and a familiar format for arranging information and, more importantly, layering it. The reader needs to be able to know where to begin reading, where to move to subsidiary information, and where to end. In this chapter, the first of three which explore dial formats, I interrogate the clock and watch dial as a form of text and diagram with the aim of restoring the numerous, and changing, components of dial format to their rightful position within the history of perceptions of knowledge communication. Crucially, dials were designed to convey meaning and transmit knowledge through specific information arrangements and notation in a similar way as printed paper sources.

The products of the printing press exerted the largest influence on the arrangement of information on dials and the characters chosen to represent that information. By arguing this point I will contribute to the work of historians of the book and of printing such as Eisenstein[7] and others[8] by introducing the issue of communication on instruments and the ways in which printed paper sources and instruments influenced each other. This influence was much stronger than any attempt to provide a purely aesthetically-pleasing object for a wealthy client as historians of horology such as Landes[9] and Thompson[10] have claimed up

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[5] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.172.
[6] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.57.
[7] Eisenstein, E.L. 1983. *The Printing Revolution in Early Modern Europe.* Cambridge: Cambridge University Press.
[8] Johns, A. 1998. *The Nature of the Book: Print and Knowledge in the Making.* Chicago: University of Chicago Press, Darnton, R. 1982. What is the History of Books? *Daedalus.* 111(3).pp.65-83.
[9] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[10] Thompson, D. 2004. *Clocks.* London: British Museum Press, Thompson, D. 2007. *Watches.* London: British Museum Press.

until now. Glennie and Thrift, the only authors of a work on clocks to refer to user comprehension, state that the way in which clock-makers understood how users read the time from clocks was important,[11] but they do not elaborate. The early modern printing press disseminated knowledge of mathematics, astronomy, astrology, and memory from recovered ancient texts and new authors, which was reflected in the different types of knowledge conveyed by dials.[12] The press also provided readers, which included successful craftsmen,[13] with a repository of numerals, symbols and pictures for use in conveying certain types of information such as astrology and mathematics and crucially, methods of arranging and ordering information.

The work of Foucault reminds us that while our methods of ordering knowledge appear logical to us and the only way of doing so, there are always other methods, which is evident from considering those used in the past and in other cultures.[14] That dials reaffirmed the communication methods used by printers for texts meant that, together, these texts and dials provided readers and users with the conventions which they were compelled to become accustomed to in order to make good use of both media. Contrary to the view implied by most historians of horology,[15] that dials were made in horological isolation, this chapter will reinterpret dials within the much wider context of knowledge communication and representation.

Johns, emphasises the role played by the controllers of the printing presses, for example the Stationers Company in England, in deciding which publications would be disseminated by their presses.[16] This control is echoed by Topham, who considers the expansion and diversification of the book trade as a consequence of the repeal of perpetual copyright in 1774,[17] which demonstrates the context of controlled publication in the period under investigation here. Johns briefly mentions that those working in the printing presses set conventions, but does not elaborate. Given the extent of the components of a page of astrological text such as an almanac, this would clearly involve the selection of the typeface, point size, language, numeral type and symbols determined the most efficient for selling

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[11] Glennie, P. and Thrift, N.J. 2009. *Shaping the Day: a History of Timekeeping in England and Wales 1300-1800.* Oxford: Oxford University Press.p.253.

[12] The specific use of calendrical, lunar and astronomical knowledge on dials is considered in depth in chapters five to seven.

[13] Many clock-makers and instrument makers were wealthy. They were a literate and numerate group of people and must have had their own libraries or access to publications.

[14] Foucault, M. 2001. *The Order of Things: an Archaeology of the Human Sciences.* London: Routledge.p.xvii-xxii.

[15] Thompson, D. 2004. *Clocks.* London: British Museum Press, Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club.

[16] Johns, A. 1998. *The Nature of the Book: Print and Knowledge in the Making.* Chicago: University of Chicago Press.p.59-60.

[17] Topham, J. 2009. Scientific and Medical Books. In Suarez, M. and Turner M. eds. *The Cambridge History of the Book in Britain Volume 5 1695-1830.* Cambridge: Cambridge University Press.p.817.

books and pamphlets. In turn this would reflect styles of communication that buyers were familiar with, but to some extent would introduce them to new styles that they would become accustomed to. Indeed, Eisenstein argued that decisions made by printers regarding the layout of works guided readers' thought patterns and their perceptions of the most effective ways of ordering information.[18] I expand Eisenstein's point by introducing instruments to the discussion. I argue that dials not only formed part of this process of convention establishment, but as indicated information moved on dials, they represent an automated form of information ordering and as such a memory trigger.

I will explain the changes in communication methods and perception of them, alluded to above, using two sections in which I bring these bodies of literature together. In section 2.2 I will consider the act of looking and the pathways that were created for the eye to follow. In section 2.3 I will move to consider theories of knowledge transmission. Through these two sections I will provide part of the answers to some of the main thesis research questions. The chapter will improve our understanding of the relationships between dials and printed paper sources in the period. In both sections 2.2 and 2.3 I will argue that there was a fluid boundary between dials and printed paper sources. Dials mirrored printed paper sources in the way in which information was arranged, layered and represented. I will argue that conventions established on dials mirrored printed paper sources in the sixteenth and early-seventeenth centuries and identify where they outlived printed paper sources and became part of the standard format by 1770. This chapter will provide a substantial part of the answer as to the extent of the relationship between dials and perceptions of knowledge transmission. In section 2.2 I will argue that dials layered information and created hierarchies for the eye to follow using the circular method, concentric rings, subsidiary dials and typeface in a similar way to printed paper sources in the sixteenth and early-seventeenth century. Both printed paper sources and dials were useful, through these hierarchies, for astrological and mnemonic purposes and for achieving higher knowledge. As these ideas declined during the seventeenth century, dials and almanacs became plainer in their arrangements.

In turn this will enable me to offer a part of the answer as to the extent of the relationship between dials and the practice of astrology and memory up until the late-seventeenth century and the influence of its subsequent decline in sections 2.2 and 2.3. In section 2.3 I will argue that both dials and astrological works shared a communication

[18] Eisenstein, E.L. 1983. *The Printing Revolution in Early Modern Europe.* Cambridge: Cambridge University Press.p.64.

method and were intended to be of similar use. Together these answers will improve our understanding of why the standard format took the form that it did by 1770.

2.2 The act of looking and pathways for the eye

In this section I will offer the first in-depth discussion of the methods used to communicate information on clock and watch dials in the period. My approach is unique because it considers the dial not only as text but also as a diagrammatic representation of information. I progress the argument of historians who have written about the early modern diagram, such as Lefèvre[19] and others,[20] by introducing working, three-dimensional instruments to the discussion and by undertaking a more in-depth evaluation of the communication methods used in diagrams since these authors have not extended the investigation far enough. The approach shared by these authors represents a popular school of thought in the history of science which moves beyond the printed or written word in the search for evidence of ideas. Nevertheless, their commitment to printed diagrams has become a limitation, which is corrected in this chapter by the deconstruction of dial formats, as examples of diagrams, thereby enabling an improved judgement of their capacity and efficiency for transmitting knowledge to users. While I agree with their central argument that diagrammatic representation provides a convenient route to further understanding of the different ways in which information was presented and thus knowledge shared in the period, there is a distinct lack of discussion of the ways in which people in the period believed knowledge was acquired through the physical reading/viewing of these various formats.

Mahoney's criticism of Edgerton[21] for what he considers to be a teleological argument does not detract merit from Edgerton's work.[22] The most important contribution Edgerton made was his assertion, after Gadamer,[23] that diagrams can reveal profound truths about the society which produced them. This is an assertion other authors are in agreement with as it may be inferred from their work, but is not explicitly stated. However, it must be

[19] Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.
[20] Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press; Freeland, G. and Corones, A. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic; Kemp, M. 2000. *Visualizations: the Nature Book of Art and Science.* Oxford: Oxford University Press.
[21] Edgerton, S. Y. 1985. The Renaissance Development of the Scientific Illustration In Shirley. W. and Hoeniger, David F. eds. 1985. *Science and the Arts in the Renaissance.* Washington, D.C.: Folger Books.pp.168-197.
[22] Mahoney, M. S. 2004. Drawing Mechanics. In Lefèvre, Wolfgang. ed. 2004. *Picturing Machines 1400-1700.* Cambridge, Massachsetts: MIT Press.p.305.
[23] Gadamer, H. G. 2004. *Truth and Method.* 2nd ed. translation revised by Weinsheimer, J and Marshall, D. G. eds. London: Continuum.

expressly stated if analysis of the dials in this instance, and diagrams more generally, at a deep enough level is to take place.

Historians such as Hall,[24] Dolza,[25] Lüthy[26] and Franklin[27] find potential in diagrams through their inherent codification and conventions, from which it can be inferred that they acknowledge the need for the reader/user to possess prior knowledge of the language of the diagram, which I will refer to as 'diagram literacy'. However, although it remains important to identify these codes and conventions and is something undertaken here also, this method is insufficient for extracting the maximum quantity of information possible from these formats about communication methods used on dials and diagrams in the period. The apparent deficiency in the work of previous authors lies with the absence of an analysis of various components of diagrams, such as the positioning of different pieces of information in the space available and the relation between them. Only when looking at them in this kind of detail can deeper understanding of communication methods be achieved and judgements of effectiveness made.

The main focus of this section is the multi-function dial made and used up until the mid-late seventeenth century. From the late-seventeenth century the number of format components such as concentric rings and subsidiary dials went in to decline. However, the two concentric rings and single subsidiary dial of the standard format which emerged by 1770 were a product of the conventions established during the era of the multi-function dial and its decline.

2.2.1 Contrast

Contrast was fundamental to dial legibility and provided the landscape on which pathways for the eye were created. On a basic physiological level the requirement for contrast between the background and the inscribed notation was the same for text and diagrams in printed paper sources. For the latter cream-coloured paper represented the lightest background colour available and black ink represented the darkest imprint available and thereby created the ideal contrast. Dials, however, were not made with white backgrounds

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[24] Hall, B.S. 1996. The Didactic and the Elegant. In Baigrie, B.S. ed. *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science.* London: University of Toronto Press.p.10.

[25] Dolza, L.M. 2003. Reframing the Language of Inventions: The First Theatre of Machines. In Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.p.98.

[26] Luthy, C. 2003. The Invention of Atomist Iconography. In Lefèvre, W. Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.p.117.

[27] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.pp.53-97.

until 1727.[28] The challenge with metallic dials was to provide a sufficiently light background with sufficiently-dark engraved characters to create sufficient contrast for the characters to be immediately legible.

Dial backgrounds were either gold- or silver-gilded (see figures 2.1 and 2.2) until the white dials of the eighteenth century (as seen in figure 2.3). These backgrounds provided a light-reflecting background, ideal for low-level lighting, which assisted legibility by giving the effect of a lighter background than there was in reality. Inscriptions were filled with dark wax,[29] which provided a similar effect as dark print on light-coloured paper. On some multi-function dials some indices were differentiated by their background colour, such as using silver gilt for the lunar index ring on a gold-gilded dial. This practice is indicative of knowledge hierarchy, discussed in detail below. Furthermore, gold and silver had a symbolic role indicative of God's structure. Henry informs us that silver was the second metal after gold and corresponded to the Moon and queens. Gold corresponded to the Sun, kings and princes.[30] This made the different coloured rings on multi-function dials ideal in the period for contemplating God's hierarchy.

Figure 2.1[31] ©British Museum

Figure 2.2[32] ©British Museum

[28] George Graham was the first to use white enamel dials from around 1727 onwards. They quickly became popular and gradually replaced the metallic dials.
[29] Wax was usually black, but there were some examples from 1660 until the emergence of the white enamel dial in 1727 which used red wax.
[30] Henry, J. 2002. *Knowledge is Power: Francis Bacon and the Method of Science.* Cambridge: Icon.p.46.
[31] British Museum 1958,1006.2112. Reproduced by kind permission of the Trustees of the British Museum.
[32] British Museum 1958,1201.837. Reproduced by kind permission of the Trustees of the British Museum.

Figure 2.3[33] ©British Museum

The only historian of horology to comment on colour contrast is Betts who states that: "The original reason for a silver-coloured dial was to enable the dial to be read…, and as more silvering appeared with blued steel hands…dials became even easier to read."[34] Betts does not elaborate on this point. His statement that silvering enabled dials to be read is logical, but his argument that dials became easier to read is not supported by the evidence. All dials, whether they were metallic or white-enamelled, provided the necessary contrast for legibility. The white-enamel dials were no easier to read than the earlier metallic dials.

McKenzie[35] and Hunter[36] both provide a scientific insight in to the way in which humans perceive light, which is useful for understanding contrast on dials. Despite the fact that the scientific principles on which appearance is now evaluated were not known to early modern clock and watch-makers, the dials they made conformed to most of these preferred conditions. This was achieved in the period through trial and error and experienced recognition by makers of what constituted an effective surface appearance and contrast of inscribed characters on that surface.

McKenzie informs us that colour is described in terms of its hue, saturation and luminosity.[37] In these terms metallic dials were of silver or gold hue and white enamel dials of white hue. Their saturation would need to be evaluated, which is something that would be beneficial for a future researcher to undertake, but is beyond the scope of this thesis. In terms of luminosity, if used in candlelight or firelight then the metallic surfaces could create

[33] British Museum CAI.1565. Reproduced by kind permission of the Trustees of the British Museum.
[34] Betts, J. 1985. *The National Trust Pocket Guide to Clocks.* London: Octopus Books.p.36.
[35] McKenzie, A.E.E. 1965. *A Second Course of Light.* Cambridge: Cambridge University Press.
[36] Hunter, R.S. 1973. *The Measurement of Appearance.* Washington: Hunter Associates Lab. Inc.
[37] McKenzie, A.E.E. 1965. *A Second Course of Light.* Cambridge: Cambridge University Press.p.190.

a greater intensity of reflected light to the eye than the white enamel dials. Although, enamel dials would also have reflected light given their white backgrounds. This is further evidence that metallic dials were intended as effective reading devices for candle and firelight.

Early modern dials did not feature a wide variety of colours for the background or information represented on them. Sometimes this was in contrast to colourful cases, but not in every instance. It has been noted that there are some surviving examples of dials with red wax instead of black from 1660 to 1727, but these were the minority. One of the reasons why makers continued to use black on gold, silver, and then white backgrounds was because this was the most effective form of contrast for legibility. As McKenzie points out, in the non-daylight setting red and purple along with violet and black are nearly indistinguishable.[38] This is an extreme example, but demonstrates that some colour combinations worked better than others in the context of different lighting situations.

When Hunter says that we evaluate objects with our eyes and determine their usefulness to us based on whether they appear old or new, beautiful or ugly, pristine or worn,[39] he could equally be describing the judgements made today, those made when he was writing in the 1970s, or those made in the early modern period. This is why dials also had to be aesthetically pleasing to the kinds of customer that could afford them as identified in chapter one. As Hunter points out, similarly to McKenzie, there is more going on with our perceptions of objects due to light then we realise. He says that six attributes affect our perception and subsequent judgement of objects: the spectral quality, intensity, and angular size of the light source, the direction from which the light strikes the object and from which the object is viewed and the background.[40] For dials and their users in the early modern period this meant that the spectral quality, related to the reflectance of the light from either the metallic surface or the white enamel surface, was important. With dials in this period the surface had to reflect enough candle and firelight to enable reading, but not dazzle the user in daylight conditions. This was also how dials had to be useful in different kinds of intensity of light source. Daylight and candlelight are of course very different. The last four also depended on the user in relation to the light source available. Ideally, the dial could be read at multiple angles rather than one, which they were.

The difference between gold and silver gilding and white backgrounds is better understood within the context of improving domestic lighting technology. For most of the

[38] Ibid.p.193.
[39] Hunter, R.S. 1973. *The Measurement of Appearance.* Washington: Hunter Associates Lab. Inc.p.3.
[40] Ibid.p.49.

period under investigation, users would be viewing their dials in daylight and by fire and candle light in the evenings.[41] This is confirmed by O'Dea's reference to Boswell's account in the 1760s of the inconvenience of attempting to write in the evening by candle light and then accidently putting the candle out.[42] In this context of dim lighting levels produced by candles, a strong contrast between dial background and inscribed characters was necessary. Both metallic and white enamel dials provided this contrast. According to O'Dea, it was not until 1732 that Clayton reported his experiments with coal gas for lighting to the Royal Society.[43] Gas lamps provided better light levels and, most importantly, a constant level of lighting. They would not have been lit for quick reference of the time in the middle of the night, but would have been used in the evening by the wealthy owners of clocks and watches. In this context of improved viewing conditions from the 1730s, dials with white backgrounds, which emerged just a few years earlier in 1727, were easier to read than in the low lighting of candle light. This is one reason why the white enamel dial superseded the metallic dial during the eighteenth century.

At the most fundamental level the dial mirrored the book in the way it was presented to the user as a medium designed to be read. These were undoubtedly aesthetically-pleasing objects, as emphasised by historians of horology,[44] and would certainly have been a sign of wealth, but when deconstructed to the basic design features, such as contrast, they were clearly designed to be useful. If an instrument was only designed to be a status symbol efforts to create the level of contrast described above would not have been made.

2.2.2 The circular method

The components of the mid-sixteenth to the mid-late seventeenth century multi-function dial should be considered as deliberate pathways created by makers for the eye of the user to follow. They conformed to perceptions of effective knowledge transmission in the period. Admittedly, primary source reference to the ways in which makers engaged the eye is rare, if existent at all, but the use of diagrams in craft books can be used to infer intended pathways for the eye to follow, which is useful to compare with clock and watch dials. It is probably due to this lack of primary material that few historians, who have considered the diagram and knowledge acquisition in the early modern period, refer to the eye and the process of

[41] The lighting context is discussed in greater detail in chapter four on enablement.
[42] O'Dea, W.T. 1964. *Making Fire.* London: Science Museum.p.6.
[43] O'Dea, W.T. 1967. *Lighting 2: Gas, Mineral Oil, Electricity.* London: H.M.S.O.p.3.
[44] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon, Thompson, D. 2007. *Watches.* London: British Museum Press.p.104-119.

looking. Given this lack of primary evidence, it is necessary to consider as much detail as possible if our existing knowledge is to be expanded. Clark[45] may provide contextual background relating to contemporary perceptions of vision and the process by which it was believed that an image travelled to the mind, but he does not refer to diagrams or instruments. The result is a similarly self-constrained approach to vision as experienced by historians who have previously commented on the diagram. All of which neglect the movement of the eye.

Franklin is the only historian to describe the way in which the viewer is intended to follow round the parts of the diagram and then infer meaning from it.[46] Franklin's assessment of the viewing process may not account for different components of format, but it does provoke thought about the intended and actual movement of the eye around a particular diagram. If clock and watch dials are contemplated in this way then it further raises the question about the intended sequence of reading and thus information hierarchy. That the eye, and therefore the focus of the mind, moves around a dial with concentric rings in one direction means that it moves around a dial with subsidiary dials differently. This difference may be small, but is significant.

No historian has focussed on diagram components in as fine detail as I do here. For writers such as Lefèvre[47] it is sufficient to distinguish diagrams from technical plans. Lüthy,[48] Franklin[49] and Maclean[50] define different types of diagram on the basis of shape or arrangement of information, for example circular or square arrangements. If I follow the example of these four authors I can identify similarities between printed diagrams and dials such as arrangement of information, numeral type, words, symbols, colour contrast, method or indication and motion. However, this method is insufficient for my purposes as more detail is required and thus further deconstruction. While their method enables these authors to discuss the significance of these forms of communication, for example the square

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[45] Clark, S. 2007. *Vanities of the Eye: Vision in Early Modern European Culture.* Oxford: Oxford University Press.p.10-11.

[46] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In Freeland, G. and Corones, A. eds. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.p.55.

[47] Lefèvre, W. 2003. The Limits of Pictures. In Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.pp.69-88.

[48] Luthy, C. 2003. The Invention of Atomist Iconography. In Lefèvre, W., Renn, J., and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.pp.119-127.

[49] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.pp.56-69.

[50] Maclean, I. 2006. Diagrams in Defence of Galen: Medical Uses of Tables, Squares, Dichotomies, Wheels and Latitudes 1480-1574. In Maclean, I. and Kusukawa, S. eds. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe* Oxford: Oxford University Press.pp.137-164.

representing contrary relationships between terms, their limited deconstruction of diagram format means that they then move on to other discussions.

The various components of a multi-function-dial format must be recognised as the result of deliberate choices made by clock and watch-makers from a range of options to provide the eye with an effective pathway around the dial by which the user could acquire knowledge. When in 1622 Richard Banister said: "The eye is a spherical figure, which form is most apt to contain much…Spherical bodies doe as it were move of themselves, resting upon a point…"[51] he alluded to the fact that circular diagrams, and therefore dials, were effective conveyors of information because they were shaped like the eye, which was also circular and consisted of concentric rings. The mimetic function of instrument and text to the human body was important. He also alludes to the importance of creating a visual pathway for the eye when he refers to movement and a resting point.

Dials provided pathways that could be followed to their end in order to acquire the full range of information offered, but they also presented an overview to a user, with the indications at the top of the hierarchy most noticeable. Rossi helpfully informs us that book frontispieces were intended to be used to acquaint oneself with the contents of the work before reading it.[52] However, he did not take this idea beyond books. Material objects also provide a summary of their contents or use. Multi-function dials conceivably served a similar purpose; providing users with an overview of that day or moment's combination of temporal information before the user looked at the specifics of each indication.

Despite any mechanical necessity for the circular method, this method was drawn from a genre of diagrams in print and paper instruments/volvelles. These diagrams represented temporal information, schematic representations of the universe (see figure 2.4) which were found in examples such as Recorde's *Castle of Knowledge*, Apianus' *Cosmographia*, Honterus' *Rudimenta Cosmographica*,, and mnemonic diagrams (see figure 2.6). Figures 2.4 to 2.6 demonstrate the influence of print on dials from the mid-sixteenth to the early-seventeenth century. The circular method was also a representation of the concept of the macrocosm and microcosm. On the dial it enabled users to contemplate their place in the Great Chain of Being created by God.[53]

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[51] Richard Bannister *A Treatise Of 113 Diseases of the Eyes*, (London, 1622).
[52] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.27-28.
[53] Henry, J. 2002. *Knowledge is Power: Francis Bacon and the Method of Science.* Cambridge: Icon.p.57.

Figure 2.4[54]

Figure 2.5[55] **©British Museum**

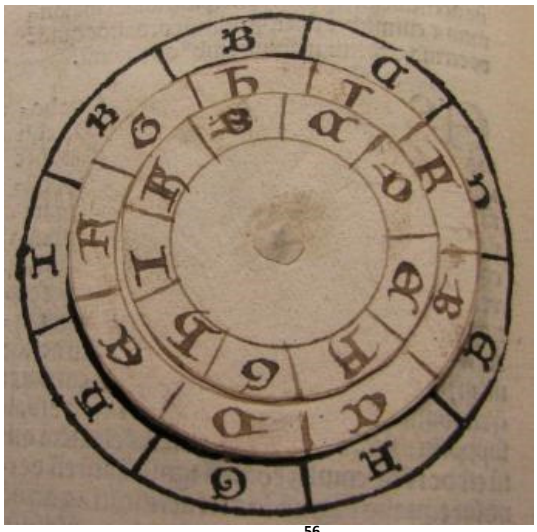

Figure 2.6[56]

Historians agree that the mnemonic genre was widespread in the sixteenth- and early-seventeenth century.[57] It is important that its notable contributors such as Ramon Lull[58] and Giordano Bruno[59] utilised the circular method. Given the aim was to provide readers with a method for retaining information in the memory, the circular method must have been chosen deliberately for its efficiency as a method of organising information that was to be retained. Yates successfully connected the circular method with the desire to

[54] Apianus, P. 1550. *Cosmographia.* Vaeneunt G. Bontio: Antuerpiæ. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[55] British Museum 1856,0429.1. Reproduced by kind permission of the Trustees of the British Museum.
[56] Lull, R. 1514. *Ars Brevis Illuminati* London. Photograph by Jane Desborough. Reproduced by kind permission of the Trustees of the Science Museum Group.
[57] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.1
[58] Lull, R. 1514. *Ars Brevis Illuminati* London. Although a thirteenth-century writer, Lull's work enjoyed a revival in the early modern period.
[59] Bruno, G. 1584. *De la Causa, Principio, et Uno.* Venice.

acquire total knowledge in the period.[60] However, it was not only achieved in paper form. Clock and watch dials were designed using similar formats, as can be seen in figure 2.5, and were a part of this mnemonic tradition. The identification of the similarity between instrument and text in terms of format, demonstrative of similarities in terms of use, has not been made until now.

The pathway created for the eye to follow in the circular method is a ring around which the eye can read a fixed sequence of values with a start and end point. This enables the reader to both remember the previous value and anticipate the next value within that range. Utilisation of such an information range embeds all dials and diagrams with a sense of past, present and future. It is one method for providing an additional layer of information. Historians who have discussed the diagram have not considered layering, which is a result of their lack of thorough diagram deconstruction.

2.2.3 Hierarchy

Decisions made to layer information on the dial equated to decisions made to order knowledge and thus create hierarchies. This was achieved in several ways: concentric rings; subsidiary dials and apertures; and typeface. Layering was an essential part of the art of memory in the sixteenth and early-seventeenth century. While Rossi informs us that mnemonic combinations on wheels were intended to enable the reader to attain truth and higher knowledge, he does not consider combinations beyond the world of print. Clock and watch dials were a distinct form of combination-bearing device given that indications were self-moving. Combinations of information on multi-function dials enabled users to order knowledge according to the hierarchies provided by the dial. Users first had to associate facts and concepts with indications on the dial and then would be able to contemplate them in an ordered fashion. Unlike paper volvelles, users could not manipulate the indications on the dial whenever the need arose, they instead had to carefully assign concepts to temporal sequences that would then mechanically move without input from the user. In order to create a hierarchy on the dial, makers had to choose where to place particular indices on the main dial. Works on the art of memory from the sixteenth- to the early-seventeenth century, such as Bruno's *Umbris Idearum,*[61] provided advice to readers on how to order information. During the mid-late seventeenth century, categorization advice came instead from the movement to create encyclopaedias of knowledge and universal languages.

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[60] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.p.369.
[61] Gosnell, S. 2013. *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582.* Huginn Muninn & Co.p.107.

As we have seen many of the authors who utilised the circular method were mathematicians, astronomers, and astrologers. As Dear[62] and Clark[63] remind us, people in the sixteenth and early-seventeenth century did not distinguish between these different 'professions'; they were all part of the natural magic tradition. The proponents of which were seeking to distance themselves from spiritual magic. Dials were very much part of the outward expression of this separation. Clock and watch-makers drew on these branches for inspiration regarding format and content,[64] but not the spiritual branch. Henry[65] and Eamon[66] agree that it was through mathematics that machines were perceived as part of the magical tradition known as 'mathematical magic' in this period. Indeed, mathematics was well represented on the dial.

Geometrical shapes were an important component of sixteenth and early-seventeenth century dials. The most obvious was the overall circular shapes of the dial perimeter and any subsidiary dials and concentric rings. However, many dials from the mid-sixteenth to the early-seventeenth century also featured the lunar aspect diagram, which presented the triangle, square, and hexagon representing the trine, quartile and sextile aspects (see figure 2.7). These indicated the position of the Moon in relation to the Sun, expressed in terms of opposition, trine, quartile and sextile.[67] Each aspect was meaningful in terms of astrology. These aspects were cited in sixteenth- and early-seventeenth-century almanacs such as figure 2.8, but disappeared during a similar period as their representation on dials declined also. The shapes created on the aspect diagram were important in terms of their geometric symbolism of the platonic solids. I progress the discussion of Beltramini and Gasparotto,[68] who say the platonic solids indeed featured in art works, by emphasising that they also featured on dials of the period. It could be imagined that the wealthy owner of a painting[69] and a dial with these representations used them both as a reminder of the four elements and the universe with which the platonic solids were associated.

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[62] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.17-18.
[63] Clark, S. 1997. *Thinking with Demons: the Idea of Witchcraft in Early Modern Europe.* Oxford: Clarendon Press.p. 214-215; 218.
[64] Dial content is discussed in detail in chapters five to seven.
[65] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.58.
[66] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.197.
[67] Opposition was represented by a straight line, trine by a triangle, quartile by a square, sextile by a hexagon.
[68] Beltramini, G. and Gasparotto, D. 2016. *Aldo Manuzio: Renaissance in Venice.* Venice: Marsilio.p.28.
[69] Such as Jacometto Veneziano, *Portrait of Luca Pacioli and Guidubaldo da Montefeltro,* 1495. Museo di Capodimonte, Naples.

Historians of mathematics and its application in the period, such as Merzbach, Boyer[70] and Bennett,[71] emphasise the increased demand for Euclid's *Elements*[72] in the vernacular after the invention of printing. However, neither author refers to dials and diagrams within this context of increased use or reference to Euclidean geometry. Building on Barrow-Green's emphasis on the 'groundplat' in John Dee's preface to the Billingsley edition of Euclid's *Elements,*[73] not singled out by other historians, I argue that both Dee and clock and watch-makers drew on tree diagrams as a method perceived in the period to be effective for ordering knowledge.

Figure 2.7[74] ©British Museum

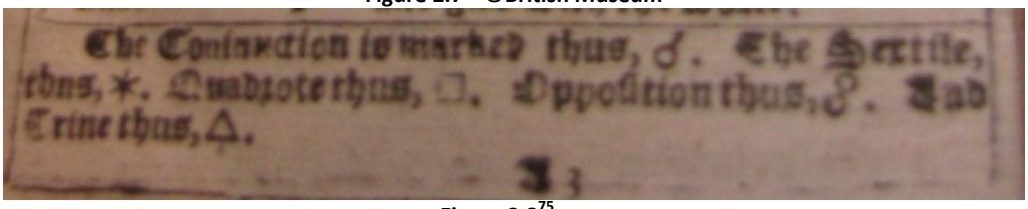

Figure 2.8[75]

Shapes were not merely perceived as varying geometric forms in the period. Their representation had a greater significance related to hierarchy. Franklin's point that the *Elements* are about the interrelations between spatial parts, not just a catalogue of shapes,

[70] Merzbach, U.C. and Boyer, C.B. 2011. *A History of Mathematics.* 3rd ed. Hoboken, New Jersey: John Wiley.p.119.
[71] Bennett, J. 2000. Instruments and Illustrations in Eighteenth Century Astronomy In Shea, W.R. 2000. *Science and the Visual Image in the Enlightenment.* Canton, Massachusetts: Science History Publications.pp.137-142.
[72] Billingsley, H. and Dee, J. 1570. *The Elements of Geometrie of Euclide.* London: John Daye.
[73] Barrow-Green, J. 2006. 'Much necessary for all sortes of men': 450 years of Euclid's *Elements* in English. *BSHM Bulletin.* 21.p.7.
[74] British Museum 188,1201.105. Reproduced by kind permission of the Trustees of the British Museum.
[75] Allestree, R. 1624. *A New Almanacke and Prognostication.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

is progressed by considering diagrams and dials.[76] In this context, there was a relationship between different concentric rings on dials and therefore also between the different types of information represented on them. Where each ring displayed a different temporal unit, the relationship between each of them represented an overall concept of time and the consequent manner in which it must be divided. Where some rings also included astronomical information, the relationship between them represented the concept of our place in the hierarchy of the Great Chain of Being[77] in a similar way that schematic representations of the universe did.

To create hierarchies of information on dials in the late-sixteenth and early-seventeenth centuries, makers used concentric rings to represent different functions on the dial. At a basic level there might be two concentric rings. This was a format which survived the introduction of the pendulum in 1657, with its introduction of the minute index, and became part of the standard format by 1770. However, from the mid-sixteenth to the early-seventeenth century, concentric rings could number five or six, which was potentially problematic for legibility and at-a-glance use.

Some makers responded by alternating different types of numeral or symbol over each ring as seen in figures 2.5 and 2.7. The equivalent response in printed diagrams was colour contrast. Almanacs often used red ink instead of black to distinguish full Moons from new Moons. Whereas Kusukawa deems it sufficient to say that variation in text colour was important,[78] I can be more specific and identify coloured Moons in almanacs and the changing lunar phase on dials as comparable communication methods. It may not have been possible or practical to try to include a wide range of different colours on dials in this period, but in both media the aim was to render the information easy to read. This provides further support for the idea that makers made decisions about format based on legibility and comprehension, not only aesthetics.

While mechanical gearing restricted the choices of communication method used on clock and watch dials, makers utilised combinations of subsidiary dials and apertures as comparable methods to achieve the kind of results printers created with tables or tree diagrams (see figure 2.10). Bruno's mnemonic works, for example, utilised a range of different diagrammatic communication methods. One of which was the use of smaller parts

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[76] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In: Freeland, G. and Corones, A. eds. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.p.53

[77] Henry, J. 2002. *Knowledge is Power: Francis Bacon and the Method of Science.* Cambridge: Icon.p.57.

[78] Kusukawa, S. 2012. *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-century Human Anatomy and Medical Botany.* Chicago: University of Chicago Press.p.69.

within an overall shape.[79] Similarly, almanacs throughout the period utilised tables as a method for presenting calendrical, lunar and astronomical information. Layers were represented using multiple columns, which can be seen in figure 2.9. This similarity supports the idea that there was a mutual consideration of legibility and ease of comprehension and a mnemonic and astrological intention written in to dial formats.

Lüthy[80] and Dolza[81] have not considered formats in sufficient detail to be able to describe the layers of information they provide. The only author to have come close is Franklin when he remarks on the complexity of Lullian wheel diagrams representing parallels between the seven Beatitudes and gifts of the Holy Spirit,[82] but he does not expand the point and moves on to describing other types of diagram. Similarly, Maclean identifies different types of diagram, but his chronological approach, where he says the circular method was the third method to come about in print after the table and the square, means that he does not account for different methods being used for different purposes in the same period.[83] By contrast, I consider the more complex issue of varying formats dependent on use, layers of information across these different types and equivalent methods of achieving the same ends.

Similarly to the way in which the multi-function dial could be seen as a representation of the relations between temporal units in a concept of time or our place in God's hierarchy, as mentioned earlier, subsidiary dials can be viewed as replications of the main dial in miniature. They appeared from the late-sixteenth century, rose in popularity during the seventeenth century with examples of up to four subsidiary dials, sometimes in place of a main dial. Their use then declined in the late-seventeenth century, but only in the number appearing on the dial. The existence of one subsidiary dial, usually located above the 'VI' position on the main dial characterised the standard format by 1770.

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[79] Bruno, G. 1591. *De Monade Numero et Figura.* Frankfurt.

[80] Luthy, C. 2003. The Invention of Atomist Iconography. In Lefèvre, W., Renn, J. and Schoepflin, U. eds. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.pp.117-128.

[81] Dolza, L.M. 2003. Reframing the Language of Inventions: The First Theatre of Machines. In Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.p. 89-98.

[82] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In: Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.p.58-59.

[83] Maclean, I. 2006. Diagrams in Defence of Galen: Medical Uses of Tables, Squares, Dichotomies, Wheels and Latitudes 1480-1574. In Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press..pp.137-164.


March hath xxxj. dayes.

I March gainſt Ianuary who doth ſtriue,
And keepes vniuſtly my prerogatiue;
Which if he not brooke, my ſword ſhall mak't appeare,
That he vſurpes and falſly gins the yeare.

Figure 2.9[84]

Figure 2.10[85] **©British Museum**

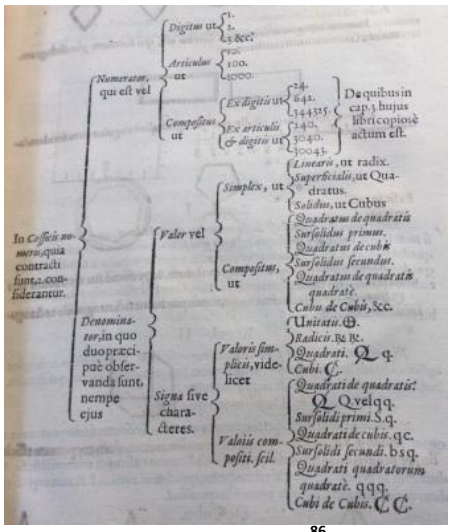

Figure 2.11[86]

Whereas Lüthy and Smets[87] refer to the fluid boundary between image and text in the period and claim that tree diagrams are an example of text becoming image, my argument is that there was also a fluid boundary between diagrams in text and diagrammatic representation on instruments, evident in the example of early modern clock and watch dials. By considering the layering of information on diagrams and dials, which has not been looked at before, similarities can be drawn between tree diagrams and dials. If tree diagrams such as those of Fludd[88] seen in figure 2.11, represented ever-smaller or more distinct units of information as the viewer reads along the branches, then similarly dials with

[84] Hawkins, G. 1624. *An Almanacke and Prognostication 1624.* London: Printed for the Company of Stationers. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[85] British Museum 1888,1201.177. Reproduced by kind permission of the Trustees of the British Museum.
[86] Fludd, R. 1617. *Utriusque Cosmi.* Oppenhemii. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[87] Luthy, C. and Smets, A. 2009. Words, Lines, Diagrams, Images: Towards a History of Scientific Imagery. *Early Science and Medicine.* 14.p.399.
[88] Robert Fludd, *Utriusque Cosmi Historia* (London, 1619).

subsidiary dials also represent ever smaller sizes of temporal units. This apparent similarity, albeit achieved slightly differently in dials due to mechanical constraints, improves our understanding of the hierarchy of information represented on dials with subsidiary dials. Compared to the tree diagram, the larger dial, or the largest of the set of subsidiary dials and/or apertures, is the equivalent of the far left, or top, position of the tree diagram. The hierarchy then descends through ever smaller sizes of subsidiary dial or aperture.

Sources such as Ramus' *Compendium of the Art of Logic and Rhetoric*[89] confirm the importance of knowing how to order and divide information in the early modern period. Located within the genre of the instruction book, it provided the reader with the categorisation process of creating a tree diagram which could be applied to anything in the natural world. The association between tree diagrams and the technique of division can be extended beyond Maclean's basic description of what a tree diagram was[90] to the world beyond text using the example of subsidiary dials and apertures. While Rossi informs us that in the mid-late seventeenth century these techniques were applied to the pursuit of *pansophia* and the creation of an encyclopaedia of knowledge,[91] he does not allow for three-dimensional objects to be part of the key to reading God's alphabet. It is conceivable that multi-function dials were perceived as a tool for unlocking these meanings before they went into decline during the mid-late seventeenth century.

By the eighteenth century, clock and watch-makers were keen to make dials as simple as possible. Alexander Cumming, in an unpublished manuscript entitled *Remarks on a Clock*, criticised an astronomical clock[92] for an overly-complex dial, saying that it would have been: "…equally complete…", by which can be interpreted to mean efficiently legible and comprehensible, "…without the circular tables…", by which he meant subsidiary dials, representing the lunar and astronomical information. He offered an alternative, comprising of fewer subsidiary dials, that: "…would have been very well."[93] Cumming's views on dial formats were clear. They should not be cluttered, but nor should information be removed.

Texts and dials also conveyed ordered knowledge throughout the period using different sized letters and numerals. While Carter *et al* cite the importance of the

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[89] Petrus Ramus' *Compendium of the Art of Logic and Rhetoric* (London, 1651).
[90] Maclean, I. 2006. Diagrams in Defence of Galen: Medical Uses of Tables, Squares, Dichotomies, Wheels and Latitudes 1480-1574. In Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press.p.137-140.
[91] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.38.
[92] The identity and location of the particular clock are unknown. Cumming, A. 1766-1812. *A Folio Volume Containing Memoranda, Descriptions, Observations, and Correspondence Relating to Various Matters, Mostly Mechanical* MS3964.
[93] Ibid.

proportions of individual letters in today's typography,[94] this sentiment can also be applied to the period under discussion here. This means that using different typefaces for different indices on a dial, for example, would provide immediate contrast. In text, different sizes often differentiate subheadings from the main body of text. In dials, different sized numerals differentiate the various indices. This also creates a visual hierarchy in the sense that the eye is drawn to the largest letters or numerals first. Both printers of text and clock and watch-makers chose which information to place at the top of the hierarchy and which was to be secondary and tertiary. In text, subheadings provide the central message of the text in one sentence or phrase. In dials, tables and diagrams, the largest numerals, occupying the top of the hierarchy, were often the hour numerals.

Over the period, the proportional size of the hour numeral in relation to the overall dial diameter, and the other numerals, also changed. This had an effect on the visual hierarchy which makers communicated to users through their dials. The proportional difference in numeral size became less pronounced over the period. It was at its most varied in the first half of the seventeenth century and then became less varied form the late-seventeenth century onwards. This is indicative of the gradual decline of the dial as a communicator of knowledge ordered as a hierarchy and thus the decline of its role as a mnemonic device or representation of complete knowledge. It is also indicative of the first steps towards dial uniformity.

Proportional size was more significant the greater the number of indices on the dial. On dials throughout the period, which conveyed only the hour and its subdivisions, the hour numeral was largest and thus positioned at the top of the hierarchy. This indicates the numeral, or piece of information, that the maker intended to be read first, for example the fourth hour. In the period up until 1657[95] for clocks and 1675[96] for watches, it was then followed by the quarter of the hour such as one quarter past the fourth hour. This was represented as smaller in proportion to demonstrate that it was read next and was given meaning by the larger hour numeral which was to be read before it.

Proportion was equally significant in printed books in this period. Beltramini and Gasparotto helpfully inform us that book margins were harmoniously arranged and the proportions echoed the famous 'golden ratio' or 'divine proportion',[97] which according to

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[94] Carter, R., Meggs, P. and Day, B. 2007. *Typographic Design: Form and Communication.* Hoboken, New Jersey: John Wiley p.32.

[95] The pendulum was first applied to clocks in 1657 and enabled the representation of minutes rather than quarters.

[96] The balance spring was first applied to watches in 1675 and enabled the representation of minutes.

[97] Beltramini, G. and Gasparotto, D. 2016. *Aldo Manuzio: Renaissance in Venice.* Venice: Marsilio.p.28.

Cole was a further example of revival in the period.[98] This view can be expanded. Proponents believed that art and architecture should reflect the harmony with which God-created nature clearly exemplified. Crucially, harmony consisted of the sympathy between parts. Adding or subtracting any of the parts led to imbalance and the loss of harmony. Mathematics, namely Euclidean geometry, was a tool by which artists and architects could ensure the balance of parts. This was no less true for clock and watch dials. The positioning of subsidiary dials and the number of concentric rings discussed above was clearly important, but as significant was the proportional size of the characters on each index of the multi-function dial. They were harmoniously proportioned to reflect information hierarchies.

In the mid-late sixteenth century, both Roman and Arabic numerals served a magical purpose. For Roman numerals this was a prognostic purpose. In pamphlets on the creation of horoscopes, instructions were given to make note of the Roman numerals contained within the maiden name of the child for whom the horoscope was being created.[99] Advice was then given as to what these numerals signified about the future of the child. A clock or watch dial would be a useful aid in this context for making a note of the Roman hour in which the child was born, but also for contemplating the significance of the other Roman numerals. For Arabic numerals the magical purpose was attainment of higher knowledge. Magic squares such as that seen in Durer's *Melancolia*[100] (see figure 2.12) represented the perceived relationship between Arabic numerals, the notation of choice for mathematical texts, when arranged in an order where each row equals the same sum as the other rows. This was perceived as a representation of God-created mathematical perfection and harmony. Dials were slightly different as they represented numerical sequences, but the cyclic sequence of the hours or months of the year similarly represented God-created perfection.

[98] Cole, A. 1994. *The Renaissance: the Essential Guide to the Art of the Northern and Italian Renaissance from the 14th to the 16th Century.* London: Dorling Kindersley Limited.p.30.
[99] Roussat, R. 1562. *The Most Excellent, Profitable, and Pleasant Booke of the Famous Doctour and Expert Astrologien Now Newly Tourned out of French into our Vulgar Tonge by Williamd Warde.*
[100] The magic square is situated in the top-right hand corner of the painting.

Figure 2.12[101] ©The Metropolitan Museum of Art

Roman and Arabic numerals harmoniously co-existed in almanacs before the early-seventeenth century, at which point authors and printers ceased to use the former altogether. Prior to this, Roman numerals were sometimes used to represent the dates of the month as I-XXXI. Almanacs and other printed works, including the Bible, represented the numeral IV as IIII as did dials. So completely had Arabic numerals taken hold of mathematics in the seventeenth century, that when the minute index was enabled by the invention of the pendulum in 1657, Arabic numerals were immediately used for that index and there were no examples that used Roman numerals.

Where they co-existed on dials, Arabic numerals were smaller than Roman numerals throughout the period. However, there was a difference in representation between Arabic numerals used in the pre-pendulum, pre-minute representation, context and the post-pendulum context. Those Arabic numerals used in the pre-pendulum context were generally of larger proportion to the Roman numeral than those in the post-pendulum context. Despite being made by different generations of clock and watch-makers this difference was a statement of hierarchy. The Arabic hour numerals 13-24 of the pre-pendulum era were the same temporal units. Both represented the hour of the day, but the Arabic numeral provided an extra layer of information if the hour was in the afternoon as it told the user that the III was known as 15 in the context of the afternoon. The Arabic minute numeral of the post-pendulum context represented a subdivision of the hour. The 15 numeral in this context was not another interpretation of the hour numeral, but instead represented 15 minutes past the hour indicated by the Roman hour numeral. Makers of this period

[101] The Metropolitan Museum of Art: 43.106.1. Albrecht Durer *Melancholia I*, 1514. Reproduced by kind permission of the Metropolitan Museum of Art.

deliberately chose to represent this numeral in smaller proportion than makers of the previous era. This was a communication device intended to distinguish the new dials from what had come before; a new temporal unit was being indicated and was made possible through new technology housed in the movement.[102] Despite being new information and new technology, this is indicative of a convention of information representation which continued over the generations.

Arabic numerals were also significant in terms of the development of universal languages in the mid-late seventeenth century. Drawing from the mnemonic tradition of finding pictures and symbols to represent facts and ideas, authors such as Cave Beck, who equated the numeral five with God,[103] and Cheney Culpeper,[104] amongst others, suggested schemes which associated Arabic numerals with concepts. This was their answer to Francis Bacon's earlier call for real characters.[105] While Lewis tells us that their aim was to create a written system, rather than a spoken language, which would order knowledge and was comprehensible to people from different countries,[106] he too confines his discussion to print. Dials may not have provided enough Arabic numerals to be used as a tool for universal languages, but their representation of Arabic numerals was accessible to most users, regardless of language. During the late-seventeenth century multi-function dials, similarly to almanacs, became plainer in appearance and lost many of their symbols in favour of numeral sequences. Such dials were conceivably part of the trend for making Arabic numerals a basic framework for communicating knowledge.

Due to their focus on the development of precision timekeeping, historians of horology such as Loomes and Baillie, comment on the gradual elongation of hour numerals,[107] but do not say anything else. However, these details are significant for placing the dial within the context of its printed-paper counterparts even at the level of the individual numeral. The continued presence of Roman numerals on dials became a convention in the early-seventeenth century, distinguished from the previous period in which it mirrored text, and simultaneously became one of the last vestiges of an era in which numerical information was widely represented using Roman numerals.

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[102] See appendix two for the meaning of this horological term.
[103] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.160-161.
[104] Lewis, R. 2007. *Language, Mind and Nature: Artificial Languages in England from Bacon to Locke.* Cambridge: Cambridge University Press.p.46-47.
[105] Ibid.p.13-14.
[106] Ibid.p.62.
[107] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club; Baillie, G.H. 1929. *Watches: their History, Decoration and Mechanism.* London: N.A.G. Press.p.38.

The conventions established in this period such as use of the circular method and layering information with the use of a subsidiary dial, though less complex than the early examples, became part of the standard format by 1770.

2.3 Transmission of knowledge to the mind

Having considered the components of information arrangement, it remains to return to the whole. The idea that dials were intended to represent concepts of time and our place in God's hierarchy through connected information, can be progressed. This is with reference to the ways in which people in the early modern period believed that knowledge was transferred to the mind. Primary sources on perceptions of the role of sight, relative to the other senses, help improve our understanding of communication methods used on dials.

It may be obvious to Hall[108] that seeing, or 'seeing as' according to Coliva's distinction between looking and comprehension,[109] is dependent upon that which the user wishes to see and whether or not they are in tune with the prevailing conventions. Yet, this is insufficient for increasing knowledge of early modern communication methods beyond merely identifying conventions. However, if we can understand how people in the period believed that knowledge was processed, then we can interpret different components of dial and diagram formats as methods considered the most efficient for assisting that transfer process, given that makers intended knowledge to be acquired from them.

The complex nature of the early modern perception of seeing and understanding is subtly demonstrated by Richard Surphlet who in 1599 said: "…nothing can enter into the understanding part of our minde, except it passe through one of the five senses…."[110] No great power is ascribed to the eyes here, but the distinction is made between different parts of the mind by identifying the understanding part. If subscribing to this view, clock and watch-makers would have intended their formats to transfer temporal information to the understanding part, as opposed to a quick-reference part, which demonstrates further contemplation of information represented on dials. Hall's semi-dismissive remark that 'seeing involves many parts of the brain' is inadequate for further consideration of the reasons why early modern makers made the decisions they did regarding dial and diagram

[108] Hall, B.S. 1996. The Didactic and the Elegant. In: Baigrie, B.S. ed. *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science.* London: University of Toronto Press.p.10.
[109] Coliva, A. 2012. Human Diagrammatic Reasoning and Seeing-as. *Synthese.* 186.pp.121-148.
[110] Surphlet, R. 1599. *A Discourse of the Preservation of the Sight: of Melancholic Diseases; of Rheumes, and Old Age*. London.

formats.[111] Surphlet's use of the terms 'enter into' and 'pass through' confirm the process by which knowledge was perceived to be acquired.

Hall refers to the modern research on the brain by Zeki,[112] but misses some key points from Zeki's work, which offer further support for the argument that with diagrams and dial formats there was more to interpretation than convention and expectation. Zeki's work is crucial for providing a modern context of how the eyes work, which reveals why certain dial formats would have been more successful in terms of legibility and comprehension than others. The significance being that formats which fulfilled these requirements reveal the pragmatic solution found by early modern makers, even though they did not know the science behind why they worked. The measure of how effective methods of communication were was based on how well they provided for what Zeki identified as the four related, but different capacities that controlled vision and interpretation in the brain: motion, colour and two different types of form.[113] Motion and colour were the most distinct,[114] which perhaps accounts for why colour contrast, other than between background and notation inscription, was not developed on clock and watch dials where motion was a prerequisite. Bruno, certainly one individual who had pragmatically found the recipe for rapid recall of information through images, also identified light, colour, figures, and form as four crucial ingredients for efficient memory images.[115]

For Clark,[116] Dolza,[117] and Akbari,[118] primary sources on the senses and the eyesight reveal that, for the majority in the early modern period, sight was considered to be at the apex of the hierarchy of senses. Indeed the sources considered here support this claim, but they have the potential to provide more information. If according to Akbari, sight was a metaphor for knowledge,[119] the viewing of a multi-function dial that represented the universe, was a vision of the universe or understanding of it there-acquired.

When Richard Brathwayt said: "though the eye of my bodie allude to the eye of my soule, yet is the eye of my soule darkned by the eye of my bodie…"[120], he suggested that

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[111] Hall, B.S. 1996. The Didactic and the Elegant. In: Baigrie, B.S. ed. *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science.* London: University of Toronto Press.p.10.
[112] Zeki, S. 1992. The Visual Image in Mind and Brain. *Scientific American.* (September).
[113] Ibid.p.70-71.
[114] Ibid.p.70-71.
[115] Bruno, G. 1584. *De la Causa, Principio, et Uno.* Venice.
[116] Clark, S. 2007. *Vanities of the Eye: Vision in Early Modern European Culture.* Oxford: Oxford University Press.p.9.
[117] Dolza, L.M. 2003. Reframing the Language of Inventions: The First Theatre of Machines. In Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.p.89.
[118] Akbari, S.C. 2004. *Seeing Through the Veil: Optical Theory and Medieval Allegory.* Toronto: University of Toronto Press.p.3.
[119] Ibid.
[120] Brathwayt, R. 1620. *Essaies Upon the Five Senses.* London.

what is seen feeds directly to the mind and has the capacity to alter it, a power he did not ascribe to the other senses. Though there is a sinister meaning here, we can infer from it that temporal knowledge once seen enters the mind and can alter it accordingly. If clock and watch-makers subscribed to this perception, the formats chosen by them were intended to alter the mind's idea of the relationship between different temporal units, or our place in God's hierarchy, on multi-function dials; to unveil higher truths.

According to the early modern perception of knowledge transmission, the end result was the location of the image in the long-term memory. For Bruno the mind and memory were in three parts. To prevent messages getting lost on route he recommended the reader should perform exercises which would stimulate the senses.[121] In other words, the transmission of knowledge to the mind and long-term memory was an active, not passive, process where users had to be dedicated. In another of his works Bruno expanded the user's role when he said that the purpose of the imagination was to receive images derived from the senses and to preserve, combine and divide them.[122] In other words, once information was received in the mind, the user had to work to order it so that it would enter the long-term memory. The process by which it travelled there was thought to be complex. It is conceivable that dials were designed with this process and active role for the user in mind. In part two of the thesis I return to this idea and demonstrate that calendar, lunar and astronomical functions on dials were useful as a mnemonic device to prompt the user's long-term memory.[123] By Clark's definition,[124] image making was crucial to thought and this constructed mental image, whose final destination in the memory was the final product of the entire process of sense perception. In the case of clock and watch formats, the mental image is either a representation of a whole, or a specific reading of a temporal unit in image form, as indicated on the dial. This reading would depend on the different functions of the timepiece, but could be the hour of the day, the lunar phase, or the day of the week.

When Richard Bannister in 1622 said: "…seeing beames come from the eye…",[125] it is evidence in agreement with Clark's emphasis on Roger Bacon and Aquinas who expressed the distinction between matter and form as a theory of species.[126] For vision, this entailed

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[121] Gosnell, S. 2013. *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582.* Huginn Muninn & Co.p.14-15.
[122] Bruno, G., Lucca, R. and Blackwell, R.J. 1998. *Cause, Principle and Unity.* Cambridge: Cambridge University Press.p.138.
[123] See chapters five to seven.
[124] Clark, S. 2007. *Vanities of the Eye: Vision in Early Modern European Culture.* Oxford: Oxford University Press.p.10.
[125] Bannister, R. 1622. *A Treatise of 113 Diseases of the Eye*. London.
[126] Clark, S. 2007. *Vanities of the Eye: Vision in Early Modern European Culture.* Oxford: Oxford University Press.p.15.

objects producing species which radiated out from these objects into the surrounding air, transmitting likenesses of them physically to the eye. In the case of dial formats this would mean either the complete image of the dial was transmitted as a likeness to the eye, or again a particular reading in image form. The notion of radiation into the surrounding air of species from the dial brings into question whether this was envisaged in the period to mean the arrangement of the complete range of information, for example the lunar calendar ring of numerals 1-29½, or the single indication there read.

Expanding both Clark[127] and Franklin's[128] provision of various examples of multi-staged processes of image transmission in the mind, the crucial point when thinking about clock and watch formats is the essence of that belief in a multi-stage process. The first Clark refers to is the imagination, the memory and reason.[129] Although expressed in a different order, this agreed with Francis Bacon's emphasis on sense, memory, imagination and reason. For others such as Mirandola, there was a hierarchy of sense, imagination and intellect. Nevertheless, the most significant point for clocks and watches is the concept of a location in the mind between the capturing of information from the dial and the retention of that reading in the long-term memory. If clock and watch-makers subscribed to this belief, they would have formatted dials in a way that aided this process. Perhaps concentric rings and subsidiary dials, as a device for layering information, was also the form in which it was thought that knowledge was arranged in the imagination before being retained in the long-term memory.

2.3.1 Indication

The way in which dials and diagrams indicated information to users differed throughout the period. Printed diagrams provide a snapshot of unchanging information, whereas dials provide a range of information where specific values are constantly changing. This was conceivably perceived as a method of effective transmission of that knowledge to the mind. The user did not need to find the information as the indication was made for them.

The most common method of indicating information on clock and watch dials throughout the period was the hand, known in the period as the 'index' or 'pointer'.[130] Use of a hand, or pointer, was a convention established in the first mechanical clocks fitted with

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[127] Ibid.p.14-15.

[128] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In: Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.p.86-97.

[129] Clark, S. 2007. *Vanities of the Eye: Vision in Early Modern European Culture.* Oxford: Oxford University Press.p.14-15.

[130] The term hand was applied to clock dials in the nineteenth century.

dials in the thirteenth century and has survived until the present day on analogue dials. It forms part of the circular method of communication where a defined range of information is usually arranged on the dial's ring, or rings, and mechanical gearing ensures that the hand continuously moves around the ring in one direction. This enables specific values within the information range to be read by the user on demand.

To a large extent this indication method was determined by the mechanical gearing within the movement. However, it was circular motion that was predetermined and not the exact direction of that motion. Most dials in the period indicated information in a clockwise motion. However, there were examples of anti-clockwise indication, which existed on particular rings within a dial with concentric rings or on timepieces which had a front and rear dial. In both cases, particularly the former, the choice of which type of information was to be indicated in an anti-clockwise direction was significant. It was rarely the hours[131] and was usually calendrical information. Apianus' *Cosmographia*[132] provides a printed example of a circular calendrical diagram, with no moving parts, where the index progresses in an anti-clockwise direction, which lends further weight to the argument that seemingly subtle differences in format were deliberate choices. This was either for convention's sake or for legibility. One exception to the hand-indication method was the use of apertures where information to be read was revealed below, but these were nearly always used as a method of layering information as discussed above.

For Kusukawa[133] the hands were perceived as mediators between the heavens and the Earth in the early modern period, but this point needs expansion. In this period pointers, often in the shape of index fingers, were regularly used in paper volvelles with moving parts to indicate information within a defined range and in text to highlight a particular passage.[134] In works of art, figures depicted with an extended index finger, usually the right, to point to something are usually indicating the divine or truth. Index fingers in art are also sometimes used to represent seeing, telling.[135] In Sanders' *Chiromancie* of 1653, he associated the index finger with the planet Jupiter and said it is the indicative or demonstrative finger.[136] In art-historical terms the indicative or demonstrative nature was clearly a representation of higher truths. In texts, images of a finger in the margin were used

[131] The only exception being some extremely rare Jewish timepieces. For more information see Robey, J.A. 2012. A Large European Iron Chamber Clock. *Antiquarian Horology.* 33(3).pp.335-346.
[132] Apianus, P.1550. *Cosmographia*. London.
[133] Kusukawa, S. 2001. A Manual Computer for Reckoning Time. In: Sherman, C.R. and Lukehart, P.M. eds. *Writing on Hands: Memory and Knowledge in Early Modern Europe.* Seattle: University of Washington Press.p.28.
[134] John Dee used images of the index finger to point to particular passages in his preface to Billingley's edition of Euclid's *Elements*. Billingsley, H. and Dee, J. 1570. *The Elements of Geometrie of Euclide.* London: John Daye.
[135] Battistini, M. 2005. *Symbols and Allegories in Art.* Los Angeles: Getty Press.p.118.
[136] Sanders. 1653. *Physiognomie and Chiromancie*. London.

to highlight parts the author wished to draw attention to. In this context, rather than only indicating the hour, hands on dials would have been important in those multi-function clocks and watches that were considered to be representations of our place in God's hierarchy. The hand, or hands, on a multi-function dial indicate a combination of information. While texts and art works stopped representing the index finger as a symbolic pointer during the seventeenth century, dials continued to indicate information using hands. However, as mentioned above, combinations of information on dials declined during the mid-late seventeenth century. This meant the indices, and thus combinations, to which they formerly indicated were no longer present, which removed some of their significance.

2.3.2 Symbol literacy

Almanacs, volvelles, frontispieces, and mnemonic works utilised symbols and pictures to convey meaning, both individually and in combination. They were part of a wider European language of symbolism. Clock and watch-makers drew on this tradition for their representation of symbols. They were not unique to clocks and watches and would have been recognised by the book-reading public across Europe in the early modern period. Dials thus represent a form of symbol and pictorial literacy which they shared with text. Symbols and images played an important representational role in perceptions of knowledge transmission up until the early-mid seventeenth century.

Rossi claims that in the mnemonic tradition certain images came to have widely-understood meanings such as the scales for justice and the astrolabe for astrology.[137] Yet, if the astrolabe had this association then the multi-function dial must have had also. Indeed, it is significant that Bruno,[138] Romberch[139] and Fludd[140] all used an image of a clock in their mnemonic works (see figure 2.13). Yates said that practitioners of the art of memory searched for signs and symbols to use in the art, but this needs expanding to say which bodies of knowledge authors drew upon.[141] One was clearly religion, another was astrology, and another was the world of material culture, which clearly included clocks.

[137] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.27.
[138] Gosnell, S. 2013. *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582.* Huginn Muninn & Co.p.147.
[139] Romberch, J. 1533. *Congestorium Artificiose Memorie.* Venice.
[140] Fludd, R. 1617. *Utriusque Cosmi.* Oppenhemii.
[141] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.

Figure 2.13[142]

Figure 2.14[143] **©British Museum**

The lunar phase,[144] represented pictorially on dials and almanacs as seen in figures 2.15 and 2.16, was the most common form of non-numerical character on dials up until the mid-eighteenth century when makers decided not to include it as part of the standard format.[145] An imitation of what the eye saw in nature in terms of the changing phase, this was the most realistic of the representations on the dial. For Foucault sixteenth-century representation of resemblance was perceived as an important way of relating things within the macrocosm, but in the early-seventeenth century similitude was no longer the method

[142] Romberch, J. 1533. *Congestorium Artificiose Memorie.* Venice. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[143] British Museum WB.222. Reproduced by kind permission of the Trustees of the British Museum.
[144] The representation of the man-in-the-moon on dials is discussed in detail in chapter six on lunar wisdom.
[145] I have discussed the use of lunar knowledge on dials in depth in chapter six. The emphasis in this section is on physical similarities between the way in which the Moon was represented on dials and the way in which it was represented in print and other sources.

by which knowledge was thought to be acquired.[146] However, the life-like representation of the Moon, which may have begun life as an attempt to convey similitude, as Foucault described, survived beyond the decline of that perception. The reasons for which will be discussed in detail in chapter six, but the important point here is the legacy of the belief in similitudes.

Figure 2.15[147] ©British Museum

Figure 2.16[148]

In combination, these characters were at their most meaningful. Taking the dial in figure 2.14 by way of example, the twelve zodiac months are represented using pictures, the lunar phase is represented pictorially, and the lunar aspects of trine, square and sextile are represented using the triangle, square and star shapes respectively. These picture groupings provided a pictorial overview of a specific point in time, which in this case is a lunar one with astronomical, and thus astrological, association. These groupings were conceivably intended to efficiently transfer this temporal and astrological knowledge to the mind.

Individually and in combination, these examples of symbol use indicate a high level of symbol literacy in the period in which they appeared from the mid-sixteenth to the mid-seventeenth centuries. Historians of horology have not interpreted these characters; they listed them in their catalogues but nothing more. In fact their presence on dials demonstrates the influence of the wider culture of communication on clock and watch-makers.

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[146] Foucault, M. 2001. *The Order of Things: an Archaeology of the Human Sciences.* London: Routledge.p. 56;60-61.

[147] British Museum 1888,1201.105.

[148] Stephins, T. 1569. *A Newe Almanacke and Prognostication for the Yeare of our Lorde God, M.D.LXIX.* London: Thomas Marshe. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

2.4 Conclusion

In the epigraph to the chapter I showed that users of clocks and watches at different ends of the period 1550-1770 were in agreement that dials were a 'telling' device. I argued that the context in which they were writing differed, however, in terms of their perceptions of knowledge communication and thus the capacity of clocks and watches. In the world of Greene's fictional character, the dial communicated magical, astrological and mnemonic knowledge. Whereas in the world of Duncan it was unimaginable that a dial could interpret information for a user, they did that part themselves. Throughout this chapter I have shown that different dial formats were methods of communication, selected by clock and watch-makers, by which information was presented, layered and indicated. Until now, the different parts of the clock and watch dial have not been identified in this level of detail. Given that supporting archival sources are rare, my unique method of comparing each component of dial format with printed paper sources has improved our knowledge of the dial as a communication device. Doing so provides parts of the answers to the main thesis research questions that could not have been attained in any other way.

I substantially improve our understanding of the relationships between dials and printed paper sources in the period. I argued throughout the chapter that there was a fluid boundary between them. In section 2.2 the circular method of arranging information was shown to be similar to schematic representations of the universe and mnemonic diagrams. These examples demonstrate the reciprocal nature of the relationship between dials and texts in the period. Each medium influenced the other and were consumed by the same people. The early-seventeenth century use of subsidiary dials, part of which became a component of the design of the standard format by 1770, were closely linked to the tree diagrams which were popular in mnemonic works of the period. There were points at which certain features, which began as a mirror of printed paper sources such as the numeral IIII, became a convention unique to dials by the mid-seventeenth century and although they survived, no longer mirrored those printed paper sources. In section 2.3 I demonstrated that the representation of symbols and pictures on dials placed timepieces within a wider context of symbol and pictorial literacy and illustrated a close relationship between dials and mnemonic works through their representational role. Symbols such as the lunar phase reflected representation in text in the period. It was a symbol that was recognisable to users throughout the period. However, while this chapter has shown that there was a fluid boundary between dials and printed paper sources in terms of the way in which information

was arranged, it cannot offer the complete answer on its own. There is more to come in the remaining five chapters.

I offer a substantial part of the answer as to the extent of the relationship between dials and perceptions of knowledge transfer in the period. For the first time, the clock and watch has been positioned into debates about perceptions of knowledge transmission in the period. Thereby contributing to not only horological history, but also expanding an area of epistemological history such as the work of Kusukawa and Johns. The standard format's concentric rings and single subsidiary dial were echoes of a much different perception of knowledge transfer in the early period. In both sections 2.2 and 2.3 the way in which information was arranged on dials throughout the period was shown to be indicative of perceptions of effective knowledge transmission. In section 2.2 I argued that concentric rings, subsidiary dials, and proportional sizes of different numerals demonstrated that dials were designed in order to provide pathways for the eye to follow in much the same way as mnemonic and classification diagrams of the period. This changed over the period as dials became more uniform. I argued that contrast between the background and the inscribed characters provided the backboard on to which the pathway for the eye was carved. The background colour of dials only changed with improvements that were made to domestic lighting technology. Effective reading of the dial, similarly to text, required a suitable level of colour contrast between the background and inscriptions. I argued that through trial and error, makers had found the ideal level of contrast. Again, the dial played an active role in validating existing communication methods. The dial was not merely an imitator, but an influencer. In section 2.3 I argue that makers designed dials according to the sixteenth and seventeenth-century perceptions of the three-stage process by which images were transferred to the mind and then housed in the long-term memory. Again, while a focus on communication methods in this chapter has shown one way in which knowledge was transmitted on dials, it cannot answer the question fully. There is more to come in chapters three on trust, four on enablement, and six on lunar wisdom.

I offer part of the answer as to the extent of the relationship between dials and astrological and mnemonic practice in the period up until the mid-late seventeenth century. I argue that similarities in format between dials and almanacs demonstrate that dials were a mechanised version of the almanac and mnemonic diagram. In section 2.2 I argued that combinations of shapes, concentric rings and subsidiary dials were useful for the art of memory. Layering techniques used on the dial provided users with a ready-made, automatically-indicating set of information which they could assign to different concepts. In

section 2.3 I argued that symbols and pictures were useful for the art of memory. Clock and watch-makers drew inspiration from these traditions. Changes in representation of symbols on dials, such as the zodiac symbols and representation of the lunar phase, indicated changes in use of symbols in the period which was comparable to the decline of books of symbols and use of the mnemonic method. The way in which information was arranged on dials demonstrates astrological and mnemonic use, but does not offer a full answer to this question as dials reveal more as will be shown in chapters five, six and seven.

I also offer part of the related answer as to the extent of the influence of the decline of astrology and mnemonics on dials. In both sections of the chapter I showed that there was a concurrent decline evident in both almanacs and dials during the mid-late seventeenth century. It was evident through the representation of layered information. In the case of dials this was a decline of concentric rings, subsidiary dials, apertures and symbols.

I have argued in this chapter that the standard format which emerged by 1770 was not a random arrangement but the result of a variety of methods of representation used by makers in the years prior, parts of which were retained and parts of which were discarded. There is a great deal of weight in this chapter on the sixteenth- and seventeenth-century context because the formats which became conventions in the late-seventeenth and eighteenth centuries were drawn from these earlier traditions. Earlier formats had a very different purpose, which was not shared by the later examples, although they bore the signs of them. The standard format retained some representations from that previous era such as the circular method of information arrangement, one subsidiary dial, and representation of the numeral IV as IIII. While this chapter has shown that the way in which information was communicated on dials, and the way this changed over the period, provides parts of the answers to the main research questions, there is more to be revealed through a focus on changing dial formats. I now turn to chapter three, which focusses on the way in which dial formats are revealing of the trust relationship between makers and users.

Chapter 3

Trust and Distrust

Tis with our Judgements as our Watches, none Go just alike, yet each believes his own.[1]
Alexander Pope, *An Essay on Criticism*, 1711

Figure 3.1[2] ©Science Museum

3.1 Introduction

This sentence, written by Alexander Pope in 1711, immediately demonstrates that trust was an immensely important issue for clock and watch users. Watches were not the subject of this epic poem, but that Pope refers to them demonstrates the degree to which they had pervaded life and that they were an obvious reference to the material world when making an analogy about an individual's opinions. When Pope said that each man believed his own watch, this really meant that each man trusted his own clock or watch-maker more than others. Indeed, the unknown man portrayed with his pocket watch in the portrait in figure 3.1, painted 150 years before Pope wrote this line, is deliberately identifying it as his own watch as opposed to anyone else's. Such images have traditionally been interpreted[3] as examples of sitters showing off their wealth, which this man is undoubtedly doing, but I argue that he's also identifying this particular watch as a representation of his personal

[1] Pope, A. 1713. *An Essay on Criticism.* 4th ed. London: W. Lewis.
[2] Science Museum 1976-13, Unknown artist, *Man Holding a Watch*, c.1558. Reproduced by kind permission of the Trustees of the Science Museum Group.
[3] Johnson notes that scientific instruments and other expensive objects were depicted in portraits of wealthy monarchs, aristocrats and merchants during the sixteenth century. The increased wealth of the latter led to them wanting portraits of themselves to show their status. Johnson, G.A. 2005. *Renaissance Art: a Very Short Introduction.* Oxford: Oxford University Press.p.91-92.

qualities. Mayr's claim that sixteenth and early-seventeenth century multi-function clocks were, in a sense, representations of the universe in miniature[4] is useful for thinking about perceptions of timepieces. However, he bases his argument on references to clocks and watches in literature, whereas paintings provide a visual expression of these perceptions in addition to the identification of a type of user. By holding this watch, the sitter is also representing himself as the holder of knowledge. He could have chosen any number of other objects, but his choice of this watch indicates his high opinion of it and thus of its maker. For Topham the texts people read contributed to shaping their identities[5] and this was similar for the users of clocks and watches. Both of these sources demonstrate that trust in one's timepiece continued to be important throughout the period 1550-1770. Building on my findings in chapter one, that dial formats both reflected and stimulated changes in the wider context of textual and pictorial communication, in this chapter I approach dial format from another angle. Here I argue that trust played an important role in the modification of dial layouts in this period. Clock and watch-makers needed to build and maintain trust in their timepieces, which were judged through the dial in terms of both the way they looked, they had to answer to users' needs and be legible, and their communication of the work of the mechanism, the dial was the means by which a user determined the relative[6] accuracy or inaccuracy of the timepiece.

The role of trust within the history of science and technology has been explored by Gooday[7], Porter[8] and Shapin,[9] but it has not been addressed within the history of horology, which has left a gap in the historical account that I address through a focus on dials. Trust has played a large role in horological developments and I will demonstrate in this chapter that clock and watch dials bear signs of the relationship makers established with users. Shapin claims that there is no limit to the considerations that might be relevant to securing

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[4] Mayr, O. 1986. *Authority, Liberty & Automatic Machinery in Early Modern Europe.* Baltimore: Johns Hopkins University Press.p.10.

[5] Topham, J. 2010. Science, Religion, and the History of the Book. In Dixon, Thomas, Cantor, Geoffrey, and Punfrey, Stephan. eds. 2010. *Science and Religion: New Historical Perspectives*. Cambridge: Cambridge University Press.p.231.

[6] Acceptable accuracy in the period, within fifteen minutes per day, was sufficient for the pre-pendulum context, but not after.

[7] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.

[8] Porter, T. 1995. *Trust in Numbers: the Pursuit of Objectivity in Science and Public Life.* Princeton, New Jersey: Princeton University Press.

[9] Shapin, S. 1994. *A Social History of Truth: Civility and Science in Seventeenth-century England.* Chicago ; London: University of Chicago Press, Shapin, S. 2010. *Never Pure: Historical Studies of Science as if it was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority.* Baltimore, Maryland: Johns Hopkins University Press.

credibility.[10] I extend this by reversing the phrase and say there is also no limit to the considerations that might be relevant to losing credibility. Part of my focus in this chapter is on efforts made by clock and watch-makers to maintain trust. Both Gooday and Porter question the criteria by which trust judgements were made and the factors which influenced these criteria. Until now neither historians of horology nor of time experience have asked these questions of timepieces. I intend to broaden the interrogation initiated by Gooday's approach where he focusses on trust between people and objects rather than Porter's approach where his focus is purely on trust between people. In the case of clocks and watches, similarly to the electrical meters which Gooday discusses,[11] there were three parties influencing the trust relationship. One was the clock or watch-maker, another was the user and the third was the timepiece itself which, as a working instrument, operated beyond the control of the maker once it left the workshop. The questions Porter raises about trust are important, but his approach would not be adequate in this instance.

Building on my premise in chapter two that dials are a form of diagram, in this chapter I argue that clock and watch-makers, acting in the role of 'authors' of dial format, arranged information in different ways in order to convince users that they and their timepieces were trustworthy. I reveal different instances when makers actively responded to issues that had the potential to generate distrust in their work. Historians of the book and of reading such as Finkelstein and McCleery[12] have explored the issue of author authority in texts. They inform us that the author's status improved from the sixteenth century onwards.[13] One reason for this, they say, was the new trend of attaching names to printed works.[14] Due to the reproducibility enabled by the printing press and the increasing distribution networks for texts, authors could become quickly known throughout Europe. I argue that there is a clear correlation between clocks, watches and other instruments and texts in terms of this trend for increased 'author authority' given that the former were increasingly engraved with their makers' signatures in the same period. However, until now no historian has extended this approach to consider instrument makers in the role of creators and sharers of knowledge, which I rectify.

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[10] Shapin, S. 2010. *Never Pure: Historical Studies of Science as if it was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority.* Baltimore, Maryland: Johns Hopkins University Press.p.21.
[11] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.
[12] Finkelstein, D. and McCleery, A. 2005. *An Introduction to Book History.* New York, NY: Routledge.p.70-71.
[13] Ibid.p.70-71.
[14] Ibid.p.71.

Trust is a unique angle by which part of the answer to the main research questions of the thesis can be reached. I have taken a case-study approach to the structure of this chapter and divide my discussion in to four sections in which I reinterpret four important moments in the history of horology through a focus on the trust relationship between users and makers. In section 3.2 I will discuss the use of alternative hour schemes in different countries in Europe from the mid-sixteenth to the early-seventeenth century. In section 3.3 I will move on to discuss the co-existence of both quarters and minutes in the mid-late seventeenth century. In section 3.4 I will consider the changing relationship between the sundial and the clock dial in the late-seventeenth and early-eighteenth centuries. Lastly, I will explore the imitation of precision timepieces in the mid-late eighteenth century in section 3.5. Through these four sections I will provide part of the answers to some of the main thesis research questions. This chapter will provide a substantial part of the answer as to the extent that users' emotions influenced dial development in the period. In section 3.2 I will argue that dials with multiple hour schemes enabled users to cross-reference between schemes while they were travelling. They enabled the user to refer to their hour scheme of preference. In section 3.3 I will argue that dials which represented both quarters and minutes were a form of transition dial whereby makers provided reluctant users with a method by which to begin to accept the new minute indication. In section 3.4 I will argue that whereas clocks and watches were initially dependent on the sundial, the equation-of-time represented the beginning of a shift in this relationship. By the mid-late eighteenth century clocks and watches were no longer dependent on the sundial. In section 3.5 I will argue that users began to see the dial of precision timepieces such as the observatory clock as a sign of precision timekeeping and makers began to replicate this design for non-professional timepieces.

This chapter will improve our understanding of the relationships between dials and printed paper sources. In section 3.3 I will argue that the introduction of the new minute indices on clocks in 1657 and watches in 1675 stimulated the publication of printed paper sources to accompany them. In section 3.4 I will argue that increased precision of the mechanism stimulated the production of equation-of-time tables and instruction pamphlets to accompany them.

This chapter will improve our understanding of the extent of the relationship between dials and perceptions of effective knowledge transmission. In section 3.2 I will argue the provision of different hour schemes over concentric rings was perceived to be the most effective tool for enabling users to cross-reference. In section 3.3 I will argue that the

new minute indices were enthusiastically welcomed by natural philosophers who used minutes as a form of verification for their experiments. Together these four sections provide another angle which improves our understanding of why the standard format which emerged by 1770 had the appearance that it did.

3.2 Alternative hour schemes

Historians of horology such as Bruton[15] have noted that from the mid-sixteenth to the early-seventeenth century different countries in Europe favoured different hour schemes.[16] German dials represented the twenty-four hours as 1-24; Italian dials often represented six hours as I-VI, French and English dials either represented the twenty-four hours as two sets of I-XII or just the twelve hours as I-XII. Dutch dials represented the latter. However, such historians have not considered the significance of these different hour schemes for users who travelled between countries or the reasons for their decline, which is a gap I will fill in this chapter. In chapter two I assessed the use of different numerals to distinguish between indices including different hour schemes. There my focus was on legibility and numeral hierarchy, but here my focus is on what these hour scheme differences reveal about trust.

When clock-makers in different countries were making dials with different hour schemes they were providing their users with the scheme that was most relevant and useful to them in that place. They could have chosen to represent any hour scheme, but they chose one over others. This decision by the makers to reflect local needs generated trust in them and their timepieces for their users. The clock-maker of timepieces which represented multiple hour schemes played an important role in providing the user, such as a travelling merchant, with a dial by which they might convert time references to their own preferred hour scheme. This is both indicative of the user's trust in their own hour scheme and distrust of other schemes and also of another way in which makers responded to their users' needs to generate trust and maintain business success.

In this context it is clear that users of clocks and watches, some of which were wealthy merchants travelling across Europe,[17] would have sometimes experienced conflict between their preferred hour scheme and the one in use at their location when away from home. In this situation the user might have wanted to cross-reference between hour schemes. They would certainly feel most comfortable traveling with their own watch or

[15] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.p.64-65.
[16] Rare examples survived up until the early-eighteenth century, such as six-hour dials, in rural Italy, but the vast majority of different hour schemes in Europe declined during the early-seventeenth century.
[17] As discussed in chapter one.

small clock, as Pope's sentiment in this chapter's epigraph demonstrates. This would enable cross referencing with city turret clocks and hosts' clocks in the different locations visited. Dohrn-van Rossum, for example, refers to Jakob Krause who carried a letter for Duke Albrecht of Saxony from Nuremberg to Venice in 1494 where Krause reported that he set out from Nuremberg: "…at 23 hours as it strikes at Venice."[18] Dohrn-van Rossum correctly emphasises the practical importance of different hour schemes, but does not discuss trust or the need for cross reference between schemes, which was certainly important.

Clock-makers responded to the need for cross referencing in different ways. The ultimate device for cross referencing between hour schemes was the dial which represented multiple hour schemes such as the dial in figure 3.2 in the late-sixteenth century. Historians of horology such as Thompson concentrate on its ornate decoration and list the indications on the dial,[19] but do not explain their significance. This dial enabled a user to cross reference between four different hour schemes: I-XII, 1-24 in terms of I-XII twice or as 1-24, and as I-VI four times, which made it relevant to a user travelling between three and four different countries as we know that some merchants and wealthy individuals did.

Figure 3.2[20] ©British Museum

Figure 3.3[21]©British Museum

Critics might argue that this clock was a one off, designed for a wealthy individual as an over-the-top device to show off to friends. However, in the context of different hour schemes and examples such as that of Krause, mentioned above, the utility is obvious. At a glance, the user of this clock could interpret a given time or articulate the time to someone

[18] Dohrn-van Rossum, G. 1996. *History of the Hour: Clocks and Modern Temporal Orders.* Chicago: University of Chicago Press.p.329.
[19] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.40.
[20] British Museum 1888,1201.102. Reproduced by kind permission of the Trustees of the British Museum.
[21] British Museum 1958,1006.2113. Reproduced by kind permission of the Trustees of the British Museum.

else according to a different hour. Further evidence is clear from the existence of other clocks from this period designed along the same lines such as the dial in figure 3.3, which indicates two hour schemes I-XII twice and 1-24. Comparing these two dials reveals one user who visited many different countries in Europe, possibly including England, France, the Netherlands, Germany and Italy, and another user who visited fewer countries but nevertheless travelled between England or France and Germany. No other historian has made these links before and it is only through my unique focus on trust that this is revealed.

Another, less common, response from clock-makers was the dial with an interchangeable hour ring, which would have been useful in different countries. We can see from the dial in figures 3.4 and 3.5 that one ring represents the hours as two sets of 1-12 and the other as 1-24.

Figure 3.4[22] ©British Museum

Figure 3.5[23] ©British Museum

A user who travelled could leave England or France with the 1-12 hour ring facing upwards and reverse it to reveal the 1-24 hour ring once they arrived in Germany for example. Historians of horology, such as Thompson,[24] correctly identify that the indices on these sorts of dials are indeed different hour schemes, but do not comment on the significance. Having a dial such as this one, or traveling with one's own dial with preferred hour scheme, provided the user with reassurance and trust in their own timepiece when faced with alternative hour schemes and unfamiliar town clocks.

Alternative hour schemes began to decline during the early-seventeenth century, from which point onwards both clocks and watches made in Germany, France and England

[22] British Museum 1888,1201.105. Showing one side of the hour ring with hours 1-12 twice. Reproduced by kind permission of the Trustees of the British Museum.
[23] British Museum 1888,1201.105. Showing one side of the hour ring with hours 1-24. Reproduced by kind permission of the Trustees of the British Museum.
[24] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.40.

represented the I-XII hour scheme only. This scheme had been favoured in the Netherlands and by some in England and France previously. This change was due to the decline of some hour schemes rather than the introduction of something new. Dials became more uniform in terms of their hour representation from this point onwards. This was the first step towards the standard format of 1770. This particular case of uniformity was not a result of the arrival of the pendulum in 1657 as the change had already begun to take place. This is significant because historians of horology traditionally consider horological development in terms of a pre- and post- pendulum dichotomy. Indeed, some Italian six-hour dials continued to be made until the mid-eighteenth century and even represented minutes, which demonstrates that the invention of the pendulum did not determine the lifespan of the alternative hour scheme. The main reason was that people in Europe began to refer to time in the same terms and clock-makers responded to this change. In mid-late sixteenth century German almanacs, for example, the hours of sunrise and sunset were represented according to the twenty-four hour scheme whereas in English almanacs they were represented according to the twelve hour scheme. By the early-seventeenth century almanacs in both countries used the twelve hour scheme.

Provision of indices that were preferred by users was just one example of makers responding to users' needs, and I now move on to consider the effect of the introduction of minutes to clock and watch dials in the late-seventeenth century.

3.3 Co-existence of quarter and minute indices

My focus in this section is on the smaller temporal units and subdivisions of the hour, namely the four quarters and minutes. Whereas almanacs are a key source of comparison with dials throughout this thesis, I treat them with caution here and they are not the main focus. Almanacs traditionally represented the times of the rising and setting of the Sun and Moon in hours and minutes, but this did not translate to minutes being used to co-ordinate everyday life. This was a convention of recording astronomical data. Minutes were not reliably or often represented on dials before the introduction of the pendulum in 1657. Once established they were represented using two concentric rings and two centrally-pivoted hands, as can be seen in figure 3.7. This format became a convention which was part of the standard format in 1770 and is still in use today. The presence of multiple hands and concentric indices on one dial was not new in 1657 or 1675. They had been used as an

indication device on multi-function dials since the mid-sixteenth century.[25] Before 1657 dials either indicated the hour and each quarter using a single hand as can be seen in figures 3.2 to 3.5 or featured a subsidiary dial which represented the four quarters, as can be seen in figure 3.6.

Figure 3.6[26] ©British Museum

Figure 3.7[27] ©British Museum

Dials influenced the recoding of temporal references in diaries where event times were not recorded in minutes until after the application of the pendulum in 1657. By way of example, Roger Lowe's diary references of 1663[28] referred to the nearest hour whereas those of the West Country Physician after 1684[29] referred to minutes. This is also evidence of the varying temporal accuracy needs of different professions. The transition from the indication of quarters to minutes after the introduction of the pendulum to clocks in 1657 and the balance spring to watches in 1675 was another example of makers responding to their users' needs in order to generate trust. It was the capability of the mechanism to reliably count minutes that was new in 1657 and 1675 and the mounting of two hands from the same arbor.[30] Representation on the dial followed existing conventions, which helped maintain trust in timepieces for some users through the provision of enough familiar features. Most users trusted minutes immediately, which is evident from references such as the diaries mentioned above and in records of early scientific experiment in addition to the

[25] As I demonstrated in chapter two, dials followed existing conventions in communication methods making them more familiar to existing and potential users.
[26] British Museum 1888,1201.130. Reproduced by kind permission of the Trustees of the British Museum.
[27] British Museum CAI.492. Reproduced by kind permission of the Trustees of the British Museum.
[28] Lowe, R. and Winstanley, I.G. 1994. *The Diary of Roger Lowe of Ashton-in-Makerfield, Lancashire, 1663-1678.* Wigan: Picks.
[29] Morris, C. and Hobhouse, E. 1935. *The Diary of a West Country Physician 1684-1726.* S.I: Simpkin Marshall.
[30] See appendix two for a definition of this horological term.

prevalence of older clock mechanisms which were converted to pendulum operation.[31] However, some users distrusted minutes and required reassurance from makers. They preferred using quarters as their point of reference. One response from makers was to provide dials which represented both the new minutes and the traditional quarters. This type of dual representation was short lived, the first were made around 1675 and the last around 1700.

The secondary literature is silent regarding the co-existence of quarters and minutes on clock and watch dials. It constitutes a gap in both the history of horology and social histories of time, which could be filled with closer reference to the material culture of the period. For both historians of horology, such as Thompson[32] and Bruton,[33] and some social historians of time, such as Landes[34] and Whitrow,[35] the introduction of minute indication marked a watershed in the history of clocks and the way time was experienced. Collectively, these authors give the impression that the transition from indication of hours and quarters to hours and minutes on clocks and watches took place immediately in 1657 and 1675 respectively. For Thompson the introduction of the pendulum "…changed matters overnight…"[36] which does not leave any room for reluctance on the part of some users. Historians of horology rarely acknowledge a period in which both quarters and minutes co-existed on the same dial. Bruton acknowledges that the quarter hour divisions on the dial survived the introduction of the pendulum and balance spring, but does not mention a period of co-existence.[37] Social historians of time such as Whitrow discuss the impact of increased precision on people's lives and address the issue of changing accuracy needs, but do not acknowledge differences in dials. They accept that at one point there were hours and quarters and later there were hours, minutes and seconds. Glennie and Thrift refer to the difference between single-handed dials and double-handed dials, but make no further comment.[38] Historians of temporal experience have relied on historians of horology for their information about clocks, which is how this particular silence has been indirectly maintained until now.

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[31] Some users in the late-seventeenth century wanted the new pendulum technology, but were unable to buy a new timepiece, so instead their clock-maker converted the mechanism by fitting it with a pendulum.
[32] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.66.
[33] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.p.68.
[34] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[35] Whitrow, G.J. 1988. *Time in History: Views of Time from Prehistory to the Present Day.* Oxford: Oxford University Press.p.122-123.
[36] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.66.
[37] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.p.86.
[38] Glennie, P. and Thrift, N.J. 2009. *Shaping the Day: a History of Timekeeping in England and Wales 1300-1800.* Oxford: Oxford University Press.p.140.

I argue that change did not occur overnight for all users. The transition was more gradual for those who were reluctant to accept the new design. Gooday's point that consumers can be conservative and prefer their own conceptual frameworks than getting to know something new[39] can be extended to the realm of timekeeping. It is conceivable that these were older people, or those who were content with the technology they were accustomed to, who preferred to continue using quarters as their point of reference rather than minutes. The reason for this was initial distrust of both the new units of measurement and the method of indication by two hands pivoted from the same point. For these users to eventually accept the new display and temporal unit, makers had to gain their trust. Reputation was clearly important. The words of a well-known or experienced maker would be more convincing and had the potential to be more trustworthy than those of a person unknown to the user.

I base my claim of late-seventeenth century reluctance in this area on two sources. The first are clock and watch dials that incorporated both quarters and minutes, constituting a short-lived period of coexistence from the late-seventeenth to the early-eighteenth century. The second source consists of a new genre of literature which included instructions written and published by clock and watch-makers and aimed at users. The nature of these publications, as instructions to the user, has similarly not received attention in the secondary literature, but they are highly significant in terms of their potential to reveal information about trust.

The existence of a relatively large number of 'wandering-hour'[40] and 'sun-and-moon'[41] watches might indeed exist as evidence of the attempt to offer a more aesthetically-interesting display. Landes described them as 'lively layouts'[42] and Thompson as 'a means of attracting new customers', [43] but it is more likely that they were evidence of an intermediary period[44] between the traditional single-handed dials, which indicated hours and quarters and the eventual unanimous adoption of the two-handed dials which indicated hours and minutes. An example of the wandering hour dial can be seen in figure 3.8. The hour is indicated by the Roman numeral which moves along the semi-circular aperture. The position of the numeral in the aperture indicates the minutes at the top and the quarters

[39] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.p.262.
[40] See appendix two for a definition of this horological term.
[41] Ibid.
[42] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.p.139.
[43] Thompson, D. 2007. *Watches.* London: British Museum Press.p.58.
[44] Termed an 'intermediary period' as perceived from a modern perspective.

below meaning that a user who wasn't yet ready to use a dial with only hours and minutes could still easily read the quarters on this dial.

Figure 3.8[45] ©British Museum

In his two catalogues, Thompson does not mention the co-existence of quarters and minutes on a selection of clocks and watches where they were both present. On the one hand his focus is different in the sense that the catalogues documented increased precision. On the other hand the aim of a catalogue is to describe everything visible so to not mention something suggests he does not consider it significant. Of a wandering-hour watch by Bushman, Thompson comments that the watch came from a period where makers designed 'unusual' dials, but offers no further comment.[46]

The relatively short life span of the wandering-hour dial indicates that by the time they disappeared around 1700 they were no longer needed because the reluctant had been persuaded to accept the new temporal unit. Had this design been made at any other time then perhaps I would consider it to be merely an aesthetic novelty, but there were plenty of wealthy customers buying new timepieces after 1657 and 1675 and not all were reluctant to trust the new indications, meaning that makers were not struggling financially. There was no urgency to create novelties to keep business going. Furthermore, as with the majority of the conventions and changes discussed throughout my thesis, this type of dial was not unique to a particular country or maker. Examples were made throughout Europe and are to be found in a range of different museums.

[45] British Museum CAI.656. Reproduced by kind permission of the Trustees of the British Museum.
[46] Thompson, D. 2007. *Watches.* London: British Museum Press.p.58.

It is particularly significant that Baillie refers to an example of a wandering-hour dial made by Ahasuerus Fromanteel.[47] Fromanteel was a well-renowned maker of the period and made the first pendulum clocks in England. He was clearly a maker at the forefront of his profession with a great interest in accuracy. With this in mind, I refute the dismissal of the importance of wandering-hour dials by Landes who states: "...these lively layouts were not conducive to good timekeeping, but made for colourful and attractive faces..." and refers to the watch-maker Henry Sully's comment in 1717 that they were: "…the epitome of foolishness" as evidence for his point.[48] Firstly, Sully's comment is inappropriate for this type of dial because it was made seventeen years after the wandering-hour type had declined. Secondly, while this may have been Sully's opinion, the fact that a master maker such as Fromanteel made them is evidence that they were significant. Other master makers such as Thomas Tompion and Daniel Quare also made wandering-hour dials and experimented with representation of minute indication, which is further evidence of a period of transition rather than the overnight change that Thompson claims. It is not surprising that such makers played the role of persuaders to gain trust from reluctant users through their dial formats.

The watch made by Quare in figure 3.9 not only kept the quarter indication but even introduced half quarters displayed alongside the quarters. The attempt is to show increased accuracy for users of both temporal units.

Figure 3.9[49] ©British Museum

[47] Baillie, G.H. 1929. *Watches: their History, Decoration and Mechanism.* London: N.A.G. Press.p.162.
[48] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.p.139.
[49] British Museum CAI.147. Reproduced by kind permission of the Trustees of the British Museum.

Figure 3.10[50] ©Science Museum

Figure 3.11[51]©British Museum

The early balance spring watch by Tompion in figure 3.10 also shows experimentation with the new minute indication. This watch truly emphasises the minutes. They are allocated the prime position in the hierarchy, which in this case is the outer rim. The subsidiary dials for hours and for seconds both take a secondary position in relation to the minute index. The Arabic numerals are an aid to the indices as are the touch-pins.[52] Both makers have marginalised the hours on these dials, by only giving space to six hours rather than twelve, in order to emphasise the new minutes.

The role played by clock and watch-makers in persuading users to accept the new minute indication is revealed by the instruction pamphlets and sheets published by makers and aimed at both existing and potential users. By way of example Tompion's *Directions for Setting a Watch with a Spring Balance Commonly call'd a Pendulum Watch* was published in 1705[53] and described how to look after a watch such as that in figure 3.11. It is worth noting that the dial seen in figure 3.11 was made by Tompion in 1688 and might be the earliest surviving example of the format and content of the standard format, before it became a standard just under a hundred years later. It is significant that this was some thirty years after the invention of the balance spring. This was not the overnight change that Thompson claims. In this instruction sheet, which must have been written in response to repeated questions by customers, Tompion covered three points: winding; setting the hands, which was different to single-hand watches; and setting the time by comparison with a sundial. On single-handed watches, users moved the hand on the dial to the correct time, but on

[50] Science Museum 1985-1537. Reproduced by kind permission of the Trustees of the Science Museum Group.
[51] British Museum, 1958,1201.2381. Reproduced by kind permission of the Trustees of the British Museum.
[52] Touch-pins are discussed in detail in chapter four on enablement devices.
[53] Tompion, T. 1709. *An Exact Measure of the Roads from Bath to London.* London: J. Good.

balance-spring watches Tompion explained to users that they must not do this and should use a key on the hand-setting square. This change in the practicalities of owning a watch had the potential to be distrusted by some users and Tompion's instructions offered reassurance to them. This sheet offers a glimpse into one of the ways that leading makers such as Tompion generated trust and also proactively encouraged users to accept the new timepiece.

Gooday warns historians not to: "…underestimate the power of commerce to dictate which technologies would be available for consumers to have to learn to trust."[54] To a large degree this sentiment can be extended to late-seventeenth and early-eighteenth century clocks and watches. Clock and watch-makers played a proactive role in deciding that the two-handed dial was the new type of dial that users, reluctant or not, would have to trust eventually. Their provision of a short-lived alternative demonstrates their capacity for both assisting reluctant users and persuasion, given that they did not continue to make single-handed dials, choosing instead to incorporate the minutes they wanted to promote and the quarters their customers were accustomed to. For Shapin, within the context of the exchange of goods there is an acknowledged trust dependency between parties. [55] I expand this by demonstrating the give-and-take co-dependency between makers and users. Makers provided a service and responded to user needs, but also determined what the user would need to get used to.

Through dials we can get an idea of the power exerted by makers, but control was also being exerted by clock-making guilds, unbeknown to most customers. The archives of the Worshipful Company of Clockmakers to the seizure of 'bad dials' from various shops in the City of London[56] in 1635 and 1674 is evidence of the control the guild were willing to exert over which dials were made available to customers.[57] While most of the references were to sundials, the indication is that this would have been extended to clock and watch dials. A clue to the definition of 'bad dials' can be found by the details of a seizure which took place on 4th May 1674 in which dials were confiscated for having incorrect divisions engraved.

Language also played a role in maintaining trust and persuading users to accept the new technology. Baillie referred to the late-seventeenth century term 'pendulum watch',

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[54] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.p.262.
[55] Shapin, S. 1994. *A Social History of Truth: Civility and Science in Seventeenth-century England.* Chicago ; London: University of Chicago Press.p.8.
[56] MS3975. 1632-1816. *Index of and Abstracts to Journals and Ordinanaces*. Worshipful Company of Clockmakers.
[57] This is an example from London, but was mirrored by guilds across Europe.

for balance spring watches.[58] For Baillie this association with the pendulum by the provision of an small disc attached to the balance wheel: "…invested in the eyes of the public…" the same virtues as the pendulum.[59] This would convey the message to users that this watch was the equivalent of the pendulum clock, even if they couldn't see the balance. Britten was highly critical of the term and the device: "…there is little doubt that it was hoped that a little blob, swinging back and forth like a pendulum bob, would delude the ignorant into thinking that the watch was endowed with the virtues of a pendulum…"[60] It may have been an easy device to dismiss as impractical, but it was very important in terms of the balance of trust. Even Tompion used the term 'pendulum watch' to communicate with readers in his *Instructions* considered above. As late as 1773, 116 years after the introduction of the pendulum and ninety-eight years after the introduction of the balance spring for watches, watch-makers such as Thomas Hatton continued to use the term to describe watches. He said: "The reason they are called pendulum watches is from the regularity of their strokes, and motion, which were pretended to be not inferior to those of a real pendulum. This exactness is effected by the government of a small spiral spring…"[61] In this lengthy sentence Hatton acknowledged that the pendulum exacted more trust than the balance spring and that was why mock pendulums had been fitted in the past and why the term continued to be used. This was more about communicating trust than deception, given that the balance spring was very effective despite users' evident concerns.

Other users welcomed the new minute representation, which is the main reason why the new minutes had to be accepted eventually. Social historians of time such as Sherman note the interest that people at the Royal Society had with new clocks and watches in terms of individual possession, but he does not discuss the role of trust.[62] I argue that the timepiece clearly played a role, alongside written notes and other instruments, in verifying the validity and thus generating trust in the work of natural philosophers such as Robert Boyle and Samuel Hartlib.

In three of his published works, Boyle referred to using watches during his experiments and cited minutes as the temporal unit by which he timed events, which demonstrates the trust that natural philosophers such as Boyle had in minutes measured using watches. It also reveals the role they assigned to such timepieces in their research,

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[58] Baillie, G.H. 1929. *Watches: their History, Decoration and Mechanism.* London: N.A.G. Press.p.212.
[59] Ibid.p.212.
[60] Britten, F.J., ed.,. 1982. *Britten's Old Clocks and Watches and their Makers: a History of Styles in Clocks and Watches and their Mechanisms.* London: Methuen.p.142.
[61] Hatton, T. 1773. *An Introduction to the Mechanical Part of Clock and Watch Work.* London.p.12-13.
[62] Sherman, S. 1996. *Telling Time: Clocks, Diaries, and English Diurnal Form 1660-1785.* Chicago: University of Chicago Press.p.83.

along with other measurement devices, as a form of verification of their exploration of the natural world and construction of sharable proofs. In his *Certain Physiological Essays*[63] of 1669, Boyle used minutes to describe the highly-skilled task of bluing steel for instruments: "We have also with pleasure observ'd, how Artificers in the tempering of Steel, by holding it but a minute or two longer in the flame…do give it very…differing tempers, as to brittleness or toughness, hardness or softness…"[64] This process was not new, but the reference to minutes was. Minutes were measured relatively accurately by clocks from 1657, but in 1669 watches did not yet benefit from the regulation provided by the balance spring. Sandglasses had been used to measure short durations of time previously,[65] but only the new pendulum clock indicated units as small as the minute. Later in the work Boyle referred to minutes again when he described an experiment with spirit of nitre in which potassium nitrate was observed forming in the substance: "in lesse than a minute of an hour."[66]

In his *A defence of the doctrine touching the spring and weight of the air*[67] of 1662, he described experiments made with various animals in the air pump. In a reference to someone else's experiment he distinguished the minute in terms of a newly measurable temporal unit that he used for experiment from the common use of the term to signify a moment:

> For the Creatures he mentions were a Bee, a Flye, and a Caterpillar, and those included too in a small Receiver, which could be suddenly exhausted: and these indeed became moveless within a Minute of an Hour; but that Minute was not (as the word is often us'd to signifie in English) a Moment, but the Sixtieth part of an Hour.[68]

He went on to describe his own, rather distressing but very common, air-pump experiment in which he referred to the minutes taken for an animal to die in the air pump compared with one held under water:

> For, having purposely made tryal upon a couple of Moles that were brought me together alive, one of them included in a small, though not very small, Receiver was between two and three Minutes in killing; whereas the other being immediately after detain'd under water did not there continue full a Minute and a quarter, before it finally ceas'd from giving any sign at all of life.[69]

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[63] Boyle, R. 1669. *Certain Physiological Essays and Other Tracts Written at Distant Times.* London.
[64] Ibid.
[65] Sandglasses were calibrated to measure hours and quarters.
[66] Boyle, R. 1669. *Certain Physiological Essays and Other Tracts Written at Distant Times.* London.
[67] Boyle, R. 1662. *A Defence of the Doctrine Touching the Spring and Weight of the Air.* London.
[68] Ibid.
[69] Ibid.

It is significant that it was a temporal difference, expressed in minutes, which Boyle used to make his comparison between the experiments with these two animals. These experiments are uncomfortable reading for a modern audience, but must be cited in order to reveal one way in which clocks and watches were at the forefront of nascent science. Their role in this context helped to secure trust in both clocks and watches as instruments and the minute as a temporal unit on the verge of becoming a quotidian point of reference.

In his *New experiments physico-mechanicall*[70] of 1660, Boyle described an experiment with a lit candle in the air pump. Again he referred to the minutes taken for the flame to be extinguished: "…we found that within little more then half a minute after the Flame went out…"[71] He went on to add: "But we found upon two several tryals, that from the beginning of pumping, the flame went out in about a minute of an hour."[72] In all of the other references to measurement by minute in Boyle's experiments he did not specifically mention how he measured them. However, later in this work he described a similar experiment with fire in the air pump saying that at the end: "…casting our eyes upon a Minute-Watch we kept by us on this occasion, we found that from the beginning of the Pumping (which might be about two minutes after the Coals had been put in glowing) to the total dis-appearing of the Fire, there had passed but three minutes."[73] Boyle referred to the use of a minute-watch, but given the publication date of 1660 for this work, he must have been referring to a pre-balance spring watch given that the balance spring was not invented until 1675. As Boyle's reference indicates there were watches that represented the minute before 1675, but they were not as accurate as later balance-spring examples. It is further evidence that some people wanted devices with minute indication once the pendulum enabled it for clocks.

In Hartlib's papers there are also numerous references to the minute. Hartlib may not have written about conducting experiments himself, but his correspondence about nascent scientific subjects reveals both his interest and his faith in the minute as a means, along with other recorded measurements, by which experiments could be perceived as trustworthy and verifiable. Hartlib is interesting because he referred to both quarters and minutes, thus clearly indicating the transition from one temporal unit to another that was rapid for some people. In one note dated 1657, Hartlib referred to an invention for draining land by Mr Owefield in which he says: "Hee made a trial in a Pipe of 3. inches bigenes, can raise water of 12. gallons in a minute to 12. foot (or 30. foot) high. only with one man

[70] Boyle, R. 1660. *New Experiments Physico-Mechanicall.* Oxford: H. Hall.
[71] Ibid.
[72] Ibid.
[73] Ibid.

turning the Instrument. Bressieu's Invention judged but a bable."[74] The pendulum, which enabled minute measuring, had only just been invented making this a very early reference to minute measurement beyond the astronomical context.[75] There had been remarks featuring minutes, which cannot have been accurate, before 1657 but Hartlib's clear adoption of them as a reference is better appreciated when we compare this with a previous letter written to him in 1649 which describes a process of distillation:

> …not distilling it promiscuously with fire any fire/ but eyther with a lampe because this may be too chargeable with small coale, which is most cheape, carefully tending it that it never is warmer then my finger can for a quarter of an howre endure it; and so my spiritt distilld thus leysurely, coole…[76]

Writing only eight years earlier, here he used quarters as his temporal reference point.

Thus we have two examples from the archives of prominent people welcoming the introduction of the new minute representation, which demonstrates the diversity of responses to the new minute indication. Clock and watch-makers worked hard to cater for a spectrum of different user needs. This only becomes apparent through the lens of changing dial formats, without which it is very difficult to pinpoint different user contexts. In this section we have encountered the response of makers to reluctant users, but also the ready acceptance of other users to the new minute indication. I now move on to considering user perceptions of the mechanical timepiece compared with the sundial.

3.4 The changing relationship between the sundial and the mechanical timepiece

In this section I move the focus to the world beyond horology, but shift my attention to explore timepieces within the wider context of mathematical instrument making. Here I consider the changing relationship between the sundial and mechanical timepieces through a discussion of trust. During the sixteenth and for much of the seventeenth century sundials were the means by which users set their mechanical timepieces. For this reason the sundial was one of the means by which the time represented on the dial, and thus the timepiece, was judged as trustworthy or untrustworthy up until the late-seventeenth century. However, by the early-eighteenth century the increased accuracy of the mechanical timepiece meant that this relationship of dependency was changing and eventually users no

[74] Samuel Hartlib, *Ephemerides*, [29/6/5B], 1657. https://www.hrionline.ac.uk/hartlib/.
[75] Minutes had been used as a reference in astronomy for decades.
[76] Samuel Hartlib, Letter, Benjamin Worsley To Hartlib, 22 June 1649, 26/33/1A-3B, [26/33/2A]. https://www.hrionline.ac.uk/hartlib/.

longer had to rely on the sundial to set their timepieces. Clocks and watches had become sufficiently trustworthy to not require verification by the sundial. I argue that users became more critical of their timepieces once there was an increased need for greater accuracy after the introduction of the pendulum in 1657 and the balance spring in 1675. Before this, a user doubtless wanted their timepiece to function and some clock and watch-makers had better reputations than others. However, increased accuracy in mechanical clocks and watches raised new questions, or if not entirely new then new to a greater number of people, which affected their trust in timepieces and makers. With increased need for accuracy, the issue of trust became more poignant and there was greater scope for distrust if a timepiece could not maintain high standards of expectation. There were consequences to bad timekeeping, without which trust would be unaffected. However, users could miss coaches or the best times to cross rivers[77] if they did not have the correct time in the eighteenth century.

The pendulum, balance spring and escapement refinements brought about greater accuracy, but evidence of improved mechanical capability in extant clocks and watches does not reveal user attitudes apart from the fact that lots of people clearly owned them. One method of gauging the way in which people judged this greater mechanical capability is by evaluating the limited archival references to experiences of the new minute-indicating timepieces. One of the only pieces of evidence of a user's experience of their timepiece in the period is found in the diary of Samuel Pepys and it may even be the first critique of mechanical timepieces. In 1665 Pepys recorded his excitement of using his new watch:

> But, Lord! to see how much of my old folly and childishnesse hangs upon me still that I cannot forbear carrying my watch in my hand in the coach all this afternoon, and seeing what o'clock it is one hundred times; and am apt to think with myself, how could I be so long without one; though I remember since, I had one, and found it a trouble, and resolved to carry one no more about me while I lived.[78]

The joy Pepys experienced with his new possession is a feeling that transcends temporal boundaries and more so his acknowledgement of the relative burden that this new technology brought with it. Accuracy had a price, both financial and emotional, which in the case of Pepys was the diversion of his attention to the dial instead of talking to a companion, pondering his own thoughts or looking out of the carriage window. This was the beginning of user critique of timepieces.

Moreover, in 1665 he recorded testing his new minute-watch:

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[77] Tompion, T. 1709. *An Exact Measure of the Roads from Bath to London.* London: J. Good. At the back of this pamphlet are some instructions on how to calculate the best time to cross the River Severn. I discuss this in detail in chapter five.

[78] Diary of Samuel Pepys, *Saturday 13th May 1665*. http://www.pepysdiary.com/.

> Up, and walked to Greenwich, taking pleasure to walk with my minute watch in my hand, by which I am come now to see the distances of my way from Woolwich to Greenwich, and do find myself to come within two minutes constantly to the same place at the end of each quarter of an houre.[79]

Though Pepys called his device a 'minute watch', as Boyle did,[80] again this cannot have been a balance-spring watch given that he was writing in 1665 which was ten years before its development. He must therefore have been using a pre-balance-spring watch with minutes represented in anticipation of a regulation device which made their indication accurate. Alternatively he may have been using a watch with quarters. His reference to arriving at the same place 'within two minutes of each quarter' indicates his approximation of the minutes passed by reference to the hand's position between each quarter on the scale and indeed the continued importance of the quarter in the late-seventeenth century. Sherman mapped diary-writing changes with reference to developments in timekeeping capability in the late-seventeenth century and cites this same reference from Pepys' diary. Sherman did not discuss the issue of trust as his focus was on the emergence of the private ownership of minutes enabled by watches.[81] However, this reference is more revealing about trust than anything else. The action Pepys performed was an important part of the trust-generation process. Trust needs to be earned; it is not always immediate even in the context of an instrument made by a maker of high repute. Further, it is significant that users such as Pepys made a record of the performance of the timepiece. This kind of instrument interrogation and personal record keeping was new and only made possible due to the increased performance of the timepiece itself.

While Pepys represents the beginning of a more rigorous method of timepiece assessment, most users continued to judge their clock or watch by reference to a sundial. The sundial had a long history and continued to be used throughout the period under consideration here. Pamphlets written by clock and watch-makers instructing users on how to make use of the equation-of-time tables reveal that users habitually cross-referenced their timepieces with sundials and made adjustments accordingly. Sundials were clearly important in generating trust in a timepiece. They were a form of verification. It is known that seventeenth-century clocks and watches were often supplied with a sundial for setting the time. This was no longer needed once clocks and watches achieved similar accuracy as the chronometer in the late-eighteenth century. While this is perfectly logical, this view

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[79] Diary of Samuel Pepys, *Wednesday 13th September 1665*. http://www.pepysdiary.com/.
[80] As discussed in the section on the acceptance of the new minute indication in section 3.3.
[81] Sherman, S. 1996. *Telling Time: Clocks, Diaries, and English Diurnal Form 1660-1785.* Chicago: University of Chicago Press.p.79.

does not account for the role of trust in the provision of the sundials initially and the decision not to later. In fact, trust played the greatest role. Sundials were already everywhere. They were in people's gardens, on their houses, and in public spaces. This means that people, wealthy enough to buy a timepiece, already had access to many sundials as a form of verification. In this context the sundials that makers supplied with their clocks and watches were in effect trust tokens.

The numerous pamphlets published on 'the art of dialling', which were guides on how to make various kinds of sundial, were popular until the late-seventeenth century.[82] Higton argues that they were popular until the nineteenth century, but acknowledges that the number peaked at the end of the late-seventeenth century and then interest gradually became antiquarian in nature rather than practical.[83] Her qualification to the initial claim is more in tune with my findings. It is significant that these guides continued to be published even after the introduction of the pendulum in 1657 and the balance spring in 1675, which historians such as Landes have termed the 'horological revolution'.[84] The introduction of the pendulum may have been a decisive horological moment in terms of accuracy, but it did not equate to immediate trust as the references to verification by sundial demonstrate. The second half of the seventeenth century was a period of significant development, but not a revolution. For Turner the co-existence and user ownership of both sundials and clocks revealed the complementary nature of the two instruments.[85] However, I interpret the evidence differently and maintain that their relationship was about dependency rather than complementarity. Sundials supported timepieces based on trust generation. That relationship then changed as timepieces began to outperform sundials.

As I emphasise throughout the thesis, archival references to dial use such as those seen in Pepys' diary are rare, which I have responded to by looking for evidence elsewhere. In terms of understanding the changing relationship between the mechanical timepiece and the sundial, the proliferation of equation-of-time tables is highly revealing. The way in which they were written about in the period helps us to understand the role of clock and watch dials within the complex trust relationships between makers and users in the period. Improved timepiece performance brought the difference between solar and mean-solar time to the attention of more users. Prior to 1657 and 1675 clocks and watches often lost

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[82] A well-known example is Blagrave, J. 1609. *The Art of Dyalling* Simeon Waterson: London.
[83] Higton, H. and Ackermann, S. 2002. *Sundials at Greenwich : a catalogue of the sundials, nocturnals, and horary quadrants in the National Maritime Museum, Greenwich.* Oxford: Oxford University Press.p.24.
[84] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[85] Turner, A.J. 1993. *Of Time and Measurement: Studies in the History of Horology and Fine Technology.* Variorum.p.21.

thirty minutes per day,[86] which meant that when they were compared with a sundial for setting they would not be expected to agree. However, after 1657 and 1675, timepieces were capable of keeping time to within a few minutes per day and when compared with a sundial the discrepancy varies according to the date. The difference could be explained by the equation of time. However, that this was confusing to some users is evident from some of the pamphlets published by clock and watch-makers and addressed to users. Between 1675, only ten years after Pepys wrote the comments above in his diary, and 1731 a new genre of pamphlets written by makers emerged. It focussed on explaining the importance of the equation of time. Within these pamphlets I have identified portions of a conversation between users and makers, in addition to the techniques used by makers to reassure users and defend their work in light of user criticism. From these pamphlets I can account for some aspects of the complex trust relationship in the late-seventeenth and early-eighteenth centuries. I have selected several different pieces of writing which act as evidence of clock and watch-makers advising users and defending their work.[87]

John Smith began his pamphlet entitled *Horological Dialogues* of 1675, with an audacious justification of clocks: "Clocks being things in themselves so useful and excellent, that no production of Art whatsoever doth surpass them…"[88] In this sentence Smith promoted the timepiece. In the next sentence he acknowledged potential problems, but then defended the good maker and timepiece when he said they: "…are extraordinarily subject to give dissatisfaction to those that own them, which happeneth' from two causes; the one from the workman's unskilfulness and unfaithfulness in making them and the other is from the Owner's unskilfulness in keeping and managing them."[89] Here we find Smith, the clock-maker, acknowledging untrustworthy clock-makers, but also reprimanding some users. This was in order to reassure readers that timepieces made and owned by skilled and faithful clock-makers and proficient users, were trustworthy and unsurpassed by any other mechanical device. Gooday raises the question as to who was responsible for errors: was it the instrument or the maker?[90] Smith included the user in his answer to this question and attempts to distance the maker and the timepiece from it by distinguishing between good and bad work.

Smith claimed he wrote this pamphlet to reveal: "…to those that are ignorant…" some of those secrets that are necessary to be known by those that would: "…rightly

[86] This that was sufficient for users' needs prior to 1657.
[87] Selected as examples of both the equation of time and advice to users.
[88] Smith, J. 1675. *Horological Dialogues.* London.
[89] Ibid.
[90] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.p.66.

manage…' their clocks.[91] In other words this constituted his reassurance that, although he may have disconcerted the reader by suggesting they might be one of those unskilled owners, by reading this pamphlet they would become skilled and be able 'to rightly manage their timepieces.' Again this indicates that some people had complained about their timepiece and tried to set it incorrectly. This passage also reveals that not only was the maker active in creating the image they wanted of clocks and of promoting acceptance of new technology, but the user was also required to play an active role. Clocks and watches needed proper attention.

In his *Horological Disquisitions* of 1694, written nineteen years after the *Dialogues*, Smith opened his pamphlet by saying:

> The Design of these Papers is not to cover the Clock-Makers Imperfections, as some have suggested, but plainly to demonstrate the true Reason of those unavoidable Variations between the Time given by the Sun and that of a good and well-adjusted Clock; and to give such Directions as may yet reduce them to a nearer Agreement in Time.[92]

Here we learn that some people claimed that pamphlets such as these were intended to mislead the user/reader by blaming something else to mask the failings of makers and their timepieces. This is the sentiment of those who distrusted makers and timepieces. Smith's reaction was to try to dispel this distrust and generate trust by reassuring the reader/user of how the equation of time relates to clocks. His reference to the 'true reason' was a method of trying to gain trust by showing respect for the reader's intelligence by letting them into a secret or sharing knowledge.[93]

Smith explained the equation of time and then said that given his explanation he: "…hopes men will be less demanding and critical of their timepieces."[94] By this statement we know that users, and most likely Smith's customers, complained about their timepieces after the introduction of the pendulum and balance spring. Again, it is significant that thirty-seven years had elapsed after the introduction of the pendulum and nineteen years since the balance spring. The late-seventeenth and early-eighteenth centuries was the period in which the equation of time was most discussed. This was not the first time people had noticed a discrepancy between their timepiece and sundial, but it was the first time that it was felt by them to be an inconvenience because their perceived need for more accurate

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[91] Smith, J. 1675. *Horological Dialogues.* London.
[92] Smith, J. 1694. *Horological Disquisitions* London.
[93] The desire to share craft knowledge was very popular at this time and not unique to clock-making. For more information see Eamon, W. 1994. *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture.* Princeton, New Jersey: Princeton University Press.
[94] Smith, J. 1694. *Horological Disquisitions* London.

time had increased. This also served as a reassurance to the reader/user that there was no problem with their timepiece and that they must not judge its efficiency by those standards.

We learn what exactly users had been doing when Smith went on to advise: "…that you can't just adjust your clock by observing the sun because the number of hours per day vary…."[95] Smith went on to advise that: "…this adjustment is only to be done by the help of an exact Table of Equations."[96] This tells us that there were different qualities of equation tables. He recommended Parker's[97] and Salmon's[98] almanacs of 1694. This is a firm link with almanacs and is evidence of users comparing almanac and dial in addition to being a sign of trust in specific editions of almanac.

Controversially, Smith claimed that these tables are useful if you: "…understand them rightly…", but from his experience: "…not many truly do."[99] This sharing of a secret and bringing the user into a confidence with the maker is also a technique for gaining trust. Smith distinguished between trustworthy City-of-London makers and provincial makers when, as late as thirty-seven years since the introduction of the pendulum, he stated: "The difficulty of setting up pendulum Clocks rightly in such places where the help of the Clock maker cannot be had, is the Reason that many Gentlemen who live far off from London are as yet unfurnished with them."[100] He said that he had written this publication so that owners could get their timepieces going again. There were clock-makers all over England at this time, but Smith denied their existence which is a trust and reputation judgement. It was probably due to the distrust of London makers for their provincial counterparts given the association of the former with the Clockmakers' guild.[101]

In his preface to *An Explanation of the Nature of Equation of Time,*[102] Clay informed the reader in no uncertain terms: "Without understanding the Nature of Equation of Time, and use of the Table, it is impossible to know whether a Watch or Clock goes right or wrong…"[103] In other words the equation of time was the only way of judging the performance of a timepiece and thereby determining its trustworthiness. The role of the sundial had thus begun to diminish. It was still important, but similarly to the clock, needed to be compared with the equation-of-time table of data. Furthermore: "…it is impossible to

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[95] Ibid.
[96] Ibid.
[97] Parker, G. 1694. *Mercurius Anglicanus or The English Mercury Being a Double Ephemeris for the year of our Lord 1694.* London.
[98] Salmon, W. 1694. *The London Almanac.* London.
[99] Smith, J. 1694. *Horological Disquisitions* London.
[100] Ibid.
[101] The Worshipful Company of Clockmakers controlled clock-making in London from 1631 onwards.
[102] Clay, F. 1731. *An Explanation of the Nature of Equation of Time.* London.
[103] Ibid.

distinguish betwixt Good and Bad workmanship of these machines; or at any time to know the True Moment of Day or Night by the best Watch or Clock in the World."[104] Even the trustworthiness of the maker was knowable by reference to the equation of time according to Clay.

Clay, similarly to Smith, identified untrustworthy watch-makers: "…most Gentlemen, nay (which more surprising) most Watch-makers in the Country are intirely Strangers to it."[105] Similarly to Smith, he differentiated between clock-makers in London and those in the rest of the country, separating them into trustworthy London makers who were part of the guild and untrustworthy provincial makers who were not. Clay accounted for this lack of knowledge by reference to the equation of time having previously been a matter discussed by astronomers and mathematicians: "…whose Descriptions are above the Reach of Common Readers…'[106] His reaction, similarly to Smith, was to share knowledge with his readers:

> I have endeavoured to explain this Mystery in such a Manner, that the most ordinary Capacity may easily apprehend what is meant by Equation of Time and what the Use of the Equation-Table. By this means Gentlemen not vers'd in Astronomy and Mathematicks, will perfectly understand how to manage their Watches and Clocks, so that the exact Moment of Day or Night may at any time be discovered.[107]

Clay offered reassurance, similarly to Smith, 'read this pamphlet and you will be able to judge any timepiece or clock-maker' he appeared to say.

In a similar manner to Smith, Clay's pamphlet revealed the problems users encountered. He claimed a benefit of knowing how to use the equation tables was: "To prevent Gentlemen from spoiling their watches by constantly altering them to reduce them to an Agreement with the Sun…"[108] That this is an issue of trust is clear from his comment that: "We have so good an Opinion of the Sun that we are apt to fancy it can be guilty of no mistakes: that therefore, whatever Disagreement happens betwixt the Dial and Watch, the Fault can only be chargeable on the latter."[109] Some users trusted the sundial more than the watch or clock. Clay defined such a user as someone who did not understand the equation of time. His audacious suggestion that the Sun 'can be guilty of mistakes' is a defence of the clock against criticism and a promotion of its performance in order to generate trust. It was also a blow to the sundial.

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[104] Ibid.
[105] Ibid.
[106] Ibid.
[107] Ibid.
[108] Ibid.
[109] Ibid.

Until now I have argued that clock and watch-makers used dial formats to respond to changing user needs both within and beyond the context of horology. I now move on to consider the influence of precision timepieces on dial formats and trust relations.

3.5 Imitation of precision timepieces

In this section I take a slightly different angle and argue that clock and watch-makers from the late-seventeenth century onwards also sought to imitate the dial formats of precision timepieces in order to generate and maintain trust in their work. Part of the reason why the standard format appeared the way it did in 1770 was a legacy of the observatory clock used by astronomers. The longevity of the standard format was in part due to the adoption of the format used by John Arnold and Thomas Earnshaw who initiated a commercial market for the marine chronometer. These were two examples of precision timepieces used for professional purposes which were developed during the late-seventeenth and early-mid eighteenth century. They were the most accurate type of clock in the period and their design became a mark of quality. They influenced domestic-timepiece dials because users wanted a dial that resembled the precision timepiece in the observatory or on the chronometer. In this context the dial was perceived by users as the outward sign of technical capability, which won their trust. Clock and watch-makers gave them what they wanted; they provided users with a representation of high-end precision through the dial format.

Observatory clocks are significant because they provide an example of astronomy influencing the standard format dial. These dials did not feature astronomical information,[110] but were used by astronomers and were considered to be the most accurate available in the late-seventeenth century. An example can be seen in figure 3.12. Howse correctly emphasises that provision of time to the nearest minute and second, provided by Tompion's clocks for Greenwich Observatory, played a role in John Flamsteed's work on the star catalogue which he spent the majority of his life compiling.[111] However, he implies that this was the first time clocks were used in an observatory setting. As North points out, an illustration of Tycho Brahe's instruments in use at his observatory depicts two clocks.[112] This clearly demonstrates that although clocks in observatories were not new in the late-seventeenth century, what was new was trust in their capacity as instruments.

[110] I discuss the astronomical function in detail in chapter seven on astronomical knowledge.
[111] Howse, D. 1971. The Tompion Clocks at Greenwich. *Antiquarian Horology.* 7(2).p.114.
[112] North, J.D. 2008. *Cosmos: an Illustrated History of Astronomy and Cosmology.* Chicago: University of Chicago Press.p.325.

Once clocks such as those made by Tompion entered the observatory in the late-seventeenth century, they began to be perceived by astronomers as a key tool for generating knowledge. They were therefore perceived as being extremely trustworthy. The Tompion clock in figure 3.12 was commissioned for Flamsteed, the first Astronomer Royal, for the Observatory at Greenwich by his patron Sir Jonas More in 1676. According to the National Maritime Museum,[113] this clock offered unprecedented accuracy and allowed Flamsteed to determine that the speed of the Earth's rotation was constant. Thus clocks were not a new technology for the observatory, but the improvement provided by the pendulum which enabled greater accuracy put them ahead of other instruments such as the quadrant, for the first time.

This made them a reliable astronomical instrument in not only the eyes of users at the observatory but also the wider book-buying public, the wealthier sections of which were also clock and watch users. In Stephenson's almanac of 1677 for example, a note at the back advised readers who were interested in astronomy to contact Flamsteed at the observatory and to see Tompion for: "They are made at Mr *Tompions*, Clock-maker at the Black-Lion at *Water-lane-end* in *Fleet Street*, where may be had curious and exact Clocks, Watches, and Movements, regulated by *Pendulums* and Springs, after the newest way, and finished with his own hand, and warranted by him." [114] The recommendation of Tompion's clocks and watches to almanac readers in 1677 provides another direct link between almanacs and timepieces. Here the almanac reader was given six forms of assurance in a single sentence that the clocks, watches and movements[115] were trustworthy. The first was Tompion's name, given that he was well-known as a high-end clock and watch-maker. The second was the address of his workshop in Fleet Street, which was a centre of fine clock and instrument making throughout the seventeenth and eighteenth centuries. The third was the description of the clocks and watches as 'curious and exact'. In his positioning of these qualifications after locating the workshop in London's Fleet Street, Stephenson differentiated Tompion's clocks and watches from those of other London clock-makers. The fourth was the description of the timepieces being regulated by pendulums and springs 'after the newest way.' The fifth was the assurance that each clock or watch was finished by Tompion's own hand rather than one of his journeymen or apprentices. The sixth was that they were warranted or guaranteed by him, which was an assurance to the user that they could take a timepiece back to him if there were any problems. We know from Pepys' diary that wealthy

[113] National Maritime Museum online catalogue entry for object number ZAA0885.
[114] Stephenson, N. 1677. *The Royal Almanack.* London.
[115] See appendix two for a definition of this horological term.

clients such as him did indeed take instruments back to their makers for minor adjustments.[116] This was a service high-end makers, such as Tompion, were committed to providing as it helped maintain trust in their work and thus their reputation.

It was the wider perception of astronomical clocks that made their dials significant in the story of dial development. The dials of clocks such as Tompion's clocks for Greenwich were arranged in a manner that was very similar to what would become the standard format of clocks and watches in 1770. It consisted of two concentric outer rings with the hours and minutes, but in this case the minutes were arranged as 1-60 twice, and a subsidiary dial indicating seconds. The subsidiary dial was located below the XII position on these dials, but on the standard format dial it was located above the VI position, as seen in figure 3.13. It is clear that changing perceptions of astronomy and astronomical instruments in the period influenced the emergence of the standard format dial. Makers of provincial longcase clocks, who did not make observatory clocks, were just one example of makers selling timepieces that resembled the observatory clock. They provided their customers with a representation of trustworthy timekeeping.

Figure 3.12[117] ©National Maritime Museum

Figure 3.13[118] ©British Museum

The marine chronometer, developed from 1736 onwards, did not become firmly established as a commercial product until the 1780s and 1790s, meaning that it did not influence the format and content of the standard format which emerged by 1770. However, makers such as Arnold and Earnshaw, who made the chronometer into a commercial

[116] Diary of Samuel Pepys, *Monday 10th August 1663*. http://www.pepysdiary.com/. In this entry Pepys described an error with the engraving of an almanac that he had asked Ralph Greatorex to engrave on his ruler and said he would return it to be re-engraved.

[117] National Maritime Museum ZAA0885. Reproduced by kind permission of the Trustees of the National Maritime Museum.

[118] British Museum 2010,8029.46. Reproduced by kind permission of the Trustees of the British Museum.

product on a larger scale and thus in to more widespread use, used the standard format for chronometer dials.[119] Figures 3.14 and 3.15, demonstrate that apart from their signatures, the dial format used by both was identical and probably sourced from the same dial-maker.[120] Betts cites the important economic role played by Arnold and Earnshaw informing us that whereas Thomas Mudge may have made around seventy chronometers in forty years, they made thousands. [121] However, Betts does not comment on the dials as this was not his focus. However, by concentrating on dials I have been able to identify chronometer dials as part of a wider trend, making use of and perpetuating the standard format. By using the standard format, makers such as Arnold and Earnshaw enabled the standard format to enjoy a long life from the late-eighteenth to the late-nineteenth century.[122]

Figure 3.14[123] ©British Museum

Figure 3.15[124] ©British Museum

Previous discussions of the chronometer have either been within the context of the history of the quest to find the longitude such as Dunn and Higgitt[125] or of horological development such as Betts[126] and Cronin.[127] In the case of the former, their focus has understandably been on the political context of the Board of Longitude and the biographies

[119] The standard format was not used on Harrison's or Kendal's marine chronometers that were part of the Board of Longitude project, but these were not commercially-available products, they were experimental models, and so will not be considered as formats influencing other timepieces.
[120] In chapter one I explained that it is extremely difficult to identify specific dial-makers in this period.
[121] Gould, R.T. and Betts, J. 2013. *The Marine Chronometer: Its History and Development.* Antique Collectors' Club Ltd.p.105.
[122] The nineteenth-century chronometer and dial is beyond the scope of this thesis, but it serves to demonstrate why the standard format once established enjoyed a long period of use.
[123] British Museum CAI.1565. Reproduced by kind permission of the Trustees of the British Museum.
[124] British Museum CAI.1553. Reproduced by kind permission of the Trustees of the British Museum.
[125] Dunn, R. and Higgitt, R. 2014. *Ships, Clocks & Stars: the Quest for Longitude.* London: Collins.
[126] Gould, R.T. and Betts, J. 2013. *The Marine Chronometer: Its History and Development.* Antique Collectors' Club Ltd.
[127] Cronin, J. 2010. *The Marine Chronometer: its History and Development.* Ramsbury: Crowood.

of the main protagonists such as John Harrison[128] and Nevil Maskelyne.[129] When they refer to chronometers they discuss who made them, how they performed when tested, and how willing their makers were to share their designs. The influence of the chronometer on non-chronometer clock and watch-making is beyond their scope. Similarly, historians of horology such as Betts and Cronin consider the fine detail of the chronometer mechanism and explain why each one was so accurate. Cronin's only mention of dials was to say that they were physically made in the same way as other dials, but he does not refer to the content or the format.[130] Again, the effect of the chronometer on domestic clocks and watches is beyond their scope. However, it is significant that clock and watch makers such as Arnold and Earnshaw utilised the standard format for their chronometer dials; thus drawing from an existing and accepted form of communicating those temporal units. This was very much a part of the longer story of development and convention building that I argue for in this thesis.

There have been discussions in the secondary literature about imitation, but none discuss the practice in relation to trust. Moreover, until now no one has discussed imitation with regard to clock and watch dials. Writing about a different subject and different historical period, Edwards refers to the role of imitation in product design.[131] He informs us that machined decoration was used in the nineteenth century to meet demand for the originals. For Edwards this was more about status showing,[132] but I argue that imitation is also about trust. Edwards refers to Bemrose's comments of 1872 that imitation could provide a product for people who couldn't afford the high-end original.[133] For clocks and watches the situation was similar in the sense that some users buying a domestic clock or watch with the standard format dial probably couldn't afford the high-end observatory clock or marine chronometer, but it was more for a mark of quality, rather than a cheap alternative. Through dial imitation, the maker was saying 'this clock or watch will perform as well as an observatory clock or marine chronometer; you can see that from the dial.'

Berg, who focusses on the luxury products of the eighteenth century, argues that in the late-eighteenth century specifically, there was a concept of imitation which was perceived as an art and was more about paying homage to the original than merely

[128] John Harrison was the first to develop a timekeeper that could be used to find the longitude at sea.
[129] Nevil Maskelyne was Astronomer Royal and sought to solve the longitude problem using the lunar method.
[130] Cronin, J. 2010. *The Marine Chronometer: its History and Development.* Ramsbury: Crowood.p.76-77.
[131] Edwards, C. 2012. "Improving" the Decoration of Furniture: Imitation and Mechanization in the Marquetry Process in Britain and America 1850-1900. *Technology and Culture.* 53.
[132] Ibid.p.428-430.
[133] Ibid.p.416.

copying.[134] Imitation was in this sense perceived as part of the invention process. Whereas Berg draws examples from an extremely wide context such as England borrowing designs from the rest of the world during the eighteenth century and Western Europe learning from the Classical world,[135] my focus on dials is much narrower. However, Berg's notion is a useful one. Dial imitation in the late-eighteenth century was part of a wider culture of imitation in material culture. In a sense standard format dials of the late-eighteenth century were a form of salutation to the observatory clock and in this sense the chronometer was also. The chronometer dial thus becomes the subject of the imitation process rather than an active agent that influenced the standard format. This was despite it enabling the longevity of the format in the subsequent decades and century. Berg goes on to refer to Adam Smith's emphasis on imitation as enabling one object to represent a different object.[136] On a small scale the standard format dial of the domestic clock and watch, and indeed the chronometer, thus represents the observatory clock despite not being one.

Considering the role played by the observatory clock and the marine chronometer in terms of generating trust has revealed that the observatory clock played a role in the adoption of the standard format through the process of imitation. Furthermore, instead of playing a similar role, the marine chronometer in fact drew on the standard format and itself became part of the imitation, or representation, of accuracy. The widespread acceptance of the standard format and its longevity as a dial format was in part attributable to the legacy of the Arnold and Earnshaw chronometers. If a dial looked like these fine instruments then it was more trustworthy in the perceptions of users than a dial that looked completely different.

3.6 Conclusion

In the epigraph to the chapter I referred to Pope's inclusion of watches as an analogy to human opinions in his epic poem. Pope said that each man believes his own watch. In the course of this chapter I have expanded this gesture to the trust relationship between users and their makers through instruments. I argue that the different ways in which formats were used to generate and maintain trust and dispel distrust provides another angle of answers to the main research questions that could not have been attained in any other way.

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[134] Berg, M. 2002. From Imitation to Invention: Creating Commodities in Eighteenth-century Britain. *Economic History Review.* 55(1).p.3.
[135] Ibid.p. 6-7; 9.
[136] Ibid.p. 13-14.

In each of the four sections of this chapter I substantially improved our understanding of the extent to which users' emotions influenced dial development. In section 3.2 I argued that some users from the mid-late sixteenth century preferred the hour scheme in use in their home location and distrusted other hour schemes. In this context I argued that dials with multiple hour schemes provided such users with a reassuring method of cross referencing while away from home. In section 3.3 I argued that when the pendulum clock and the balance spring for watches enabled the representation of minutes in addition to hours from 1657 and 1675 respectively, some users were reluctant to accept the new indication, but were eventually persuaded to accept a new form of time reading. For a relatively short period in the late-seventeenth century, some makers used a wandering-hour format where both minutes and quarters co-existed on the dial. The wandering-hour format, not unique to any particular country, was the makers' solution to initial distrust of minutes by users accustomed to the traditional time display of hours and quarters. In fact, minutes were still considered to be new as late as thirty years after the invention of the balance spring. In this situation, the maker played the role of teacher, gradually exposing his users to the new minute indication which they eventually had to accept. In effect, the wandering-hour format represented a period of transition between the old and new systems. In section 3.4 I demonstrated that the equation of time was another instance where the maker played the role of advisor to maintain trust in timepieces in the face of change. Sources such as Tompion's pamphlet, advising users to not continue adjusting their timepiece to agree with their sundial, is important for understanding the role of formats in the building of trust relationships. The new minute index, arranged as a ring concentric with the hour index, combined with the equation-of-time tables was not just accepted by users; it needed explaining. The equation of time was in effect a period of transition between user preference for the sundial and user preference for the mechanical timepiece. The relationship of users to the sundial and the mechanical timepiece is also revealing about the emotional influences on dial development. The equation-of-time example demonstrated that some users trusted the sundial more than the clock, but by the eighteenth century accuracy requirements meant that the sundial had declined from importance in relation to the mechanical clock. The sundial went into decline in a similar period as the proliferation of published works on how to make sundials and this also coincided with the decline of clock and watch-makers' advice on the equation of time; it was no longer required. In section 3.5 I argued that some users perceived the observatory clock, and later the marine chronometer, as the height of accuracy, which it was. Such users judged timepieces with

dials that looked the same as these professional precision timepieces to be of the same high standard. I argue that this was one reason why the standard format appeared the way it did by 1770. While focussing on trust has revealed a large part of the answer to this question, it does not provide a full answer. There is more to come in chapters five and seven.

In section 3.3 I offer part of the answer as to what the relationships between dials and printed paper sources were in the period. I argued that minutes were immediately accepted by some people, such as natural philosophers, while others were reluctant to accept them and favoured quarters. This was evident in diaries, correspondence and published accounts of experiments. In both dials and printed paper sources before the introduction of the pendulum in 1657 the hours and quarters were provided and afterwards the hours and minutes, and later seconds, were provided. I noted that the exception to this was almanacs, which referred to minutes as a matter of astronomical convention in the era before the pendulum.

In sections 3.2 and 3.3 I offered part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. I argued that alternative hour schemes and the representation of minutes and quarters together were different ways that layers of information were represented to enable cross referencing in the late-sixteenth to early-seventeenth century and late-seventeenth century respectively.

These points reposition clocks and watches into existing works, such as that of Gooday and Wyatt, about the relationship between maker, instrument and user and the ways in which trust is generated, maintained or lost. The standard format which emerged by 1770 showed neither sign of alternative hour schemes, nor the transition from quarter to minute indication, nor of the equation of time or reliance on the sundial. The fact that it bore none of these signs is indicative of the success of older attempts made by past makers to maintain trust in timepieces by users. Users had indeed begun to use a shared hour scheme, become accustomed to minute indication, and had dispensed with reliance on the sundial. The absence of signs of these past attempts at format variation and the emergence of the standard format is testament to the success of those attempts; they were no longer needed. Focussing on trust has enabled me to reveal hitherto undiscussed issues which contribute to answering the main research questions. However, there is one more angle by which clock and watch dial formats can improve our understanding of dial use in the period and thereby answer the research questions. This is the instances in which they act as devices of enablement to which I now turn in chapter four.

Chapter 4

Tools of Enablement

Figure 4.1[1] ©British Museum

Figure 4.2[2] ©British Museum

4.1 Introduction

This chapter is based on my identification of the only two commercially-available dial formats in the period 1550-1770 that were designed as tools of enablement. Over two sections I will provide a reinterpretation of these two different dial formats which have hitherto not been discussed from this angle. In section 4.2 I will discuss the touch-pin of the mid-sixteenth to early-seventeenth century (see figure 4.1). In section 4.3 I will discuss the illuminated night clock of the mid-seventeenth to early-eighteenth century (see figure 4.2). Through these two sections I will argue that these two formats are in fact evidence of two contexts of use for which dials were designed to enable users. They were designed for those who might otherwise have been dis-abled[3] by an absence of full sight, such as users who were partially sighted and blind, or the absence of light during the night. Most sixteenth- and seventeenth-century dials and all eighteenth-century dials, including the standard format that emerged around 1770, required sight and light to be read. These traditional formats excluded some users all of the time and some users in certain situations.

Through these two sections I will provide part of the answers to some of the main thesis research questions. Both sections will improve our understanding of the relationships

[1] British Museum 1958,1201.2203. Reproduced by kind permission of the Trustees of the British Museum.
[2] British Museum 1980,1002.1. Reproduced by kind permission of the Trustees of the British Museum.
[3] I have specifically chosen the term 'dis-abled' to distinguish it from 'disabled' to move the focus from the person to their environment.

between dials and printed paper sources. In section 4.2 I will argue that dials with touch-pins and early attempts to create text that was interpretable by touch were part of the same strategy of creating a communication device that was accessible to blind people. In section 4.3 I will argue that the illuminated night clock was an aid to religious contemplation in a similar way as the older books of hours had been. Section 4.3 will also offer part of the answer as to the extent of the relationship between dials and astrological practice up until the mid-late seventeenth century. I will argue that illuminated night clocks provided the time in the dark for users who needed to know the time at night to conduct certain tasks according to astrological practice such as planting of seeds. Astrology had begun to decline when the illuminated night clock emerged and neither had it long left before they disappeared. Both sections will offer a substantial part of the answer to the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. I will argue that here were two discrete examples of clock and watch-makers providing an alternative format in order to enable those who could not use traditional formats because they had been dis-abled by their environment and society. In section 4.2 I will argue that blind and partially-sighted users could acquire knowledge of the hour and quarter from dials with touch-pins. In the sixteenth- and early-seventeenth century touch was considered to be the second sense in the hierarchy after sight. I will argue that an increase in the availability of spectacles and changing attitudes to blindness led to the decline of the touch-pin during the early-seventeenth century. In section 4.3 I argue that illuminated night clocks enabled users to contemplate human dominance over the night and undertake religious devotion. I will argue that the decline of the practice of dividing the night by two sleeps and human triumph over nature's limitations, imposed by the setting of the Sun, led to the decline of the illuminated night clock. Together these sections will improve our understanding of why these formats did not survive to be part of the standard format by 1770.

This chapter will make a strong contribution to the growing secondary literature which reassesses history from the perspective of people who were dis-abled by their environment and society. Historians such as Hobgood and Houston Wood emphasise that the aim should not be to write 'disability histories', but to write more inclusive histories, which take into account multiple perspectives.[4] Along with others[5] they have made a start at reassessing the surviving written and pictorial evidence. However, they have not as yet

[4] Hobgood, A. and Houston Wood, D. 2013. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p.3-11.

[5] Eriksson, Y. 1998. *Tactile Pictures:Pictorial Representations for the Blind 1784-1940*. thesis, Acta Universitatis Gothoburg University.

sufficiently considered the context of material culture. By discussing the way in which clock and watch-makers responded to different user needs in the early modern period I will contribute to the work of these historians. As a response to Hobson and Houston Wood's call to offer a more inclusive approach instead of focusing on disabled users, I am considering two contexts in which the user, able-bodied or otherwise, was dis-abled and the response of clock and watch-makers to enable such users in these situations. An early modern user, who was blind, partially sighted or who lacked the means to create artificial lighting in the dark, would be dis-abled by a society that required them to know the time. Similarly, this user would be dis-abled by their environment by timepieces that required sight or light to be read. Historians of horology, such as Thompson,[6] Bruton[7] and others,[8] have not discussed contexts of dis-ablement. Their focus is on technical development rather than use, which means there is a gap in the literature which I will fill by reassessing clocks and watches from this perspective.

A continuing challenge to my research is a lack of primary material and this is no less true for considering touch-pins and illuminated night clocks. My solution is to compare dials with touch-pins with the wider context of availability of spectacles from the mid-sixteenth to the early-seventeenth century and to compare the dials of illuminated night clocks with the availability of domestic lighting from the mid-seventeenth to the early-eighteenth century. In the case of both of these devices of enablement, the period in which they were in use and the apparent date of their disappearance is of paramount importance for understanding their use and understanding why they were not a part of the standard-format dial by 1770.

4.2 Ascertaining the time in the absence of full sight

An early modern person who could not, or had significant difficulty, reading the time from a traditional dial due to their eyesight was necessarily excluded and became a non-user of clocks and watches. However, the provision of touch-pins as part of a dial's format, used alongside the dial hand, gave such people a method of ascertaining the time by touch and enabled them to become active users. It also enabled active users to remain so and not become excluded due to changes in their eyesight. This is a context of dial use which has not been considered before. I have chosen the phrase 'absence of full sight' to distinguish

[6] Thompson, D. 2004. *Clocks.* London: British Museum Press, Thompson, D. 2007. *Watches.* London: British Museum Press.
[7] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.
[8] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club, Loomes, B. 1981. *White Dial Clocks: the Complete Guide.* Newton Abbot: David & Charles.

the specific need which touch-pins alone fulfilled. This was to enable clocks and watches, from the mid-sixteenth to the early-seventeenth century, to be used by people with varying levels of eyesight. This distinction is necessary given that the touch-pin was also of use for the second context of use which I consider in this chapter, which is ascertaining the time in the absence of light. However, in this section I argue that the touch-pin's primary use was for blind and partially-sighted users.

An absence of full sight encompasses a wide range of different levels of eyesight. Some people are partially sighted, either from birth or due to health problems such as age-related presbyopia. Some people are blind, either from birth or due to health problems. Rather than focussing on the health-related reasons as to why such users experienced difficulty using traditional dials, which would be known as a medical view of disability history,[9] my focus is on the responses made by late-sixteenth and early-seventeenth century clock and watch-makers to enable users. My view follows the cultural model of disability,[10] which emphasises that people are dis-abled by their environment rather than their bodies. The makers of clock and watch dials which required full sight to be read were guilty of dis-abling blind and partially-sighted users. These users were intellectually capable of processing the information gathered from touch and rendering it meaningful in terms of the hour hand pointing at the third touch-pin in the sequence indicating three o'clock for example. Clock-makers of the period knew this and provided the touch-pin as a device of enablement.

In this section I argue that there were three reasons why touch-pins were used as a tool of enablement for the partially-sighted and blind. This was because they were designed to suit early modern perceptions of the blind and partially sighted, to suit perceptions of the power of touch as a form of knowledge communication, and to suit users before spectacles were widespread or while they remained side-less. Changes to these two perceptions and the rise of spectacle use plus introduction of sides were factors which led to the decline of the touch-pin. However, there was no one definitive reason.

4.2.1 Early modern perceptions of blindness and the sense of touch

Touch-pins and the dial hand constitute a positional form of reading by touch (see figure 4.1). The user would need to be familiar with the temporal concept of twelve, or twenty-four hours, to be able to make sense of the dial. This indicates either a user who had

[9] Hobgood, A. and Houston Wood, D. 2013. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p.4.
[10] Ibid.p.5.

experienced visual degeneration, possibly age-related, but had been previously fully sighted and accustomed to reading a dial or a blind user who had learned to interpret objects by touch. Foucault claimed that sight prevails over the sense of touch, and indeed the other senses, because touch can only distinguish between rough and smooth.[11] He went on to conclude that: "…the blind man in the eighteenth century can perfectly well be a geometrician, but he cannot be a naturalist."[12] However, this is only the case if blind people are considered according to the medical view of disability mentioned above. If their environment does not dis-able them, then they are no less able than anyone else. According to the cultural view of disability, touch-pins demonstrate that if a device is designed with the blind or partially-sighted user in mind then positional reading, and thus ordering of information, can take place.

During the late-sixteenth century, attitudes to blindness were more inclusive than they were to become during the early-seventeenth century when the touch-pin had for the most part disappeared. Chess informs us that the inclusion of blind characters in early modern plays was significant as they were not being ignored.[13] Referring to a play based on the biblical account of Jacob and Essau,[14] she says Isaac's blindness was intended to show the audience that it was neither unique nor avoidable; it was just a part of getting older.[15] With blindness perceived in this manner, it is not surprising that clock and watch-makers chose to include the touch-pin as a tool of enablement. This indicates their desire not only to sell more timepieces, but to do so by realising different user needs; different contexts of use. Chess points to references in the early-seventeenth century to the blind as being miserable. She makes the link between increased circulation of texts, enabled by the printing press, leading to greater exclusion of the blind. This is inaccurate given that texts were not new to the seventeenth century. What had changed were public attitudes to the blind and this was conceivably one reason why the touch-pin disappeared from dials.

Taking inspiration from Wyatt, who distinguished between users and non-users,[16] I argue that touch-pins are a useful tool for distinguishing between users, potential users and

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[11] Foucault, M. 2001. *The Order of Things: an Archaeology of the Human Sciences.* London: Routledge.p.144
[12] Ibid.p.144-145.
[13] Chess, S. 2013. Performing Blindness: Representing Disability in Early Modern Popular Performance and Print. In: Hobgood, A.P. and Houston Wood, D. eds. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p.106.
[14] Genesis 27:1-40.
[15] Chess, S. 2013. Performing Blindness: Representing Disability in Early Modern Popular Performance and Print. In: Hobgood, A.P. and Houston Wood, D. eds. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p. 111-114.
[16] Wyatt, S. 2003. Non-Users Also Matter: the Construction of Users and Non-Users of the Internet. In: Oudshoorn, N. and Pinch, T. eds. *How Users Matter: the Co-Construction of Users and Technology* Cambridge Massachusetts: The MIT Press.pp.67-80.

non-users in the context of clock and watch dials. If a person could not physically see the information presented on the dial then they were excluded from, or dis-abled by, it and forced to be a non-user of that instrument. The use of a striking train,[17] which provides an audible time signal, permitted them to be potential users of the dial because they had the intellectual capability to interpret time as twelve (or twenty-four hours), but were not yet active users in the same way as the sighted. The blind or partially-sighted were passive in this context since they had to wait for the timepiece to strike in order to know the time, whereas the dial provided the sighted with an indication of time on demand. Touch-pins enabled potential, blind and partially-sighted, users of the dial to become active users. They could ascertain the time by touch whenever they chose.

Notwithstanding some casual references to the existence of touch-pins, no historian of horology has discussed how a user would orientate the timepiece to begin with. For dials with touch-pins to be interpreted effectively, the watch or clock had to be correctly orientated. Users could not count the number of pins between the start of the sequence and the pin being indicated by the dial hand without knowing where the start of the sequence was located. On some examples the pin located at the XII position was larger than the others, making orientation easy. Where the pin at the XII position was identical to the others the method by which the watch was orientated depended on the casing. Most watches had pendants from which they were attached, or hinges for lids, which acted as an orientation device. Horizontal table clocks (see figure 4.4) were more difficult to orient, but were perhaps not re-positioned very often. Weight-driven clocks (see figure 4.3) were always upright and so did not need to be oriented. The hour hand also had to be strong enough to be touched by the finger and rubbed without being damaged. The user needed to find the hour hand first and then move their finger along the stem to find the nearest pin and thus ascertain the time by counting the pins from twelve or twenty-four. This sensory process, repeated regularly, whenever the user wanted to know the time, coupled with the feel of the circular pins and the methodical counting from one pin to another, was also a devotional experience. In this sense, for Catholic users, it must have been reminiscent of praying with rosary beads.

The term ‘touch-pin’ is a modern horological term. The first references to them, though using a different term, were made in 1899 and 1929 by Britten[18] and Baillie[19] respectively. In 1899 Britten in his section on early watch-making in Germany described

[17] See appendix two for a definition of this horological term.
[18] Britten, F.J. 1982. *Britten's Old Clocks and Watches and their Makers.* 8th ed. edited by G.H. Baillie, Courtenay Ilbert, Cecil Clutton, 9th ed. revised by Cecil Clutton. ed. London: Methuen.p.41.
[19] Baillie, G.H. 1929. *Watches: their History, Decoration and Mechanism.* London: N.A.G. Press.p.59.

them as: "… knobs at each hour, which were provided on both watches and table clocks for feeling the time in the dark."[20] In 1929, Baillie described them in the same terms as 'feeling knobs' that were located at each hour and enabled "the time to be read in the dark."[21] Baillie said they were common until the mid-seventeenth century, whereas I found them to have declined by the early-seventeenth century with just one late example made around 1640.[22] Furthermore, by only providing examples of watches he implied that touch-pins were unique to watches, which is untrue. [23] Britten, on the other hand, acknowledged their presence on table clocks, but did not mention upright clocks whereas I have identified examples on those also. This supports my argument that there was a context of use for touch-pins other than in the dark. People were less likely to walk around a dark room feeling for their clock to ascertain the time than feel for a watch on their bedside.[24] Britten and Baillie's work focussed on the development of precision timekeeping, which means different contexts of use were beyond their scope.

Thompson accepts Britten and Baillie's interpretation by describing touch-pins himself as 'being located at each hour to allow the time to be found in the dark.' [25] This single reference is deemed sufficient by Thompson and he does not comment on them elsewhere in his book, even where there were images that provided the opportunity for doing so.[26] I am by no means denying that touch-pins were used to ascertain the time in the absence of light, which I discuss in the next section. Yet my reinterpretation of the touch-pin as an enablement device serves as a challenge to these hitherto uncontested claims. Furthermore, both Britten and Baillie suggested through their section headings that touch-pins were unique to Germany. However, I contest this view since I have identified examples from France (see figure 4.4), Italy, Switzerland, and England made by indigenous makers in the same period.[27] Indeed, there were more examples from Germany, but this apparent skew comes from the fact that more clocks and watches were made in Germany in the late-sixteenth century, when touch-pins were prevalent, so it is not surprising that there seem to be more examples of German dials with touch-pins.[28] Throughout this thesis I argue that the

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[20] Britten, F.J. 1982. *Britten's Old Clocks and Watches and their Makers.* 8th ed. edited by G.H. Baillie, Courtenay Ilbert, Cecil Clutton, 9th ed. revised by Cecil Clutton. ed. London: Methuen.p.41.
[21] Baillie, G.H. 1929. *Watches: their History, Decoration and Mechanism.* London: N.A.G. Press.p.59.
[22] See appendix one.
[23] See appendix one.
[24] Glennie and Thrift claim that most early modern clocks were located in the bedroom, hallway and kitchen Glennie, P. and Thrift, N.J. 2009. *Shaping the Day: a History of Timekeeping in England and Wales 1300-1800.* Oxford: Oxford University Press.p.174.
[25] Thompson, D. 2007. *Watches.* London: British Museum Press.p.15.
[26] Ibid. p.16;22;28.
[27] See appendix one.
[28] See appendix one.

various components of dial format and content that I discuss transcended national boundaries throughout the period 1550-1770.[29] Later on in this section I refer to other methods of enabling the blind and partially sighted and refer to the work of Eriksson who also claims there were no geographical boundaries with the production of tactile images.[30] Dials were not alone.

Figure 4.3[31]©British Museum

Figure 4.4[32] ©Musée du Louvre

Figure 4.5[33]©Musée des Beaux Arts

[29] There are perhaps two exceptions, astronomical teaching clocks made in England in the late-seventeenth and early-eighteenth centuries and tidal indication in the late-seventeenth century.
[30] Eriksson, Y. 1998. *Tactile Pictures:Pictorial Representations for the Blind 1784-1940*. thesis, Acta Universitatis Gothoburg University. 21-22.
[31] British Museum 1989,0914.1. Reproduced by kind permission of the Trustees of the British Museum.
[32] Musée du Louvre OA.8397. Reproduced by kind permission of Musée du Louvre.
[33] Musée des Beaux Arts, Montreal 2012.50 Jan Lievens, *Scholar at Desk*, 1630s. Reproduced by kind permission of the Musée des Beaux Arts.

Art works can help us get closer to imagining the user. I propose that a clock dial such as that in figure 4.3 and a watch dial such as that in figure 4.1, both with touch-pins, would have been highly useful to a person who was partially sighted or blind and must be viewed in this context. It could easily be imagined that the watch depicted on the table of a scholar such as the individual represented in figure 4.5 might be equipped with touch-pins to enable reading of the time. It looks similar to the small table clock seen in figure 4.4, or the watch seen in figure 4.1. Jan Lievens depiction of elderly sitters has been described as a 'sympathetic' one by Wheelock and Dickey.[34] His skill at rendering the chiaroscuro effects enabled him to present his figures as very close.[35] It is for both of these reasons that one can imagine that the man in figure 4.5 is just about to put down his quill and feel the time on the pocket watch next to his hand, before searching for his side-less spectacles to enable him to continue writing, as he is struggling to see. Furthermore, it is known that Lievens painted portraits for merchants[36] and painted scholars, identifiable by hats similar to that in figure 4.5, for patrons such as civic leaders.[37] Wealthy individuals such as these were the types of user I identified in chapter one.

All except one of the dials with touch-pins that I have examined date from the period 1550–1600.[38] This gives a commercial lifespan of fifty years. 1550 marks the date of the first widely-available watches,[39] meaning that touch-pins were not a new invention after their establishment as a commercial product. Clocks were not new in 1550, but domestic clocks[40] increased from the mid-sixteenth century and there were new types available, for example table clocks (such as figure 4.4) and an increase in weight-driven chamber clocks (such as figure 4.3). Thus touch-pins were part of the design of the earliest dials for domestic use. They were not present on all, but were on many. The apparent disappearance of touch-pins from both clock and watch dials in around 1600 is more significant for understanding their use than their first appearance on dials. This raises the question as to what had changed by 1600. I alluded above to changing attitudes towards the blind as one reason, but perhaps it was due to a change in attitude towards the senses rather than to a perceived disability.

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[34] Wheelock, A.K. and Dickey, S. 2008. *Jan Lievens: a Dutch Master Rediscovered.* New Haven, Connecticut: Yale University Press.p.120.
[35] Ibid.p.7.
[36] Ibid.p.164.
[37] Ibid.p. 186-187.
[38] See appendix one.
[39] The first known watch was made around 1524, but most extant examples date from the 1550s onwards, suggesting that this was when the watch became a commercial product.
[40] As distinguished from public turret clocks.

The different types of enablement device, of which touch-pins were a part, constituted a more positive attitude towards the partially sighted and the blind. In his in-depth survey of attitudes towards the blind as represented in art, Barasch stated that in the early-sixteenth century, the perception of blindness underwent change.[41] He refers to the book of emblems and blind man carrying the one-legged man. This was an image of limitations being overcome. This source and all of those instruments discussed in this section demonstrate that changing attitudes to blindness or failing sight meant that effort would have been made to provide people with a non-visual form of communication in this period.

The role ascribed to the senses within perceptions of cognition in this period was different from the role we ascribe to it today. Referring to the trilogy of object-medium-organ concept said to be the way in which Renaissance thinkers believed that knowledge was acquired from the senses, Mazzio claims that the sense of touch eluded these three categories.[42] However, the provision of touch-pins on dials indicates that touch was perceived by people during the mid-sixteenth to the early-seventeenth century according to this concept. In the case of the watch in figure 4.1 for example, the object is the dial consisting of twelve divisions with touch-pins and a hand indicating time, the medium is the touch-pins themselves, and the organ is the finger used to feel the position of the hand and count the touch-pins.

Figure 4.6[43] ©British Museum

Figure 4.7[44] © Museo Del Prado

[41] Barasch, M. 2001. *Blindness: the History of a Mental Image in Western Thought.* London: Routledge.p.122-123.
[42] Mazzio, C. 2005. The Senses Divided: Organs, Objects, and Media in Early Modern England. In: Howes, D. ed. *Empire of the Senses: The Sensual Culture Reader.* Oxford: Berg.p.88.
[43] British Museum 1958,1201.2112. Reproduced by kind permission of the Trustees of the British Museum.

Indeed Mazzio expresses disappointment that other historians have not considered the objects of touch, which she defined in terms of the theatre as the 'associated texts'.[45] However, by limiting herself to the basic relationship of person and a non-specific object which is only picked up and held, she is unable to consider objects which are interpreted by touch. Similarly, Chess also inadvertently limits her discussion of adaptive technology to the use of human guides, dogs, and canes by looking for references to how blind people navigated their way through an outside space.[46] Instead, by comparing representations of touch in art with touch-pins on dials, I can identify differences within the human capacity to derive meaning from touch. Jusepe de Ribera's painting *Sense of Touch,*[47] seen in figure 4.7 for example, depicts a blind man feeling the face of a statue in order to identify the subject. Sanchez and Spinosa inform us that Ribera's renowned skill at creating a sense of realism and heroism[48] is clear in this case. They point to the rendering of the elderly man's closed eyelids, representative of blindness, his dirty fingernails, his wrinkled skin to show movement of the hands, the application of pressure through touch, and the look of concentration on his face bringing out the essence of touch.[49] The painting certainly shows the acquisition of knowledge through touch, and more so than Foucault allowed for as mentioned above, but it was just one type of interpretation by touch. Distinguishing a particular face is not the same as reading the indication of a constantly changing instrument such as the timepiece in figure 4.6. Dials with touch-pins are tangible evidence of the way in which people from the mid-sixteenth to the early-seventeenth century perceived the sense of touch. They believed touch had the capacity to be used as a tool, which enabled communication between maker and user through a mechanical instrument.

4.2.2 The influence of spectacles

The early modern perception of spectacles as a visual aid was not uniform. There were at least two opposing views, which are best expressed by reference to the author Bartisch[50] on the one hand and the engraver Stradanus[51] on the other. The late-sixteenth and early-

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[44] Museo Del Prado PO1112, Jusepe Ribera, *The Sense of Touch*, 1632. Reproduced by kind permission of the Museo Del Prado.
[45] Mazzio, C. 2005. The Senses Divided: Organs, Objects, and Media in Early Modern England. In: Howes, D. ed. *Empire of the Senses: The Sensual Culture Reader.* Oxford: Berg.p.87.
[46] Chess, S. 2013. Performing Blindness: Representing Disability in Early Modern Popular Performance and Print. In: Hobgood, A.P. and Wood, D.H. eds. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p.114-115.
[47] Jusepe Ribera, *The Sense of Touch*, 1632.
[48] Perez Sanchez, A.E. and Spinosa, N. 1992. *Jusepe de Ribera 1591-1652.* New York: Metropolitan Museum of Art: Distributed by Harry N. Abrams.p.xii.
[49] Ibid.p.97-98.
[50] Dr Georg Bartisch, 1535-1607, was a medical practitioner working in Germany.
[51] Johannes Stradanus, active in 1590, was born in Bruges and moved to Italy.

seventeenth century genre of pamphlet which listed and described the various health problems that could affect the eyes, such as Banister's *A Treatise of 113 Diseases of the Eye*,[52] advised against sleeping in damp places and closing the windows at night to preserve the eyesight. There are no suggestions in these texts about what to do if your sight was damaged or deteriorated. I interpret the lack of even a reference to spectacles as an indication that in this context the authors were not thinking about how they could assist the partially sighted or blind. Their priority was to preserve sight. While there might appear to be nothing too unusual about this attitude, it becomes significant in the context of similar publications such as Bartisch who in 1583 stated that:

> Spectacles are harmful. It is much better and more useful that one leaves spectacles alone. For naturally a person sees and recognises something better when he has nothing in front of his eyes than when he has something there. It is much better that one should preserve his two eyes than that he should have four.[53]

Bartisch's use of the word 'harmful' is significant. It suggests that despite spectacles becoming widespread, some people avoided them in the hope of preserving the level of sight they possessed. Devices such as touch-pins that enabled the partially-sighted to get-by would be valuable in this context. It is surprising to a modern reader that some people in the period thought negatively about spectacles. However, in one sense this explains the use of touch-pins on early dials and the disappearance of them around 1600 when attitudes such as Bartisch's disappeared and spectacles became more widespread. Indeed, I interpret Rosenthal's findings that spectacles were out of fashion with the upper classes across Europe in the sixteenth century as evidence of the consequences of fear generated by such pamphlets.[54] Moreover, Bartisch's insistence that 'two imperfect eyes were better than four' implies that he perceived of spectacles as devices that enhanced vision to a point where things were not seen as they truly were; spectacles compromised the ability to acquire truth. The implied risk was that objects and truths would not be recognised. Following this line of thought, it is conceivable that spatial memory, or the construction of images in the mind based on memory, enabled a person to recognise something which they could no longer see properly. Dials with touch-pins constituted an enabling device for such a user.

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[52] Banister, R. 1622. *A Treatise of One Hundred and Thirteene Diseases of the Eyes and Eye-Liddes. Translated from J. Guillemeau.* London: F. Kyngston for T. Mann.
[53] Goerg Bartisch, '*Ophthalmodouleia Das ist Augendienst'* part translated in Corson, R. 1980. *Fashions in Eyeglasses.* 2nd ed. ed. London: Peter Owen Ltd.p.37.
[54] Rosenthal, W. 1996. *Spectacles and Other Visual Aids.* San Francisco: Norton.p.40.

An alternative view was expressed in a series of eighteen prints entitled *Nova Reperta* (New Discoveries) by Stradanus in 1590[55], one depicts horology (see figure 4.8) and one depicts spectacles (see figure 4.9). Although neither were absolutely new inventions in 1590, that they were included in the series demonstrates that they were becoming more widespread. As Vannucci *et al* inform us it was significant that inventions from the period were depicted and not from the Classical world.[56] This was indicative of a sentiment of optimism and a forward-looking focus in addition to a reverence for the Classical past.

Figure 4.8[57] ©British Museum

Figure 4.9[58] ©British Museum

[55] Johannes Stradanus, *Nova Reperta*, 1590.
[56] Baroni Vannucci, A., Sellink, M., Cecchi, A., Janssens, S. and Paumen, V. 2012. *Stradanus 1523-1605: Court Artist of the Medici.* Turnhout: Brepols.p.148.
[57] British Museum 1958,1006.3048. Reproduced by kind permission of the Trustees of the British Museum.
[58] British Museum 1948,0410.4.205. Reproduced by kind permission of the Trustees of the British Museum.

This notion of optimism with regard to the capability of technology can be expanded. The Latin caption beneath figure 4.9 can be translated as: "Eyeglasses have been invented which remove the more obscure diseases of the eyes."[59] Unlike the authors of tracts on the preservation of sight, such as Bartisch, Stradanus represented people who conceived of spectacles as a form of treatment or an aid. To which diseases Stradanus referred is not clear, but perhaps it was a cure for the inability to read and thereby acquire knowledge, given that he represented most of the figures wearing spectacles as being engaged in reading. Indeed, his depiction of a blind man being led by a dog, and not included in the group of readers, in the background (see figure 4.10) is a strong statement about past and future. The spectacles are the device of the future whereas those not wearing them are relegated to the distant past.

Furthermore, the seated figure approximately in the centre of the print (see figure 4.11) is wearing spectacles, has some work on their lap and has a raised right hand with an extended index finger. In the history of art this pose has been interpreted as a tool to guide the viewer's eyes.[60] In some paintings this is to religious figures and represents divine truth. Thus, in this figure Stradanus suggested that with the aid of spectacles, an individual could move closer to truth, which is in direct contrast to Bartisch's view written less than a decade earlier. If users wanted to gain the truth about time from dials they needed to see them properly. It is conceivable that touch-pins disappeared from dials once ideas such as Stradanus' took hold. In this period it could have taken forty years for this to happen if tracts such as Bartisch's professed that spectacles were not only best avoided, but were genuinely harmful.

[59] Translation kindly provided by Dr. Sophie Weeks, University of York.
[60] Johnson, G.A. 2005. *Renaissance Art: a Very Short Introduction.* Oxford: Oxford University Press.p.78.

Figure 4.10[61] ©British Museum

Figure 4.11[62] ©British Museum

While critics might argue that spectacles were readily available to the wealthy owners of clocks and watches during the sixteenth century, it is nevertheless true that in the sixteenth and early-seventeenth centuries people continued to produce aids for the partially sighted and blind. Having examined many examples of tactile images, Eriksson claims that in the seventeenth century individuals made their own for relations and people in the community, but they were not commercially available.[63] It is conceivable that touch-pins were influenced by this wider tradition of assisting the partially-sighted and blind to acquire knowledge and not just get-by, as Mazzio and Chess inadvertently suggest through their examples as noted above. Writing in 1873, Moon began his work on a system of reading for the blind by saying that: "More than three centuries have elapsed since the first attempt was made to provide means for the Blind by which they could read for themselves…"[64] referring to engraved forms of letters on blocks of wood in the late-sixteenth century. Moon said that this attempt was not successful because the text was not in relief form. If Moon's statement of the efficiency of the relief method of engraving is correct then it provides a firm link between block engraving and touch-pins. It indicates that touch-pins were deliberately included by clock and watch-makers because they were useful for blind and partially-sighted users. Nevertheless, it wasn't until 1623 that the first text was dedicated to spectacle use, which indicates that they experienced a rise in popularity in the early-seventeenth century in around the same period that touch-pins went into sharp decline.[65]

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[61] British Museum 1948,0410.4.205. Reproduced by kind permission of the Trustees of the British Museum.
[62] Ibid. Reproduced by kind permission of the Trustees of the British Museum.
[63] Eriksson, Y. 1998. *Tactile Pictures:Pictorial Representations for the Blind 1784-1940*. thesis, Acta Universitatis Gothoburg University.p.21.
[64] Moon, W. 1873. *Light for the Blind: a History of the Origin & Success of Moon's System of Reading for the Blind.* London: Longmans.p.1.
[65] Benito, D.V. 1623. *The Use of Spectacles.*

User-interaction was required to operate and read volvelles in textual sources, which consisted of arms and wheels that had to be turned by the user in order to set them before the indicated information could be read, for example Apianus' volvelles seen in figure 4.12.[66] While most volvelles were not constructed with the enablement of the partially-sighted or blind in mind, the tradition of providing information in a way that required user interaction was a tradition from which makers that included touch-pins drew inspiration. In this sense touch-pins had a third purpose which was reinforcing information for the sighted. A person often remembers information acquired through the combination of a physical task and reading rather than by simply looking at something, so it is likely this was an aid to the mnemonic method. Giordano Bruno claimed that physically making one's own mnemonic images was very important since the act of assigning an image to a subject or concept and then drawing it reinforced that subject or concept in the mind.[67] This idea is most conceivable within the context of multi-function dials such as that in figure 4.13. That touch-pins were not only present on dials that only represented the hour, indicates that they served different purposes on different dials. This distinction between different types of dial within the context of touch-pins has not been made before.

Touch-pins featured on both multi-function dials and dials that only represented the hour and quarters. In some examples they were used over two hour schemes, where they were represented using concentric rings. In other examples they were used on subsidiary dials to indicate the quarter hours and sometimes the alarm-setting subsidiary dial. To the best of my knowledge there are no examples where touch-pins were used to communicate other information such as calendrical or lunar information. It is likely that if touch-pins were used on all the indices of a multi-function dial then calendrical information such as the twelve months would be confused with indication of the twelve hours, as there would be two sets of twelve touch-pins, and there was no easy way of standardising it. This indicates a partially-sighted user who was aware of each new day and did not need touch-pins on the calendar function, but struggled to quickly and easily distinguish between the different hours.

[66] Apianus, P. 1550. *Cosmographia.* Vaeneunt G. Bontio: Antuerpiæ.
[67] Luthy, C. 2010. Centre, Circle, Circumference: Giordano Bruno's Astronomical Woodcuts. *Journal for the History of Astronomy.* 41(3).p.311.

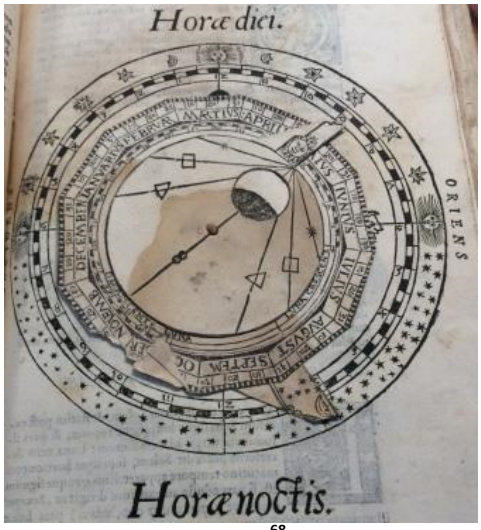

Figure 4.12[68]

Figure 4.13[69] **©Society of Antiquaries**

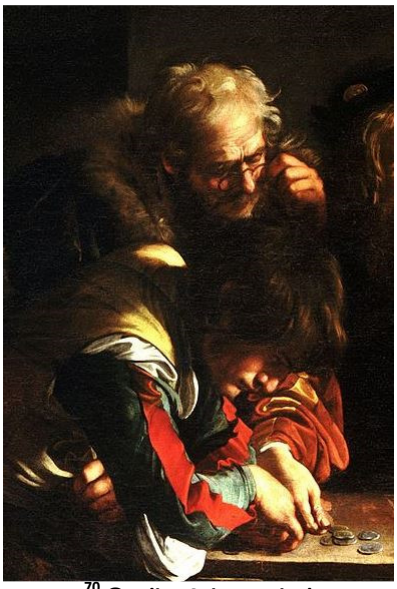

Figure 4.14[70] **©Eglise Saint Louis des Français**

Further evidence against criticism that spectacles were readily available in the late-sixteenth century can be found in a pamphlet published in around the same period that the last dials were being made with touch-pins in the early-seventeenth century. It was entitled *A Sight of ye Trans-actions of these latter yeares Emblemized with engrauen plats which men may read without spectacles*.[71] It is a summary of the English civil war up to 1646 presented in graphic form. Readers interpret events through pictures from one box to the next without having to read any text. It represents another form of enablement and is self-styled

[68] Apianus, P. 1550. *Cosmographia.* Vaeneunt G. Bontio: Antuerpiæ.
[69] The Society of Antiquaries LDSAL.131. Reproduced by kind permission of the Society of Antiquaries of London.
[70] Eglise Saint Louis des Français: Caravaggio *The Calling of Saint Matthew*, 1599-1600. Reproduced by kind permission of the Eglise Saint Louis.
[71] Vicars, J. and Hollar, W. 1646. *A Sight of ye Trans-actions of these Latter Yeares Emblemized with Engrauen Plats which Men may Read without Spectacles.*

as such. It also serves a rhetorical purpose, suggesting that opinions and judgements are not needed to understand it, but nevertheless it remains a form of communication which could be interpreted without reading the text. Its claim to be understandable without the need for spectacles speaks to the impracticality of spectacles before sides were introduced to them in the mid-seventeenth century, which meant examples before this date could not be worn easily if the wearer wanted to move around.[72] Figure 4.14 depicts the way in which early spectacles were worn in the late-sixteenth and early-seventeenth century when this work was painted. They were either balanced on the nose or help up to the face. In this work by Caravaggio, a master of the chiaroscuro technique, the elderly man holding his spectacles stoops to read the tokens/coins held by a young man seated at the table in front of him. Despite this not being the central point of this painting, which tells the religious story of the calling of St. Matthew, Caravaggio's trademark rendition of lifelike people represented not in poses but engaged in activities, gives us an insight in to the experience of using spectacles without sides for the elderly in this period. Varriano observes that none of the characters in the painting interact with the viewer.[73] Caravaggio has thus worked hard to create a busy, realistic scene that is believable to the viewer, given that no one character appears to engage with them. This was the same period that touch-pins were prevalent on dials.

In every-day use side-less spectacles such as those in figure 4.14 were more difficult to use than those with sides, improvised versions of which began to emerge in the mid-seventeenth century.[74] Side-less spectacles could become easily lost, or simply left behind, and were not efficient for use on the move. If a user was seated reading, with spectacles balanced on their nose, and had a watch next to them they would be able to read the time, but would need to carry spectacles around with them for reading clocks in other parts of the building. Spectacles with sides on the other hand enabled the user to move from one task to another with more ease. Additionally, as Ilardi claims, spectacles needed to be repaired regularly,[75] which I interpret as evidence that they were not always to hand when required. For the period in which they were made from the mid-sixteenth to the early-seventeenth century, touch-pins on dials served a similar purpose as pamphlets such as the graphic representation of the civil war. They enabled the partially-sighted to read the indicated time

[72] Corson, R. 1980. *Fashions in Eyeglasses.* 2nd ed. London: Peter Owen Ltd.p.31.
[73] Varriano, J.L. 2006. *Caravaggio: the Art of Realism.* Pennsylvania: Pennsylvania State University Press.p.40.
[74] http://www.college-optometrists.org/ which provides online content. For more information see the section on spectacles and sides within the online exhibitions section.
[75] Ilardi, V. 2007. *Renaissance Vision from Spectacles to Telescopes.* Philadelphia, PA: American Philosophical Society.p.210.

without putting on spectacles. The emergence of side-less spectacles occurred in a similar period as the disappearance of touch-pins from dials and was one reason for their decline.

Wadsworth, writing about the quarter-repeat mechanism, which I refer to in the next section, describes the process of feeling the time in the dark as only possible because of the poor time-keeping ability of pre-pendulum clocks and pre-balance spring watches.[76] This is a rather anachronistic view given that the touch-pin's primary use was as a tool of enablement for the blind and partially-sighted user. His claim that the decline of ascertaining the time through touch was due to its replacement by the quarter-repeat mechanism is also incorrect. Touch-pins declined at least sixty years before the introduction of the repeat mechanism.

Touch-pins did not form part of the standard format by 1770. As soon as two-handed dials and the minute representation were made from 1657 and 1675 onwards, being able to touch the dial was made difficult by a more sensitive and fragile set of dial hands. When white enamel dials, which were completely smooth, were first used from around 1727 onwards reading by touch was not possible.[77] However, by this time spectacles with sides were much more prevalent and users' needs had changed. Touch-pins provide another example of clock and watch dials reflecting the changing practical needs of their users. Having identified one aspect of dial format designed as a form of enablement, I now move on to the only other commercially-available example of the period.

4.3 Ascertaining the time in the absence of light

Writing in 1975, Brusa concluded his article on the origin of the illuminated night clock by stating that he hoped for future research on the subject.[78] After forty-one years, this section offers three new angles of interpretation through a focus on the illuminated night clock as a tool of enablement. Firstly, it was a tool for physically seeing the time in the dark for which users had a need in this period. Secondly, it was a symbolic tool for contemplating human dominance of the night, or the overpowering of the limitations imposed by the absence of the sun's rays. Thirdly, it was a tool of religious devotion. However, the illuminated night clock, referred to hereafter simply as 'night clock', declined during the early-eighteenth century and was not part of the standard format by 1770. There was no single cause of its disappearance and it is only through a consideration of its contexts of use that we can

[76] Wadsworth, F. 1966. A History of Repeating Watches Part 3. *Antiquarian Horology.* 5(2).p.364.
[77] Until the braille watches of the twentieth century.
[78] Brusa, G. 1975. Italian Night Clocks. *Antiquarian Horology.* 9(2).p.167.

improve our understanding of the combination of influences which led to its decline. Similarly to Topham's claim that the experience of reading the same text differed according to where it was read,[79] so the experience of using dials differed according to its context of use.

Historians of horology have not considered night clocks from this enablement angle before. Thompson refers to an example by Pietro Tomasso Campanni and another by Edward East. While he refers to the origin of the former, utilising Brusa's research, he does not offer any comment on the use, other than that these were night clocks which would have been situated in the bedroom.[80] Similarly, Britten's volume includes just one example, for which he used a single caption to say that it was a night clock and how it worked in terms of the moving aperture.[81]

Returning to the literature on the history of disability, in this section I consider the way in which clock and watch-makers provided aids to users who were dis-abled by the natural disappearance of light at the end of the day. According to the cultural view of disability,[82] mentioned above, the environment and society dis-ables a person. If clock and watch users were required by society to know the time in the dark but had no easy means of creating a light to read their dials, they were by this definition dis-abled by society and their environment. Through the dial of the night clock (such as that seen in figure 4.2), clock-makers empowered sighted-users by enabling them to read the time in the dark in the traditional manner rather than drawing on another of the five senses as touch-pins had. The night clock emerged in the mid-late seventeenth century and disappeared by the early-eighteenth century.

Mechanical timepieces were devices of enablement in and of themselves. Historians of horology, such as Christianson,[83] emphasise the fact that a means to measure time without reliance on the Sun during overcast days and long winter nights was perceived as immensely beneficial during the sixteenth century. Clearly this was one of the reasons for the rapid, widespread acceptance of mechanical timepieces throughout Europe. However, the user required artificial light to read traditional dials at night. Light was the second pre-requisite for an effective visual communication device as established at the beginning of this

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[79] Topham, J. 2010. Science, Religion, and the History of the Book. In Dixon, Thomas, Cantor, Geoffrey, and Punfrey, Stephan. eds. 2010. *Science and Religion: New Historical Perspectives*. Cambridge: Cambridge University Press.p.224.

[80] Thompson, D. 2004. *Clocks.* London: British Museum Press.

[81] Britten, F.J. 1982. *Britten's Old Clocks and Watches and their Makers.* 8th ed. edited by Baillie, G.H., Ilbert, C. A., and Clutton,C. 9th ed. revised by Clutton, C. eds. London: Methuen.p.103.

[82] Hobgood, A. and Houston Wood, D. 2013. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p.5.

[83] Christianson, D. 2002. *Timepieces: Masterpieces of Chronometry.* Newton Abbot: David & Charles.p.9.

chapter. For situations where light was absent, or too difficult or costly to produce for quick time-checking, clock-makers experimented with devices that enabled users to ascertain the time without the need of an artificial light.

In addition to the night clock, there were two other ways in which this was achieved and none were entirely free from problems until the means for achieving instant light, which could quickly be turned on and off, were developed. Christianson informs us that this was not until 1855 when striking matches became widely available.[84] Indeed, the existence of matches called 'Dowler's nocturnal vesta' made in the 1850s by Bryant and May indicates that people were still struggling with creating a light quickly in the mid-nineteenth century.[85] In chronological order, the first device which was probably used, although certainly not primarily designed, for ascertaining the time in the dark was the touch-pin discussed in the section above. The second was the night clock where numerals were illuminated in a rotating aperture on the dial. As the numeral moved along the aperture it indicated the hour and quarter on an index below. The third was the quarter-repeat mechanism, which enabled the user to pull a lever or press a pin and the timepiece would strike the last hour and quarter on demand. This development provided a safer alternative to the night clock, which was a fire risk, and continued as a means for ascertaining the time in the absence of light beyond the other two devices. However, it could not be said that the night clock replaced the touch-pin, which had generally declined at least fifty years beforehand. The reason for this, as I demonstrated in the previous section, was that the touch-pin was primarily designed for use by the blind and partially sighted, although ascertaining the time at night was also one of its uses. The quarter-repeat function involved the mechanism and the case, there was no sign of it on the dial.

4.3.1 A tool of enablement within the context of early modern domestic lighting

Context is absolutely crucial to understanding the significance of the night clock as a form of enablement. The work of historians of light, an under-researched area, such as O'Dea[86] and Bowers[87] reveal that once the household fires and candles had been extinguished for the night, it was not practical or economical to create lights for one-off purposes. Bowers informs us that the cost of candles represented a significant part of most people's budgets,[88]

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[84] Ibid.p.118.
[85] Christy, M. 1926. *The Bryant and May Museum of Fire-Making Appliances.* London: Bryant & May Ltd. See entry for Dowler's nocturnal vesta.
[86] O'Dea, W.T. 1958. *The Social History of Lighting.* London: Routledge & Kegan Paul, O'Dea, W.T. 1966. *Lighting 1: Early Oil Lamps and Candles.* London: H.M.S.O.
[87] Bowers, B. 1998. *Lengthening the Day: a History of Lighting Technology.* Oxford: Oxford University Press.
[88] Ibid.p.16.

meaning they wouldn't have been wasted to just check the time in the night. We get an insight in to the impracticality of domestic lighting of the period from O'Dea where he foregrounds his work on lighting the home with a chapter entitled 'bad light', on the first page of which he says that from 15000 years before Christ until 1782: "...there was practically no improvement in lighting at all."[89] The most important part of this statement is not its huge timespan, but the year in which it ends, with the arrival of the Argand lamp. 1782 is twelve years beyond the temporal parameters of this thesis, so O'Dea's information gives us an indication of the lighting challenges faced by users of each of the dials considered in this thesis.[90] However, it must be remembered that this was a view expressed in order to contrast later developments in lighting; to show the real difference that they made. O'Dea also informs us that experiments with gas lamps took place from the 1730s.[91] While it is true that the wealthy owners of clocks and watches would have been able to afford these, it would have been equally impractical to ignite a gas lamp for quick reference of the time in the middle of the night. Thus, the findings of this section will expand O'Dea's critique by providing additional information on the kinds of tasks that people in the period needed light for, which in this case was the use of clock and watch dials in addition to activities such as reading and writing.

Figure 4.15[92] ©The J. Paul Getty Museum

[89] O'Dea, W.T. 1958. *The Social History of Lighting.* London: Routledge & Kegan Paul.p.1.
[90] See chapter two for a discussion of the implications of fire and candle light for dial contrast in the period.
[91] O'Dea, W.T. 1967. *Lighting 2: Gas, Mineral Oil, Electricity.* London: H.M.S.O.p.2.
[92] The J. Paul Getty Museum 86.PB.732. Gerrit Dou, *Astronomer by Candlelight*, c.1650s. Reproduced by kind permission of the J.Paul Getty Museum.

The painting in figure 4.15 shows the way in which people used candles to work when it was dark in the early modern period. In this work Gerrit Dou depicts an astronomer/astrologer[93] working in to the night with the help of a candle. Dou was a master of the chiaroscuro method and rendering a realistic sense of the effect of different light sources.[94] The painting helps us to imagine the difficulties faced by a clock or watch user wanting to know the time once it was dark. The man in this painting is making use of an hour-glass to keep a record of the time passed. This may have been sufficient for working during the night by candlelight, but would be of no use for quick-reference of the time once the candle had been extinguished. Not only was it expensive to keep candles burning and impractical to light one to note the time, but a single candle used for working did not light an entire room. A night clock such as that seen in figure 4.2 was a solution offered by clock-makers for wealthy clients.

Night clocks disappeared once their use was no longer required in the early-eighteenth century. However, given the claim made by O'Dea that lighting continued to be incredibly poor before 1782 they must have declined for another reason. Historians of horology such as Thompson[95] describe these clocks as purely used to physically see the time in the dark. However, their overall focus on the development of precision timekeeping has meant that they've judged early modern clocks and watches by that criterion alone. Thus, in their view, touch-pins and night clocks were fads in the history of horology, relevant to a society where domestic lighting was poor. By not engaging with the historiography of lighting in this period and not mentioning it with respect to any other types of clock, they inadvertently present the view that lighting had improved so much by the early-eighteenth century that the night clock was no longer needed. However, this was not the case and indeed was not the view such historians argued for explicitly either. In fact, historians such as Brusa[96] argue that the night clock was superseded by the quarter-repeating mechanism invented by Daniel Quare in the late-seventeenth century which I will return to below. However, this is an example of where the approach which considers purely the technical development of a technology in more-or-less isolation with only a few casual references to the wider context, limits itself in terms of what it can reveal and sends mixed messages about specific types of clock.

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[93] As noted throughout the thesis, in the early modern period there was not a strict distinction between astronomy and astrology.
[94] http://www.getty.edu/. See entry for *Astronomer by* Candlelight by Dou.
[95] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.72;78.
[96] Brusa, G. 1975. Italian Night Clocks. *Antiquarian Horology.* 9(2).p.166.

Night clocks cannot be understood purely in terms of lighting technology or technical development; they were not merely an alternative to a lamp. To understand their purpose fully, we need to know why clock and watch users wanted to know the time in the dark.

4.3.2 A tool for ascertaining the time in the dark

In chapter one users were defined as encompassing wealthy merchants who travelled across Europe. While Maczak,[97] a historian of travel, informs us of the experience of the traveller arriving at an inn in early modern Europe including the food, staff, and rooms, he neglects to comment on the lighting. He dedicates a chapter to the reading and writing conducted by the traveller, but does not provide information on when and in what context this reading and writing took place. Presumably it was in the evening by candle light after a day's travel. Similarly, Maczak does not discuss how a traveller awoke in the morning or caught the next coach. With a lack of information the reader is left to imagine that the innkeeper woke all the lodgers at once in the morning so that they would be on their way. However, many watches from this era were fitted with alarms, which must have been useful while traveling.

Whereas Maczak is unhelpful in ascertaining concepts of dial use, historians of the night, another under-researched area, such as Koslofsky[98] are more helpful. He informs us that up until the eighteenth century people in the early modern period often separated the night in to two periods of sleep, balanced between a periods of at least one hour of wakefulness in which they busied themselves with various tasks.[99] He is unclear about what these tasks were, but nevertheless this tells us that clock and watch users did have a genuine need to know the time in the dark so as to manage their night. Night clocks would have been useful in this context. This evidence runs in contradiction to O'Dea's statement that activity ceased once the Sun went down[100] and in fact shows that the situation was more complex. Indeed, sources of early modern health advice refer to the first and second period of sleep. In his *The Boke for to Learne a Man to be Wyse in Building of his Howse for the Health of Body* of 1550, Andrew Boorde advised: "…When ye be in your bed, lye a lytell whyle on youre left side and slepe on your right syde, and when you do wake of your first

[97] Maczak, A. 1995. *Travel in Early Modern Europe.* Cambridge: Polity Press.p. 41-44; 50-51; 54-62.
[98] Koslofsky, C. 2011. *Evening's Empire: a History of the Night in Early Modern Europe.* Cambridge: Cambridge University Press.
[99] Ibid.p.6.
[100] O'Dea, W.T. 1958. *The Social History of Lighting.* London: Routledge & Kegan Paul.p.21.

slepe make water yf ye fele your bladder charged, and then slepe on the left syde."[101] References such as this continued up until the end of the seventeenth century.

Critics might argue that knowing the time was irrelevant before the era of the pendulum in 1657, but temporal references in various texts from the period suggest otherwise. If a user lived by set hours, as was recommended by writers such as Francis Quarles[102] in 1698, then knowing when to get up and when to continue sleeping was important. Quarles advised: "…keep temperate diet, use moderate exercise, observe reasonable and set hours for Rest; let the end of thy first sleep raise thee from thy repose: then hath the body the best temper…"[103] Astrological works, such as almanacs, advised of the best times to conduct certain activities such as planting seeds in the night, which I discuss in detail in chapters five to seven on calendrical, lunar and astronomical knowledge. This was another reason that people needed to be able to ascertain the time in the dark. Thus my work on night clocks contributes to the broader history of the night in the early modern period.

If a user had to rise in the night to pray or conduct household activities then they would light a fire and read the time in the usual way, but if they wanted to be sure they were not rising too early then they may want to consult the timepiece during restless hours. Touch-pins on watches, before the early-seventeenth century, and the night clock of the mid-late seventeenth to early-eighteenth century would have been useful in this context. Touch-pins on clocks would not have been useful given that they were probably situated at a different place in the room or in another room, which would have been difficult to access in the dark.

4.3.3 A symbolic tool

Despite its clear practical use, the night clock also had a symbolic use in terms of representing the spirit of human dominance over the night and thus triumph over nature's limitations. This is significant with respect to Koslofsky's point that in early modern Europe, the night imposed fundamental limits on daily life and served as a symbol of those limits.[104] However if this line of thought is taken one step further to consider the various tools designed to enable people during the night, the illuminated-night-clock maker's (and indeed

[101] Boorde, A. 1550. *The Boke for to Learne a Man to be Wyse in Building of his Howse for the Health of Body* London.
[102] Quarles, F. 1698. *Wisdom's Better than Money or The Whole Art of Knowledge and the Art to Know Men.* London.
[103] Ibid.
[104] Koslofsky, C. 2011. *Evening's Empire: a History of the Night in Early Modern Europe.* Cambridge: Cambridge University Press.p.1.

the artificial-light maker's) attempts to solve the challenges posed by the night constitute a challenge to these natural limits. In this sense the night clock is a symbol of the mechanical approach to nature.

Koslofsky terms the process of increased activity during the night as the 'nocturnalisation of early modern life,'[105] which he dates to taking place after 1650. This is significant given that the first night clocks appeared only fifteen years later in around 1665. Indeed, diaries from the period reveal that people possessed both an awareness of the time and a clock consciousness concerning the night. The Diary of Roger Lowe, written in the late-seventeenth century, used temporal references in his entries, including night hours to refer to when he had been out: "…So John and I went and stayd till 12 clock in night drinkeing, and afterwards we came home..."[106] Lowe had at least one clock from the inventory of his estate,[107] which suggests that he used this timepiece to make the temporal references in the diary, checking when he got home or when certain events took place for example.

Koslofsky's weakness is his lack of attention to technology which enabled early modern people to make use of the night. In this discussion of 'nocturnalisation' he refers to street lighting, but not to other devices. Candles, flint and tinder, and night clocks were an essential part of the process of human dominance of the night, as I emphasise here. Night clocks were not random toys; they played an important representational role in this changing context.

4.3.4 A devotional tool

Until now no historian has considered the night clock within the context of religious devotion. Art works are helpful here, but these have not been used to their full potential by historians of horology, who focus only on those which depict a timepiece. Such an approach is extremely limiting as it is the wider context that improves our knowledge of clocks and watches. The night was often represented in seventeenth-century art using a scene with a woman deep in thought such as Georges La Tour's *Repentant Magdalen* of 1635-40 seen in figure 4.16. The night was clearly a time for quiet contemplation. La Tour is known for the

[105] Ibid.p.1-5.
[106] Lowe, R. and Winstanley, I.G. 1994. *The Diary of Roger Lowe of Ashton-in-Makerfield, Lancashire, 1663-1678.* Wigan: Picks.p.80.
[107] Ibid.p.134. The clock is described simply as 'one clocke weights and case'.

powerful silences that he created in his paintings.[108] This striking effect is comparable to the effect created by the illuminated numerals on the night clock in figure 4.17.[109]

While the term 'night clock' is a modern horological one and it is not known how people in the early modern period referred to them, the adjective 'illuminated' captures the essence of the religious use of this type of clock. In this context, the night clock of the late-seventeenth and early-eighteenth century was both practical and a tool of devotional enablement. It provided the user with a visual focus when the fire or candle had been put out. Its illumination of a specific hour, whose numeral was seen to move from one quarter to the next along the semi-circular aperture, in the same manner as the wandering hour watches discussed in chapter three, was significant. The hours had a long history of religious importance, which is evident from the numerous 'Books of Hours' created to contain prayers appropriate to different parts of the day. I argued in section 4.2 that touch-pins from the mid-sixteenth to the early-seventeenth century also had a devotional use similar to the rosary, the night clock conceivably provided a similar service during the late-seventeenth and early-eighteenth century. Indeed, as Koslofsky points out the act of waking oneself during the night for the prayers of the 'Nocturnal Offices' was perceived as a significant act of self-denial.[110] I interpret this private devotion during the night as a nocturnal path to the divine, which was represented as a travelling hour on the night clock. The limited light provided by the candle in La Tour's painting and the night clock in figure 4.17 are both indicative of the divine light that draws the eye and could bring the viewer one step closer to God.

[108] http://www.nga.gov/. See entry for *Repentant Magdalen* by Georges La Tour.
[109] Pictured as seen in the British Museum gallery with a light illuminating the numerals as an oil lamp would have done in the late-seventeenth century.
[110] Koslofsky, C. 2011. *Evening's Empire: a History of the Night in Early Modern Europe.* Cambridge: Cambridge University Press.p.75.

Figure 4.16[111] ©National Gallery of Art

Figure 4.17[112] ©British Museum

Indeed, the night clock had a religious origin, which adds weight to my argument. It was requested by Pope Alexander VII in 1655.[113] Brusa informed us that the Pope asked for a clock to: "…show the hours clearly during the night but in such a way that the eyes of the viewer should not be annoyed by the light of an oil lamp….", which was often placed in front of a clock.[114] Brusa did not elaborate on the issue of use driving clock design. For him the use was an obvious one, for physically reading the time, but within the wider context of early modern perceptions of the night and of religious devotion it was more significant than he realised.

In an attempt to contextualize the night clock within the development of dials generally, Brusa claimed that before the accurate timekeeping of the pendulum in 1657 this aperture method of representing the time was preferred to the conventional single-handed dial prevalent in this period. However, this was not the case. In fact, the night clock and its use of the aperture was an enablement device. The similarity with the wandering-hour display on watches, which Brusa claimed was an imitation, was actually the result of a much bigger issue of user reluctance to the new minute display as my discussion of it as a transition device to generate trust in the preceding chapter demonstrated.

For Brusa, as noted above, the decline of the night clock was a consequence of their high cost and that they were superseded by the quarter-repeat mechanism.[115] Some

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[111] National Gallery of Art, Washington, 1974.52.1. Georges La Tour, *Repentant Magdalen*, 1635-40. Reproduced by kind permission of the National Gallery of Art.
[112] British Museum 1980,1002.1. Reproduced by kind permission of the Trustees of the British Museum.
[113] Brusa, G. 1975. Italian Night Clocks. *Antiquarian Horology.* 9(2).pp.159-168.
[114] Ibid.
[115] Ibid.

historians of horology have based their argument on two references made in the late-seventeenth century to the utility of the quarter-repeat mechanism for night-time use. Both Smith and Derham, writing in the late-seventeenth century about the quarter-repeat mechanism, said that it was of use for the night. Smith's comment about a repeating clock was that: "…this clock is of excellent use for the night."[116] Derham introduced his section on this type by saying: "The clocks I now shall speak of are such as by pulling of a string and c. do strike the hour, quarter or the minute at any time of the day and night…"[117] However, neither author commented on night clocks, which implies the claim that one function superseded another is based only on a technical-development approach to horological history. It is this focus on technical change rather than changes in use and the wider context that has led historians such as Brusa to argue that the night clock was superseded by the quarter-repeat mechanism and that this was the sole reason for its decline.

While it is true that night clocks declined at around the same time as the introduction of the quarter-repeat mechanism, some clock and watch-makers in England, such as Joseph Knibb, were making night clocks and quarter-repeating clocks (see figure 4.18) at the same time, so there was a period of transition and perhaps different uses. It is conceivable that by the early-eighteenth century the night clock was no longer needed and in fact the quarter-repeat mechanism served a day-time purpose rather than an improved night-time purpose.

Figure 4.18[118] ©British Museum

[116] Smith, J. 1675. *Horological Dialogues.* London.
[117] Derham, W. 1696. *The Artificial Clock-Maker.* London: James Knapton.
[118] British Museum 1958,1006.2143. Reproduced by kind permission of the Trustees of the British Museum.

Indeed, I am in agreement with historians such as Robey who are sceptical that a half-asleep person would be able to keep track of the hour struck during the night.[119] They might have to pull the lever several times before it made sense whereas a night clock provided a more gentle experience for checking the time during the night. Even if the quarter repeat mechanism did supersede the night clock, it does not mean that we can work backwards from that and say that because the quarter-repeat function repeated the hours that this was all the night clock was used for. I have demonstrated that it was also a symbolic and devotional tool in addition to a practical and symbolic one. Nevertheless, if the claim is true then it suggests that sound replaced the need for vision in the dark. While it is true that the quarter-repeat mechanism outlived the night clock, it did not replace it immediately nor did it replace the other roles of the clock demonstrated above. The quarter-repeat function took the signs of enablement away from the dial as seen in figure 4.18. Previously the dial had been the enabler through the touch-pins or night clock, but the quarter-repeat mechanism was not indicated on the dial.

There were many reasons why the night clock disappeared from use. Users' needs for knowing the time in the dark changed, including astrology and religious devotion, the process of overpowering the limitations imposed by the night was completed, there were safety issues concerning the use of a lamp in a wooden case, and the introduction of the quarter-repeat mechanism were all factors which contributed to the decline of the night clock. However, it was an important enablement device which should not be understood merely in terms of the arrival of the quarter-repeat mechanism which devalues its importance. The night clock was designed as a tool of enablement for three different contexts.

4.4 Conclusion

At the beginning of the chapter I provided two examples of relatively short-lived formats which I argue were utilised by clock and watch-makers to enable users who were dis-abled by traditional dials. I argued that these formats should be understood as different contexts of use. I expanded my comparison of dials with printed paper sources to paintings and prints, which helped to improve our understanding of dials by offering some visual context. Crucially, by employing the cultural approach to disability history, I have shown that dials played a key role in the history of enablement devices. This opens up future avenues of

[119] Robey, J.A. 2005. Who Invented Rack-and-Snail Striking? The Early Development of Repeating and Rack Striking. *Antiquarian Horology.* 28(5).p.585.

research in terms of horology and disability studies. This novel approach to understanding dial formats has provided some crucial parts of the answers to the main thesis research questions, which could not have been attained in any other way.

In both sections of this chapter I offer a substantial part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. In section 4.2 I argued that the touch-pin of the mid-sixteenth to early-seventeenth century enabled users to ascertain the hour and quarter by touch from the dial. It provided the user with an active role. Touch-pins enabled blind and partially-sighted users to read the time from a dial in a period when spectacles were not as widespread as they were to become later and in the era when spectacles did not have sides and were thus more challenging to use as the comparison with the painting in figure 4.16 demonstrated. This view was further supported by my identification of touch-pins on clocks in addition to watches, which was indicative of use around the home and not just outside. In the early modern period, touch was perceived as an important part of multi-sensory knowledge acquisition. Feeling and looking were considered to improve memory acquisition and attainment of higher knowledge, which meant that those with poor sight were not excluded from this pursuit if they had a timepiece with touch-pins. Touch-pins disappeared from dials once spectacles became more widespread, and improvised sides were added, in the early and mid-seventeenth century. Given that some people in the late-sixteenth century, when touch-pins were very common, believed that spectacles were bad for health it is not surprising that alternative enablement devices were made. In terms of discussions within disability history, these points expanded existing debates within the work of Hobgood and Houston Wood. Clocks and watches were thus positioned, as enablers of knowledge acquisition, into discussions about responses to disability in the early modern period for the first time.

In section 4.3 I argued that the illuminated night clock of the late-seventeenth to early-eighteenth century enabled users to see the time in the dark once candles and fires had been extinguished. The night clock enabled users to interpret the significance of the illuminated hour numeral. This had both a representational significance in terms of human dominance over the night, expanding Koslofsky's work, and a religious one in terms of assisting religious devotion during the night. These points expanded existing discussions about domestic lighting in the work of O'Dea and Bowers. For the first time the clock and watch was positioned so as to expand the discussion about the experience of reading either from instrument or text in poor lighting and the need for knowledge-acquisition during the

night. This chapter demonstrates that there were two different devices of enablement which responded to perceptions of effective knowledge acquisition in the period in non-traditional contexts. While a focus on dial formats has revealed three different parts of the answer to this question, there is more to come in chapters six and seven.

In section 4.3 of this chapter I offer part of the answer as to what the relationships between dials and printed paper sources were in the period. I argued that the illuminated night clock was an aid to religious texts such as the earlier books of hours. They both figuratively and literally illuminated the hour. The comparison with the art work in figure 4.16 helped to improve our understanding of this context of use.

In section 4.3 I offer part of the answer as to the extent of the relationship between dials and astrological practice up until the mid-late seventeenth century. I argued that the illuminated night clock enabled the time to be ascertained in the dark for users who needed to know the time at night to conduct certain tasks according to astrological practice such as planting of seeds. Astrology was already in decline by this time, which is one reason, I argue, that the illuminated night clock did not survive beyond the early-eighteenth century.

Neither touch-pins nor the illuminated night clock survived to be part of the standard format which emerged by 1770. In fact they both experienced a relatively short life. I argued that this was due to a combination of changing use and new technologies such as spectacles and the quarter-repeat mechanism, which did not appear on the dial. The decline of the enablement device was one reason why the standard format appeared the way that it did. Having revealed the different ways in which a consideration of dial format improves our understanding of dials over the course of three chapters, I now move on to discuss what a focus on dial content can reveal, how it improves our understanding of dials and further contributes to answering the main research questions of the thesis. I now turn to chapter five where I focus on the ways in which dials provided calendrical insight to their users in the period.

Part Two:

Content

Chapter 5

Calendrical Insight

Figure 5.1[1] ©British Museum

5.1 Introduction

In this first of three chapters which focus on clock and watch dial content, I consider the calendrical insight which users were able to obtain, and subsequently apply, from dials with a calendar function. The wider narrative of the thesis being the changes which led to the emergence of the standard format around 1770, in this chapter I focus on the way in which calendrical information represented on dials changed over the course of the period. I will argue that changes were the result of changes in the wider context of ideas, evident in almanacs, mnemonic and astrological works. I have chosen the phrase 'calendrical insight' to reflect the accurate and deep understanding of the calendar in terms of individual days or dates and in terms of sequences and combinations, which the dial provided for users. I argue that the calendrical function must be considered separately from the lunar and astronomical functions as it developed differently.

The user of a multi-function dial (see figure 5.1) from the mid-sixteenth and up to the mid-late seventeenth century was able to read a combination of calendrical information from it. Conversely, by the early-eighteenth century the owner of a timepiece with a calendar function would only be able to read one piece of information, which was usually the day of the month. The standard format which emerged by 1770 did not include a calendar function.

[1] British Museum 1888,1201.229. Reproduced by kind permission of the Trustees of the British Museum.

Throughout this chapter I refer to the changing 'levels of calendrical detail', by which I mean the different calendrical cycles within the larger cycle of a calendar year. This includes: periods of the day; the seven days of the week; day of the month; the twelve months; the four seasons; the Golden Number;[2] Epact;[3] and the Dominical Letter.[4] These were all significant in the early modern period in terms of religion, the natural magic traditions of mnemonics and astrology, and day-to-day financial matters. Where historians of horology have listed calendrical information they have not interpreted the significance of the particular cycles represented at different moments and how this changed. Bruton[5] and others[6], through their focus on the development of precision timekeeping, inadvertently marginalise the calendar function. They either group it with the lunar and astronomical functions as 'other' or describe it in very basic terms before moving on. This lack of attention has left a substantial gap in our understanding of both dials and the wider context of early modern knowledge transmission, practice and application. This chapter will restore the calendar to its rightful position within the history of horology by reinterpreting it within the wider context of printed paper sources from the period.

As noted in chapter one my approach is an inter-disciplinary one, bringing together different bodies of literature in order to answer my research questions. This chapter will thus contribute to several branches of secondary literature. It will build on the work of book historians who have concentrated on the calendar such as Richards[7] and others[8] by introducing a horological angle. It will also contribute to several branches of the history of early modern science and ideas by introducing the calendar function on clocks and watches to their discussions. Firstly, the work of historians of early modern science such as Henry[9] and others.[10] Secondly, the chapter will contribute to the work of historians of astrology

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[2] The Golden Number was a number between 1 and 19 based on the cyclic relationship between the Sun and Moon and was used to calculate religious dates.

[3] The Epact is the age of the Moon on the first day of the year and is used to calculate the date of Easter.

[4] The Dominical Letter was a letter from A-G - an ancient system where the 1st January is set as A enabling any Sunday of the year to be worked out quickly by consulting a calendar which has assigned each date its letter accordingly.

[5] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.p.104-111.

[6] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking; Loomes, B. 1981. *White Dial Clocks: the Complete Guide.* Newton Abbot: David & Charles; Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club; Thompson, D. 2004. *Clocks.* London: British Museum Press; Thompson, D. 2007. *Watches.* London: British Museum Press.

[7] Richards, E.G. 1998. *Mapping Time: the Calendar and its History.* Oxford: Oxford University Press.

[8] Blackburn, B.J. and Holford-Strevens, L. 1999. *The Oxford Companion to the Year.* Oxford: Oxford University Press; O'Neil, W.M. 1975. *Time and the Calendars.* Sydney: Sydney University Press.

[9] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science*. Basingstoke: Palgrave Macmillan.

[10] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave; Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70; Clark, S. 1997. *Thinking with Demons: the Idea of Witchcraft in Early Modern Europe.* Oxford: Clarendon Press;Webster, C.

such as Curry[11] and others.[12] While greatly improving our understanding of the reach of astrology in the early modern period, these authors have not commented on the role of timepieces, which were beyond their scope, meaning that this chapter will contribute to their work by introducing a horological angle. Thirdly, it will contribute to the work of historians who have focussed on memory such as Rossi[13] and others.[14]

I will employ my novel approach by comparing dials with printed paper sources which contain the range of calendrical information available to users in the period. These are most notably almanacs, mnemonic diagrams, printed calendars, craft books and diaries. In this chapter I will explain changes to the calendar function using two sections. In section 5.2 I will focus on the use of calendrical information on dials for astrological and mnemonic purposes from the mid-sixteenth to the mid-late seventeenth centuries. I then move on to section 5.3 where I will consider the decline of astrology from the mid-late seventeenth century and the survival of the calendar function on dials in to the eighteenth century. Through these two sections I will provide part of the answers to some of the main thesis research questions. The chapter will improve our understanding of the relationships between dials and printed paper sources. I will argue in sections 5.2 and 5.3 that the calendrical information represented on dials reflected the content of mnemonic diagrams up until the early-seventeenth century and of almanacs throughout the period. In some instances dials also influenced printed paper sources. The chapter will offer a substantial part of the answer as to the extent of the relationship between dials and astrological and mnemonic practices in the period up until the mid-late seventeenth century. I will argue in section 5.2 that up until the mid-late seventeenth century, calendrical dials featured the level of temporal locating information that almanacs used for astrology. Dials also featured similar imagery to mnemonic diagrams up to the early-seventeenth century. Dials served as prompts for individual days and dates, but also combinations. The chapter will similarly offer a substantial part of the answer as to the extent of the relationship between dials and the decline of astrology. I will argue in section 5.3 that when astrology declined so did the combinations of calendrical information. However, the calendar function survived as it was useful for other purposes such as within the context of the change from the Julian to Gregorian calendar and for economic and religious use. The chapter will also offer part of

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1982. *From Paracelsus to Newton: Magic and the Making of Modern Science.* Cambridge: Cambridge University Press.

[11] Curry. P. 1989. *Prophecy and Power: Astrology in Early Modern Europe*. Cambridge: Polity.

[12] Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber, Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.

[13] Rossi, Paulo. 2000. *Logic and the Art of Memory: the Quest for a Universal Language*. London: Athlone Press.

[14] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.

the answer as to the extent that users' emotions influenced dial development. I will argue in section 5.2 that the rare examples of planetary symbols used to represent the day of the week on dials in the eighteenth century were useful for people who were accustomed to thinking of the week in terms of a by-then outdated concept. I will argue in section 5.3 that the change from the Julian to Gregorian calendar and the introduction of the equation-of-time, or reactions to these things, brought about new content on dials and explanations in print. Together these answers will improve our understanding of why the calendar function was not part of the standard format in 1770.

5.2 Calendrical insight for astrological and mnemonic purposes

In this section I focus my discussion of the calendrical function by regularly returning to the dial seen in figure 5.1, the content of which was typical of multi-function dials from the late-sixteenth to the mid-late seventeenth centuries, while making comparisons with other dials as I progress. This approach is unique to this chapter, given the nature of the calendar function which I argue acted as a temporal locating device for users. Initially there were five levels of calendrical detail on multi-function dials, which I interpret as five 'co-ordinates' of calendrical location. From the mid-late seventeenth century some of these co-ordinates became less important, due to the decline of astrology for which they were important, and so disappeared from dials. Some, however, remained important as location co-ordinates for other purposes which is why the function survived on dials, up until the mid-eighteenth century.

The role of the calendar function on clock and watch dials from the mid-sixteenth to the mid-late seventeenth century was unique, in terms of astrological practice. Users could temporally locate themselves according to the astrological advice they read in almanacs and other sources or according to their own astrological knowledge. In this manner, users derived from the dial the calendrical insight necessary to make sense of advice acquired previously.

Curry,[15] Dear,[16] and Perkins[17] are in agreement that astrology was still very much a part of the core beliefs of many people during the period from the late-sixteenth- to the mid-late seventeenth century. This would have included the wealthy owners of clocks and

[15] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.3.
[16] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.18.
[17] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.17.

watches. The calendar was significant within the astrological tradition. Perkins observes that since the first printed calendars of the fifteenth century, it was accepted that they were strongly connected to astrological beliefs and practices. She assigns an immensely significant representative role to the calendar when she says that it was in the calendar that astronomy and astrology met.[18] I do not completely agree with this last point and I am in closer agreement with Dear[19] and Curry,[20] who emphasise that astronomy and astrology were not distinguished in the early modern period as they are today. However, in terms of her first point dials show this to be true. Calendrical representations and references on instruments and in printed paper sources in the early modern period, specifically before the mid-late seventeenth century, should be interpreted as being related to astrological concepts. In the period up to and including the early-seventeenth century they should also be seen as potentially serving a mnemonic purpose for users/readers given the extent of works on the art of memory which drew on familiar ideas and practices for its imagery including astrology.

An opening claim of the section was that information on the dial enabled the user to follow astrological advice that had been read elsewhere. In the sixteenth and early-seventeenth centuries the main source of calendrical information applied to astrology was the almanac. Comparing the two reveals the closeness between instrument and printed paper source. Almanacs and timepieces are clearly different media, but the most significant difference is that a calendar made in paper and ink is necessarily able to offer more information to a user, in terms of an overview of a whole year, than a continuously-working mechanical device, which can only offer a daily combination. Nevertheless, almanacs are the main surviving sources of the use of calendrical information for astrological purposes and there were similarities between them and dials. Furthermore, sixteenth- and seventeenth-century almanacs were very similar in form and content across Europe as were clock and watch dials.[21]

Timepieces and almanacs shared combinations of calendrical information.[22] These combinations were an integral part of all almanacs and played a crucial role in the making of

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[18] Ibid.p.14.

[19] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave. P.18.

[20] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.31-32.

[21] Examples have been examined from France and Germany such as Anonymous. 1693. *Almanac ou Calendrier Pour L'Annee 1693.* Paris; Thurneisser Zum Thurn, L. 1583. *Alter und Newer Corrigirter Allmanach.* Berlin. As previously noted, this thesis emphasises the fact that the issues discussed in each chapter transcended national boundaries.

[22] In chapter two I discussed the significance of the way in which information was arranged on dials and printed paper sources.

prognostications in those published before the mid-late seventeenth century. This indicates that combinations on dials from the same period were also related to prognostications. Again, for Perkins the term 'almanac' was synonymous with astrological prediction by the seventeenth century.[23] By introducing clock and watch dials I expand this claim by arguing that dials with calendar functions were also equated with astrological prediction up to the mid-late seventeenth century. Furthermore, combinations of calendrical information on dials existed from the mid-sixteenth century, but were at their most common in the seventeenth century and then declined during the mid-late seventeenth century and gave way to singular indications of calendrical information. Dials and almanacs shared a timeline of change with respect to the popularity and subsequent decline of astrological belief, which Curry,[24] Henry,[25] and Tester[26] agree took place during the mid-late seventeenth century. Prior to this decline, both dials and almanacs enjoyed popularity because they fulfilled the same requirement for calendrical knowledge from the user's perspective. The most common combination of calendrical information on dials was period of the day, day of the week, month of the year, and day of the month, which can be seen in the dial seen in figure 5.1. It was noted in chapter two that Rossi states that in the sixteenth century there was a push to categorise the different 'arts'.[27] While mechanical devices are beyond Rossi's scope, this is significant in terms of the calendar. The calendar function had also been categorised on dials in terms of the four or five calendrical co-ordinates provided by almanacs in the period.

5.2.1 Period of the day

Critics might argue that such an indication as period-of-the-day (see figures 5.2 which shows a detail from figure 5.1 and figure 5.3 which shows a detail from a different watch) could not have had a practical function given that the user must have been aware of what part of the day it was. However, there was an astrological reason for its inclusion on dials. Almanacs often based their advice on conducting activities 'in the morning' or 'after noon'. In Stephins' almanac, for example, he predicted: "…at iiii a clocke in the morning, temporat, cloudy, after rayne weyndy with snowe, wynd southwest, after, easterly."[28] We can easily

[23] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.15.
[24] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.7; 45.
[25] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.60; 116.
[26] Tester, J. 1987. *A History of Western Astrology.* Woodbridge: Boydell.p.223.
[27] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.
[28] Stephins, T. 1569. *A Newe Almanacke and Prognostication for the Yeare of our Lorde God, M.D.LXIX.* London: Thomas Marshe.

imagine a user with a watch planning to head out after the weather change. The changing of the aperture on the watch dial from night to morning may have been enough to prompt the user to remembering the weather change that was to be expected in the early morning.

Figure 5.2[29] ©British Museum

Figure 5.3[30]©British Museum

However, the astrological use of this function is best understood within the context of the combination of which it was always a part. It was always displayed alongside day of the week, day of the month, and month of the year and never as a single calendrical indication. Dials such as these were conceivably used as mnemonic devices to remind the user of something they had read in their almanac when away from the house. In the case of the dial in figure 5.2 for example, it could be imagined that the period of day completed the combination as a mnemonic device. Thus, the autumn night of Saturday 3rd September may have been ascribed an additional meaning in the almanac for that year, for example a weather change or a particularly unlucky day. Similarly, in the case of the dial in figure 5.3 the ruling planet of the hour also had an astrological meaning. According to Hunter and Gregory, the influence of Venus was thought to be largely innocuous.[31] While these authors confined themselves to printed sources, our understanding can be progressed by considering mechanical timepieces with calendar function. The indication above was likely to have been interpreted by an early modern user as an opportune moment to perform certain activities given that other planets such as Saturn and Mars were thought to exert a harmful influence.[32] The watch thus prompts the user to make the most of a window of

[29] British Museum 1888,1201.229. Reproduced by kind permission of the Trustees of the British Museum.
[30] British Museum 1874,0718.23. Reproduced by kind permission of the Trustees of the British Museum.
[31] Hunter, M. and Gregory, A. eds. 1988. *An Astrological Diary of the Seventeenth Century: Samuel Jeake of Rye 1652-1699.* Oxford: Clarendon.p.260.
[32] Ibid.p.260.

opportunity to perform any tasks that might have been negatively affected by Saturn or Mars at other times of the day.

While it could be argued that period-of-the-day indication was instead a cue for remembering the hours of sunrise and sunset, this is not entirely accurate. While this may have been one of its uses, the major use was most likely astrological and mnemonic. The watch is a working, mechanical instrument and offers new symbols in the aperture throughout a given day, but data for the hours of sunrise and sunset is presented to the user of an almanac for reference at any point. It is provided in advance and although it is different each day, it does not change during the course of the day. Thus, instead of acting as a cue for the hours of sunrise and sunset, its appearance on a dial means that it was more conceivably a prompt for astrological advice. Furthermore, images such as that in figure 5.2, representing night, and the symbol for Venus in figure 5.3 would have been powerful images and symbols to associate with other facts and concepts read in the almanac or elsewhere. In this role they were part of the mnemonic tradition. This both supports and expands Yates' claim that the memory tradition was characterised by a search for signs and symbols to use as memory images.[33]

5.2.2 Planetary days

Day of the week was an even more common element of seventeenth-century calendrical dial combinations. I claimed at the beginning of this section that calendrical representations on instruments and in printed paper sources should be interpreted as being related to astrological concepts. That many early clock and watch dials with calendar function represented the days of the week with planetary symbols, or pictures of ruling deities, in addition to text supports this claim. The astrological week was one of these concepts. Blackburn and Holford-Strevens, who also focus only on printed sources, inform us that in the astrological concept of the planetary week each day was influenced by the planet controlling its first daytime hour, Venus for Friday, Saturn for Saturday and so on.[34] Again, this can be progressed by considering the dial in figure 5.4 which makes the influence of Mercury on Wednesday clear for its user through the representation of both its name in Latin and a stylised version of its planetary symbol. Located at the top of the dial, this is a strong reminder for the user to think about the effects of Mercury's influence on this day.[35]

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[33] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.p.378.
[34] Blackburn, B.J. and Holford-Strevens, L. 1999. *The Oxford Companion to the Year.* Oxford: Oxford University Press.p.567.
[35] See chapter two for an in-depth discussion of arrangements of information on dials and its hierarchical significance.

Given that Mercury was known in Ancient Rome as the bearer of news and protector of travellers,[36] a user of this watch may have expected news or a safer journey than the previous day.

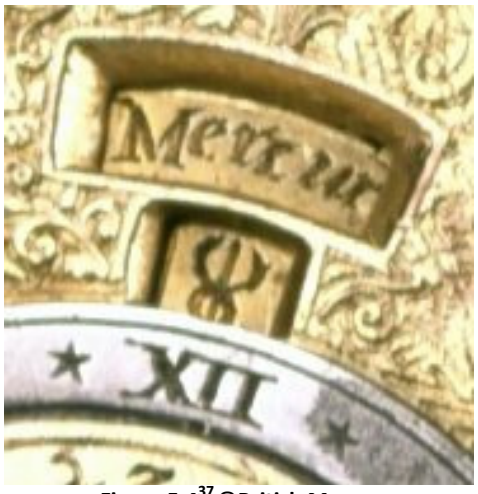

Figure 5.4[37] ©British Museum

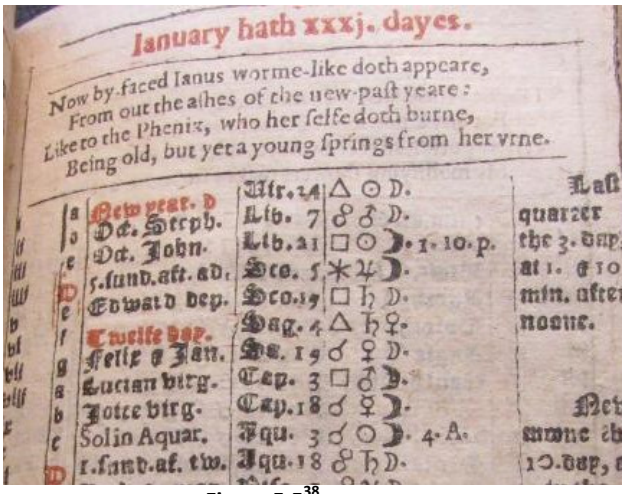

Figure 5.5[38]

Figure 5.6[39] ©British Museum

O'Neil claims that the idea that each of the seven planets controlled the first hour of the day was an ancient one which spread through Europe by astrology.[40] While O'Neil bases his claim on print, this view can be expanded by providing material evidence in the form of clocks and watches to show how this idea continued to be transmitted and experienced in the first half of the seventeenth century. Blackburn and Holford-Strevens go through each

[36] Impelluso, L. 2002. *Gods and Heroes in Art.* Los Angeles: Getty p.162.
[37] British Museum 1874,0718.21. Reproduced by kind permission of the Trustees of the British Museum.
[38] Hawkins, G. 1624. *An Almanacke and Prognostication 1624.* London: Printed for the Company of Stationers. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[39] British Museum 1888,1201.229. Reproduced by kind permission of the Trustees of the British Museum.
[40] O'Neil, W.M. 1975. *Time and the Calendars.* Sydney: Sydney University Press.p.37.

day of the week referencing examples of what made particular days lucky or unlucky.[41] They say, for example, that during the sixteenth and seventeenth centuries, Monday was considered to be the most unlucky day and Saturday was considered to be lucky sometimes and unlucky at other times.[42] Clearly there was a great deal to remember and the sixteenth or seventeenth-century user would be able to gain the calendrical insight they needed to navigate through this potential minefield of lucky and unlucky days from the indication of the planetary symbol on the dial. The calendrical combinations on the dial conceivably helped users determine whether a particular Saturday was lucky or unlucky. For Thompson[43] and Landes,[44] representation of planetary symbols was merely a decorative feature with no other meaning. They were indeed beautiful elements of the dial, but this view is not wholly convincing given the astrological context of which they were a part. By returning to the watch seen in figure 5.1 we can now focus on another of its apertures as seen in figure 5.6. The decision to symbolically represent Saturday with a man holding a scythe and sickle, indicative of Saturn the god of Agriculture,[45] in addition to the word 'satur' which would have been sufficient for purely indicating the day of the week in civil-calendrical terms, demonstrates the astrological and mnemonic use of dials such as these. In the mid-seventeenth century users would have been familiar with this symbolism and recognised Saturn as the ruling planet of Saturday, which astrologically speaking exerted a harmful influence.[46] The use of the agricultural image was also useful in terms of the art of memory. The user may have assigned this image to a task they wished to remember.

Where planetary symbols indicated days of the week on dials it was always alongside the name of the day in text. That these symbols did not appear alone shows that, on the one hand, some users did not think solely in terms of the astrological week, but wanted to cross-reference between two calendars. This expands the scope of Richards' notion that two calendars, for example the liturgical and lunar, were often used simultaneously in the medieval period.[47] On the other hand, provision of the planetary symbol would also enable the dial to be used by those that did not understand the language in which the text was written. This meant that such timepieces had the potential to be sold in another country, which was plausible given that craftsmen took their wares to the large

[41] Blackburn, B.J. and Holford-Strevens, L. 1999. *The Oxford Companion to the Year.* Oxford: Oxford University Press.p.570-582.
[42] Ibid.p.570-582.
[43] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.106.
[44] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking. p.139.
[45] Impelluso, L. 2002. *Gods and Heroes in Art.* Los Angeles: Getty p.228.
[46] Hunter, M. and Gregory, A. eds. 1988. *An Astrological Diary of the Seventeenth Century: Samuel Jeake of Rye 1652-1699.* Oxford: Clarendon.p.206.
[47] Richards, E.G. 1998. *Mapping Time: the Calendar and its History.* Oxford: Oxford University Press.p.6.

fairs of Europe such as Frankfurt, as noted in chapter one. Similarly, they may have been useful for those who struggled to read without spectacles in this period.[48]

Almanacs provide further support for the idea that dials representing the astrological concept of the planetary week were used as a tool to remind people of the meaning of the day in question. In sixteenth- and early-seventeenth century almanacs, the influence of the planets over each day of the week was represented by the symbols indicating the planetary aspects specific to each day as seen in figure 5.5. Differing from dials, the days of the week were not represented by symbols, but instead by the dominical letters A-G which were a key part of the religious calendar.[49] Nevertheless, the presence of the planetary symbol on the dial adjacent to text as seen in figure 5.6 would remind the user of the planetary aspects in the almanac. It would either help them to remember an earlier reading or prompt them to consult the almanac.

Unlike the period-of-the-day indication, the use of planetary symbols or pictures of ruling deities were equally common on clocks as on watches. Watches retain a portable characteristic and are suggestive of outdoor use, but clocks which displayed the ruling planet for the day in question could also act as a reminder to the user as they left the house or awoke in the morning and looked at the dial. This view provides some interpretation, in the form of contexts of use, for Glennie and Thrift's statement that most clocks in the period were either located in the bedroom, the hallway or the kitchen.[50]

On the decline of planetary symbols, Perkins claims that some almanacs continued to represent astrological symbols until 1781.[51] Planetary symbols on dials generally declined by the mid-late seventeenth century, which is in contrast to Perkins' date. However, there were a few rare exceptions such as those seen in figures 5.7 and 5.8, made in the first half of the eighteenth century. Nevertheless, this change indicates there was a fading awareness of astrological terminology amongst the population from the mid-late seventeenth century, which became outdated by the end of the eighteenth century.

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[48] Discussed in detail in chapter four.

[49] An ancient system where the 1st January is set as A, enabling any Sunday of the year to be worked out quickly by consulting a calendar which has assigned each date its letter accordingly.

[50] Glennie, P. and Thrift, N.J. 2009. *Shaping the Day: a History of Timekeeping in England and Wales 1300-1800.* Oxford: Oxford University Press.p.174.

[51] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.199.

Figure 5.7[52] ©British Museum

Figure 5.8[53] ©British Museum

These unusually-late examples may have been used by older people who were accustomed to the concept of the astrological week that was by then in decline. Some people prefer tools, methods and terminology which they are accustomed to regardless of changing patterns. This is supported by Dear who claims that some astrological ideas survived in to the eighteenth century.[54] An elderly user could easily be imagined ordering a dial with these waning indications, preferring to abide by the signs of good and bad fortune, which they had grown up with, rather than to risk enduring bad luck for ignoring them. In this sense the dials enabled such users in the mid-late eighteenth century to mitigate against perceived risk. In a sense this was similar to the experience of users who were reluctant to accept the new minute indication in the late-seventeenth century as discussed in detail in chapter three and reveals another aspect of the influence of emotion on dials.

5.2.3 Zodiac and civil months

A further element of some calendrical combinations on dials, which exemplifies the representation of astrological concepts, is indication of months of the year using zodiac symbols. In Foster's *Elliptical or Azimuth Horologiography* of 1654,[55] he described how to make a timepiece. On the subject of calendrical detail he said that the user could choose which kind of index they preferred: "How to make the Zodiac, or dayes of the yeare, whereby the Ellipsis and Index are to be set in a right position, that they may daily stand true to shew the houre…whether the 12 Signes or the 12 Moneths be fittest for use, is left to

[52] British Museum CAI.2192. Reproduced by kind permission of the Trustees of the British Museum.
[53] British Museum 1977,0702.1. Reproduced by kind permission of the Trustees of the British Museum.
[54] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.28.
[55] Foster, S. 1654. *Elliptical or Azimuthal Horologiography.* London: R. & W. Leybourn.

every man's choice…"[56] This reference demonstrates that some users in the period preferred to think of months in astrological terms, which was a reason to include them on dials. This is further supported by the absence of eighteenth-century examples despite there being rare examples of day-of-the-week indication by planetary symbol.

Figure 5.9[57] ©British Museum

Figure 5.10[58] ©British Museum

The months on the subsidiary dial of the sixteenth-century clock in figure 5.9 are solely represented by zodiac symbols, clearly demonstrating that the user understood, or wished to refer to, the months of the year in terms of the twelve signs of the zodiac. This manner of representation was rare. It was more common for the zodiac calendar to be represented alongside the civil calendar as seen in figure 5.10. The user of this dial, on the other hand, could cross-reference between the zodiac months and the civil months. Here they are arranged in an off-set manner to indicate their relationship. This trend in representation is similar to that identified above with the planetary days of the week. In his huge work on astronomy and mechanical instruments, published in 1615, Levinus Hulsius offered a calendar table of the twelve months of the year along with the corresponding signs of the zodiac.[59] This is evidence of early-seventeenth-century use of zodiac signs as an additional calendrical reference point, which was not unique to clock and watch dials. The use of these two reference points enabled astrological theory to be located within the civil calendar.

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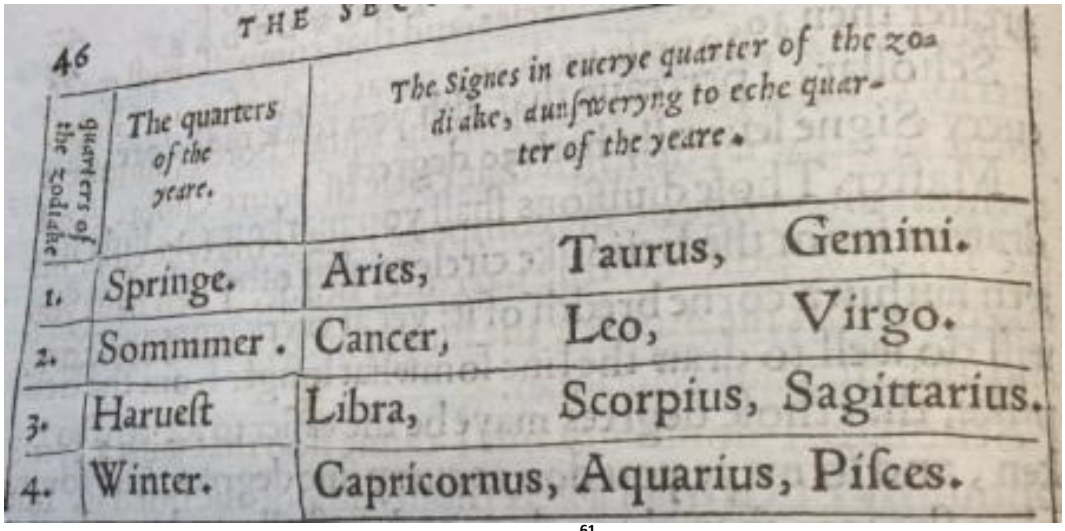
[56] Ibid.
[57] British Museum 1958,1006.2097. Reproduced by kind permission of the Trustees of the British Museum.
[58] British Museum WB.222. Reproduced by kind permission of the Trustees of the British Museum.
[59] Hulsius, L. 1615. *Vierdter Tractat der Mechanischen Instrumenten.* Franckfurt am Mayn.p.29.

Figure 5.11[60] ©British Museum



46

quarters of the zodiake	The quarters of the yeare.	The Signes in euerye quarter of the zodiake, aunſweryng to eche quarter of the yeare.		
1.	Springe.	Aries,	Taurus,	Gemini.
2.	Sommmer.	Cancer,	Leo,	Virgo.
3.	Harueſt	Libra,	Scorpius,	Sagittarius.
4.	Winter.	Capricornus,	Aquarius,	Piſces.

Figure 5.12[61]

Returning to the watch seen in figure 5.1, looking at the aperture seen in figure 5.11 the month of the year is represented using the name of the month beside both a symbol and a picture representing the zodiac sign of Libra. In figure 5.11 the signs of the zodiac have been assigned to each month whereas they are traditionally off-set as depicted in figure 5.10. Examples such as figure 5.11 are convincing as evidence of users thinking of the zodiac and civil months as interchangeable. On the other hand, examples such as figure 5.10 indicate a user who is familiar with the relationship between the two and cross-references between them. The representation of the month in three ways in figure 5.11 conceivably had a mnemonic function where the zodiac symbol was associated with one task or idea, and the picture and word were associated with something else. In a sense this provided the user with additional layering. Critics might mistakenly argue that using pictures or symbols

[60] British Museum 1888,1201.229. Reproduced by kind permission of the Trustees of the British Museum.
[61] Recorde, R. 1556. *The Castle of Knowledge.* London: R. Wolfe. p.46. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

for the index on a dial was solely to aid legibility. Proponents of this view might cite Robert Recorde, who stated that due to the use of small instruments, signs and symbols were developed to represent them: "And because that their names always can not bee placed in small instruments, there ar certain figures devised for their names…."[62] This would be true of the example in figures 5.9 and 5.10, but not in the example of figure 5.11 where the name of the month is represented alongside the zodiac symbol and image.

The changing seasons were very important to people in the period and thinking in terms of the zodiac months was one way of thinking about climatic patterns. Support for this view can in fact be found in the work of Recorde. He wrote *The Castle of Knowledge*, 1556, as a part of a range of books aiming to be accessible to students and others, which makes his work valuable for understanding ideas in the mid-sixteenth and early-seventeenth century, given that it went through many editions. Of calendars he referred to the use of the zodiac to represent calendar months: "For as there bee but twelve moneths in the yeare, so there are twelve partes of the zodiacke distincte by severall names, and correspondent to every moneth, although they varye something now from their first application…."[63] By 'variance' he meant the fact that the zodiac months do not exactly match the calendar months in terms of temporal parameters, as noted above with reference to the off-set indices on some dials. Nevertheless, they continued to be used as if they did in some cases as noted above. A major reason was that although they may not have corresponded exactly, this was not important because they could be divided in to groups according to the seasons of the year. Recorde provided a table to explain the relationship between the signs of the zodiac and the seasons (see figure 5.12). Johnson's almanac seen in figure 5.13 similarly made this connection by using a sequence of images of agricultural activities associated with each month. The association created for the user between Taurus, April and planting seeds is effected by the addition of the pictorial representation of the zodiac sign for Taurus in the top-right hand corner of the image and the name of the month next to the image. Clock and watch dials with representations were equally useful in this context.

The representation of the month, or even season, on a dial provided users with much-needed information. In an era when predictions of the seasons were referenced in almanacs to the hour and minute of a particular day, a dial which changed an aperture from winter to spring on the allotted date may have been enough to prompt a user in to action or to referring to their almanac. Hawkins' almanac of 1624, for example, is typical of late-sixteenth and seventeenth-century almanacs in its prediction and description of the seasons.

[62] Ibid.p.29.
[63] Ibid.p.46.

It was also produced in the same period as the watch in figure 5.1. Hawkins specified the beginning of summer: "Now Summer begins…the 11 of June, at two of the Clocke, 52 minutes, 4 seconds after noone…"[64]

Figure 5.13[65]

Figure 5.14[66] **©British Museum**

Returning to the dial seen in figure 5.1, looking at the aperture seen in figure 5.14, the season of the year is represented by its Latin name 'autumnus' beside a picture representing the season. The picture is a lady holding two dishes in the action of a balance, which is a stylised representation of Libra, whose symbol is represented in the adjacent aperture for month seen in figure 5.11. This dial would have been useful as a prompt to refer to what the almanac said about autumn that year. While it was noted in chapter two that the symbols and images which characterised late-sixteenth century mnemonic works were intended to

[64]Hawkins, G. 1624. *An Almanacke and Prognostication 1624.* London: Printed for the Company of Stationers.
[65] Johnson, W. 1569. *A New Almanacke and Prognostication.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[66] British Museum 1888,1201.229. Reproduced by kind permission of the Trustees of the British Museum.

veil secrets from the vulgar,[67] and dials may have been a part of this, almanacs and dials drew on a shared calendrical language and both played a role in cementing the convention. It wasn't the recognisable symbols that veiled secrets, it was combinations of them.

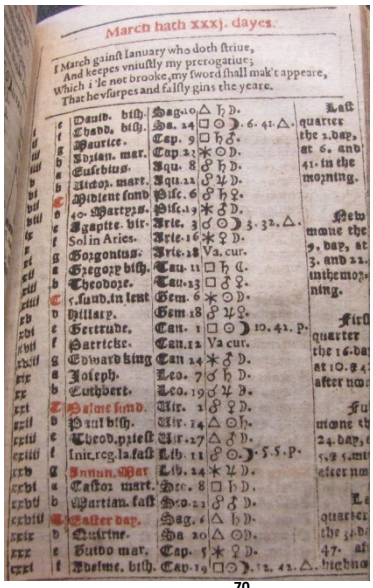
5.2.4 Combinations of calendrical information

Calendrical indications were an important layer of the information hierarchy discussed in chapter two. The mechanical manifestation of layers of calendrical combination on the dial places the multi-function clock and watch within the natural magic tradition of machine as mathematical magic, expanding the argument made by Eamon[68] by introducing clocks and watches to the discussion. Magical insight to the calendar was provided through said mechanised combinations. The number of calendrical co-ordinates in figure 5.15 is very similar to dials such as figure 5.16. Both present the four co-ordinates of day of the week, month of the year, day of the month, and season. The difference becomes apparent when considering the information, which is absent from dials but is provided by the almanac and includes details from the liturgical calendar and planetary aspects. It has already been noted that almanacs and clocks are different media, but that did not prevent them from being used simultaneously as objects for cross referencing. By providing at least the calendrical location co-ordinates, the dial empowered the user with the insight needed to make plans for the day, week or season ahead.

Calculations based on combinations of information were important to astrological prognostication. They laid the basis for the combinations of calendrical information which were chosen to be represented in the almanac and dial. In almanacs these calculations were made for the reader's convenience with the results clearly displayed. In Stephins' almanac for 1569, for example, he claimed that the aspect of Saturn and Jupiter would bring increased sickness for the common people and provided an astrological diagram as proof.[69] This capability was beyond the capacity of the dial. However, this kind of information in almanacs would be useless without calendrical location co-ordinates. Combinations of information and the way in which they were arranged on the dial, in some sixteenth- and seventeenth-century examples, were reminiscent of the astrological horoscope. Calendrical information provides the location co-ordinates for both. In the horoscope diagram the central box contained a summary, but with the dial, such as that seen in figure 5.16, the central summary took an invisible form and was constructed in the user's mind. The user

[67] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.62.
[68] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.172.
[69] Stephins, T. 1569. *A Newe Almanacke and Prognostication for the Yeare of our Lorde God, M.D.LXIX.* London: Thomas Marshe.

had to decide what this information meant to them. In calendrical terms it meant working out when these predicted events would take place. With the dial they could work out if this was tomorrow or in a few months.


March hath xxxj. dayes.

I March gainſt Ianuary who doth ſtriue,
And keepes vniuſtly my prerogatiue;
Which i'le not brooke, my ſword ſhall mak't appeare,
That he vſurpes and falſly gins the yeare.

Figure 5.15[70]

Figure 5.16[71] **©British Museum**


A generall Iudgement Aſtrologicall, for the vnder-
ſtanding of the inclination of the Ayre, by the Coniunctions
and Aſpects of the Planets amongſt the ſelues: which
Aſpects are placed in the Kallender againſt each day of
euery Moneth, as they happen this yeere
1624.

Luna ☾	Mercury ☿	Venus ♀	Sol ☉	Mars ♂	Iupiter ♃
Cold and cloudy.	If in ſum. thunder and tempeſt.	In winter cold raine or ſnow.	Darke, haile, rain thunder, & ſuch like	If moiſt ſig. rain thunder & haile.	Thunder, rain haile or ſnow.
In Aries ſo Sagit. & Leo ſa re. white clouds.	Great winds, ſometimes ſtormes.	In moiſt ſignes cold and miſtings.	Fierce windes, lightning	If moiſt ſignes thunder & raine, in wint. ſnow.	
Often thunder.	Thunder and ſodaine windes.	In moiſt ſig. raine, tempeſt or thunder:	In moiſt ſignes thunder and rain.		
In moiſt ſignes, rainy.	Winter rainy or ſnow, in ſommer tempeſt.	Thunder and fierce ſhowers.			
Clouds heate and thunder, in winter raine.	Moiſt winds, or flying clouds.				
Winde ſometimes changing or clouds.					

Figure 5.17[72]

Combinations of calendrical information used for weather prediction were an important part of almanacs throughout the period. The basis for making these predictions changed during the mid-late seventeenth century, which is discussed in detail in chapter six

[70] Hawkins, G. 1624. *An Almanacke and Prognostication 1624.* London: Printed for the Company of Stationers. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[71] British Museum 1888,1201.229. Reproduced by kind permission of the Trustees of the British Museum.
[72] Hawkins, G. 1624. *An Almanacke and Prognostication 1624.* London: Printed for the Company of Stationers. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

on lunar wisdom, but calendrical location co-ordinates continued to be vital. The number of calendrical location co-ordinates is a sign of which theories the associated weather prediction was based on. Dials up until the mid-late seventeenth century represented four of the calendrical locating co-ordinates represented in almanacs, to which their astrological weather predictions were tied. Dials were clearly of use as a prompt to remember these predictions according to the calendrical information indicated. Figure 5.17 shows Hawkins' weather predictions based on the astrological principle that the planetary aspects determined the weather.[73] On the preceding page, Hawkins instructed the reader to note the alignment of the planets on the date in question from the calendar pages: "Looke to the seventh day of January, there shall you find these characters…"[74] and then the reader was to cross reference the conjunction with the data contained in the table in figure 5.17 in order to determine what the weather would be for that date. Although, clock and watch dials did not display this level of prognostic information, they provided the calendrical location co-ordinates that enabled the user to locate themselves within the calendar, bypassing some of the pages within the almanac, and proceeding directly to the weather prediction page. This made the consultation of the almanac faster by reducing the amount of page turning.

In a sense, the calendar function can be understood as an attempt to mechanise the almanac. It could not provide everything the almanac could, but it was a useful tool to use alongside it. It could easily be imagined that a landed gentleman in possession of a watch with a combination of calendrical information and a copy of that year's almanac could glance at the dial in order to read the day of the week, day of the month, and month of the year and then open the almanac to the appropriate pages. He could then read about any warning signs or auspicious moments for instructing his agricultural labourers to carry out tasks on his land. The almanac was a resource that needed to be renewed each year, whereas the timepiece was intended to be permanent. The calendar function on dials was undoubtedly a very aesthetically pleasing feature. However, I have demonstrated that dials clearly mirrored changing patterns in thought and practice expressed in print during the period. At the very least, this in itself indicates utility alongside aesthetic appeal.

In the sixteenth and seventeenth centuries, dials with calendrical functions consisted of combinations of calendrical information, which had astrological uses as a locating or prompting device. The decline of these combinations from the mid-late seventeenth century was concurrent with the overall decline in astrology. However, it would be a

[73] Ibid.
[74] Ibid.

mistake to conclude that this was the only influence on the calendar function in the period as it continued to be used for other purposes as will be considered next.

5.3 The decline of astrology and the initial survival of calendrical indications

> Is it possible by the moving of Clockwork to represent or work any other motion or conclusion then that of the hour [?]… first they may be made to shew the month of the year, the days of the moneth, the hours of the day, the minutes of an hour, and the seconds of a minute.[75]

This dialogue from John Smith's *Horological Dialogues* of 1675 epitomizes the nature of the calendrical locating co-ordinates presented on dials from the mid-late seventeenth century. Smith referred to the calendar as the first out of eight functions that were possible on a timepiece. Its position at the forefront of his list indicates how common and how useful for daily life calendrical information was. For Smith, it completed the sequence of the division of the year, given that the list begins with month of the year and moves through subsequent temporal units until the last, which for Smith is the seconds of a minute. The list is only complete by Smith's definition as it could have contained more calendrical units.

The *Horological Dialogues* is a narrative of the capability of clockwork. As a clock-maker, Smith would have wished to sell as many clocks as possible. This would make a thorough description of the clock's capabilities, based on what the customer would find useful, a crucial part of the book. Smith was an active clock-maker from around 1669[76] until 1727.[77] Although astrology and combinations of calendrical information on dials had both begun to decline by the mid-seventeenth century, Smith would have been aware of these multi-function dials. This raises the question as to why he did not list more than two calendrical locating co-ordinates than day of the month and month of the year. It wasn't because he was only describing the division of the day, because the rest of the paragraph lists functions such as tide times, the place of the Sun in the zodiac, and the rising and setting of the stars.[78] While it is true that he could have listed more calendrical information, by 1675 his readers clearly did not want a multi-layered calendar function on their dials. Evidently month of the year and day of the month were what they wanted and could make most use of.

---

[75] Smith, J. 1675. *Horological Dialogues.* London.
[76] This date is based on his birth in 1647 and assuming he undertook a seven-year apprenticeship at the age of fourteen.
[77] This was the year in which he died.
[78] Smith, J. 1675. *Horological Dialogues.* London.

Both dials and almanacs underwent change during the late-seventeenth and early-eighteenth century, which was characterised in dials by the decline of combinations of calendrical information. This change began in the mid-seventeenth century and gradually gathered momentum. The decline of astrology from the seventeenth century onwards opened the floodgates to a steady flow of criticism, for example in John Evelyn's *Kalendarium Hortense* of 1666 which instructed the reader on the gardening duties that should be carried out during the year. In this work, Evelyn criticised astrological advice on planting found in almanacs:

> We are yet far from imposing…those nice and hypercritical Puntillos which some Astrologers, and such as pursue their Rules, seem to oblige our Gard'ners to; as if, forsooth, all were lost, and our pains to no purpose, unless the Sowing and the Planting, the Cutting and the Pruning, were perform'd in such and such an exact minute of the Moon...There are some certain Seasons, and suspects tempora, which the prudent Gard'ner ought carefully (as much as in him lies) to prevent: But as to the rest, let it suffice that he diligently follow the Observations which (by great Industry) we have collected together, and here present him, as so many Synoptical Tables calculated for his Monethly use….[79]

Evelyn's use of phrases such as 'we are yet far from imposing' and 'as if all were lost unless the sowing, the cutting and the pruning were performed in such and such an exact minute of the moon' reveal the extent of his poor view of astrological advice. His message was clear: ignore the astrologer's advice and follow mine instead. However, he also made use of calendrical locating co-ordinates when he referred to his 'tables calculated for monthly use'. Criticism of astrology was not something new to the seventeenth or eighteenth centuries. Capp informs us that criticism of almanacs first began in 1470 and was a response to its increasing popularity. Evelyn's strong criticism itself reveals that there was still astrological advice available in the 1660s and that it remained important for some people.

Nevertheless, as Evelyn's comment shows, what distinguished the mid-late seventeenth century from the previous period was that people made use of some of the same calendrical locating co-ordinates, but for different purposes. This introduces instruments to Capp's statement that the eighteenth-century almanac varied noticeably from its predecessors in terms of character and purpose rather than format.[80] While I argue in chapter two that there were slight format changes, the same could be said of calendrical combinations on dials, where the calendrical locating co-ordinates such as period of the day and the four seasons were no longer represented (see figure 5.18 of a watch made in the

[79] Evelyn, J. 1666. *Kalendarium Hortense or The Gard'ners Almanac.* London: Jo. Martyn & Ja. Allestry.p.5.
[80] Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber.p.238.

early-eighteenth century). This correlates with the user preferences identified in Smith's writing except that these dials both represent the day of the week, which was the next indication to be withdrawn. By the mid-eighteenth century only the day of the month had been retained as the calendrical locating co-ordinate on dials.

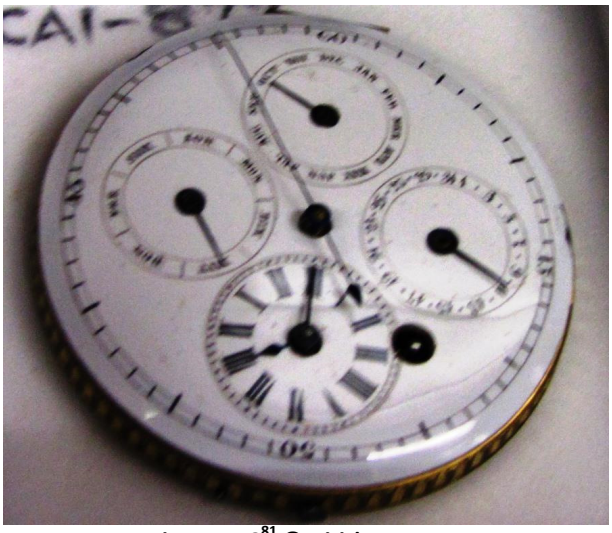


Figure 5.18[81] ©British Museum

Furthermore, echoing the point made by Capp about the significance of content change which was concurrent with format continuity, the dial in figure 5.18 is an example of the new white-enamel dials which gradually replaced metallic dials from 1727 onwards.[82] This is a good example of a dial that was modernised aesthetically, but its calendar function continued to follow the prevailing trend and its format echoed an older tradition. In this sense it underwent aesthetic change, leaving behind the useful content. This three-part combination differs from the dials discussed in the first section in its representation of information. This form of calendrical indication occurred after the decline of the four or five-layered calendrical layers and before the decline of all calendrical representation except day of the month. It is characterised by the disappearance of symbols or pictures to represent the significance of the particular month or day, which is instead only represented by text (see figure 5.19). This trend was not unique to dials; non-mechanised instruments also reflected this practice. In figures 5.20 and 5.21 of two perpetual calendars, made in the early-seventeenth and mid-late seventeenth centuries respectively, the calendrical information remains the same, but the planetary symbols visible in figure 5.20 are not present in the later example in figure 5.21.

[81] British Museum CAI.873. Reproduced by kind permission of the Trustees of the British Museum.

[82] As noted elsewhere, George Graham was the first to begin using white enamel dials in around 1727 and they quickly became popular.

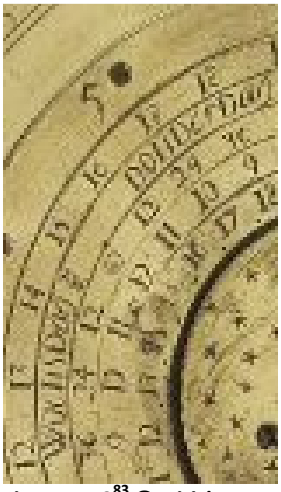


Figure 5.19[83] ©British Museum

Figure 5.20[84] ©British Museum

Figure 5.21[85] ©British Museum

Many late-seventeenth century almanacs experienced a similar period of change between displaying a mixture of numerals, symbols and images to almost only numerical information. It was this change which was discussed in chapter two as effectively creating a formatting change due to the overall appearance it made. Similarly to dials, this too was characterised by an absence of astrological reference points. The *Weaver's Almanac*[86] published in 1688 is just one example of a calendar of this period. Similarly to the dial, it is characterised by its preservation of the format and some of the calendrical locating co-ordinates of older almanacs, yet also by an absence of planetary symbols. This almanac-in-transition is similar to the dial-in-transition in its adherence to previous form, but with an altered purpose for the calendrical information provided, which is made visible by a change in notation. This supports Capp's view noted above, but expands it.

That the three sources of calendrical information, almanacs, dials and non-mechanical calendrical instruments, experienced this change demonstrates that they were all influenced by prevailing perceptions of the way in which calendrical knowledge was used to navigate through life. Navigation is the key word because information such as day of the month and month of the year was used to locate oneself in relation to the various layers of the calendar and also as a reminder of important points within different calendars. Having discussed the influence of the decline of astrology, I now move on to discuss the uses of the type of calendrical information which survived, and became thought of as non-astrological, as people began to try to distance themselves from astrology, in addition to newly emerging uses which were a result of technological improvements.

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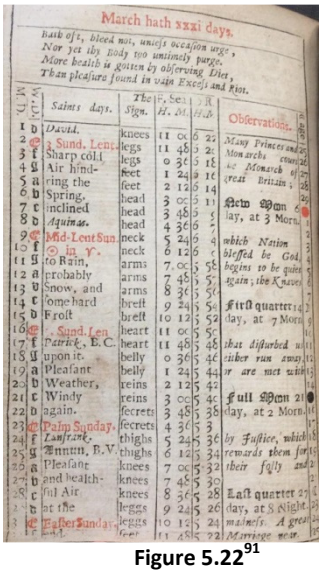
[83] British Museum 1958,1006.2102. Reproduced by kind permission of the Trustees of the British Museum.
[84] British Museum 1888,1201.332. Reproduced by kind permission of the Trustees of the British Museum.
[85] British Museum 1891,0217.8. Reproduced by kind permission of the Trustees of the British Museum.
[86] Strutt, T. 1688. *The Weaver's Almanack*. London: R. Holt.

5.3.1 Calendrical insight for religious observance

One of the oldest and most important uses of month and day-of-the-month information was for religious observance, which continued throughout the period. Its use in this context was one of the factors which led to the survival of the calendrical function on clock and watch dials in to the eighteenth century. Considered in the context of Richards' reminder of the trouble taken to back-date the Creation,[87] indicates a desire to not only locate oneself in the year, but according to God's chronology. Richards also provides motivation to think about the way in which people in the seventeenth century thought about the future by referring to the importance of *millenarianism* to natural philosophers such as Isaac Newton and Robert Hooke in the period.[88] Locating oneself within the liturgical calendar was clearly just as much about the future as it was about the past. It was also part of locating oneself in the Great Chain of being, which as Henry says was important in terms of politics and natural magic.[89] Locating oneself in relation to the sympathies and antipathies assigned by God to everything in the cosmos could help one get closer to God.

Calendrical information on the clock and watch dial provided users with a prompt for contemplating these issues. The almanac and printed calendar provided information on special religious dates throughout the period and the dial with calendrical information allowed the user to locate themselves in order to properly observe these days. Figure 5.22 is a page from Trigge's almanac of 1684,[90] in which Palm Sunday and various saints' days can be read in the third column form the left.



March hath xxxi days.

Bath oft, blood not, unless occasion urge,
Nor yet thy body too unkindly purge.
More health is gotten by observing Diet,
Than pleasure found in vain Excess and Riot.

		Saints days.	The Sign.	F. Sea. H. M.	R. H. M.	Observations.
1	D	David.	knees	11 0	6 22	
2	E	3 Sund. Lent	legs	11 48	6 21	Many Princes and
3	F	Sharp cold	legs	0 36	6 18	Monarchs counted
4	G	Air hind-	feet	1 24	6 16	the Monarch of
5	A	ring the	feet	2 12	6 14	great Britain;
6	B	Spring,	head	3 0	6 11	
7	C	inclined	head	3 48	6 9	New Moon 6
8	D	Aquinas.	head	4 36	6 7	lay, at 3 Morn.
9	E	Mid-Lent Sun.	neck	5 24	6 4	
10	F	☉ in ♈.	neck	6 12	6 2	which Nation
11	G	to Rain,	arms	7 0	5 58	blessed be God,
12	A	probably	arms	7 48	5 56	begins to be quiet
13	B	Snow, and	arms	8 36	5 54	again; the Knaves
14	C	some hard	breft	9 24	5 52	
15	D	Frost	breft	10 12	5 50	First quarter 14
16	E	4. Sund. Len	heart	11 0	5 48	day, at 7 Morn.
17	F	Patrick, B. C.	heart	11 48	5 46	that disturbed w
18	G	upon it.	belly	0 36	5 44	either run away,
19	A	Pleasant	belly	1 24	5 42	or are met with
20	B	Weather,	reins	2 12	5 40	
21	C	Windy	reins	3 0	5 38	Full Moon 21
22	D	again.	secrets	3 48	5 36	day, at 2 Morn.
23	E	Palm Sunday.	secrets	4 36	5 34	
24	F	Lanfranc,	thighs	5 24	5 32	by Justice, which
25	G	Annun. B.V.	thighs	6 12	5 30	rewards them for
26	A	Pleasant	knees	7 0	5 28	their fully and
27	B	and health-	knees	7 48	5 26	
28	C	ful Air	knees	8 36	5 24	Last quarter 27
29	D	at the	leggs	9 24	5 22	day, at 8 Night.
30	E	Easter Sunday.	leggs	10 12	5 20	madness. A great
31	F	Lent.	feet	11 48	5 18	Marriage near

Figure 5.22[91]

Figure 5.23[92] **©British Museum**

[87] Richards, E.G. 1998. *Mapping Time: the Calendar and its History.* Oxford: Oxford University Press.p.11.
[88] Ibid.p.11.
[89] Henry, J. 2002. *Knowledge is Power: Francis Bacon and the Method of Science.* Cambridge: Icon.p.55.
[90] Trigge, T. 1684. *Calendarium Astrologicum.* London: J. Playford.
[91] Ibid. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

My argument that calendrical information on the dial also acted as a locating device in the context of religious devotion expands Cressy's point that the calendar was a reminder of both secular and sacred duties.[93] In this sense the calendar function on a timepiece acted as a mnemonic device for religious observance. As mentioned in chapter two authors of the art of memory drew on familiar subjects and concepts for their mnemonic images. Giordano Bruno instructed readers to assign their own images[94] and, for some people, the passing of time from one day and one month to the next would have had a strong religious association throughout the period. Critics might argue that this is inaccurate because unlike the astrological symbols for days of the week or months of the year, there were no additional religious indicators beyond the calendrical information on any clock and watch dials. However, these doubts can be dismissed with ease given the importance of religious dates to people with great conviction. Feast dates such as the Conversion of St. Paul, which occurred on the 25th January each year and was listed in almanacs throughout the period, would have been embedded in the minds of users. It could easily be imagined that it was the 24th January and a user consulted the day-of-the month indication on their watch while away on a long journey and was reminded that the following day was the feast day of the Conversion of St. Paul, ensuring that even though they were not at home they could properly observe it by going to a nearby Church or by partaking in private worship. The date of Easter, on the other hand, varied from year to year. This was, and still is, the most important calendrical calculation that had to be made by the Christian Church.

Observance of the correct date for Easter was made more complicated for calendar users by the change from the Julian to the Gregorian calendar in Catholic and Protestant Europe in 1582 and 1700 respectively and the British Isles in 1752.[95] This three-staged transition called for cross-referencing between calendars in a similar manner to that mentioned in chapter three when users such as travelling merchants cross-referenced between alternative hour schemes in use in different countries. The dial of the high-end clock in figure 5.23, made in the mid-eighteenth century, includes an outer annual-calendar ring on which are inscribed the main religious dates and an indication of Easter both

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[92] British Museum 1985,1005.1. Reproduced by kind permission of the Trustees of the British Museum.

[93] Cressy, D. 1989. *Bonfires and Bells: National Memory and the Protestant Calendar in Elizabethan and Stuart England.* London: Weidenfeld and Nicolson.p.1.

[94] Bruno, G. 1584. *De la Causa, Principio, et Uno.* Venice. In part two of this work Bruno advised readers to consider light, colour, figure, and form when creating images that stirred their imagination, as these would be more effective as memory triggers.

[95] Duncan, D.E. 1998. *The Calendar: the 5000-Year Struggle to Align the Clock and the Heavens.* London: Fourth Estate.p.289-317; Blackburn, B.J. and Holford-Strevens, L. 1999. *The Oxford Companion to the Year.* Oxford: Oxford University Press.p.97; 862-867; Richards, E.G. 1998. *Mapping Time: the Calendar and its History.* Oxford: Oxford University Press.p.352-353.

according to the Julian and the Gregorian calendars. This dial demonstrates the continued importance of knowledge of the liturgical calendar in the period and the potential for timepieces to make such indications. Even though this clock was essentially an astronomical clock made for teaching within the context of the rise of public science as discussed in chapter seven, it is vital evidence of the perceived capability of clockwork. Its provision of both the Julian and Gregorian calendars demonstrates that this was an important issue of the day.

The works of the clock-makers, Joseph Naylor[96] and Henry Jenkins,[97] both provide support for the argument that users referred to month and day-of-the-month information as points of religious reference throughout the period. According to these authors, finding the correct date for Easter remained important. In *A Description of Several Astronomical and Geographical Clocks*, 1778, Jenkins felt it necessary to draw attention to the capacity of a clock made in 1759 to provide information for calculating the date for Easter: "…Below at one corner are three hands, pointing to as many circles. The outermost is a revolution of 28 years, and shews the Cycle of the Sun and Dominical Letter. The next is 19 years, and shews the Golden Number and Epact…"[98] Naylor's publication of 1751, *An Explanation of an Astronomical Clock*, was written as an advertisement to sell the clock seen in figure 5.23 above, by lot. Within the publication he described the clock's utility, which is to be expected given the aim of securing as many participants as possible. In terms of calendrical detail he made it clear that his clock could provide information on the day of the week, an annual calendar with the twelve months of the year and every date of the year in addition to the Dominical Letter, Golden Number and Easter:

> The first is a large plate, fifteen inches square, which is fixed. The next is a large circle, which contains the Twelve Months of the Year, with every Day of each Month, with all the Saints Days, which by the help of two indexes placed on the left-hand side of the first plate marked O.S. for Old Stile, and N.S. for New Stile shew you the Day of the Month… To find Easter, first look for the Golden Number, Old Stile, in the top plate, towards the right Hand, which is 4, and then look for the Dominical Letter, Old Stile, in the top plate towards the left hand, and you will find it F, then look in the table below, in Golden Number Old Stile for 4, then look for the next F that is either over it or after it, and over that F stands the Day of the Month that Easter Sunday falls on for that Year, so that over F stands the 7th of April, for Easter 1751….[99]

[96] Naylor, J. 1751. *An Explanation of an Astronomical Clock.* London.
[97] Jenkins, H. 1778. *A Description of Several Astronomical and Geographical Clocks.* London.
[98] Ibid.
[99] Naylor, J. 1751. *An Explanation of an Astronomical Clock.* London.

Again, the space he dedicated to the subject of Easter demonstrates its importance and relevance to users in 1751. That Naylor built in indications according to both the Julian and the Gregorian calendars also demonstrates the impact of the change of the calendar for users. Naylor and Jenkins' words enable us to imagine the devout user consulting the dial in January to find out when Easter was that year. The calendar function, specifically indication of the day of the month, survived the decline of astrology, but did not feature on the standard format.

5.3.2 Calendrical insight for financial use

Calendrical locating co-ordinates were used for noting important financial dates. This was a use which remained important throughout the period and survived the decline of astrology. It was particularly useful to the wealthy merchants, lawyers and doctors, identified as clock and watch users in this period in chapter one, who needed to know important financial dates. It is important to remember that, as mentioned earlier, believers in astrology up until the mid-late seventeenth century did not distinguish between astrological and non-astrological influence over human affairs. For them the planets also influenced financial success. When astrological belief went in to decline, calendrical information was still used to organise personal financial affairs because of state-imposed key dates such as for payment of taxes. From the late-seventeenth century and early-eighteenth century, almanacs such as Playford's of 1687[100] withdrew astrological points of reference and advice and retained economic information such as tables of interest. Playford's almanac informed users of the four dates when payments for insurance and rents were to be made within fifteen days, which was Lady Day on the 25th March; Midsummer Day on the 24th June, Michaelmas Day on the 29th September and Christmas Day.[101] A dial with month and date indication would be invaluable here

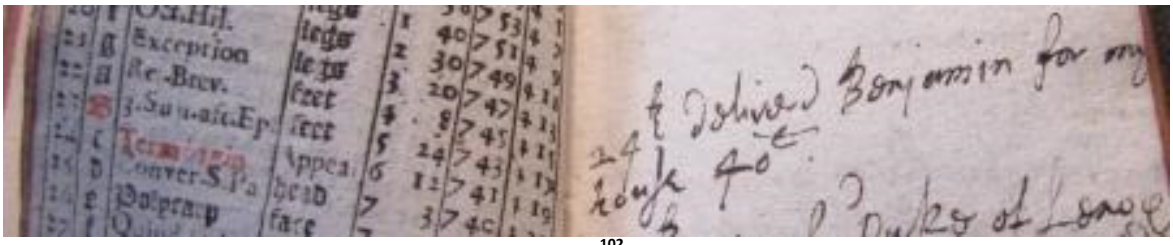

Figure 5.24[102]

[100] Playford, J. 1687. *Vade Mecum or The Necessary Pocket Companion* London: Nath. Sackett.
[101] Ibid.
[102] Gallen, T. 1641. *An Almanack and Prognostication for the Yeare of God 1642.* London: Rob Young Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

Blackburn and Holford-Strevens support the notion that these dates would have been very important to people.[103] Indeed, as can be seen from the example of annotated almanacs, such as Gallen's (see figure 5.24), users made notes about the exchange of goods and accounts paid. The user of this almanac recorded that on the 24th January 1642 they had received a delivery at their house at the cost of forty pounds. For the same reason as was noted for important religious dates, dials from this period could not present this level of information. However, the survival of calendrical locating co-ordinates such as month of the year and day of the month initially, and then later the single co-ordinate day of the month, is evidence that dials were used by owners to locate themselves within the financial calendar. By so doing they could be reminded of, and plan for, when payments were due. Based on the dates mentioned in Playford's almanac, it could be imagined that a wealthy user, such as a land owner, on the 23rd June could consult their day-of-the-month indication on the clock in the kitchen or bedchamber and remind themselves that their tenants' rental payments would be due the next day, meaning that they should confirm the route with the rent collector today. The use of the dial in this context is therefore similar to its use in observing special religious dates, and in fact astrology; it acted as a prompting device. In one sense even with the decline of astrology the central use remained unchanged, but the scope of application was reduced.

Thomas Tompion's instruction pamphlet[104] offers an insight in to the importance for business of knowing the day of the month and month of the year in the context of travel. It is also evidence of the way in which one calendrical locating co-ordinate on a clock or watch dial may have been used alongside lunar information. The *Directions for All Travellers When to Pass Over at Aust and New Passage Between England and Wales*[105] was published in an era when the River Severn had become one of the busiest waterways in Europe for commercial purposes. This demonstrates that the information the pamphlet contained would be of great interest to large numbers of people. Tompion began his instructions by saying that travellers were often delayed and lost business by having to wait to cross the river:

> The Passage over this great River *Severn* is of vast importance to those that want to travel between *England* and *Wales*; and People, being unacquainted with the Hours of Passing, so very often lose a great deal of Time and Business in waiting (on both Sides) for Passing…there is no Passing, except on the going out of the Tide at *Aust*; for then at Three-quarters Ebb you may pass: But when the Wind is above, all Passing must

[103] Blackburn, B.J. and Holford-Strevens, L. 1999. *The Oxford Companion to the Year.* Oxford: Oxford University Press.p.588.
[104] Tompion, T. 1709. *An Exact Measure of the Roads from Bath to London.* London: J. Good.
[105] Ibid.

> be on the Flood, or coming in of the Tide, and then you have Five Hours good Passing. And when the wind is below, all Passing must be on the Ebb, or going out of the Tide, and then you have Seven Hours good Passing.[106]

He then supplied a sum which would provide the user with the best times of day to expect to catch a boat. The calculation involved knowing two calendrical locating co-ordinates which were month of the year and the day of the month in addition to the age of the Moon. This demonstrates the importance of cross-referencing calendrical information on the dial with information from another source. Similarly, Tompion's dials, those of which provided calendrical information, may have been intended to be used for this purpose. He did not mention such pieces, but perhaps that is because they would have cost hundreds of pounds in 1709 whereas this pamphlet cost three pence and was clearly aimed at a wider audience. Nevertheless, it could be imagined that a travelling merchant, in a hurry to get to the other side of the river, consulted the month and day-of-the-month indication on his watch, cross referenced this information with the calculation in Tompion's pamphlet, and then was able to spend a few extra hours finalising a separate business deal at a nearby town rather than waiting on the river bank.

5.3.3 The effect of the change from the Julian to the Gregorian calendar

Travel in the user's own country required knowledge of day of the month and month of the year for attending county fairs, meeting coaches, making river crossings and sending post,[107] but travel between countries in Europe posed an additional need for calendrical insight. The change from the Julian to the Gregorian calendar in Europe did not only affect the calculation of Easter as discussed above, it also had consequences for international travel. Calendrical information appeared on dials in the late-sixteenth century and became more common, as part of multi-function dials, from the early-seventeenth century. The change of the calendar, and the confusion and complications for business and travel that it caused,[108] conceivably acted as one of the catalysts for development of the calendar function on dials from the late-sixteenth to the mid-eighteenth century. That the calendar changed from Julian to Gregorian in Catholic Europe in 1582, in Protestant Europe in 1700 and in the British Isles in 1752 meant that there was an interval of nearly two hundred years when

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[106] Ibid.
[107] Playford, J. 1687. *Vade Mecum or The Necessary Pocket Companion* London: Nath. Sackett.
[108] There were numerous pamphlets published around 1752 which explained the calendar change and expressed disapproval of public disturbances in reaction to the change. For example: Anonymous. 1752. *A Companion to the Almanack for the Year 1752.* London: T. Jefferys, and W. Clarke; J. H. 1753. *The Pancronometer or Universal Georgian Calendar.* London.

people such as travellers and merchants had to convert their calendar to that of the other region. Money, goods and ideas had a long history of being transported and transmitted across European national boundaries. A different calendar would not prevent this exchange, but clearly posed some difficulties and necessitated firstly a knowledge of which countries used the Gregorian and which the Julian calendars and secondly a method for converting between the two.

Published five years before the calendar changed in England, Saunders' *Apollo Anglicanus*, an almanac for 1746, stated on its title page that it was: "A twofold calendar, viz. Julian or English and Gregorian or Foreign computations, more plain and full than any other…."[109] On the third page, after the typical almanac summary information for the year, such as the Golden Number and the Dominical Letter, Saunders included his: "Directions for the subsequent diary or almanac..."[110] in which he listed the subject of each of the columns in the calendar pages. The calendar pages of almanacs often contained un-labelled columns indicating that users knew what each column was for and did not require further instruction. Saunders, by contrast, included both Julian and Gregorian calendars and this required explanation. Of this part of the calendar he explained: "In the first Column on the Right-hand Page you have the English account. In the second column you have the Roman Account being now Eleven Days before ours. In the third column the Roman week-days. In the fourth Column the perfect Roman Kalendar, and Saints-Days."[111] This is evidence of the need for month and day-of-the-month information on watches for a user who was a travelling merchant or gentleman. In this sense, acting once more as calendrical locating co-ordinates, they anchored their user in the calendar of their point of origin.

It can easily be imagined that such a user travelling from England to Catholic Bavaria, or *vice versa*, would have used their watch to maintain their knowledge of time passing and key dates at home while operating according to a different scheme while away. As mentioned earlier, this was much the same as users who cross-referenced between alternative hour schemes in the sixteenth and early-seventeenth centuries. Knowing the month of the year would also be important for converting between the two calendars given that the number of days in each month varies. Such a practice could avoid any delays in meeting people for business matters or arriving at a departure point for a ship or coach. The difficulties faced by travellers would have been particularly difficult for those active between 1690 and 1752. They would have been accustomed to the Protestant countries using the

[109] Saunders, R. 1746. *Apollo Anglicanus: the English Apollo.* London: A. Wilde.
[110] Ibid.
[111] Ibid.

Julian calendar and then in 1700 would have found that those countries were then using the Gregorian, but not the British Isles, and then in 1752 the British Isles also made the change. The uniformity of the calendar in Western Europe after the British Isles made the change in 1752 was another factor which led to the decline in calendrical information on dials in the eighteenth century. There was confusion at first, but as the years passed people would have become accustomed to it and no longer needed to make conversions. This is one reason why single pieces of calendrical information prevailed from the early-eighteenth century, but it is not the only reason.

5.3.4 The influence of precision timekeeping on the calendar function

Increased precision not only influenced the dial through the introduction of minutes, it also affected the calendar function. An important consequence of the pursuit of greater accuracy for the calendar function on dials was the perpetuation of day-of-the-month indication for the purposes of comparing timepieces with equation-of-time data from the mid-seventeenth to the mid-late eighteenth century.

The equation of time, discussed in terms of trust between maker and user through instrument in chapter three, influenced dials from the late-seventeenth to the mid-late eighteenth century. Authors such as Bruton state that after the invention of the pendulum in 1657 and the balance spring in 1675 enabled accurate timekeeping, the difference between solar time, as observed on a sundial, and clock time, as observed on the clock or watch, became more noticeable.[112] As the anonymous author of *An Explanation of the Nature of Equation of Time*, published in 1731 put it:

> If then I know how much my watch is too fast or too slow, it is the same thing as if it pointed exactly right: because by adding or subtracting the Difference, as Occasion requires, true Time is thereby known. And this Difference is what the Tables of Equation exhibit: they inform us how much watches are faster or slower than the Sun every Day of the Year; by adding or subtracting which Difference, as the Table directs, true Time is thereby gained...[113]

In consequence, equation-of-time data was published in almanacs so that users could read from a table the dates during the year when their timepiece should appear to be running fast or slow compared to the sundial and by how many minutes. This is clear evidence of users comparing almanac and dial on the basis of the calendar. In his *Horological*

[112] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.p.225.
[113] Clay, F. 1731. *An Explanation of the Nature of Equation of Time.* London.

Disquisitions of 1694, Smith recommended the specific almanacs of Parker and Salmon.[114] In Salmon's almanac, which was typical of many others in this period, data took the form of a column entitled 'watch too fast' or 'watch too slow' in hours and minutes.[115]

Thompson informs us that there were four dates in the year when the clock dial would agree with the sundial and these were: 15th April, 13th June, 1st September, and 25th December.[116] However, he does not comment on the significance of knowing these dates for the calendar function. These made knowing the day of the month important. Mid-late eighteenth century dials which only represented day of the month, even if manually adjusted by their users, were used with equation-of-time tables to assess the going[117] of a timepiece. Equation-of-time indication on dials was indeed expensive and therefore not common. However, in a similar manner that the high-end clocks mentioned above, which enabled special religious dates to be ascertained according to both the Julian and Gregorian calendars, were examples of what was mechanically possible, so too were dials which indicated the equation of time. Figure 5.25 is an example of a dial which provided an annual calendar with equation-of-time representation, made in the late-seventeenth century.

Figure 5.25[118] ©British Museum

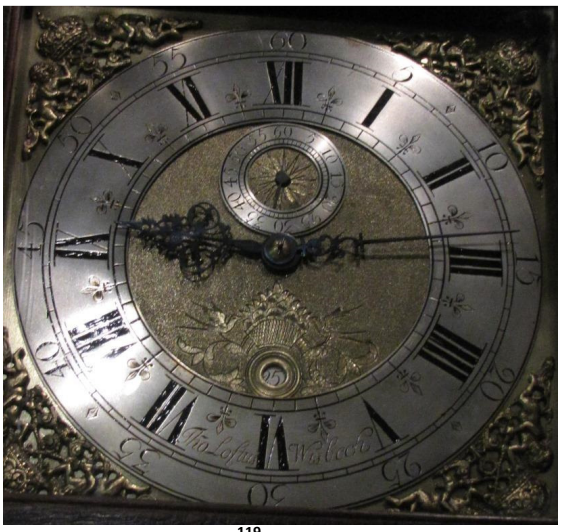

Figure 5.26[119] ©British Museum

The cheaper alternative to this example was undoubtedly to only represent the day of the month, as in the majority of eighteenth-century clocks and watches (see figure 5.26). Naylor's *An Explanation of an Astronomical Clock* of 1751 provides evidence of the importance of the equation of time for users in the eighteenth century, how they had

[114] Smith, J. 1694. *Horological Disquisitions* London.
[115] Salmon, W. 1694. *The London Almanac.* London.
[116] Thompson, D. 2007. *Watches.* London: British Museum Press.p.169.
[117] See appendix two for a definition of this horological term.
[118] British Museum 1958,1006.2098. Reproduced by kind permission of the Trustees of the British Museum.
[119] British Museum 2010,8029.4. Reproduced by kind permission of the Trustees of the British Museum.

become accustomed to thinking about it and how it affected them: "To know whether the Sun or Clock goes faster, observe the Sun in the Clock before or after the Hour Hand: the Sun at his coming above the Eastern Horizon shews his rising, and at going down below the Western Horizon, shews his setting…"[120] In this passage Naylor does not explain the equation of time or why it is important, which contrasts the anonymous *An Explanation of the Nature of Equation of Time* published twenty years earlier in 1731. It is assumed that by 1751 more people had knowledge of the equation of time and it did not need the same level of explanation.

This also supports my claim that the indication of single calendrical indications on dials in the eighteenth century was the result of the representation of the calendrical information that was most useful to people, which in this period was the equation of time. The day-of-the-month calendar function is also an example of calendar functions becoming plainer as accuracy became more complex. By the mid-eighteenth century, accuracy was the most important factor for users and calendar functions supported this by offering users a way of judging the performance of their timepieces.[121] Calendar functions may have no longer been useful for many of the earlier tasks discussed in this chapter, but the rise of accuracy had ensured the survival of this function up until the mid-eighteenth century. By the late-eighteenth century timepieces were even more precise and did not need to be compared with equation-of-time data, which contributed to the disappearance of the calendar function from most dials by 1770.

5.4 Conclusion

At the beginning of this chapter I introduced the calendar function on clock and watch dials as a calendrical locating device. I argued that rather than providing new knowledge for users, it provided the insight necessary for users to locate themselves temporally according to important tasks relating to astrology, religion and financial matters. There was a reduction in the number of co-ordinates dials provided over the period and the standard format which emerged by 1770 did not feature any. A focus on the calendar function, which I argued developed differently from the lunar and astronomical functions in the period, enabled me to provide parts of the answers to the main research questions that would not have been possible in any other way.

[120] Naylor, J. 1751. *An Explanation of an Astronomical Clock.* London.
[121] The manner in which the equation of time was used to generate trust is discussed in detail in chapter three.

In section 5.2 I substantially improve our understanding of the extent of the relationship between dials and astrological and mnemonic practice in the period up until the mid-late seventeenth century. I argued that calendrical dials featured the kind of locating information that almanacs used for astrology. They also featured similar imagery to mnemonic diagrams. They served as prompts. Individual days and dates were important, but so were combinations. As a mnemonic device, the days of the week, months of the year and dates could be assigned certain meanings, as could the larger combination such as Saturday 3rd September. The dial could then be used to remember the associated information of the user's choice. Of particular interest were special religious dates such as Easter and financial dates such as those assigned to the payment of taxes.

The chapter contributes part of the answer to the related question as to the extent of the influence of the decline of astrology and mnemonics on dials. In section 5.2 I argued that when astrology declined so did the combinations of calendrical information. However, the function survived as it was useful for other purposes such as within the context of the change of calendar, and for financial and religious use. In section 5.3 my focus on the decline of astrology and the survival of particular elements of the calendrical function, such as month of the year and day of the month, supported my claim that the decline in combinations of calendrical information presented on dials reflected the decline in astrology from the mid-late seventeenth century. I contributed to the work of writers such as Parker and Capp on the history of astrology and Dear and Henry on the scientific revolution, by introducing a horological angle when I demonstrated that there was a period of transition in dials, which reflected that in almanacs, rather than an overnight change. By considering the effect of precision timekeeping in section 5.3.4, I argued that the equation-of-time tables used for judging whether a timepiece was supposed to be running either too fast or too slow compared to the sundial, strongly contributed to the survival of the calendar function on dials in the form of a single piece of information, usually day-of-the-month indication, into the eighteenth century. Without which, the calendar function may have been lost from dials sooner than it was. Precision timekeeping eventually negated the need for both equation-of-time data and the calendar function on dials. This has contributed to the work of historians of horology by introducing a discussion of the effect of precision timekeeping on the calendar function to our understanding of the importance of the equation of time for users. These points have greatly contributed to existing histories of the calendar such as the work of Blackburn and Holford-Strevens by positioning the clock and watch into the debate for the first time and considering the use of instruments alongside paper calendars. The

clock and watch has also been introduced to existing debates about astrology and mnemonics in the period thereby contributing to the work of Henry, Curry and Perkins. While a focus on the calendar function has demonstrated the way in which users located themselves in calendrical terms in order to practice astrology, it cannot fully answer the question. There is more to come in chapters six and seven.

The chapter offers part of the answer as to what the relationships between dials and printed paper sources were in the period. In section 5.2 I argued that the calendrical information represented on dials reflected the calendrical content of almanacs and mnemonic diagrams. Both used the same calendrical locating co-ordinates. In section 5.3 I argued that the calendar function survived the decline of astrology in the mid-late seventeenth century. It continued to be useful for non-astrological purposes. However, the manner of representation changed. Instead of calendrical indices using planetary symbols or allegorical images, Arabic numerals began to be used. This transition occurred in almanacs and other forms of calendar at a similar moment. Printers and clock and watch-makers began to distance themselves from the symbols and pictures that were associated with astrology and provided their readers and users with the notation that they were more comfortable with. This is discussed in more detail in chapter seven.

This chapter offers part of the answer as to the extent that users' emotions influenced dial development in the period. In section 5.2 I argued that the rare examples of planetary symbols used to represent the day of the week on dials in the eighteenth century were useful for people who were accustomed to thinking of the week in terms of a by-then outdated concept. I argued that some users of sixteenth and very-early-seventeenth century dials preferred to use the zodiac calendar as a form of calendrical reference, which is evident from dials of this period and texts such as Recorde's who associated certain zodiac months with seasons of the year and therefore necessary tasks such as harvest. In section 5.3 I argued that the change from the Julian to the Gregorian calendar on different dates in Europe acted as both a catalyst for development of the calendar function on the dial in the period up until 1752 and afterwards acted to slow its continued presence. I also argue that the change of the calendar and the introduction of the equation-of-time, or reactions to these things, brought about new content on dials and explanations in print.

Calendrical indication was not part of the standard format which emerged by 1770, but it had been a feature from the earliest multi-function dials of the mid-sixteenth century right up until the mid-eighteenth century. Its lack of presence on the standard format was an indication of its eventual decline, but also therefore of its past prominence. While a

consideration of the calendar function has improved our understanding of the significance of clock and watch dial content, it has not fully answered all of the research questions. I now turn to chapter six where I focus on the lunar function, which developed differently in the period.

Chapter 6

Lunar Wisdom

> Of those several motions and conclusions that may be wrought by Clock-work I will give you an account as far as my knowledge or inquiry will permit…They may shew the Moon's age, time of her new, full, and quarters, her rising, and setting, and southing, her time of shining, and motion through the twelve signs of the Zodiac.
> John Smith, *Horological Dialogues*, 1675[1]

Figure 6.1[2] ©British Museum

Figure 6.2[3]©British Museum

6.1 Introduction

These words were written by the clock-maker, John Smith, in his *Horological Dialogues* of 1675. In this dialogue, where he listed the various indications that clocks could make, the lunar function was listed as fourth in his hierarchy. It appeared after calendar, the time in different geographical locations, and the position of the Sun in the zodiac. The date of publication is significant. If this work had been written in the late-sixteenth or early-seventeenth century the lunar indication would have been positioned first or second in a list of this kind. By 1675 it was still important, but its use had changed. The lunar function on clock and watch dials was present on some of the first watches and domestic clocks of the sixteenth century such as that in figure 6.1. It was also present some two hundred years later on longcase clocks such as that in figure 6.2. Although its representation may appear to the untrained eye to have remained unchanged for over two hundred years, there were subtle differences which are most convincingly explained with a reference to changing uses

[1] Smith, J. 1675. *Horological Dialogues.* London.
[2] British Museum 1958,1006.2138. Reproduced by kind permission of the Trustees of the British Museum.
[3] British Museum 2010,8029.42. Reproduced by kind permission of the Trustees of the British Museum.

based on changing ideas and practices. The lunar function developed differently in the period compared with the calendar function discussed in the previous chapter and the astronomical function which will be discussed in the next chapter. I argue that this was the result of changing uses over the period. Representation of the lunar phase was not part of the standard format which emerged by 1770.

It would be a mistake to pass by the lunar function on clocks and watches in the manner in which historians such as Thompson[4] have until now. The lunar calendar was important to people for different reasons throughout the period, as the range of almanacs and craft books demonstrate. The Moon was a symbol of purity in Christian terms and a subject of debate in the nascent science of the seventeenth century. There was a strong belief in the power of the Moon to influence life on Earth throughout the period. This was in terms of astrology, up until the late-seventeenth century, and in terms of the movement of the Earth's tides throughout the period. Moreover, the Moon provided a source of night-time light for a few days each month, which was important throughout the period. Thus, knowing the age of the Moon was immensely important. I argue that the role of the lunar function on dials was to enhance the user's pre-existing lunar wisdom. Curry correctly describes the widespread early modern references to the Moon as lunar lore.[5] This was something people grew up with. The dial provided them with a prompt to recall this prior knowledge contained within the long-term memory.

Historians such as Thompson comment on a particular clock using phrases such as: "The clock also has lunar indications on the dial"[6], but offer no further comment. His use of the adverb 'also' places the lunar function further down the hierarchy of points he perceived to be important, after the frame and the mechanism. Bruton, writing specifically about longcase clocks in the period after 1657, is unique among authors of horological history by describing the provision of the lunar phase on longcase clocks as a service to users.[7] He correctly defines the service as the provision of information on when to expect the light of the full Moon, which was useful in areas where there were no street lights, and as the provision of information on the best times to plant seeds or trees. The 'service' it provided, I argue, was as a technological aid for applying lunar wisdom.

Thompson's lack of any interpretive information on the significance of the lunar function effectively dismisses it as unimportant, which is the result of a lack of contextualization of the function. In this chapter I argue that by contextualizing the lunar

[4] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.22.
[5] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.98.
[6] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.22.
[7] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.p.111.

function in terms of related text such as almanacs and craft books, it is possible to demonstrate the way in which the lunar function changed in the period under investigation and explain this change in terms of changing use. Bruton correctly alludes to the use of the lunar function, but his focus on longcase clocks limits the extent to which he is able to discuss change over the period. His lack of references for the claims he makes about the use of information about moonlight and advice about seed planting also limits the extent to which he can discuss these uses as they effectively become common-sense points to be made and then passed by.

As noted in chapter one, my approach is an inter-disciplinary one, bringing together different bodies of historical literature. Until now there has been a lack of scholarly attention paid to perceptions of the Moon in the early modern period apart from works on astrology. For this reason I offer a contextualisation of the lunar function on clock and watch dials as an invitation for further research on lunar knowledge in the period. Similarly to chapter five, this chapter will contribute to several branches of literature. It will make a contribution to the work of historians of early modern science such as Henry[8] and others[9] by introducing the lunar function on clocks and watches to their discussions. It will certainly contribute to the work of historians of astrology such as Curry[10] and others.[11] Whereas Curry focuses on astrological use of this wisdom, which is important in this chapter too, I also consider three other ways in which knowledge of the Moon manifested itself in daily life during the period. Again, by discussing the connections in terms of lunar imagery between dials and mnemonic works, it will contribute to the work of historians of the art of memory such as Rossi[12] and Yates.[13]

I will explain the changing application of lunar wisdom through four sections based on my identification of four main uses of lunar information presented on dials which developed differently over the period 1550-1770. The lunar function has not been discussed in terms of use before, nor has anyone identified four types of use applicable to the period. Bruton and others have very briefly mentioned the function's potential use for night time journeys and tidal reckoning, but use was not their primary focus. Whereas, because it is my

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[8] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.
[9] Cressy, D. 2016. Early Modern Space Travel and the English Man in the Moon. *The American Historical Review.* 111(4), Westfall, R.S. 1958. *Science and Religion in Seventeenth-Century England.* New Haven: Yale University Press.p.961-682.
[10] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.
[11] Tester, J. 1987. *A History of Western Astrology.* Woodbridge: Boydell, Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber, Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.
[12] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.
[13] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.

primary focus, I have been able to identify additional contexts of use and, through my comparison with texts, improve our understanding of those uses that Bruton mentioned in passing. Not all of these uses were relevant to the entire period under discussion, as I will demonstrate, some enjoyed a longer lifespan than others and some overlapped. It is for these reasons that the lunar function developed differently from the calendar and astronomical functions.

In section 6.2 I will consider the pictorial representation of the changing lunar phase and its use as both an aid to religious devotion and a representational tool in the context of nascent science. I will then move to section 6.3 where I will consider the use of the lunar function for astrological and mnemonic purposes and the effect of the decline of the mnemonic method, in the early-seventeenth century, and the decline of astrology, during the mid-late seventeenth century. I will then move to section 6.4 where I will consider the use of information about the age of the Moon and the duration of moonlight on particular dates for travel at night and the undertaking of outdoor activities which required light. I will then move to section 6.5 where I will consider the renewed provision of tidal indication on dials. Through these four sections I will provide parts of the answers to some of the main thesis research questions.

This chapter will improve our understanding of the relationship between dials and printed paper sources. In section 6.2 I will argue that there were both similarities and differences in the representation of the lunar phase on dials in the period. I will argue that representation of the man-in-the-moon from the early-mid seventeenth century was a subtle change which represented larger debates in the period. The chapter will improve our understanding of the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. In section 6.5 I will argue that the tidal indication on dials in the late-seventeenth century, though not new, was given a new lease of life as part of the rise of public science and interest in why the tides and Moon were connected. The chapter will offer a substantial part of the answer as to the extent of the relationship between dials and astrological and mnemonic practice up until the mid-late seventeenth century. I will argue in section 6.3 that the lunar information represented on dials was used as a prompt to remind users of the astrological association for weather prediction, health matters, and farming-related tasks. Users possessed knowledge of this lore and the dial acted as a prompt to recall it. The chapter will also provide a substantial part of the answer to the related question as to the extent of the relationship between dials and the decline of astrology. In section 6.3 I will argue that the lunar function survived for these purposes up

to the late-seventeenth century given that it was one aspect that reformers of astrology attempted to maintain during the decline of astrology. In section 6.4 I will argue that while use of the lunar function for mnemonic practice had declined in the early-seventeenth century and for astrology in the late seventeenth century, the lunar function survived for use as a planning tool for undertaking journeys during moonless nights. I argue that it survived into the eighteenth century for this purpose in provincial areas where there was no street lighting. As a set these answers will improve our understanding of why the lunar phase was not part of the standard format by 1770, which is part of the wider thesis narrative.

6.2 The pictorial representation of the changing lunar phase

A feature of the changing face of time was the representation of the changing face of the Moon, present on many dials throughout the period, but not all, and crucially not on the standard format of 1770. Every dial with the lunar function included a pictorial representation of the lunar phase. This was often accompanied throughout the period with the numerical lunar calendar 1-29½ and, up until the early-seventeenth century, with the lunar aspect diagram, discussed in chapter two. However, while there were examples of the lunar function represented purely pictorially, there were no examples in this period of the lunar function represented without the pictorial display. From the early-mid seventeenth century, the phase was represented with the face of the man-in-the-moon. Before this it was represented as a plain disc or crescent (see figure 6.3) and, from the early-seventeenth century, onwards stars were added to the background which had previously been black.

It is clear from pictorial representation in art, in printed paper sources, and on clock and watch dials that the Moon had a religious significance. In this section I argue that makers/creators of the lunar image were conveying both a religious feature of lunar wisdom and a lunar angle of their nascent scientific view to users/readers when they made certain decisions about how to present the Moon pictorially. In the early modern period, the Moon was not just another part of the solar system as we might think of it today.

Figure 6.3[14] ©British Museum

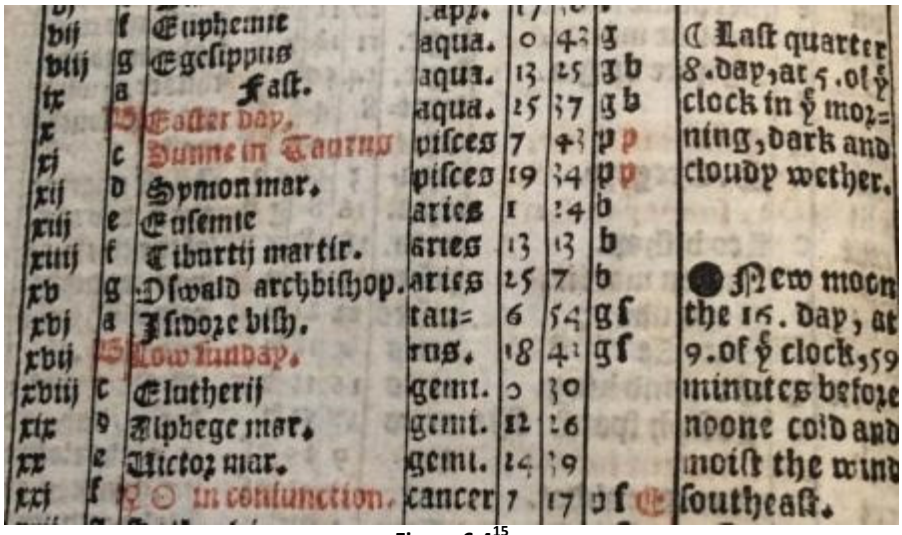

Figure 6.4[15]

In chapter five I mentioned that the lunar phase was used alongside calendrical information as a locating co-ordinate for determining the date of Easter, but the lunar phase had more of an association with religion than purely Easter. Furthermore, in chapter two, I considered the way in which the lunar phase was represented to replicate the perspective of the Moon as it is seen from Earth and that this was the most realistic form of representation on the dial in the period, which made it an effective communication device. There is more to be said about lunar representation in terms of content with respect to ideas about religion and nascent science.

Westfall is correct to mention that the late-seventeenth century was an age of questioning where many concepts, including traditional Christian ones, were being

[14] British Museum 1888,1201.105. Reproduced by kind permission of the Trustees of the British Museum.
[15] Johnson, W. 1569. *A New Almanacke and Prognostication.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

challenged.[16] However, I argue that the temporal parameter of this claim can be brought back to the early-seventeenth century with reference to the representation of the lunar phase on clock and watch dials. I have identified a discussion concerning the Moon which characterised the ways in which the Moon was represented pictorially during the early-seventeenth to the late-eighteenth century. I argue that it is partly with reference to this discussion that the lunar function on clock and watch dials must be reinterpreted. This was the possibility of the Moon as an inhabited place, which was a discussion that involved religion and nascent science and was represented in varying degrees on dials. In this section I provide further evidence, in the form of clock and watch dials specifically and mechanical devices generally, to support Henry's view that there is no doubt that religion played a major part in the development of modern science, despite the lingering view in the historiography that religion and science were opposed and incompatible.[17] Clock and watch dials bear signs of both their makers' active, and their users' passive, contributions to discussions of the possibility of the inhabited Moon.

6.2.1 Inhabited Moon

The decision to represent the Moon as a circle or crescent with the face of the man-in-the-moon was not new in the seventeenth century. As Whitaker informs us the first Moon drawings with a human face on them were in medieval manuscripts.[18] However, their meaning in that period was allegorical rather than representing a statement about the God-created universe. It continued to be so and depictions of the man-in-the-moon were common in astronomical instruction works such as Apianus' *Cosmographia* in the sixteenth century (see figure 6.5). Clock and watch-makers began to include a depiction of the man-in-the-moon on their presentations of the lunar phase during the early-mid seventeenth century (see figure 6.6). The sixteenth-century representations of the plain Moon on dials disappeared once the man-in-the-moon began to be represented. It was no coincidence that dials took on this form of representation, which continued to be present on the late-eighteenth century provincial longcase clocks (see figure 6.2). This was one area where dials and almanacs were dissimilar. Almanacs throughout the period continued to represent the Moon as a plain disc or crescent (see figure 6.4). However, during the seventeenth century,

[16] Westfall, R.S. 1958. *Science and Religion in Seventeenth-Century England.* New Haven: Yale University Press.p.9.
[17] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.85.
[18] Whitaker, E.A. 1999. *Mapping and Naming the Moon: a History of Lunar Cartography and Nomenclature.* Cambridge: Cambridge University Press.p.8.

there were abundant discussions about the possibility of inhabitants on the Moon and the man-in-the-moon began to represent these ideas.

Figure 6.5[19]

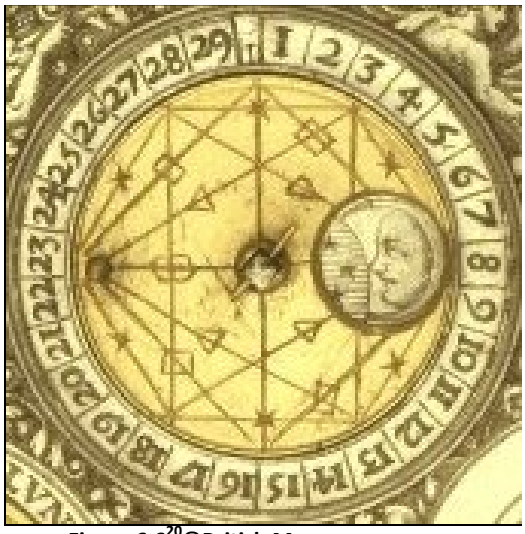

Figure 6.6[20]**©British Museum**

Cressy correctly links early modern interest in this subject with the relatively recent discoveries in America and Copernican ideas about the arrangement of the heavenly bodies.[21] He says that people became fascinated with the properties of the populated Moon. Cressy focusses on printed sources, but his view can be expanded by considering the effect on material culture. Thus, clock-makers positioned themselves in this debate when they made dials with a lunar phase which included the man-in-the-moon. As Cressy points out, despite some ridicule, it was a subject that interested people at the highest levels of society including the clergy[22] and these were the people who could afford clocks and watches. To believe in the existence of an inhabited Moon did not conflict with one's religious beliefs. Indeed, it was thought to be logical that God had made other inhabitable worlds and, given the perfection of the Moon, it made sense that He had placed inhabitants there.[23] Cressy identifies the active participants in the debate, such as John Wilkins[24] and Francis Godwin,[25] but does not consider the passive ways in which others may have contributed. While clock and watch-makers' customers appeared to have no choice in terms of the way in which the Moon was represented, given the extant examples. They could

[19] Apianus, P. 1550. *Cosmographia.* Vaeneunt G. Bontio: Antuerpiæ. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[20] British Museum 1888,1201.177. Reproduced by kind permission of the Trustees of the British Museum.
[21] Cressy, D. 2016. Early Modern Space Travel and the English Man in the Moon. *The American Historical Review.* 111(4).p.961.
[22] Ibid.p.961-962.
[23] Ibid.p.963.
[24] Wilkins, J. 1638. *The Discovery of a World in the Moone or a Discourse Tending to Prove that 'tis Probable there may be Another Habitable World in that Planet.* London.
[25] Godwin, F. 1638. *The Man in the Moone or A discourse of a Voyage Thither Domingo Gonsales.* London.

choose whether or not to have a lunar phase represented as not all clocks and watches did. The decision to own a clock or watch with the lunar phase, with man-in-the-moon representation, was also a decision to position oneself in this debate. It is conceivable that in this epistemological context, a user would look at the representation to reflect upon the plurality of worlds and quietly contemplate the God-created universe as an act of religious devotion. In this sense lunar wisdom was religious wisdom aided by the dial. My findings here expand the point made by Henry that for seventeenth-century enquirers, nature was God's other book.[26] To contemplate the Moon in this way was to come closer to God in a sense.

Cressy says the fundamental questions about God's creation was not new, but they were given new energy in this period by the new instruments such as the telescope and compass that were enabling new discoveries.[27] However, he neglects to include the mechanical timepiece with lunar indications, but they too made a contribution by acting as a prompt for thinking about the inhabited Moon. The clock and watch were also new and developing mechanical instruments and the representation of the man-in-the-moon was a deliberate decision by clock and watch-makers to position themselves and their devices at the forefront of these new debates.

Cressy correctly points out that the possibility of the inhabited Moon was part of a much wider European debate.[28] Clock and watch-makers from different countries in Europe all began to include the representation of the man-in-the-moon on their lunar image in the early-mid seventeenth century. This is further support for my view that dial designs, similarly to printed paper sources, transcended national boundaries in the period. There was no distinction to be made between dials made in Catholic Europe and Protestant Europe. This is supported by Cressy's comment that French intellectuals argued in the 1630s that God's omnipotence allowed him to create an infinite abundance of creatures.[29] Indeed, members of the Royal Society and the Paris Academie wondered whether sufficiently powerful telescopes could be constructed to see 'the reputed citizens of the Moon'.[30]

The conversation about the possibility of the plurality of worlds continued throughout the eighteenth century. By 1778 the clock-maker, Henry Jenkins, expressed his thoughts on the subject. Having discussed the motions of the planets and established they

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[26] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.98.
[27] Cressy, D. 2016. Early Modern Space Travel and the English Man in the Moon. *The American Historical Review.* 111(4).p.963.
[28] Ibid.p.963.
[29] Ibid.p.964.
[30] Ibid.p.976.

were the work of God, he says: "This induced me to make frequent digressions, and among others, the probability of an infinite number of habitable worlds."[31] Jenkins was very much part of the wider discussions going on about the universe, as created by God, and it is significant that he chose to emphasise that. Although his is the only surviving record of a maker's opinions of this issue, his thoughts would have been echoed by clock and watch-makers a hundred years previously, but were not recorded. Nascent science had clearly reinvigorated debates about the nature of the universe and our place within it, which influenced the clock and watch dial and its representation of the lunar phase. In this instance the discussion and associated representations did not conflict with religious ideas and in fact were used to emphasise the wonder of God's creation.

The pictorial representation of the Moon in the early modern period was significant in terms of what both the creators of the image and the audience thought about this religious debate about the nature of the Moon. Users of clock and watch dials which represented the lunar phase also carried around in the example of the watch, and consulted regularly in terms of the clock and watch, a reminder of God's creation of the potentially-inhabited Moon and thus a reminder of the questioning nature of nascent science.

6.3 The astrological and mnemonic use of lunar wisdom

William Johnson's extended title for his almanac of 1569 was: "A New Almanacke and Prognostication, for the yeare of our Lorde, 1569. Wherin is expressed the change, full, and quarters of the Moone, the varietie of the ayre, and divers other profitable thinges."[32] Returning to the epigraph for this chapter, I argued that had Smith been writing one hundred years earlier his reference to the Moon would have been further up the hierarchy of the list. Johnson, on the other hand, placed it at the top of his list of the information which readers would find in the almanac. Although Smith and Johnson were describing different media, clocks and almanacs respectively, the difference in where they placed the Moon in their hierarchies of use is best understood in terms of changing perceptions of astrology, rather than any difference in medium. As I argue in chapter two, dials were a form of diagram or circular table in a similar way to almanacs. This means that to argue that, because they were different media, they can't be compared in terms of use is untenable. I agree with Curry when he says that the phases of the Moon were the basic part

[31] Jenkins, H. 1778. *A Description of Several Astronomical and Geographical Clocks.* London.
[32] Johnson, W. 1569. *A New Almanacke and Prognostication.* London.

of astrology.[33] For Curry it was important that the lunar phase was visible to the naked eye and did not need further calculation. I expand this idea by identifying it as 'lunar wisdom', which must be differentiated from calendrical insight and astronomical knowledge. All three were used for astrology, but can be distinguished using clock and watch dials compared with printed paper sources.

The astrological and mnemonic use of information on dials has been a recurring theme throughout this thesis. I consider different angles of this issue in chapter two and chapter five and will return to it in chapter seven. In this section I argue that the lunar function on clock and watch dials had a unique role in terms of astrology, which in terms of content must be interpreted separately from, but with reference to, the calendrical and astronomical functions. As was mentioned in section 6.1, the lunar function had a different overall lifespan compared with the calendar and astronomical functions, which I argue was due to different uses. Its use for astrology also had a different lifespan compared with the other functions, as its application to weather prediction was one of the things that reformers of astrology in the late-seventeenth century concentrated on.[34] I argue that whereas calendrical information on dials provided the calendrical insight users needed to temporally locate themselves according to astrological advice read in the almanac as discussed in chapter five, lunar information on dials acted as a prompt to the pre-existing lunar wisdom that users possessed of the occult qualities of the Moon.

The lunar function has not been interpreted in this manner before. This section thus contributes to the work of Henry who says that occult qualities were perceived as the influencing power of the heavenly bodies.[35] The implication of this being that the lunar function on a clock and watch dial was also a tool of natural magic in this period. Henry says that natural magicians needed a good knowledge of signatures[36] and indeed, dials in this context provided a prompt to thinking about those things on Earth that were influenced by the Moon.

To the untrained eye, determining the lunar function's usefulness for astrological purposes is challenging, given that it was present on dials throughout the period and did not disappear once astrology went in to decline from the mid-late seventeenth century, which I argue in this chapter was due to continued use for other purposes. As was mentioned in

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[33] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.11.
[34] Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber.p.238-239; Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.33; Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.59.
[35] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.60.
[36] Ibid.p.57.

section 6.1, the representation of the lunar phase itself changed very little in the period under investigation, but as discussed in the preceding section, there were subtle differences. However, my unique methodology, of comparing dials to the wider context of printed paper sources, shows that the historical period is how the use of the lunar function must be interpreted. Its inclusion on multi-function dials (see figures 6.3 and 6.7), which went in to decline during the mid-late seventeenth century during a similar period to astrology, demonstrates the use of the lunar function as part of a combination. I argue that it played a distinctive role within that combination.

This section is based on my identification of three main astrological uses of calendrical information derived from almanacs. These are weather prediction, health matters, and farming. This approach expands the point made by Henry[37] and others,[38] who say that astrology was part of the natural magic tradition in this period. People did not readily distinguish between astronomy and astrology in this period. Based on this, I contribute clock and watch dials with the lunar function as part of the natural magic tradition. This also expands the argument made by Eamon[39] and Dear,[40] that magic was a technology and a method of doing in the Middle Ages and Renaissance, by contributing clocks and watches to the discussion and bringing the temporal parameters forward to include the period up until the mid-late seventeenth century. Magic was chiefly concerned with exploiting the sympathies and antipathies between things in the Great Chain of Being.[41] These subsections were groups of sympathies between the Moon and the winds and rain; the human body; animals and plants. Eamon claims that through knowledge and invention, man as magus, was able to master nature.[42] Whereas Eamon refers to nature generally, I argue that the specifics were the weather, health and farming for which the lunar function on dials was an aid.

6.3.1 Weather prediction

Weather predictions in almanacs were based on the lunar phase and changed very little in the period from the mid-sixteenth to the mid-seventeenth century. Stephin's almanac of 1569, see figure 6.8, advised its readers that: "The full moone Eclipsed on thursdaye the

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[37] Ibid.p.60.
[38] Clark, S. 1997. *Thinking with Demons: the Idea of Witchcraft in Early Modern Europe.* Oxford: Clarendon Press.p.218; Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.18.
[39] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.172.
[40] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.25.
[41] Henry, J. 2002. *Knowledge is Power: Francis Bacon and the Method of Science.* Cambridge: Icon.p.55.
[42] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.198.

third day of this moneth. at iiii. of the clock xlvi. min. in the morning colde, cloudy, after snowe, and foule weather, wynde southeast."[43] Alleyn's almanac of 1606 similarly advised:

> Januarie 1606…first quarter the fift day at 3 of the clocke, xlix minutes in the morning, dry and frostie. Full Moone the 10 day, at 3 of the clock 54 minutes in the morning, very colde and hard frost. Last quarter the 21 day, at two of the clock forty five minutes after no one, some snowe and raine…[44]

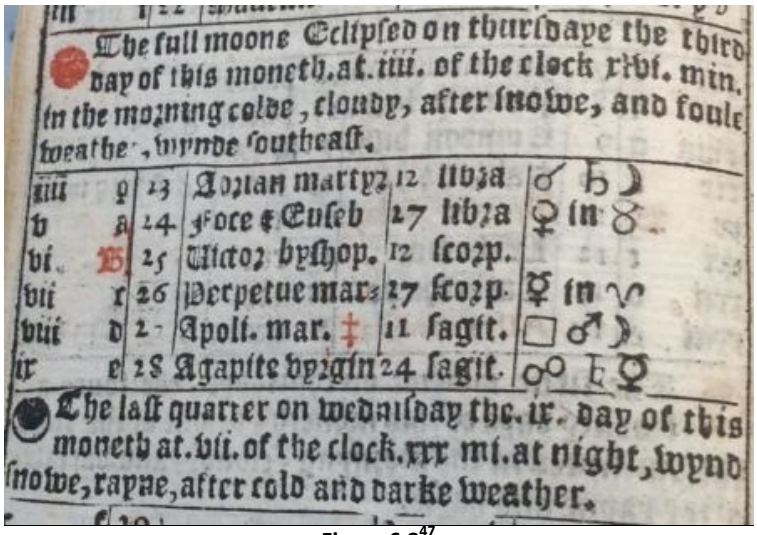
Sure enough Burton's almanac of 1621 also advised:

> January 1621…Last quarter the 4 day at 7 and 38 minutes at night windy and wet weather, if no sleete or snow. New Moone the 13 Day, at 2 and 45 minutes in the morning, cold and moist weather: but towards the latter part of this quarter some frost. First quarter the 20 day at 6 and 25 minutes at night cold and sharpe weather. Full Moone the 27 day at 3 and 7 minutes after no one, the weather much like as before.[45]

Despite being written over fifty years apart, these three almanacs linked weather change with the lunar phase. Furthermore, they each anchored the lunar change to clock time and thus weather changes were also associated with clock time. Armed with an almanac such as these, the reader needed to know when the full or new Moon would occur in order to prepare for such weather changes. If well-disciplined the user might keep track of the date of the month and the lunar date and anticipate the lunar change and the associated weather change. However, it is easy to lose track of the date and lunar date. Alternatively, a user could look at the Moon each night and anticipate the relevant quarter and the associated weather change. However, a user with a clock or watch dial such as that seen in figure 6.7, which represented the lunar phase, lunar calendar and the civil calendar, could consult the dial with a quick glance each day and anticipate the upcoming weather changes which they read in an almanac, such as that seen in figure 6.8, with greater ease. The lunar phase on the dial was conceivably a prompt to thinking about the associated advice connected with the change of the Moon for those who could afford a clock or watch.

[43] Stephins, T. 1569. *A Newe Almanacke and Prognostication for the Yeare of our Lorde God, M.D.LXIX.* London: Thomas Marshe.
[44] Alleyn, H. 1606. *An Almanack and Prognostication.* London.
[45] Burton, G. 1621. *A New Almanacke and Prognostication.* London.

Figure 6.7[46] ©British Museum


The full moone Eclipsed on thurſdaye the third
day of this moneth.at.iiii. of the clock xlvi. min.
in the morning colde, cloudy, after ſnowe, and foule
weathe, wynde ſoutheaſt.

iiii	♀	13	Adrian martyr	12	libra
v	♌	14	Foce & Euſeb	27	libra
vi	♋	25	Victor byſhop.	12	ſcorp.
vii	♈	26	Perpetue mar.	27	ſcorp.
viii	♎	2	Apoli. mar. ✝	11	ſagit.
ix	♍	28	Agapite vyrgin	24	ſagit.

The laſt quarter on wednſday the.ix. day of this
moneth at.vii. of the clock.xxx mi.at night, wynd
ſnowe, rayne, after cold and darke weather.

Figure 6.8[47]

Lunar aspects were discussed in chapter two in terms of the way in which the geometric shapes were part of the language of geometry. However, they were also important for weather prediction in almanacs. Some multi-function dials from the mid-sixteenth to the early-seventeenth century represented the lunar aspects in diagrammatic form on a central disc within the lunar calendar as seen in figure 6.7. While Rossi argues, as mentioned in chapter two, that symbols and hieroglyphs in late-sixteenth century works were often intended to act as a veil covering secret wisdom from the vulgar,[48] in this context it was the combinations of information that acted as a veil to higher knowledge. They were a manner of expressing the lunar phase. The lunar aspects were cited in weather predictions in some almanacs of the period. Burton, for example, entitled his section on the

[46] British Museum 1856,0429.1. Reproduced by kind permission of the Trustees of the British Museum.
[47] Stephins, T. 1569. *A Newe Almanacke and Prognostication for the Yeare of our Lorde God, M.D.LXIX.* London: Thomas Marshe. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[48] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.62.

weather: "A prediction of the weather for every quarter of the Moone in each Moneth throughout the yeere, the aspects of the Planets between themselves…"[49] This apparent link between dials and weather prediction based on astrological interpretations of the lunar phase was also evident in the workshop notebook of one late-seventeenth century clock-maker.

Under the title "a promis made"[50], the anonymous author included rough notes on different clocks and watches that he was evidently working on. It would appear that these notes were for timepieces that had been ordered by customers. The notes do not follow any particularly logical fashion and are incomplete due to damage, but include practice sketches of the face of the Moon for the lunar phase of a dial in addition to notes on the weather and the astronomical influence upon it. As mentioned in chapter one when discussing clock-makers, workshop notebooks are extremely rare for this period. As Evans informs us, virtually none has survived from the workshop of Thomas Tompion,[51] and he was Britain's most famous clock-maker. The notebook contains a few scattered dates between 1690 and 1721, but it is not clear when these dates were written because it seems unlikely that a single notebook would be used for over thirty years. However, if it was compiled during this period then it provides a rather late example of someone making a connection between the lunar phase and weather prediction. By the mid-late seventeenth century almanac authors stopped making explicit links between the change of the Moon and the weather, although the information was kept close together on the page or on the next page. Perhaps this close proximity of information was a device employed by the author or publisher to keep both those who continued to believe in astrological weather advice happy in addition to those who were by then turning against it. Gallen's almanac of 1642,[52] an anonymous French almanac of 1693[53] and Trigge's *Calendarium Astrologicum*[54] of 1747 all provided separate information about the age of the Moon and the weather, but did not make a link between the two.

However, as mentioned earlier weather prediction was one feature of astrology that reformers in the late-seventeenth century chose to emphasise in order to keep it going. Goldsmith's almanac of 1733[55] continued to make weather predictions based on the phase

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[49] Burton, G. 1621. *A New Almanacke and Prognostication.* London.
[50] MS6619. 1696-1708. *Anonymous Workshop Notebook*. Worshipful Company of Clockmakers.
[51] Evans, J. 2006. *Thomas Tompion at the Dial and Three Crowns: with a Concise Check List of the Clocks, Watches and Instruments from his Workshops.* Ticehurst: Antiquarian Horological Society.p.40.
[52] Gallen, T. 1641. *An Almanack and Prognostication for the Yeare of God 1642.* London: Rob Young.
[53] Anonymous. 1693. *Almanac ou Calendrier Pour L'Annee 1693.* Paris.
[54] Trigge, T. 1684. *Calendarium Astrologicum.* London: J. Playford.
[55] Goldsmith, J. 1733. *An Almanack for the Year of our Lord God, MDCCXXXIII.* London: E. Palmer.

of the Moon, similarly to the early-seventeenth century almanacs cited above, people such as John Goad[56] attempted to rescue astrology by emphasising the importance of weather prediction over other aspects such as the out-dated judicial astrology. In this context the lunar phase on dials continued to have an astrological use as a prompt for weather changes beyond the other functions. Indeed, as mentioned above, the clock-maker, Smith, may have listed the lunar indications as fourth in his list, but he still believed the Moon influenced the weather when he was writing his second book *Horological Disquisitions* in 1694: "As to the Moon, 'tis well observed, That the Weather is generaly inclinable to Moisture, about three Days before, and three Days after, both the New and Full Moon…"[57] Smith's acknowledgement of the link between the age of the Moon and changes in weather provides a direct link between makers, who were producing clocks and watches which presented lunar information, and the astrological use of that information, provided by almanacs and craft books of the period. For Webster, astrology was an adapting art,[58] and I argue that clock and watch dials were also. The representation of the lunar phase may not have changed much itself during the seventeenth century, but its use certainly did. This is something Curry would agree with given that he claimed the lunar part, as with all astrology, was more about decline than extinction.[59]

6.3.2 Health matters

That which was referred to as 'physic' in early modern almanacs and craft books, I have termed 'health matters' given that it related to physical bodily matters and not just medicines. While I am in agreement with Tester that medicine and astrology were closely associated, his statement that this lasted as late as the seventeenth century[60] could be narrowed slightly. I argue that it was up until the mid-seventeenth century.

Francis Bacon wrote in *Sylvia Sylvarum* that the Moon had an effect on the brain and the humours:

> It is like, that the braine of man waxe the moister and fuller, upon the full of the Moone: And therefore it were good for those that have moist braines, and are great Drinkers, to take fume of lignum aloes, rosemary, frankincence and c. about the full of the Moone. It is like also, that the Humours in Mens bodies, increase, and

[56] Goad, J. 1686. *Astro-Meteorologica.* London: Obadiah Blagrave.
[57] Smith, J. 1694. *Horological Disquisitions* London.
[58] Webster, C. 1982. *From Paracelsus to Newton: Magic and the Making of Modern Science.* Cambridge: Cambridge University Press.p.18.
[59] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.121.
[60] Tester, J. 1987. *A History of Western Astrology.* Woodbridge: Boydell.p.223.

> decrease, as the Moone doth; and therefore it were good to purge same day or two , after the Full: for that then the humours will not replenish so soone again.[61]

It is evident from his use of 'it is like' and 'it is like also' that Bacon knew he wasn't introducing new knowledge by saying that the Moon had this affect. What he was introducing was his advice of what people should do based on these facts as they perceived them in the period. He was not alone in issuing this advice, which was available in almanacs and craft books of the period up until the mid-seventeenth century. Indeed, as Henry points out astrology figured quite highly in the medical faculties of the early modern universities.[62] This was by no means a preoccupation of the poor. It was something that many of the wealthy owners of clocks and watches would have believed in.

Health-related advice in early modern almanacs was wide ranging. The well-known example of 'zodiac man' which held a position at the front of most almanacs up until the mid-seventeenth century, and represented different parts of the human body as ruled by the position of the Moon in the twelve signs of the zodiac, disappeared in some almanacs during the early-seventeenth century. This was before health advice based on the lunar phase disappeared in the mid-seventeenth century. Additional pages of the almanac were dedicated to detailed advice about the best times to undertake different forms of purging as the following excerpt from Alleyn's almanac of 1606, which was typical for the period up until the mid-seventeenth century demonstrated:

> Purgations are best taken, the Moone being in a waterie signe. With electuaries in cancer, potions in Scorpius, pilles in pisces. Bathe for health, the Moone being in Aries, Leo, or Sagittarius, and for cleanliness, the Moone being in Libra or Pisces. Purge by vomit the Moone being in Aries, Taurus, Capricornus. Purge the head by neesing the Moone being in cancer, leo or virgo. Good to stoppe fluxes, rewmes and laxes the Moone being in Taurus, virgo or Capricornus. Good to take Gargarisnes the Moone being in aries, cancer, capricorne. Good to sweat in a Hote-house. The Moone being in Libra or Pisces. Good to cut the hayre of the head or beard the Moone being in libra, sagitarius, acquarius or pisces.[63]

The user who could afford a multi-function clock or watch such as that in figure 6.7 would have been able to use it as a tool to prompt the recall of the lunar wisdom gained in an almanac such as this in order to take charge of their own health-related activities. The dial in figure 6.7 indicates the place of the Moon within the zodiac, which is the reference point for each of the activities listed above such as purging by vomit when the Moon is either in

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[61] Bacon, F. 1627. *Sylva Sylvarum: or a Naturall Historie in Ten Centuries.* London: John Haviland for William Lee.
[62] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.60.
[63] Alleyn, H. 1606. *An Almanack and Prognostication.* London.

the zodiac signs of Aries, Taurus or Capricorn. A user would be able to plan ahead and determine when the pointer with the Moon figure attached was going to point to the appropriate sign of the zodiac in the ring on the dial which represented the signs of the zodiac. The Moon passes through the twelve signs of the zodiac in one lunar month, spending about two and half days in each sign. The advice above was associated with the Moon being in one of three zodiac signs, which means that readers would have around seven and half non-consecutive days to perform the listed tasks. A dial such as figure 6.7 would be useful here.

Given such a detailed list of health-related tasks from different methods of purging to bathing and hair cutting, to be conducted at specific dates in the lunar calendar, it is clear that some people considered it important to perform specific activities at specific moments. Tasks were not conducted when people had a free moment or at random; advance planning was very important. In this context it is very unlikely that the lunar function on clock and watch dials of the period was purely an aesthetic decoration. In addition to almanacs, there were health-related pamphlets such as *A Treatise of 113 Diseases of the Eye*[64] and *Two Treatises Concerning the Preservation of the Eyesight*[65] in which advice for preserving eyesight was given in exactly the same wording: "Care must be had, that you sleepe not in a Chamber, or any Place in which the Moone doth Shine." The user of a dial such as that in figure 6.7 would be able to determine when the full Moon, and therefore the most intense moonlight, would occur and arrange their sleeping place accordingly. The belief that a person could preserve their sight by not sleeping in a room with moonlight was highly important and not something anyone would want to ignore.

Furthermore, Tester informs us that there were perceived to be two kinds of diseases in the early modern period: acute and chronic. [66] He says that the acute type never lasted more than a month and was to be judged according to the lunar phase. The date, time and position of the Moon were to be noted on the day the patient was taken to bed.[67] While Tester does not comment further on this scenario, this information on the lunar phase was surely supplied to the doctor as they wouldn't be called before a patient was taken ill. In this scenario the patient and family, who could afford to pay a doctor and therefore were likely to be wealthy enough to be able to afford a clock or watch, would have found one with

[64] Banister, R. 1622. *A Treatise of One Hundred and Thirteene Diseases of the Eyes and Eye-Liddes. Translated from J. Guillemeau.* London: F. Kyngston for T. Mann.
[65] Bailey, W. 1633. *Two Treatises Concerning the Preseruation of Eie-sight*. London.
[66] Tester, J. 1987. *A History of Western Astrology.* Woodbridge: Boydell.p.223.
[67] Ibid.p.223.

a lunar function extremely useful for noting this information that was considered to be vital for a patient's prognosis.

By the mid-seventeenth century, explicit health advice based on the lunar phase had disappeared, but some almanacs, such as Gallen's[68] and Goldsmith's,[69] continued to include a column with the parts of the body which were influenced by the Moon such as the knees and feet. This was instead of including the 'zodiac man'. Gallen expressly criticised the diagram of 'zodiac man' in his almanac of 1641 and said that he wouldn't insult his readers by including it, but then went on to include the same information in a column of his almanac. He did not offer any other sort of health-related advice based on the age of the Moon. By relegating the information to a column instead of a page, but not withdrawing it altogether, it is probable that his printers retained it to keep a portion of their readership happy. In the 1640s there were still people who believed in the traditional astrological principles, but these were to become fewer in the decades to come. Goldsmith, as mentioned earlier, was keen to try to rescue astrology and to emphasise, what he considered to be, the more 'scientific' parts of astrology such as weather prediction. In his almanac of 1733,[70] he also restricted the association he made between the Moon and health matters to the Moon's influence over certain parts of the body, but without advice on health-related tasks. Having demonstrated the extent to which the Moon was believed to influence the human body, I now move on to considering its perceived effect on animals and plants.

6.3.3 Farming

In his almanac of 1606, Alleyn gave the following advice:

> Good to Set, Sowe, or plant, when the Moone is in Taurus, Virgo, Capricornus, or Pisces. Good also, to sow all kinde of corn when the Moone is in Cancer. Good to grasse, when the Moone is inTaurus and Acquarius, at the increase of the Moone. Good to sheare sheepe at the increase of the Moone. Good to geld beastes and cattell, the Moone being in Aries, Sagittarie, or Capricornus. Kill fat swine for Bacon, the better to keepe theyr fatte in boyling, about the full of the Moone.[71]

This was typical of the astrological advice provided by almanacs up until the mid-late seventeenth century.[72] Allestree's almanac advised readers: "Gather Apples and other

[68] Gallen, T. 1641. *An Almanack and Prognostication for the Yeare of God 1642.* London: Rob Young .
[69] Goldsmith, J. 1733. *An Almanack for the Year of our Lord God, MDCCXXXIII.* London: E. Palmer.
[70] Goldsmith had been publishing almanacs with this format and content since 1660.
[71] Alleyn, H. 1606. *An Almanack and Prognostication.* London.
[72] Allestree, R. 1617. *A New Almanacke & Prognostication.* London.and Chamberlaine, J. 1631. *A New Almanacke and Prognostication.* London.were both other almanac examples.

fruits, herbes, and flowers to have them in most beauty and greatest virtue, the moone at the full."[73] Similarly to the weather prediction and health-related advice given in almanacs as discussed above, it could be imagined that the user of a clock or watch with lunar phase would be able to use that lunar information to plan the agricultural tasks referred to in an almanac such as this. As was mentioned in chapter one the wealthy users of clocks and watches would have included the landed gentry and other land owners. The lunar function would again have provided the user with a prompt to recall the lunar wisdom they had acquired through the almanac. The owner of a multi-function timepiece such as that seen in figure 6.9 would be able to plan the shearing of sheep after the new Moon as advised by Alleyn in 1606 or pick fruit at the full Moon as advised by Allestree in 1624. While Tester claims that instrument makers were essential in this period as people desired ever greater celestial observations,[74] while not explicit he is clearly referring to telescopes and quadrants used for sighting and measuring angles. However, clock and watch dials with the lunar function were the technology best suited to the application of lunar wisdom to astrology in connection with the almanac.

Figure 6.9[75] ©British Museum

Figure 6.10[76] ©British Museum

Almanacs were not alone. Craft books such as *the Husbandman's Practice* of 1664,[77] based on Thomas Tusser's handbook of 1557,[78] provided similar advice to almanacs of the period based on the astrological theory that the Moon influences farming. In point fifty-nine, Tusser advised: "The Moone in ye wane, gather fruit for to last, but winter fruite

[73] Allestree, R. 1617. *A New Almanacke & Prognostication.* London.
[74] Tester, J. 1987. *A History of Western Astrology.* Woodbridge: Boydell.p.226.
[75] British Museum 1890,1215.1. Reproduced by kind permission of the Trustees of the British Museum.
[76] British Museum 1893,0601.328. Reproduced by kind permission of the Trustees of the British Museum.
[77] Godfridus. 1676. *The Knowledge of Things Unknown Shewing the Effects of the Planets and Other Astronomical Constellations; Together with The Husbandman's Practice.* London.
[78] Tusser, T. 1557. *A Hundreth Good Pointes of Husbandrie.* London.

gather, when Mighel is past."[79] The advice given in this husbandry handbook is similar to that in the almanacs of the period and provides further evidence of this view.

For Curry, lunar knowledge within the context of astrology brought different social groups together.[80] My findings in this sub-section support and expand this view. It is anachronistic and an over-simplification to conclude that educated city people did not follow astrology and their lesser-educated counterparts in the countryside did.[81] It must be remembered that these texts were printed and often sold in London and that, as Earle points out, landed gentlemen spent much of their time in London[82] and probably bought these texts there and then used them for estate management at home. These were the same people who could buy clocks and watches with a lunar function.

By the late-seventeenth century some almanacs, such as Dade's, continued to offer advice on farming, but had removed any associations with the lunar phase. This was a deliberate decision to distance almanacs from the by-then outdated astrological practice. Dade advised that if a cow had lost its appetite then it should be given a mixture of salt and white-wine vinegar to restore its appetite and prevent it from becoming ill. Unlike the almanacs mentioned above, there was no mention of the Moon. The multi-function dial, such as that seen in figure 6.9, in use between the mid-sixteenth and mid-late-seventeenth century, had also gone in to decline. The lunar function remained on some dials (see figure 6.10 which was made in the same period as Dade's almanac), but given the changed references in almanacs and other works, was no longer used for astrological purposes, except for perhaps those who wanted to reform astrology in the late-seventeenth century.

Advice on the undertaking of certain tasks, such as the sowing of seeds at certain moments in the lunar phase, survived the disappearance of advice on health-related matters and explicit weather prediction in almanacs and craft books of the period. However, advice relating to other activities, such as the felling of trees, the gelding of animals and shearing of sheep, disappeared at around the same period as health-related advice in the mid-seventeenth century. Weather prediction based on the lunar phase survived a little longer, up until the mid-late seventeenth century, but all of the different types of astrological advice discussed in this section had ceased to be included in almanacs and craft books by the late-seventeenth century, with the exception of John Goad's *Astrometeorologica* and Goldsmith's almanac of 1733, which both tried to rescue astrology from its decline and

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[79] Ibid.
[80] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.p.97.
[81] Ibid.p.97.
[82] Earle, P. 1991. *The Making of the English Middle Class: Business, Society and Family Life in London 1660-1730.* London: Methuen.p.18; 92.

assume it into the nascent scientific method. Goad, writing just three years after Dade, not only continued to make the link between the Moon and a noticeable influence on beings on Earth, but made a link directly with cattle: "All things…animale, and inanimale, receive her impression… Eyes of some cattle so affected, that the Darkness shall increaseth proportionable to the Moon…"[83]

Concurrent with this decline was the disappearance of the multi-function clock and watch dial, which is indicative of its role as an instrument of practical astrological use as part of the natural magic tradition and the early modern pursuit of total knowledge, which Rossi argues dominated seventeenth-century thought.[84] However, the lunar phase continued to be represented on clock and watch dials as it was useful throughout the period for other purposes, which I will discuss in the next section. My findings in this section partly challenge the claim made by Webster that the Paracelsian prophecy theory was still in vogue at the end of the seventeenth and beginning of the eighteenth centuries.[85] It may have been for some people, but certainly wasn't for most almanac readers and clock and watch owners. The lunar phase survived because it was useful for planning night-time journeys, to which I will now turn.

6.4 The use of lunar wisdom for seeing after sunset

People throughout the period required information about the availability of moonlight to plan for travel and work after sunset. Whereas the uses of lunar information referred to in the previous section were based on a theory and once this theory declined the practices did also, the light provided by the full Moon continued to be of practical use until widespread artificial street lighting. In chapter four I discussed the way in which some dial formats enabled users during the dark inside the house, but in this chapter my focus is on how dial content enabled users to plan journeys outside. Although historians such as Bruton[86] and Uglow[87] have casually referred to the potential of the lunar function to be used to plan travel at night, until now none have based this on any evidence. For them it was a common-sense argument, which, while logical, is insufficient for understanding the lunar function on dials. I provide a more in-depth focus on this context of use by comparing dials with printed paper sources in order to improve our understanding of the user experience.

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[83] Goad, J. 1686. *Astro-Meteorologica.* London: Obadiah Blagrave.
[84] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.38.
[85] Webster, C. 1982. *From Paracelsus to Newton: Magic and the Making of Modern Science.* Cambridge: Cambridge University Press.p.16.
[86] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.p.111-114.
[87] Uglow, J. 2002. *The Lunar Men: the Friends who Made the Future 1730-1810.* London: Faber.p. xxii; 453.

Phillippes included the following paragraph in his explanation of each column of the almanac of 1655:

> In the second, or blank pages of the Almanack You have the first the day of the month; secondly, the time of the Moon's rising and setting: which though it be troublesome to calculate yet I look upon it as a very necessary and pleasant observation. For by this means any night you shall know whether it will be light or dark, and how long, or what time of the night, and so accordingly forecast your business.[88]

This excerpt was typical of information provided in almanacs throughout the period and demonstrates the acknowledged importance of using moonlight to undertake important outdoor activities. This non-astrological feature in almanacs was acknowledged by Perkins,[89] but she too skimmed past it quickly. However, despite a mention, she does not make the distinction between the different types of astrological advice based on the lunar phase and the practical need for knowledge of the duration of moonlight which endured throughout the period 1550-1770. The former developed slightly differently in the period and declined at different moments, but eventually disappeared from almanacs by the late-seventeenth century except in a few rare examples. It is conceivable that this was the crucial reason for the survival of the lunar phase on provincial longcase clocks of the mid-late eighteenth century (see figure 6.2).

In the absence of street lighting, moonlight, particularly on the night of the full Moon, was beneficial for travelling after dark. In 1667, Pepys wrote in his diary: "Having discoursed this a little with him, and eat a bit of cold venison and drank, I away, took boat, and homeward again, with great pleasure, the Moon shining, and it being a fine pleasant cool evening, and got home by half-past twelve at night, and so to bed."[90] This statement demonstrates that Pepys, and many others in this period, were able to extend their outing on nights that were moon-lit. It was also important for conducting certain activities such as harvesting crops hence the term 'harvest Moon.'[91] Undertaking agricultural activities under the light of the full Moon was different from undertaking them because of a belief that the activity would be more successful because of the influence of the Moon on that activity as discussed in the previous section.

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[88] Phillippes, H. 1655. *An Almanac for the Year of Our Lord 1655.* London.
[89] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.210.
[90] Diary of Samuel Pepys, Wednesday *24th July 1667*. http://www.pepysdiary.com/.
[91] The Harvest Moon is the name given to the full Moon that occurs nearest to the date of the autumn equinox, which was traditionally a period in which the harvest took place.

Information on the duration of moonlight on a particular date, or age of the Moon, was extremely widespread. Craft pamphlets, in addition to almanacs, often included a diagram of the duration of moonlight such as Hulsii's *Vierdter Tractat* of 1615.[92] In this context it is easy to understand why dials with a representation of the lunar phase, were of practical use to users throughout the period 1550-1770. This was whether it was in the form of a multi-function dial, which was also useful for astrological purposes as discussed earlier, or a single additional function to the hour of the day. Although not very common, some early-mid seventeenth century dials represented the hours of moonlight using a similar diagrammatic form of representation as that which featured in craft books of the period such as Leonhard Zubler's *Beschreybing dess Astronomischen Instruments*, of 1614-15 (see figures 6.11 and 6.12).

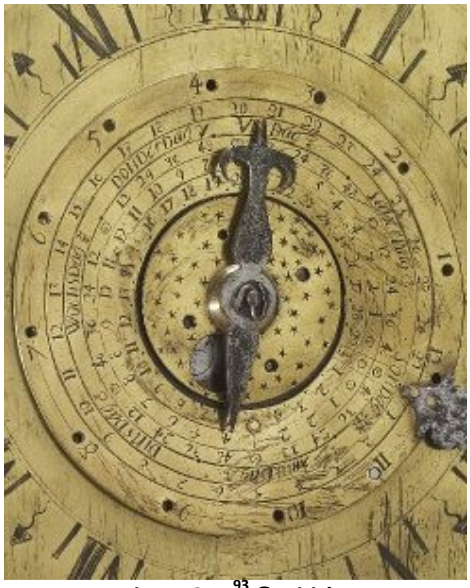


Figure 6.11[93] ©British Museum

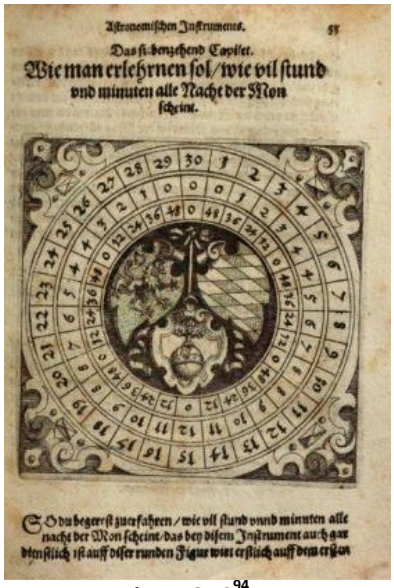


Figure 6.12[94]

Using the three concentric rings on the outside of the central lunar phase disc of the dial seen in figure 6.11, a user can read that on the 16th day of the lunar calendar, the night of the full Moon, the duration of moonlight will be twelve hours and zero minutes.[95] Similarly, on the first day of the lunar month, the night of the new Moon, there will be zero hours and zero minutes of moonlight. This dial serves as a mechanised form of the information provided in almanacs and craft pamphlets. It is probable that users would cross-reference this information with their mechanised lunar phase on the dial and would gradually come to

[92] Hulsius, L. 1615. *Vierdter Tractat der Mechanischen Instrumenten.* Franckfurt am Mayn.
[93] British Museum 1958,1006.2102. Reproduced by kind permission of the Trustees of the British Museum.
[94] Zubler, L. 1614-15. *Beschreybung dess Astronomischen Instruments.* Basel. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[95] This calendar uses a 1-30 lunar month, when it should be 1-29½. Also the full Moon has been set on the 16th day when it is actually on the 15th day.

equate certain lunar dates with certain durations of moonlight. This particular dial provides that service automatically.

Knowledge of the lunar phase was also useful for planning night-time military engagements. Edward Gresham, spreading news of a battle in Europe in 1606, wrote that night battles could only last as long as there was moonlight: "But beholde the wonderfull woorkes of Almighty God, for when the battaile began, which was from the Evening, till three of the Clocke in the Morning and then the Moone did lose her light and the Horsemen vanished quite away."[96] A watch or small table clock with lunar function and an almanac would have been extremely useful for military leaders deciding which night to plan any strategic engagement with the enemy in this context. It is extremely significant also that by 1606 record of the battle also included the hour at which the moonlight disappeared. The phrase 'till three of the clocke' indicates that a watch or small table clock was present given that a sundial would not have worked in this context. Moon-dials were used in the early-seventeenth century, but the reference to 'of the clocke' is more suggestive of a mechanical timepiece.

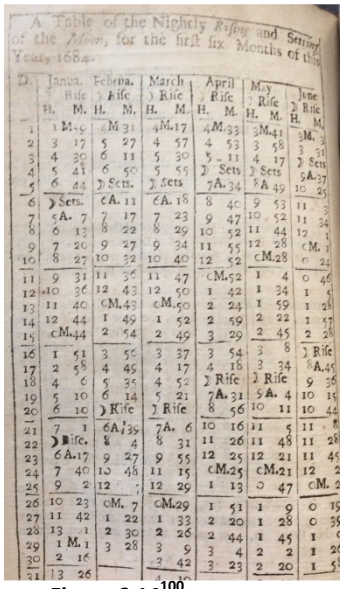
Although multi-function dials were important, dials which only represented the hours of the day and the phase of the Moon are significant in this context as this was a form of representation which was found on the first domestic dials (see figure 6.1) and some late-eighteenth century examples (such as figure 6.13). Given that the hours of moonlight were important throughout the period, it is significant that these dials provided the user with the two most important pieces of information that they needed to know. The hours of the day and the lunar phase were clearly more important to some people than an indication of the day of the month or day of the week. Indeed, the Birmingham Lunar Society, which met from 1765 to 1813, were so named because they met on the night of the full Moon so that members could travel home easily afterwards.[97] Members travelled to meetings from countryside locations, where there were no street lights, and this is a good example of a mid-late eighteenth century need for the lunar phase on a clock or watch dial. The dial in figure 6.13 was made in Oldham, an area similar to those that members of the Lunar Society may have travelled from. It could easily be imagined that one of their members owned a clock such as this one.

Dials were not alone. Almanacs throughout the period often included a data table of the times of the Moon's rising and setting such as that seen in figure 6.14. Indeed, the subject even took the interest of the natural philosopher, James Ferguson, who provided:

[96] Gresham, E. 1606. *Strange, Fearful and True Newes.* London.
[97] Uglow, J. 2002. *The Lunar Men: the Friends who Made the Future 1730-1810.* London: Faber.p.xxii.

"Tables for Calculating the true time of any new or full Moon, from the Creation of the World to A.D. 7800 near enough the Truth for any common Almanack."[98] Ferguson's provision of such extensive temporal parameters was intended to demonstrate the versatility of his method, but also demonstrates that people wanted to be able to calculate the future dates of the full and new Moon, which in part was to aid planning travel. His reference to the method being 'near truth enough for any common almanac' demonstrates that he was providing a method by which readers could calculate the date of the new and full Moon themselves, without dependency on the almanac. However, owners of clocks and watches with the lunar function had this service provided for them to a degree via the lunar phase and the representation of the lunar calendar as an index of 1-29½. When the dial represented the full Moon, for example, at 15 on the numerical lunar calendar scale, users could add 29½ days to the current civil calendar date to work out the date of the next full Moon and so on.

Figure 6.13[99] ©British Museum



A Table of the Nightly Rising and Setting of the Moon, for the first six Months of the Year, 1684.

D.	Janua.	Febma.	March	April	May	June
	☽ Rise H. M.	☽ Rise H. M.	☽ Rise H. M.	☽ Rise H. M.	☽ Rise H. M.	☽ Rise H. M.
1	1 M.45	2M 31	4M.17	4M.33	3M.41	3M.
2	3 17	5 27	4 57	4 53	3 58	3
3	4 30	6 11	5 30	5 - 11	4 17	☽ Sets
4	5 41	6 50	5 55	☽ Sets	☽ Sets	5A.37
5	6 44	☽ Sets.	☽ Sets	7A.34	5A 49	10 26
6	☽ Sets.	6A. 11	6A. 18	8 40	9 53	11
7	5A. 7	7 17	7 23	9 47	10 52	11 34
8	6 13	8 22	8 29	10 52	11 44	12 1
9	7 20	9 27	9 34	11 55	12 28	cM. 1
10	8 27	10 32	10 40	12 52	cM.28	0 24
11	9 31	11 36	11 47	cM.52	1 4	0 46
12	10 36	12 43	12 50	1 42	1 34	1 8
13	11 40	cM.43	cM.50	2 23	1 59	1 28
14	12 44	1 49	1 52	2 59	2 22	1 57
15	cM.44	2 54	2 49	3 29	2 45	2 28
16	1 51	3 59	3 37	3 54	3 8	☽ Rise
17	2 58	4 45	4 17	4 18	3 34	8A.45
18	4 6	5 35	4 52	☽ Rise	☽ Rise	9 36
19	5 10	6 14	5 21	7A. 31	5A. 4	10 19
20	6 10	☽ Rise	☽ Rise	8 56	10 11	10 44
21	7 1	6A.39	7A. 6	10 16	11 5	11 8
22	☽ Rise.	8 4	8 31	11 26	11 48	11 28
23	6A.17	9 27	9 55	12 25	12 21	11 45
24	7 40	10 48	11 15	cM.25	cM.21	12 2
25	9 2	12	12 29	1 13	0 47	cM. 2
26	10 23	cM. 7	cM.29	1 51	1 9	0 19
27	11 42	1 22	1 33	2 20	1 28	0 39
28	13 1	2 30	2 26	2 44	1 45	1 0
29	1 M. 1	3 28	3 9	3 4	2 2	1 20
30	2 16		3 42	3 23	2 20	1 5
31	13 26					

Figure 6.14[100]

As Earle informs us, in the period before the 1680s householders in London were required to display lanterns outside of their houses on moonless nights from dusk until 9pm during winter.[101] This would have been to facilitate people making their way through the city during the phase of the new Moon. Earle does not mention how they managed this, but

[98] Ferguson, J. 1790. *Select Mechanical Exercises.*

[99] British Museum 2010,8029.36. Reproduced by kind permission of the Trustees of the British Museum.

[100] Dade, W. 1683. *A New Almanack with a prognostication, deduced from the motions, distances, and aspects of the planets, and their conjunctions with the moon.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

[101] Earle, P. 1991. *The Making of the English Middle Class: Business, Society and Family Life in London 1660-1730.* London: Methuen.p.78.

I argue that dials help us to understand this task. This responsibility for lantern provision required the householder to be familiar with the lunar calendar, regardless of whether or not they themselves went out during the dark, and both an almanac and a clock with lunar function would have been an invaluable tool. It must have been a problematic task because Earle goes on to say, without making the same connection, that in the 1680s street lighting companies emerged and contacted householders offering to take over their lantern responsibilities for an annual payment. He says that by 1736 the City of London was lit from sunset to sunrise throughout the year.[102] This is further evidence to support the view that the lunar function survived on provincial longcase clocks in to the late-eighteenth century because they were used in areas that did not have street lighting, where people continued to plan their night-time travel according to the lunar calendar. Those dials it did not feature on during the eighteenth century were probably owned by city dwellers with access to street lighting. On this basis, Britain was in no way unique in this period. The same was true of the major cities throughout Europe and of dials similarly. As Koslofsky informs us, there was some street lighting in Paris in 1667, Amsterdam in 1669, Hamburg in 1673, Turin in 1675, and Copenhagen in 1683.[103] The lunar phase was not part of the standard format dial of 1770, but its continued presence on provincial longcase clocks demonstrates that the standard format was a standard but not an absolute.

As I have demonstrated, there was much more to the use of the lunar phase for planning night-time travel than a common-sense statement could provide. I now move on to discuss a use of the lunar phase, which received renewed interest during the mid-late seventeenth century and also played a role in perpetuating the lunar function on dials beyond the decline of astrology.

6.5 Lunar wisdom for tidal reckoning

On the 22nd May 1663 Pepys recorded in his diary: "So to my office, and busy all the morning, among other things, learning to understand the course of the tides, and I think I do now do it…"[104] Given Pepys' maritime work, this comment may not seem significant at first glance. However, as with all of the points made throughout the thesis, context is crucial. Pepys wrote these words in a period in which knowledge of the tides was experiencing renewed interest and a new presence in print. As mentioned in section 6.1, interest in the

[102] Ibid.p.78.
[103] Koslofsky, C. 2011. *Evening's Empire: a History of the Night in Early Modern Europe.* Cambridge: Cambridge University Press.p.131.
[104] Diary of Samuel Pepys, *22nd May 1663*. http://www.pepysdiary.com/.

tides as expressed in pamphlets and dials was a particularly British phenomenon in this period, probably due to increased maritime ambitions and the extent of trade and travel taking place on the Thames, Severn and at sea.[105] It was within this context that clock and watch dials began to include tidal indications. Again, they mirrored almanacs and a variety of pamphlets on tidal reckoning.

Returning to the chapter's epigraph, Smith included the times of high tide as the sixth in his list of possible indications that could be achieved by a timepiece: "…They may shew the time of the tide or full sea in any Port or Harbour whatsoever."[106] His reference to 'any Port of Harbour whatsoever' was significant in the sense that the most referenced location in tables of high tides and on dials was London Bridge. However, both the authors of almanacs and clock and watch-makers acknowledged that many users who wanted to know the tide times at London Bridge would also want to determine them for the other locations to which they travelled. Almanacs often provided a list of alternative locations with instructions on how to calculate the tide times if you knew the time of high water at London Bridge and dials could also be adjusted to provide alternative indications. It is significant that Smith recommended Salmon's almanac of 1694, which provided the information that he stated a clock could also represent.[107] His recommendation also provides a solid link between almanacs and clock-makers. In his almanac of 1684, Salmon professed that his tide tables were better than those provided in other almanacs: "Now by the Tables in the Common Almanacks the time of high water would be at 11h 33 which is 1h. 39m. too late; a very gross error which may make a passenger lose his Tide."[108] Similarly, to Tompion's *Instructions* considered in chapter five, there were consequences for not knowing the time of high tide. A dial such as that seen in figure 6.15 provided a solution to a very practical challenge.

Tidal indication on clock and watch dials emerged in the 1640s and coincided with the first almanacs with tidal data in around 1642.[109] Almanacs of the period and publications such as Gadbury's diary[110] 1673 and Flamsteed's tables[111] 1685 all provided the hour of high

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[105] People in other countries were interested in the tides, but did not produce clocks and watches with tidal indication and did not simultaneously produce a variety of pamphlets on tidal reckoning in the late-seventeenth century.

[106] Smith, J. 1675. *Horological Dialogues.* London.

[107] Smith, J. 1694. *Horological Disquisitions* London.

[108] Salmon, W. 1684. *Salmon's Almanack.* London: T.Dawks.

[109] Gallen, T. 1641. *An Almanack and Prognostication for the Yeare of God 1642.* London: Rob Young is just one example.

[110] Gadbury, J. 1673. *Ephemeris or a Diary Astronomical, Astrological, Meteorological for the Year of our Lord 1673.* London: printed by J.C for the Company of Stationers.

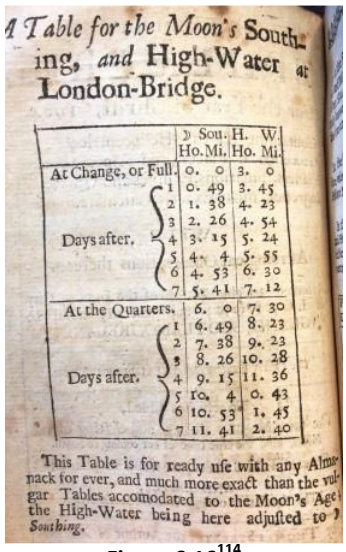
[111] Flamsteed, J. 1687. *A Correct Tide-Table Shewing the True Times of the High-waters at London-Bridge.* London: J. Stafford.

tide at London Bridge for each day of the year. Phillippes' almanac described the information provided as:

> The eighth column shewes the true time of high water at London Bridge…only note that whereas there is a Tide every 12 hours, this shews the Tide that falls out in the day time, between six in the morning and six at night…the other tide falls in the night, about half an hour later…[112]

Phillippes' comment about the provision of the time of the day-time high tide offers an explanation as to why dials also only indicated one tide per day. This was obviously the convention that users were accustomed to in almanacs and was reflected on dials. Indication of high tide was mostly indicated on watch dials, with a few clock exceptions, indicative of the portable requirement of this knowledge, which demonstrates that users would likely have been merchants or seafarers who had a commercial interest in the waterways and travelled. It could easily be imagined that users made use of both an almanac such as Dade's seen in figure 6.16 and a dial with tidal indication such as that seen in figure 6.15, which were both made during the mid-late seventeenth century.

Figure 6.15[113] ©British Museum



A Table for the Moon's Southing, and High-Water at London-Bridge.

		☽ Sou. Ho.	Mi.	H. W. Ho.	Mi.
At Change, or Full.		0.	0	3.	0
Days after.	1	0.	49	3.	45
	2	1.	38	4.	23
	3	2.	26	4.	54
	4	3.	15	5.	24
	5	4.	4	5.	55
	6	4.	53	6.	30
	7	5.	41	7.	12
At the Quarters.		6.	0	7.	30
Days after.	1	6.	49	8.	23
	2	7.	38	9.	23
	3	8.	26	10.	28
	4	9.	15	11.	36
	5	10.	4	0.	43
	6	10.	53	1.	45
	7	11.	41	2.	40

This Table is for ready use with any Almanack for ever, and much more exact than the vulgar Tables accomodated to the Moon's Age the High-Water being here adjusted to Southing.

Figure 6.16[114]

The timing of the re-emergence and then disappearance of tidal indication on dials is significant. Tidal indication had been provided on some dials of the sixteenth century,[115] but the indication regained popularity in the mid-seventeenth century. Their arrival in the 1640s

[112] Phillippes, H. 1655. *An Almanac for the Year of Our Lord 1655.* London.
[113] British Museum 1958,1201.535. The time of high tide is indicated on the inner ring, which corresponds to the lunar calendar on the outer ring. Reproduced by kind permission of the Trustees of the British Museum.
[114] Dade, W. 1683. *A New Almanack with a prognostication, deduced from the motions, distances, and aspects of the planets, and their conjunctions with the moon.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[115] Science Museum 1938-429 is one example of a table clock made by Nicholas Vallin around 1600.

was just before the beginning of the decline in the application of astrological knowledge. Almanacs did not provide astrological advice based on tidal information, which I interpret as evidence that the tidal indication on dials was not used for astrological purposes.

By around 1720 tidal indication disappeared from dials despite the lunar phase continuing to be present on some clocks into the late-eighteenth century, which were likely to have been used in the countryside where there was no street lighting as discussed above. Interest in understanding tidal motion continued, evident from pamphlets of the mid-late eighteenth century. One reason for the disappearance of tidal indication on dials in this context may have been that mid-late eighteenth century almanacs and pamphlets instructed the reader on how to calculate the time of high water themselves, in addition to providing tables of the times of high water. In a sense these publications acted more as a teaching device than merely as a directory of information. Pamphlets such as Benjamin Donn's *The Description and Use of 4 New Instruments*[116] and Oliver Goldsmith's *An History of the Earth and Animated Nature*[117] provided the explanations and calculations necessary for working out the tide times. Gentlemen were also able to purchase models such as that seen in figure 6.17, which demonstrated the Moon's gravitational pull on the Earth's waters.

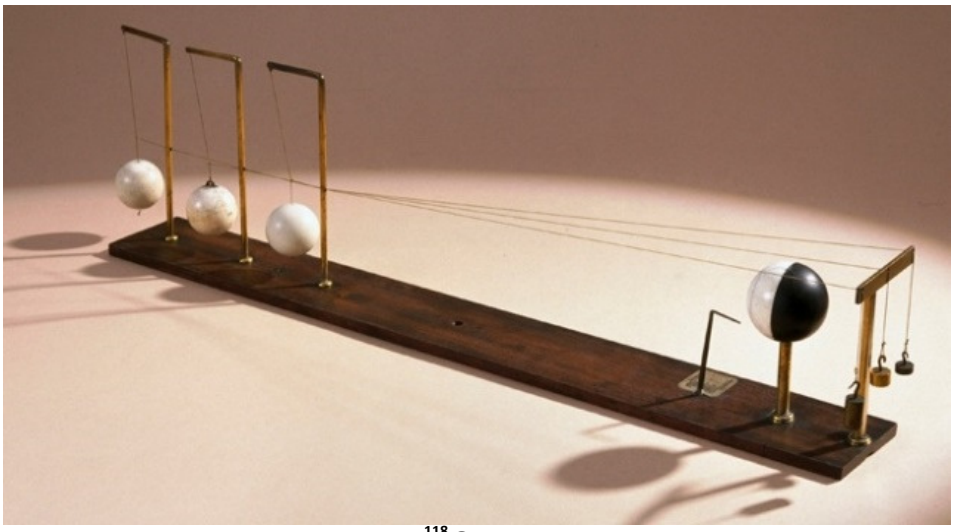


Figure 6.17[118] ©Science Museum

[116] Donn, B. 1772. *The Description and Use of Four New Instruments.* London.
[117] Goldsmith, O. 1774. *An History of the Earth and Animated Nature.* London: J. Nourse.
[118] Science Museum 1927-1852. Reproduced by kind permission of the Trustees of the Science Museum Group.

Figure 6.18[119]©British Museum

My argument might be criticised by those who claim that it was a difference in the quality of maker which separated multi-function dials from accurate timepieces such as chronometers. Landes referred to the words of a master clock-maker of the eighteenth century to dismiss multi-function dials as 'lively layouts'.[120] However, during the late-seventeenth century, when the multi-function dial was in decline but had not yet disappeared, master makers such as Daniel Quare, who had a reputation for making some of the best timepieces of the period, also made the multi-function watch with tidal indication in figure 6.18. The tidal indication index on this dial is represented with Arabic numerals 1-12 twice to account for the day and evening, suggesting that it is a rare example of a watch that indicated both tides in the twenty-four hour period. It was made in 1675, just before the invention of the balance spring, and therefore represents the hours and quarters. It is significant as an example of the work of a maker who used the best technological capability of the period. As such it serves to demonstrate that tidal indication, while desired by users, was part of the identity of an accurate timepiece of the pre-balance-spring period. Tidal indications cannot be dismissed as part of a scheme of decorative attributes which were then discarded once minutes could be represented as Landes suggested.

Another master clock-maker who was renowned for his precision timepieces was Tompion, who made regulator clocks for the Royal Observatory at Greenwich. Tompion also made several longcase clocks which indicated the lunar phase and the times of high tide.[121] On an initial inspection, such a dial might be dismissed as a product for a Gentlemen's study

[119] British Museum 1958,1201.535. Reproduced by kind permission of the Trustees of the British Museum.
[120] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.p.139.
[121] Fitzwilliam Museum M.21-1947.

which represented his wealth and status. It may well have been made for such a customer and used in this way, but if it is compared with Tompion's *Instructions* published in 1709,[122] which contained advice for calculating the best times to cross the River Severn rather than waiting for hours on the riverbank as mentioned above and in chapter five, its value is clear. As mentioned in chapter five, the River Severn was a great commercial waterway in this period, which was why this information was so important. Although in the pamphlet the author referred to printed tables for making the calculation, those lucky enough to own one of Tompion's clocks would have been able to make plans for the crossing without the need for these long-hand calculations.

The lunar phase did not feature on the standard format by 1770. Its legacy was as a decorative function and those owners of clocks and watches in the nineteenth century, which indicated the lunar phase, were unaware of its origins in the natural magic tradition or its development over the period under investigation here. This aesthetic legacy was paralleled in almanacs, which as Perkins reminds us did not stop presenting it until the nineteenth century.[123]

6.6 Conclusion

In the epigraph to the chapter the clock-maker, John Smith, listed the lunar function as fourth in a list of functions that could be applied to clocks. I argued that had Smith been writing a hundred years earlier he would have listed the lunar function as first after the hour, such was its importance to people in the period. The lunar indication developed differently from both calendrical and astronomical indications on dials in this period. The lunar function enjoyed a similar lifespan compared with the calendar function. It was present on the earliest multi-function dials of the mid-sixteenth century, but generally declined during the early-eighteenth century, which was prior to the decline of the calendar function. However, the exception was its continued presence on provincial longcase clocks. I argue that the lunar function provided users with a prompt to recall the lunar wisdom they already possessed, acquired from lunar folklore, almanacs or craft books. In this sense it was different from the calendar function which provided a locating device. The lunar function did this also in terms of the lunar calendar, but it also created knowledge for users when it was equated with advice such as the best times to conduct agricultural activities. By

[122] Tompion, T. 1709. *An Exact Measure of the Roads from Bath to London.* London: J. Good.
[123] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.p.17.

approaching the lunar function in this manner I improved our understanding of the clock and watch dial and provided parts of the answers to the main thesis research questions, which could not have been attained in another way.

Section 6.3 of this chapter offers a substantial part of the answer as to the extent of the relationship between dials and astrological and mnemonic practice in the period up until the mid-late seventeenth century. I argued that the lunar function on dials was used for astrological and mnemonic purposes in the period up until the mid-late seventeenth century, similarly to the calendar function. However, the Moon was associated with slightly different astrological advice. It was believed, for example, that one shouldn't sleep in a room in which the Moon shone so as to protect the eyesight. Much of the astrological advice given in almanacs related to the phase of the Moon. This included suitable times to conduct certain health practices and agricultural tasks. Again, a clock or watch user could plan using the dial. The lunar phase was also a useful mnemonic tool. It could be assigned certain meanings and then the dial could prompt the user to do something or remember something. It also provided an additional layer of mnemonic potential on multi-function dials so that users could remember even more such as Saturday 3rd September with a full moon might represent something different from the year before when there was a new moon. The early modern pursuit of *pansophia*, or complete knowledge, was important in this context given these layers of information and hierarchies of knowledge.

Section 6.4 offers a substantial part of the answer to the related question as to the extent of the relationship between dials and the decline of astrology and mnemonics influenced dials. I argued that of all of the different methods of representing the lunar calendar, the lunar phase was the last to survive. It declined from clocks and watches made in London by the end of the seventeenth century, but survived on provincial longcase clocks until the early-eighteenth century. This was due to its use throughout the period as a planning tool for arranging travel at night, and this was the legacy of the representation of the lunar phase. It was safer to travel by the light of the full moon. In a period with no street lighting this function was invaluable, which was why this function survived the decline of astrology in the mid-late seventeenth century. In country areas it continued to be useful which is why it survived on those dials after the introduction of street lighting in London. People used this information throughout the period and I argue that it was this use which enabled the lunar phase to survive the decline of astrology and feature on eighteenth-century dials. These points have introduced the clock and watch to existing debates about astrology and mnemonics in the period thereby contributing to the work of Henry, Curry and

Perkins. While a focus on the lunar function is revealing about the use of dials for astrological and mnemonic practices in the period, it does not provide the full answer. The final part of the answer is provided in chapter seven on astronomical knowledge.

Section 6.2 offers part of the answer as to what the relationships between dials and printed paper sources were in the period. I argued that it was significant that the lunar phase was represented using the man-in-the-moon from the early-mid seventeenth century. It was important in terms of representing discussions about the inhabitable Moon from the mid-seventeenth and throughout the eighteenth century. These were discussions involving natural philosophers, the clergy, and clock-makers.

Section 6.5 offers part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. I argued that the tidal indication, related to the lunar phase, was revived on dials in the same period as pamphlets on tidal reckoning and when models were being made to teach tidal motion during the mid-late seventeenth century. Tidal indication had existed on late-sixteenth century dials, but enjoyed increased popularity from the mid-late seventeenth century. Both indication on dials and almanacs declined by the early-eighteenth century. This enabled the lunar function to survive the decline of astrology in the mid-late seventeenth century, providing it with a boost, but not enough to secure its inclusion on the standard format.

Again, the lunar function was not part of the standard format dial by 1770, but its lack of presence was an indication of both its point of decline and its past prominence. I argued that the lunar function, though it continued to exist, did not form part of the standard format dial by 1770 because of the divide between town and countryside. Provision of lunar indication on dials survived only on clocks made for users in the countryside once early forms of street lighting were provided in the towns. While a focus on the lunar function has improved our understanding of clock and watch dials in this period and answered parts of the main thesis research questions, there is one more angle of dial content that will complete the picture. I now turn to chapter seven where I focus on the astronomical function.

Chapter 7

Astronomical Knowledge

Figure 7.1[1] ©British Museum

Figure 7.2[2] Royal Collection Trust/ ©Her Majesty Queen Elizabeth II 2016

7.1 Introduction

In this last of three chapters which focus on dial content, I will concentrate on astronomical knowledge derived from clock and watch dials. I argue across the three content chapters that each one requires its own chapter, as it developed differently across the period, which can only be revealed through a focus on use. This is no less true of the astronomical function. The dials seen in figures 7.1 and 7.2 illustrate two distinct contexts in which astronomical knowledge was derived from clocks and watches in the period 1550-1770. Separated by around one hundred and fifty years, one was for astrological and mnemonic use and the other was for pedagogic purposes.

The astronomical function on dials has not yet been differentiated on the basis of use. Until this re-interpretation of clock and watch dials, astronomical indications were either dismissed by historians of horology such as Thompson[3] and others[4] as performing only a decorative function or were interpreted on the basis of an eighteenth-century understanding of astronomy, which emphasised discovery. The aesthetic approach defines astronomical indication as a pleasing space-filler. The discovery approach defines

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[1] British Museum 1888,1201.105. Reproduced by kind permission of the Trustees of the British Museum.
[2] Royal Collection RCIN 30260. Reproduced by kind permission of the Royal Collection Trust/© Her Majesty Queen Elizabeth II 2016.
[3] Thompson, D. 2007. *Watches.* London: British Museum Press.p.24; 34.
[4] Britten, F.J. 1982. *Britten's Old Clocks and Watches and their Makers.* 8th ed. edited by Baillie, G.H., Ilbert, C. I. and Clutton, C. 9th ed. revised by Clutton, C. eds. London: Methuen.p.49.

astronomical indication as the communication of discoveries of new planets or stars, using instruments. However, neither of these approaches is as effective as a use-based approach for achieving a better understanding of the use of astronomical knowledge represented on dials. It is necessary to understand the nature of different people's astronomical knowledge in the period in which the dials were made and used and, perhaps more importantly, to understand their perceptions of the value and application of that knowledge.

With the exception of format differences, to the untrained eye figures 7.1 and 7.2 may appear very similar in terms of content, despite one having been made around 1530-40 and the other a hundred and fifty years later in around 1690. Indeed, very often historians of horology, such as Bruton, separated all of the indications that were not the hours or minutes of the day and merged them into one chapter entitled 'special indications'.[5] By doing so, they determine the non-hour indications as relatively unimportant and virtually relegate them to an appendix. By approaching astronomical indications in this way from the outset leads to such authors missing crucial changes over an extended timeframe. Similarly, authors such as Christianson anachronistically divide their accounts of horological change into a pre-pendulum era of pretty objects for the few and a post-pendulum era of accurate timepieces for the many, which disregards any form of usefulness to wealthy owners before 1657.[6]

As noted in chapter one, my approach is an inter-disciplinary one, bringing together different bodies of historical literature. I will make a contribution to the work of historians of early modern astronomy such as North[7] and others.[8] Whereas their focus has been on changes in astronomical knowledge and teaching of astronomy in the universities, I consider the way in which these ideas manifested themselves in material culture outside of the observatory and university. Similarly to chapters five and six, this chapter will contribute to several branches of literature. I will expand the work of historians of early modern science, such as Henry,[9] Stewart[10] and others,[11] by introducing the different contexts of use of clocks and watches with astronomical indications in the period to their discussions. In a similar

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[5] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.p.5.
[6] Christianson, D. 2002. *Timepieces: Masterpieces of Chronometry.* Newton Abbot: David & Charles.
[7] North, J.D. 2008. *Cosmos: an Illustrated History of Astronomy and Cosmology.* Chicago: University of Chicago Press.
[8] Donahue, W. 2006. Astronomy. In: Park, K. and Daston, L. eds. *Cambridge History of Science Volume 3.* Cambridge: Cambridge University Press.pp.562-595.
[9] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.
[10] Stewart, L.R. 1992. *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain 1660-1750.* Cambridge: Cambridge University Press.
[11] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave; Morton, A.Q. and Wess, J.A. 1993. *Public & Private Science: the King George III Collection.* Oxford: Oxford University Press in association with the Science Museum.

manner as chapters five and six, this chapter will make a contribution to the work of historians of astrology, such as Curry[12] and others,[13] but in this case by introducing the astronomical function on clocks and watches to the discussion. Again, by discussing the connections in terms of astronomical imagery between dials and mnemonic works, it will contribute to the work of historians of the art of memory, such as Rossi[14] and Yates.[15]

I have divided the chapter in to two sections based on my identification of the difference in use, which I will utilise to bring these bodies of literature together. In section 7.2 I will focus on astronomical dials used for astrological and mnemonic use in the period up until the early-seventeenth century. I will then move on to section 7.3 where I will focus on a specific group of astronomical clocks that were used for teaching during the late-seventeenth and early-eighteenth centuries. I will use these two sections to provide the remaining parts of the answers to the main thesis research questions.

This chapter will improve our understanding of the relationships between dials and printed paper sources in the period. In section 7.3 I will argue that astronomical clocks of the late-seventeenth and early-eighteenth centuries were part of the wider context of public demonstration of natural philosophy as evident in pamphlets.

This chapter will offer a substantial part of the answer as to the extent of the relationship between dials and astrological and mnemonic practice in the period up until the mid-late seventeenth century. I will argue in section 7.2 that, rather than acting as a locating device in the way that the calendar function did or as a prompt to users' pre-existing wisdom as the lunar function did, the astronomical function acted as a prompt to acquire new knowledge from the almanac or craft book. Section 7.3 will offer a substantial part of the answer as to the relationship between dials and the decline of astrology and the mnemonic method from the mid-late seventeenth century and the early-seventeenth century respectively. I will argue that the astronomical function on dials was the first function to decline, which occurred just before the general decline in astrology and was in fact concurrent with the decline of the mnemonic method. Section 7.3 will offer part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. I will argue that astronomical clock dials of the late-seventeenth and early-eighteenth century provided a visual aid to learning about astronomy, which complemented text in instruction pamphlets of the period. Section 7.3

[12] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.
[13] Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber; Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.
[14] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.
[15] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.

will offer part of the answer as to the extent that users' emotions influenced dial development in the period. I will argue that clock-makers tried to distance themselves and their work from the by-then out-dated astrology. The two sections as a pair will improve our understanding of why the standard format of 1770 appeared the way that it did, which is part of the wider thesis narrative.

7.2 The astrological and mnemonic use of astronomical knowledge

The dial seen in figure 7.3 was made in Denmark, but similar examples were made in Germany, England and France in the period from the mid-sixteenth to the early-seventeenth century. It clearly demonstrates that the use of astronomical information as part of a compendium of knowledge transcended national boundaries.[16] In terms of the nature of the astronomical content, all of these dials represent the signs of the zodiac to indicate the positions of the Sun and Moon, which is not inherently meaningful beyond a point of reference. It is only a convenient way of dividing the ecliptic, but it was significant in terms of astrology and mnemonic methods for many people, from the mid-sixteenth to the early-seventeenth century, which makes it meaningful in the context of explaining dial change based on use. As Henry correctly points out, there was an assumption in this period that some things, such as planets, had occult powers to influence life on Earth.[17] A user reading from any of the dials such as these would learn that on a particular day the Sun is in the 10th degree of Aries, for example. Knowing this information gave the user a calendrical locating co-ordinate. However, as discussed in chapter five on the calendar function, this zodiac calendar indication was rarely provided on dials as the sole calendrical locating co-ordinate; it was normally represented alongside the civil calendar. In chapter five I argued that this demonstrates that the zodiac calendar was provided as an alternative to the civil calendar, given that some users preferred it. However, as this chapter takes a different angle of interpretation, an equally valid reason was because the zodiac calendar and aspect diagram had an astrological and mnemonic purpose and represented a user's efforts to reach a higher plane of knowledge. While Rossi argues that the *pansophia* ideal dominated early modern thought,[18] he confines his discussion of the methods by which people hoped to achieve this to books. However, people also used three-dimensional objects. Multi-function dials with astronomical indications were conceivably intended as a tool for accessing that

[16] Most of the functions discussed in this thesis transcended national boundaries.
[17] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.56.
[18] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.38.

universal key to total knowledge, which many people believed was necessary for getting closer to God. By representing astronomical information, they represented the motions of the superlunary sphere and it was through contemplation of the relationships between the heavenly bodies that some people believed higher knowledge could be attained.

Historians of astronomy and early scientific thought, such as North,[19] Dear[20] and Donahue,[21] agree that astronomical knowledge in this period was a complex mixture of astrological prediction, star mapping, and mathematics in terms of computation. Clock and watch dials of the period reflect this mixture. As mentioned in section 7.1, traditionally historians of horology have not distinguished early examples of astronomical indication on dials from later, eighteenth-century examples, which has prevented them from identifying the different user contexts. However, it is possible to gain a better understanding of their use by comparing them with printed paper sources bearing similar astronomical information from the period.

7.2.1 Signs of the zodiac and astrological prediction

Historians generally agree that Copernicus, Brahe, Kepler, and Galileo were the leading names associated with the biggest changes in astronomical thought in the period before Newton.[22] However, their impact on almanacs and clock and watch dials, in the period in which they were writing, was negligible. This was not simply a case of dials being disconnected from intellectual ideas, the reason was that intellectual ideas took time to become accepted and astronomical ideas in particular were themselves intertwined with traditional astrology and mnemonics in this period. For Donahue,[23] Dear[24] and Henry,[25] astronomy and astrology were not often distinguished in the sixteenth century. Indeed the Latin term 'astrologia' translates as both astronomy and astrology.[26] Astronomical data was important for the practical task of creating calendars and horoscopes and dials reflected this

[19] North, J.D. 2008. *Cosmos: an Illustrated History of Astronomy and Cosmology.* Chicago: University of Chicago Press.p.321-322.
[20] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.17-18.
[21] Donahue, W. 2006. Astronomy. In: Park, K. and Daston, L. eds. *Cambridge History of Science Volume 3.* Cambridge: Cambridge University Press.p.562.
[22] North, J.D. 2008. *Cosmos: an Illustrated History of Astronomy and Cosmology.* Chicago: University of Chicago Press.p.321-377; Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.19-29; Donahue, W. 2006. Astronomy. In: Park, K. and Daston, L. eds. *Cambridge History of Science Volume 3.* Cambridge: Cambridge University Press.pp.562-589.
[23] Donahue, W. 2006. Astronomy. In Park, K. and Daston, L. eds. *Cambridge History of Science Volume 3.* Cambridge: Cambridge University Press.p.563.
[24] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.18.
[25] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p. 23; 59-60.
[26] Morwood, J. 2005. *The Oxford Latin Desk Dictionary.* Rev ed. Oxford: Oxford University Press.p.19.

by providing the positions of the Sun and Moon in the zodiac. Certainly Brahe and Kepler practiced astrology, Copernicus must have learned about it at university, and thus their ideas could not simply be separated from the wider conceptual landscape.

According to the Classical view of Man's place in God's hierarchy, the Earth had been positioned at the centre of a pre-ordered hierarchy of seven planets, which in the period included the Sun and Moon. Each planet was thought to be attached to an unchanging sphere and, through transmitted rays, thought to exert a different influence on Man's affairs depending on its position in the zodiac. As Henry points out, magic was chiefly concerned with exploiting the sympathies and antipathies between things in the Great Chain of Being[27] and this included the position of Man and the planets within that chain. If the relative positions of planets impacted life on Earth, it was believed that, by observing the position of the planets in relation to each other, one could predict changes that affected daily life such as the weather and the spread of illness. There were a number of different methods used to communicate this information to people in the period. General almanacs and personalised horoscopes have been widely discussed by historians such as Curry,[28] Capp[29] and Perkins.[30] Historians such as Morrison[31] have discussed the astrolabe in this context also, but the clock and watch with multi-function dial such as that seen in figure 7.3 were also very much an astrological tool and, as such, a tool of natural magic in the period.

Almanacs were tabulated computations, presented as a calendar of astronomical and religious information, in addition to predictions based on the relative positions of the planets. They were published annually and consequently represented an image of the coming year in tabulated and textual form. Predictions based on astronomical information usually included weather predictions or advice on the best times to conduct certain activities such as the medical procedures of purging or blood-letting and agricultural activities such as planting and harvest.[32] They were practical and suited to the needs of the period, which is a view supported by Capp who says that the astronomical information provided by the almanac was utilitarian.[33] A recurring theme throughout this thesis is the similarity between almanacs and dials. As discussed in chapter two, the almanac reader could read information and predictions for the present day, but also look ahead to plan future activities, according to the advice provided. A clock or watch dial providing the apparent position of the Sun in

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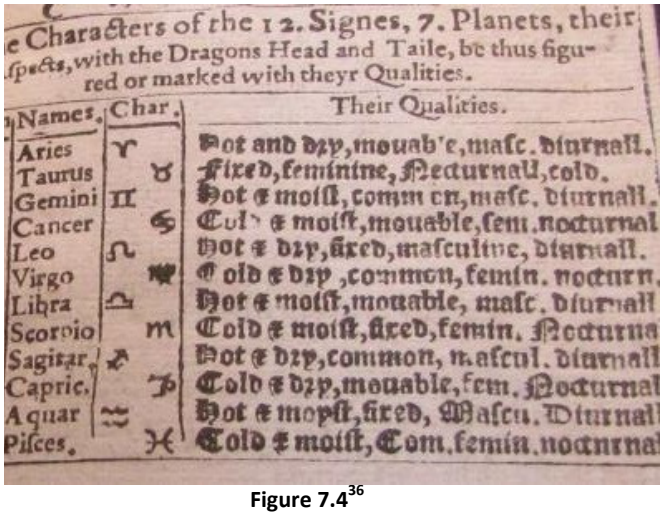
[27] Henry, J. 2002. *Knowledge is Power: Francis Bacon and the Method of Science.* Cambridge: Icon.p.55.
[28] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.
[29] Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber.
[30] Perkins, M. 1996. *Visions of the Future: Almanacs, Time, and Cultural Change 1775-1870.* Oxford: Clarendon.
[31] Morrison, J.E. 2007. *The Astrolabe.* Delaware: Janus.p.28.
[32] Those predictions and advice based on lunar information are discussed in detail in chapter six.
[33] Capp, B.S. 1979. *Astrology and the Popular Press: English Almanacs 1500-1800.* London: Faber.p.62.

the zodiac might prompt a user to recall the advice given in the almanac, corresponding to that position, or might prompt the user to consult the almanac. In this context the astronomical indication on the dial played a similar role to the lunar and calendar functions in terms of prompting.

Almanacs, astrolabes and multi-function clock and watch dials indicated the apparent place of the Sun in the ecliptic over the course of the year, which was extremely important for astrology. Similar information was provided in almanacs in the period such as Alleyn's *Almanacke* of 1606, which concludes that for January 1606: "Acquarius, the Signe which the sunne entereth into, the tenth day of this present month, is of the West, masculine, ayrie, and sanguine, and governeth the legges. And the sicknesses appropriate are, fever quartanes, blacke jaundies, swelling of the legges…"[34]

Figure 7.3[35] ©British Museum



e Characters of the 12. Signes, 7. Planets, their
ſpects, with the Dragons Head and Taile, be thus figu-
red or marked with theyr Qualities.

Names.	Char.	Their Qualities.
Aries	♈	Hot and dry, mouable, masc. diurnall.
Taurus	♉	Fixed, feminine, Nocturnall, cold.
Gemini	♊	Hot & moiſt, comm on, masc. diurnall.
Cancer	♋	Cold & moiſt, mouable, fem. nocturnal
Leo	♌	Hot & dry, fixed, masculine, diurnall.
Virgo	♍	Cold & dry, common, femin. nocturn.
Libra	♎	Hot & moiſt, mouable, masc. diurnall
Scorpio	♏	Cold & moiſt, fixed, femin. Nocturna
Sagitar.	♐	Hot & dry, common, maſcul. diurnall
Capric.	♑	Cold & dry, mouable, fem. Nocturnal
Aquar	♒	Hot & moyſt, fixed, Maſcu. Diurnal
Piſces.	♓	Cold & moiſt, Com. femin. nocturna

Figure 7.4[36]

Figure 7.5[37] ©British Museum

[34] Alleyn, H. 1606. *An Almanack and Prognostication.* London.
[35] British Museum 1958,1006.2113. Reproduced by kind permission of the Trustees of the British Museum.

It was believed that the Sun influenced different aspects of health and the weather, exerting different levels of strength according to its position in the zodiac. The dial indication seen in figure 7.5 is the Sun entering the sign of Aquarius, which is represented using the same symbol as those in the almanac seen in figure 7.4. The dial was made around 1600 and the almanac in 1617. It could easily be imagined that a user would read the dial indication and then consult the almanac as to the meaning, thereby deriving astronomical knowledge from the dial. This is then given specific meaning by the almanac. In the case of the dial seen in figure 7.5, the user could try to make the most of airy weather, try to look after their legs and avoid situations that could lead to fever according to the advice provided by Alleyn, as noted above.

Similarly, the apparent angles of separation between the planets were known as the planetary aspects and were thought to be highly influential on life on Earth. The aspects were conjunction, opposition, quartile, sextile and trine and were indicated using geometric shapes such as a square and triangle.[38] While the planetary aspects appeared in almanacs of the period, the only examples of aspects found on clock and watch dials were the lunar aspects. However, the inclusion of the aspect diagram and the use of the aspect symbols, which would have been well known to users, would surely have prompted the user to consult the almanac to see if the planets were aligned in a significant manner in the approaching days or weeks so as to plan their activities. Dear reminds us that in the sixteenth-century university context, astronomy was one of the four mathematical sciences that also included arithmetic, geometry, and music.[39] Astronomy was an extension of geometry as applied to the heavenly motions, it described and modelled the celestial bodies. The aspect diagram presented on dials, with its use of a square, triangle and hexagon is certainly a representation of astronomy as mathematical knowledge, related to geometry in this context. Representation of the position of the Sun in the zodiac, similarly to the lunar aspects, began to decline on dials in the early-seventeenth century. This was just before the general decline of astrology in the mid-late seventeenth century. The indication did not survive to be present on the multi-function watch dials with subsidiary dials, typical of the period from the mid-seventeenth century onwards.

On the one hand, the decline of the indication of the Sun's apparent position in the zodiac might be associated with the decline of the representation of the lunar aspects.

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[36] Allestree, R. 1617. *A New Almanacke & Prognostication.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[37] British Museum 1856,0429.1. Reproduced by kind permission of the Trustees of the British Museum.
[38] Discussed in detail in chapter two.
[39] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.17.

However, it was not inextricably linked because some dials did not represent the lunar aspects, but did represent the signs of the zodiac. Neither is there a specific geographical link because dials which differed in their use of zodiac symbols and pictorial representation were made throughout Europe. On the other hand, the decline might be associated with the gradual acceptance of the Copernican heliocentric theory. For people who believed in the Ptolemaic geocentric theory, the Sun was a planet, no different from the others, which orbited the Earth and influenced the weather and health according to astrological theory. The representation of the Sun's position in the elliptic, on a ring concentric to the centre of the dial, was in one sense a representation of a path by which the Sun travelled. We now term this the 'apparent motion' of the Sun, but for adherents to the Ptolemaic geocentric concept, it was true. According to North, some people at the end of the sixteenth century when Brahe was writing, and one extreme example as late as 1651, still doubted Copernican theory.[40] Further, as Pannekoek reminds us, the situation was mixed.[41] Some people received Copernican data with pleasure and used it for almanac production, while rejecting its central message.

While these points are useful for thinking about early modern perceptions of astronomy, they can be expanded by considering the user experience of timepieces. The publication of Copernicus' heliocentric theory did not mark a definitive break away from astrology. The users of the mid-late sixteenth century dials under discussion here may have been anti-Copernican in outlook or, as Pannekoek suggests, selective about which parts to accept.[42] However, at a time when the Ptolemaic system was rejected by the vast majority in the early-seventeenth century, it is logical that a representation on dials that was potentially perceived as supportive of the old Ptolemaic system was then also rejected as inappropriate. In this context, the indication of the Sun's position in the zodiac disappeared from the multi-function dials which continued to be used for astrological purposes until the mid-late seventeenth century, as discussed in chapters five and six.

[40] North, J.D. 2008. *Cosmos: an Illustrated History of Astronomy and Cosmology.* Chicago: University of Chicago Press.p.330-332.
[41] Pannekoek, A. 1989. *A History of Astronomy.* New York: Dover.p. 224-234.
[42] Ibid.p.224.

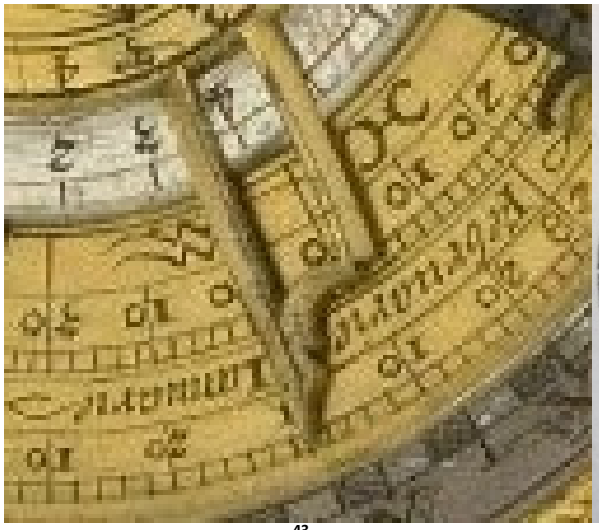

Figure 7.6[43] ©British Museum

Figure 7.7[44]

Furthermore, the zodiac ring whose index progressed in an anti-clockwise direction declined in the early-seventeenth century. On such an index the pointer used as a representation of the Sun moved in an anti-clockwise direction, which is the opposite of the apparent motion of the Sun as seen from Earth when facing South. This feature of mid-late sixteenth century dials (see figure 7.6) was explained in chapter two as a means of aiding legibility for the user, where the index of each ring progressed in a different direction, or as an initial replication of the movement of the shadow on a sundial. However, in the context of changing astronomical knowledge, and given that it did not feature on dials after the early-seventeenth century, it can also be interpreted as an expression of the theory of the geocentric universe. Thus the deliberate decision by makers to not include it after the early-seventeenth century may be interpreted as a rejection of the geocentric view in favour of the Copernican heliocentric view. This is probable given Remmert's analysis of seventeenth century frontispieces, which he claims were used to express which side of the Copernican debate the author stood.[45] Remmert cites the example of the Jesuits who expressed their opposition to Copernican theory by depicting the geocentric universe through biblical miracle images such as the sun reversing. Although this was a feature of seventeenth-century works, given the dials mentioned above, it is likely that the Jesuits and clock and watch-makers were drawing on traditional imagery. Indeed in Apianus' *Cosmographia* he made use of a schematic diagram of the geocentric universe and a zodiac calendar diagram

[43] British Museum 1856,0429.1. Reproduced by kind permission of the Trustees of the British Museum.
[44] Apianus, P. 1550. *Cosmographia.* Vaeneunt G. Bontio: Antuerpiæ. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[45] Remmert, V. 2006. 'Docet parva pictura, quod multae scripturae non dicunt.' Frontispieces, their Functions, and their Audiences in Seventeenth-Century Mathematical Sciences. In Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press.p.249-256.

which progressed in an anti-clockwise fashion in the same manner as dials from the period (see figure 7.7).

7.2.2 The decline of the astrolabe

Bennett[46] and Mosley[47] disagree about whether or not the astrolabe provided a representation of the heavens, as seen from the observer's point of view on Earth. For Bennett it was more important as an instrument for measuring celestial altitudes and making calculations for time-telling and navigation. For Mosley, while it might serve a practical purpose, its star map necessarily also represented the celestial sphere, which in the sixteenth century was important for thinking about the God-created hierarchy. For the purposes of this chapter I am in agreement with Mosely that the astrolabe was indeed a practical instrument, but by providing users with a device which they had to manipulate, makers were also enabling users to think about their place within the arrangement of stars on the astrolabe. The astrolabe equipped the user with a sense of present and future, in astronomical terms, given that the relations between the position of the user and the stars changed according to measurements made on different days. This was much like the indications on a clock or watch dial, as discussed in chapter two. Similarly, clock and watch dials provide support for the representative nature of astrolabes. Whereas almanacs provided a tabulated representation of the coming year in astrological terms, the astrolabe and the clock and watch dial provided a representation of the current day in astronomical terms, which was intended to be interpreted astrologically.

To an extent, multi-function clock and watch dials with an astronomical function superseded astrolabes by providing self-moving information through the mechanism. Whereas astrolabes had to be manually set by taking celestial altitude measurements each day and could only be used in clear weather, clocks and watches, once set with reference to an almanac or similar, would have automatically presented the information appropriate to each day. Clocks and watches may have been easier to use, but many provided less information than astrolabes. This difference was important as it shows clock and watch-makers responding to changing user needs. Multi-function dials from the mid-sixteenth to the early-seventeenth century indicated the position of the Sun and Moon in the zodiac and the aspect diagram, which showed their positions in relation to each other. Astrolabes

[46] Bennett, J. 2003. Knowing and Doing in the Sixteenth Century: What Were Instruments For? . *The British Journal for the History of Science.* 36(2).p.135.

[47] Mosley, A. 2006. Objects of Knowledge: Mathematics and Models in Sixteenth Century Cosmology and Astronomy. In Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press.p.193-201.

showed the positions of the principal stars visible on any given night. However, there were exceptions. Some mid-late sixteenth century clock dials consisted of a mechanically-driven astrolabe rete with many of the same principal stars as astrolabes from the same period, such as *canis minor*, rotating on an engraved plate with horizon lines, which indicated the positions of those stars and when they would be visible (see figures 7.8 and 7.9). The astrolabe had a much longer history than the domestic mechanical clock and some early dials reflected the user needs, which in that period, continued to be fulfilled by the astrolabe. However, the latter began to decline during the late-sixteenth century and clock and watch-makers responded by no longer including it on dials.

Figure 7.8[48] ©British Museum

Figure 7.9[49]©British Museum

Historians of the astrolabe such as Morrison[50] claim that it would never have achieved the popularity it did if it uses had only been astronomical. He says that there were simply not enough people interested in astronomy as a science; whereas astrology was deeply embedded in contemporary culture. He goes on to say that many astrolabes had astrological features allowing the user to determine the astronomical elements of horoscopes such as the positions of the planets. While Morrison is correct in his claim that the astrolabe was used for astrology, a view that is echoed by Gibbs,[51] his assertion that this is evident due to a lack of interest in astronomy proper is inaccurate. As mentioned earlier, there was little distinction made in the sixteenth century between astronomy and

[48] British Museum 1888,1201.1275. The pointers indicate the position of the stars, which are labelled. The curved lines below represent the horizon enabling the viewer to determine when particular stars have risen and are thus visible. Reproduced by kind permission of the Trustees of the British Museum.
[49] British Museum 1958,1006.2097. Reproduced by kind permission of the Trustees of the British Museum.
[50] Morrison, J.E. 2007. *The Astrolabe.* Delaware: Janus.p.40.
[51] Gibbs, S. 1980. Astrolabe Clock Faces. In Maurice, K. and Mayr, O. eds. *The Clockwork Universe: German Clocks and Automata 1550-1650.* New York: Neale Watson Academic Publications.pp.49-56.

astrology,[52] which means that instruments bearing astronomical knowledge were suited to this mixed purpose. Whereas historians such as Bennett and Mosley have disagreed about whether the astrolabe represented the heavens or was solely practical, for my discussion this is not the main issue. A lack of distinction epistemologically was also a lack of distinction in practical terms and equated to instruments with a multiplicity of uses; both practical and representational. If astrolabes played an astrological role, then clock and watch dials, which bore similar information and outlived the decline of the astrolabe, certainly did also.

Gibbs contemplates the purpose of astrolabe clocks and concludes that they were added to dials because astrolabes were popular in the period and that both served an astrological purpose.[53] Gibbs does not comment on the astrological potential of other mechanical clocks and watches and thus implies that only those with astrolabic dials were used for this purpose. However, in a sense the emphasis should not be placed on why astrolabic plates were incorporated on dials, but on when and why they both disappeared. Astrolabic clocks and astrolabes declined in the same period as the indication of the Sun's apparent position in the zodiac on dials, in the first few decades of the seventeenth century. For historians of horology such as White,[54] the disappearance of astrolabic dials was merely the result of them no longer being a requirement of the final masterpiece examination of the Augsburg guilds. However, White does not compare the astrolabic dials with astrolabes more widely and so is unable to make the connection that both declined at a similar time. This lack of contextualisation also leads White, in the tradition of many other historians of horology, to categorise these masterpiece items, such as the clock seen in figure 7.9, as: "…elaborate clockwork toys…."[55] However, their inclusion in the final exam in a place like Augsburg, which was a centre for astrolabe and clock production and almanac printing in the period, meant it was considered important for makers to provide instruments that would be useful to their buyers.

Morrison attributes the decline of the astrolabe to the decline of astrology, the application of the pendulum to clocks in 1657 and the advent of the telescope in the early-seventeenth century. However, the astrolabe and the astrolabic clock dial went into decline in the first decades of the seventeenth century, slightly before the general decline of astrology and several decades before the invention of the pendulum. Furthermore, multi-function dials with astronomical indications, used for astrology, survived the decline of the

[52] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.p.18.
[53] Gibbs, S. 1980. Astrolabe Clock Faces. In Maurice, K. and Mayr, O. eds. *The Clockwork Universe: German Clocks and Automata 1550-1650.* New York: Neale Watson Academic Publications.p.49; 54.
[54] White, G. 1998. *The Clockmakers of London.* Hampshire: The Midas Press. p.12.
[55] Ibid.p.12.

astrolabe and began to decline a few decades later. That the dial survived the decline of the astrolabe indicates that the self-moving form of representation was more desirable to users than the one which had to be set manually using measurements and was dependent upon clear skies.

7.2.3 A mnemonic role

At the beginning of this section it was mentioned that the astronomical function on clock and watch dials served a similar mnemonic purpose to the calendar and lunar functions discussed in chapters five and six. This was to prompt the user to recall astrological advice and make plans. However, as was mentioned in section 7.1 the astronomical function developed differently from the other functions in the period. One thing that made it different was its mnemonic role beyond acting as a prompt within the context of astrology.

Based on the significance attributed to the celestial realm in works on the art of memory, which pervaded Europe up until the early-seventeenth century,[56] it is clear the astronomical function on dials was a useful tool for the mnemonic memory. Indications such as the positions of the Sun and Moon in the zodiac and the planetary aspects were image devices that could be made use of while following advice on image and *loci* construction in mnemonic works. Rossi's claim that the frontispiece was perceived as a mnemonic aid for getting to know the contents of a book before reading it[57] is useful for thinking about multi-function dials. The multi-function clock and watch dial surely provided this service also. It could be used as a method for recalling information that was personal to a specific user, if they used the various indices and indications on the dial as a system of *loci* and associated its symbols and numbers with their own ideas or items of information.

In *De Umbris Idearum* (On the Shadow of Ideas) of 1582 Giordano Bruno provided the reader with a list of useful and significant images for use in his mnemonic wheels.[58] A common source for Bruno's mnemonic images was astronomical nomenclature from the period, such as the twelve signs of the zodiac or the seven planets.

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[56] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.2
[57] Ibid.p.27-28.
[58] Gosnell, S. 2013. *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582.* Huginn Muninn & Co.p.167-189.

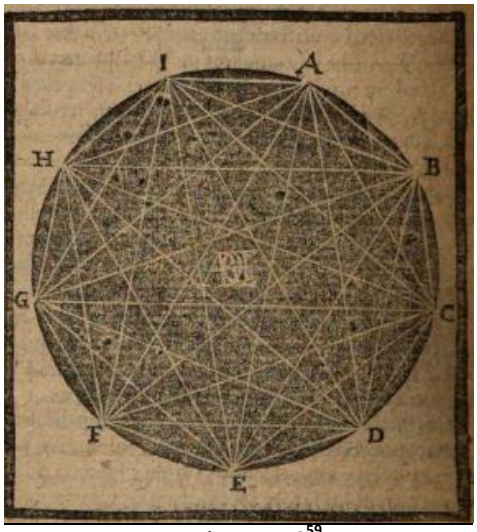

Figure 7.10[59]

Figure 7.11[60]**©British Museum**

As a representative for the combination AE in a diagram of two concentric rings or one that expressed multiple two-way combinations, such as that seen in figure 7.10, for example, he suggested Aries: "In the second [face of Aries], a beautiful woman dressed in a tunic dyed in true tyrian purple, her loose hair crowned with laurel."[61] Similarly for BE he suggested Gemini: "In the first face of the Twins, a servant, having a rod in his right hand, of cheerful and happy countenance…."[62] The zodiac may have been a convenient method for dividing the ecliptic, but as Bruno's work shows it was also an effective method for memorising information. It could easily be imagined that users of dials with zodiacal information used them as a mnemonic tool. When the Sun pointer on the dial in figure 7.11 moved into the zodiac sign of Gemini, the user could associate this indication with a servant according to Bruno's suggested images, which might prompt them to attend to certain household affairs.

Crucially, astronomical representation on dials also served to represent the higher knowledge, which people in the period believed it was possible to attain through acquisition of facts and concepts.[63] Attaining higher knowledge was part of the natural magic tradition and it was believed that those who could attain it would become one of God's Elect.[64] Webster claims the Elect were to face the future wary of the stars' powers to corrupt but determined to overcome the forces of evil.[65] However, he does not tell us how people were to do so. In this context, multi-function dials were one of many devices, including printed

[59] Bruno, G. 1591. *De Monade Numero et Figura.* Frankfurt. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.
[60] British Museum 1888,1201.105. Reproduced by kind permission of the Trustees of the British Museum.
[61] Gosnell, S. 2013. *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582.* Huginn Muninn & Co.p.152.
[62] Ibid.p.154.
[63] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.3.
[64] Webster, C. 1982. *From Paracelsus to Newton: Magic and the Making of Modern Science.* Cambridge: Cambridge University Press.p.49.
[65] Ibid.p.23.

paper sources, which helped users to achieve higher knowledge and thus come closer to God. Their task was to order knowledge as God had ordered the cosmos,[66] clock and watch dials reflect this ordering of information. As discussed in chapter two, whether dials used multiple concentric rings or subsidiary dials as a method of organising information there was always a visual hierarchy. Creating hierarchies was an important part of the mnemonic method and the realisation of higher knowledge. Multi-function dials always represented numerals and symbols of differing sizes, which indicates the order of importance of each piece of information on the dial. In the case of subsidiary dials, as mentioned in chapter two, they resembled Lullian trees[67] in which the user was intended to move from one branch, or subsidiary dial, to the next in order to attain knowledge. Of relevance to this chapter is that one of the sixteen branches on the Lullian tree was the celestial tree which focussed on knowledge relating to astronomy and astrology. The multi-function dial with rings or subsidiary dials bearing astronomical information was a representation of an important branch of knowledge according to the Lullian tree.

Generally speaking multi-function dials survived the decline of publications on the art of memory, which took place in the mid-seventeenth century according to Rossi.[68] However, the astronomical indications on these dials declined in around the same period, the early-mid seventeenth century. This demonstrates that while the use of the multi-function dial was not solely mnemonic, the astronomical function as a part of such dials, from the mid-sixteenth to the early-mid seventeenth century, was. Dials such as that seen in figure 7.11 would have been useful for recalling astrological advice and indeed any other information assigned to the images and indices by the user. This is further evidence that timepieces in the early modern period were representative of perceptions of knowledge and knowledge acquisition that disappeared in the seventeenth century and thus appear alien to modern readers. In the early modern period, dials did indeed reflect ideas, but not always the ideas that modern historians have singled out as being part of the story of enlightened progress. I now move on to consider the very different use of astronomical knowledge indicated on dials some fifty years later.

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[66] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.31.
[67] The works of Ramon Lull enjoyed a revival in the Renaissance.
[68] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.p.129.

7.3 The pedagogical use of astronomical knowledge

The focus of this section are the clocks made in Britain between the late-seventeenth and mid-eighteenth centuries which represented the movements of the heavens and were, I argue, a distinct group designed for teaching astronomy. This is one of the few national differences in dials identified in this thesis. Historians of horology have not considered these clocks in this way before, preferring to clump all astronomical indications together rather than distinguishing different types on the basis of the context in which they were made and used. As a type of clock the astronomical teaching clock was relatively short-lived; being made for about sixty years. In that which follows, I take a case-study approach and focus on four examples of astronomical clocks from three different museum collections.

Teaching with instruments was certainly not new in the late-seventeenth century. The multi-function clocks and watches described above would no doubt have been used for the teaching of astrology and the mnemonic method in private circles or the home. Indeed, Mosley cites the example of John Blagrave's new astrolabe of 1596 as a teaching device and it was marketed as such during the late-sixteenth century.[69] However, what was different about the late-seventeenth and eighteenth centuries was that there was a new form of public lecturing which included demonstration using instruments. Stewart credits Newton's followers with the rise of public science and what he calls the translation of private to public science through the communication of Newton's work.[70] His reference to the first public lectures taking place in 1698 provides the pedagogical backdrop to a better understanding of instruments that were made as teaching aids such as the astronomical clocks under consideration here.

The content of astronomical teaching clocks always included: a form of representation of the solar system; the apparent rising and setting of the Sun, Moon and principal stars; and the lengths of the day and night. These were the same subjects that were taught as part of the lectures and demonstrations of astronomy in the early-mid eighteenth century such as *An Introduction to the True Astronomy* of 1760 for example.[71] In the first half of the eighteenth century there was a wide range of pamphlets published which offered tuition on subjects such as astronomy and mechanics for example James Ferguson's

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[69] Mosley, A. 2006. Objects of Knowledge: Mathematics and Models in Sixteenth Century Cosmology and Astronomy. In Kusukawa, S. and Maclean, I. eds. 2006. *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe.* Oxford: Oxford University Press.p.195.

[70] Stewart, L.R. 1992. *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain 1660-1750.* Cambridge: Cambridge University Press.p. xxxiv, 453.

[71] Keill, J. 1760. *An Introduction to the True Astronomy or Astronomical Lectures.* London.

The Use of a New Orrery of 1746;[72] Benjamin Martin's *A Course of Lectures in Natural and Experimental Philosophy, Geography and Astronomy* of 1743;[73] and Joseph Moxon's *Use of the Astronomical Playing Cards* of 1717.[74] It is clear from such pamphlets that astronomy was an important component of these courses of natural philosophy. Often orreries and celestial globes were used for teaching, but the astronomical clocks I have identified here were also made for the same kinds of purposes and must be seen as part of this context.

Moxon's *Astronomical Playing* Cards, accompanied by his instruction booklet mentioned above, were an example of astronomical teaching material (see figure 7.12). There were several makers who made and sold these sets in the late-seventeenth and early-eighteenth century, but Moxon was the most well-known. These were a legacy of the mnemonic method. Though not part of the art of memory discussed in section 7.2, they demonstrate the continued importance of the visual prompt as a memory aid. The dials of astronomical clocks of this period were also very much a part of this pedagogical context. The dial of the clock, seen in figure 7.13, and the playing cards, seen in figure 7.12, are two devices that offer the viewer with at-a-glance knowledge of astronomy and a tool which operates by visual stimulus to prompt previously-acquired knowledge to aid learning. Both the cards and the clock dial effectively promise that the user will learn about astronomy by repeated viewing. The only difference is that the cards must be manually moved by the viewer, whereas the clock dial is self-moving.

Connected with the arrival of these types of clock in the late-seventeenth century was the emergence of a specific sub-genre of writing authored by clock-makers themselves. Each of the four astronomical clocks I consider below was accompanied by a pamphlet describing it. John Smith was one of the first clock-makers to publish a pamphlet which became a sub category within the wider genre of publications on instruments or mechanical devices. The wider genre contained works that were usually called 'Descriptions of…' for example George Adams' *The Description and Use of the Universal Trigonometrical Octant*[75] and Caleb Smith's *The Description of a new Sea Quadrant*.[76] The appearance of the instrument treatise genre was significant. Writing about an earlier period, Eamon says that in the sixteenth- and early-seventeenth centuries artisan craftsman were perceived as

[72] Ferguson, J. 1746. *The Use of a New Orrery.* London.
[73] Martin, B. 1743. *A Course of Lectures in Natural and Experimental Philosophy, Geography and Astronomy* London.
[74] Moxon, J. 1717. *The Use of the Astronomical Playing-Cards.* London: John Lenthall, Stationer at the Talbot.
[75] Adams, G. 1753. *The Description and Use of the Universal Trigonometrical Octant, invented and applied to Hadley's quadrant*. London.
[76] Smith, C. 1740. *The Description of a new Sea Quadrant*. London.

magicians, given their closely-guarded secret knowledge of the machines they made.[77] This view is useful here for contrasting with the later period where clock-makers shared secrets. When they began to share secrets, from the late-seventeenth century, this constituted a deliberate attempt to distance themselves and their work from the natural magic tradition and its associated secrets. As I argue throughout this thesis, clocks and watches were not made in horological isolation, and one of the contexts of which they were an important part was natural magic and early science. Indeed, Henry says that natural philosophers sought to separate naturalistic elements from the rest of the magic tradition thereby discarding what they did not want.[78] As astronomical teaching clocks of the late-seventeenth and early-eighteenth century displayed some of the same features as their earlier counterparts used for astrology, the only way clock-makers could distance their work was by publishing accounts to accompany them.

In his first work, Smith described the different indications that clocks could make. He did not describe one particular clock and it is unknown whether any of his clocks survive. However, he was one of the first to describe astronomical indications as a type of: "…conclusion that may be wrought by clockwork."[79] His choice of the term 'conclusion' demonstrates that he perceived the clock as conveying pre-interpreted knowledge to the user rather than information that required subsequent interpretation. The pamphlets accompanying each of the four clocks under discussion emphasised the utility of the clock for instruction above mere visual pleasure. The authors' choice of language and tone demonstrates that they were deliberately distancing themselves from the by-then outdated astrological tradition, which astronomical functions on multi-function dials were associated with. Makers tried to emphasise what they perceived to be new. Such pamphlets could be purchased at the same time as the clock in order for users to continue learning at home, as with other instruments such as the globe or microscope, which were also popular in the early-mid eighteenth century with wealthy and inquisitive gentlemen.

Thompson includes some of these astronomical clocks in his work.[80] His descriptions generally follow the same established format, which includes provision of biographical details of the maker, a list of the indications on the clock dial, and some information about the mechanism. However, he provides little, if any, contextual information to make these dials meaningful to a historian who is trying to place them within the wider development of

[77] Eamon, W. 1983. Technology as Magic in the Late Middle Ages and the Renaissance. *Janus.* 70.p.178.
[78] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.p.57.
[79] Smith, J. 1675. *Horological Dialogues.* London.
[80] Thompson, D. 2004. *Clocks.* London: British Museum Press.p. 104; 106; 108; 112.

dials or use. However, it is significant that the clocks were made in a context of widespread lecturing and natural philosophy demonstrations. Astronomy was a major part of this and, along with teaching on the subject of mechanics, was heavily influenced by the popularity of Newton's *Principia*[81] earlier in the century. The target audiences for both the astronomical clocks and lectures on natural philosophy were wealthy gentlemen and it is clear that these clocks were a part of this demonstration and learning context.

Figure 7.12[82] **©British Museum**

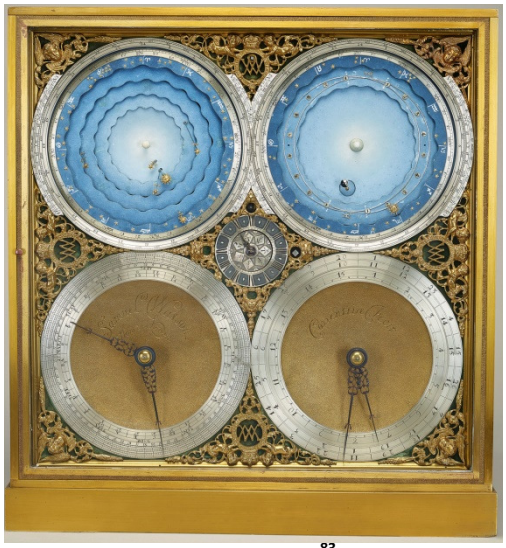

Figure 7.13[83]
Royal Collection Trust/
©Her Majesty Queen Elizabeth II 2016

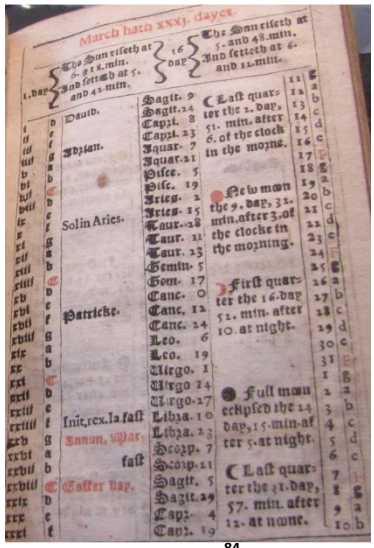

Figure 7.14[84]

[81] Newton, I.S. 1687. *Philosophiæ Naturalis Principia Mathematica.* Londini.
[82] British Museum 1896,0501.944.1-24. Reproduced by kind permission of the Trustees of the British Museum.
[83] Royal Collection RCIN 30260. Reproduced by kind permission of the Royal Collection Trust/© Her Majesty Queen Elizabeth II 2016.
[84] Dade, W. 1683. *A New Almanack with a prognostication, deduced from the motions, distances, and aspects of the planets, and their conjunctions with the moon.* London. Photograph by Jane Desborough. Reproduced by kind permission of the British Library.

Samuel Watson published *The Chronological Automaton or Self-moving Ephemeris of the Celestial Motions*[85] in 1690 as a method of marketing the sale of the clock seen in figure 7.13, which was initially made for the late King Charles II.[86] By styling it a 'self-moving ephemeris', Watson made the link between almanacs, also known as ephemerides, and clocks which I have been arguing throughout this thesis. There were so many similarities between multi-function clocks and almanacs that those early multi-function clocks must have been created as mechanical versions of almanacs to some degree. As discussed in chapters two, five and six, from the sixteenth to the mid-late seventeenth centuries the joint purpose of almanacs and multi-function dials was astrology, but when this went into decline, the use of both almanacs and clocks changed. Both media survived but the majority of almanacs no longer represented astrological information. Similarly, multi-function dials declined. Instead almanacs provided information such as the times of sunrise and sunset and the duration of the day and night, as seen in Dade's almanac of 1683 in figure 7.14. Most late-seventeenth and early-eighteenth century dials provided singular calendrical indications such as the date of the month or the lunar phase. However, the dial in figure 7.13 presented the full range of information that was found in almanacs of the late-seventeenth century.

Further evidence for astronomical clocks of the eighteenth century being used as teaching aids is provided by Watson's assertion that the clock seen in figure 7.13 could be set to any date in the past or future to indicate the planetary positions applicable to that date: "…by the help of one key it [the clock] is movable for any number of months or years, either backward or forward presenting to the eye the afore-mentioned phenomenon."[87] He said it could be set for any location, which means the user could learn the planetary positions observable for any date at any location. It is logical that this would make a very effective learning device. Questions could be posed to the user who could then solve them with reference to the clock and reinforce their learning of the movement of the heavenly bodies in much the same way that people in the period learned from celestial globes and orreries. Indeed, Watson went on to describe all of the indications the clock could make which were diverse enough to teach people about the apparent rising and setting of the stars, the precession of the equinoxes, also known in the period as the motion of the fixed stars, and eclipses.[88] In terms of the uses of these indications he said they were too diverse

[85] Watson, S. 1690. *A Chronological Automaton or, Self-Moving Ephemeris of the Cælestial Motions.* London.
[86] Charles II died before the clock could be completed. The clock was due to be sold by lot.
[87] Watson, S. 1690. *A Chronological Automaton or, Self-Moving Ephemeris of the Cælestial Motions.* London.
[88] Ibid.

to cover in such a short pamphlet.[89] By emphasising use and not mentioning planetary aspects, Watson was distancing himself from the previous era of astrology, which earlier dials with astronomical indications were associated with. This clearly demonstrates that astronomical clocks of this period were different to the multi-function dials of the earlier period because they were not intended for astrological use. They were intended for teaching.

The clock seen in figure 7.15 was made by Henry Bridges in 1733 who toured it around the United Kingdom, which is evident from numerous newspaper adverts from the period.[90] It was called the 'Microcosm', but the word had by this period lost the meaning it had in the sixteenth and early-seventeenth centuries. Learning by this representation of the universe in miniature was indeed intended to increase the viewer's knowledge of astronomy, but not as a tool for attaining higher knowledge in the sense discussed in section 7.2.

Figure 7.15[91] ©British Museum

Figure 7.16[92] Science Museum

Thompson claims that advertisements, similarly to those associated with this clock, prove that it was conceived as an entertainment.[93] Indeed, the advert in the *Daily Journal* in 1734 described the clock as: "…the most curious and magnificent Piece of Mechanism…" and informed readers that it was: "…Shewn to any Two or more from Ten in the Morning till Nine at Night…[94] Taken in isolation, away from the context of public lecturing on natural philosophy mentioned above, this advert may appear to be claiming that the clock in

[89] Ibid.
[90] Anonymous. 17th July 1734. To be Seen: the Microcosm Clock. *Daily Journal*, Anonymous. 16th-19th December 1769. Microcosm. *Dublin Mercury*, Bridges, H. 2nd January 1750. Wanted: a Convenient Light Chamber or Room. *General Advertiser*.
[91] British Museum CAI.2101. Reproduced by kind permission of the Trustees of the British Museum.
[92] Science Museum 1912-222. Reproduced by kind permission of the Trustees of the Science Museum Group.
[93] Thompson, D. 2004. *Clocks.* London: British Museum Press.
[94] Anonymous. 17th July 1734. To be Seen: the Microcosm Clock. *Daily Journal*.

question was nothing more than entertainment in the modern sense, suggesting that it provided amusement or enjoyment. This is understandable given that the venue for the event was the King's Theatre and that a clock was the centre of an event for which people purchased tickets. To a modern reader, this seems an alien setting for a clock compared to the home or office where timepieces are referred to only by members of the household and guests. However, if the advert is considered within the wider context of the page and publication in which it featured, its meaning changes. An adjacent advert to this one was one advertising the recent publication of the *Philosophical Transactions* of the Royal Society, which indicates that the readers of this newspaper were wealthy gentlemen who would be interested in the proceedings of the Royal Society and attending a demonstration of an astronomical clock for learning.

Later adverts demonstrate that the clock was also displayed in coffee houses, which were venues for gentlemanly discussions in the eighteenth century. A notice in the *General Advertiser* in 1750, for example, stated that a room was wanted that was large enough: "…to read Lectures upon, and exhibit to the Curious, that elaborate Piece of Mechanism, called the MODERN MICROCOSM, now at the Royal Exchange Coffee-house…"[95] In this advert a direct link is made with lecturing and the clock. The reference to associated lectures is further evidence to support the idea that the clock was very much a part of the mid-eighteenth-century fashion for learning through demonstrations rather than something people filed past without much attention.

Thompson's only additional comment on the use of the clock is that it went on tour around the world.[96] However, by not commenting further he leaves the reader to interpret the word 'entertainment' as possibly meaning something akin to a traveling circus or a music hall. On the other hand, by thinking about this clock within the context of eighteenth-century lecturing and demonstration of natural philosophy it is clear that the clock was intended as a teaching aid. Many pamphlets on demonstration of natural philosophy, from this period, such as George Adams' *Micrographia Illustrata,*[97] used the term 'entertainment' to mean learning in an informal, or non-university, environment.

The adverts for the clock use similar language compared with those lectures and demonstration pamphlets of natural philosophy in the period. The one for the clock used terms such as 'elaborate' and of interest to the 'curious'.[98] Adverts for lectures such as that

[95] Bridges, H. 2nd January 1750. Wanted: a Convenient Light Chamber or Room. *General Advertiser*.
[96] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.104.
[97] George Adams, *Micrographia Illustrata*, (London, 1747).
[98] Anonymous. 17th July 1734. To be Seen: the Microcosm Clock. *Daily Journal*.

by John Clarke used terms such as 'peculiar method.'[99] Both of the adverts featured in the same newspaper, the *Daily Journal*. The one for the lectures was also placed beside an advert for the sale of the stock of a mathematical instrument maker, which gives a sense of the practical side of these adverts rather than the music-hall style entertainment that Thompson alludes to in his single sentence claiming that the clock was conceived as an entertainment.

After the death of the maker, Bridges, the clock was purchased by Edward Davies who continued to tour it as before. He also wrote a pamphlet describing it, which could be purchased at the same time as viewing the clock,[100] evident in an advert in the *Dublin Mercury* in 1769 where it stated: "Of the proprietor may be had…. A Succinct account of the Microcosm."[101] Similarly to Smith and Jenkins (see below), Davies claimed to be writing at the repeated request of several people of distinction who had inspected the clock. In the pamphlet, Davies claimed that the clock took Bridges twenty years to make and required close study and application.[102] He also claimed that the Royal Society admired it greatly,[103] which is further evidence that it was considered by some to be an educational device rather than merely an object of fun. The Royal Society had a reputation for rejecting things that were not useful and prided themselves on demonstration and practical experiment. [104]

Davies' description of the clock followed the typical format, shared by Smith, Watson and Naylor, which was a list of indications. He balanced the aesthetic appeal of the outer case with the intellectual appeal of the clock's workings when he emphasised that the astronomical indications were made according to accepted theory: "…it [the clock] is most beautifully composed of architecture, sculpture, painting, music and astronomy according to the most approved rules and principles."[105] It wasn't unusual for makers and retailers to combine the two elements of utility and beauty in their marketing strategies aimed at wealthy gentlemen in this period. Most of the clocks and watches I have discussed throughout this thesis are beautiful objects in their own right and this is one reason why

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[99] Clarke, J. 15th June 1730. A Demonstration of Some of the Principal Section of Sir Isaac Newton's Principles of Natural Philosophy.

[100] Davies, E. 1765. *A Succinct Description of that Elaborate and Matchless Pile of Art, called, the Microcosm constructed by Henry Bridges. The seventh edition.* Glasgow: R. & A. Foulis.

[101] Anonymous. 16th-19th December 1769. Microcosm. *Dublin Mercury*.

[102] It is known that Bridges was active between 1697-1754, so it must have been made in the first half of the eighteenth century. Thompson attributes it to c.1733. If it took twenty years to make, Bridges must have started it in c.1713.

[103] A published reference for the Microcosm clock could not be found in the *Philosophical Transactions* and Davies did not identify the Fellows who examined the clock.

[104] Nurse, P. ed. 2015. *Philosophical Transactions: 350 Years of the Royal Society 1665-2015.* London: The Royal Society.

[105] Davies, E. 1765. *A Succinct Description of that Elaborate and Matchless Pile of Art, called, the Microcosm constructed by Henry Bridges. The seventh edition.* Glasgow: R. & A. Foulis.

previous historians have chosen to neglect the dial's knowledge-conveying attributes, but this does not detract from their utility. Indeed, Davies went on to market this clock as both an educational device, by claiming that it could improve the mind, and a work of art by claiming that it would strike every beholder with admiration: "…its internal parts are calculated to delight the eye, please the ear, and improve the mind; its external to strike every beholder with admiration at the regularity and magnificence of its structure."[106]

Davies drew attention to the division of the clocks' astronomical indications into two astronomical systems. The upper dial is Ptolemaic and the lower dial is Copernican, as seen in figure 7.15. This was similar to Watson's clock seen in figure 7.13. Davies emphasised the invalidity of the former system. The fact that Bridges constructed a clock which displayed a by-then outdated theory adjacent to the true theory is evidence that he was enabling users to compare the two systems and demonstrates the clock's use as a learning device. There would be no other reason to make this construction as late as the early-eighteenth century, given that the Copernican system was accepted by all but a few exceptions by then.

Davies then listed the duration of each planet's revolution around the Sun such as Mercury revolving around the Sun in 87 days and 23 hours for example. This was information that could be acquired from the clock dial, but was useful to have in a pamphlet which could be compared with the clock. Davies also included the distances of each planet from the Sun, which could not be derived from the dial, but was used to work out the proportional relationships between the planets as they were represented on the dial. It provided the viewer with some additional information and enabled them to gain a better understanding of the clock in terms of the calculations required to make it.

Further evidence of the teaching capacity of this clock is in Davies' description of the additional compartments that were housed in the case of the clock beneath the lower dial.[107] Each compartment housed a detail of the astronomical system in model form. There was a representation of the planets according to their proportional sizes; a representation of Jupiter and its four Moons; a representation of the eclipses of the Sun and Moon: "showing that no eclipse of either can take place but at a new or full Moon"; and a representation of the stationary and retrograde motions of the planets: "plainly proving the earth's annual motion."[108] These four compartments were clearly all teaching aids which would have been referred to in lectures on the clock. Similar models were made in the mid-eighteenth

[106] Ibid.
[107] The case and thus the additional compartments and demonstration models have not survived.
[108] Davies, E. 1765. *A Succinct Description of that Elaborate and Matchless Pile of Art, called, the Microcosm constructed by Henry Bridges. The seventh edition.* Glasgow: R. & A. Foulis.

century to demonstrate astronomical principles such as Martin's miniature orrery, see figure 7.16.

Sixty years after Watson sold the chronological automaton by lot, Joseph Naylor also published a pamphlet proposing to sell an astronomical clock by lot in 1751. It was entitled Explanation of *An Astronomical Clock*. For this entry in his catalogue, Thompson cites the eighteenth century as a period in which astronomy was popular and there was a fashion for astronomical clocks due to the works of James Ferguson and the Transits of Venus in 1761 and 1769.[109] However, whereas Thompson claims the fashion for astronomical clocks revolved around demonstrating knowledge to associates, I think these clocks were also teaching aids and devices of knowledge creation and retention. Given that these types of clocks could be purchased with a pamphlet explaining them, users could sit at home and compare the indications to the pamphlets. As mentioned above, most of the clocks could be manually turned backward or forward to view past or future astronomical positions. Again, this was not a learning method unique to clocks. Many instruments of learning such as globes, telescopes and microscopes were also purchased with an accompanying pamphlet for gentlemen to practice at home, such as Adams' *Micrographia Illustrata*[110] for microscopes. Thompson goes on to compare the eighteenth-century fashion for astronomical clocks with astronomical clocks of the sixteenth century that were present in royal and aristocratic cabinets of curiosity.[111] While there were some similarities in terms of content, such as the apparent position of the Sun in the zodiac, I argue that the use was very different.

Naylor described the capability of his clock in great detail and placed particular emphasis on its ability to indicate the rising, southing and setting of the Sun and principal stars. However, he made absolutely no mention of astrology or planetary aspects. His statement that the clock shows "…many more astronomical questions…"[112] is an indication of its role as a learning device: "One plate shows the stars that are at any time either above or below the horizon, and their rising, setting and southing with many more astronomical questions."[113] An effective educational aid would be required to represent as many different scenarios to the user as possible, which Naylor was keen to point out that this clock did. In the context of this pamphlet serving as a form of advertisement for the clock and its sale by lot, Naylor needed to be able to make the clock appeal to the wealthy gentlemen that could

[109] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.106-108.
[110] Adams, G. 1747. *Micrographia Illustrata*. London.
[111] Thompson, D. 2004. *Clocks.* London: British Museum Press.p.106-108.
[112] Naylor, J. 1751. *An Explanation of an Astronomical Clock.* London.
[113] Ibid.

afford to take part in the lottery. It is true that such gentlemen may have wanted something entertaining, but given the fashion for learning and attending demonstrations, they would have found it more appealing if the clock answered those ends. Similarly to Watson, Naylor's emphasis on the use of this clock with no mention of the planetary aspects, was an attempt to distance himself and his clock from the by-then outdated astrology with which the astronomical function on earlier multi-function dials was associated.

In 1778 Henry Jenkins published a pamphlet entitled *A Description of Several Astronomical and Geographical Clocks*,[114] which described the astronomical clocks he made between 1757 and 1759. None of those clocks have survived, but the publication coincided with his making of one example that has survived.[115] It is highly probable that this was Jenkins' second publication and that he had previously published a similar pamphlet in the late 1750s to accompany those other astronomical clocks because in the preface to the 1778 edition he claimed that he had published this pamphlet "…to oblige those who had brought them [the clocks]…" and in the introduction revealed that people had asked him to provide descriptions: "…having been frequently solicited by several noblemen and gentlemen."[116] He went on to say that after the descriptions were read by others, which indicates a previous version, he was presented with a description of other clocks that were made differently and some of which were said to represent things improper or profane. In response he defended his own clocks against a similar association: "And though these of mine show much more than any of them; and if any value may be set on their usefulness for instruction" then his must be superior. He stated that it was his hope that nothing he had represented was: "capable of such a construction of improper or profane".[117] The rest of the pamphlet consists of an argument for the utility of his astronomical clocks against claims that they were profane.

His central argument was that the clocks were useful for instruction. This was especially so for users with prior knowledge that had lapsed with time: "The utility of these clocks will more particularly appear to those, who have in their early years learned astronomy or geography; which sciences…are oftentimes, after a long and expensive education, in great measure lost."[118] He even extended the argument one step further by saying that the clock was even more effective for improving the more mature mind: "…the assistance of one of these clocks…will …convey to the mind ideas of the solar system… in a

[114] Jenkins, H. 1778. *A Description of Several Astronomical and Geographical Clocks.* London.
[115] See appendix one.
[116] Jenkins, H. 1778. *A Description of Several Astronomical and Geographical Clocks.* London.
[117] Ibid.
[118] Ibid.

more perfect manner, and to better advantage, than at a less mature age."[119] Clearly marketing the clock as an educational device was an effective strategy for attracting older customers.

However, Jenkins was careful not to exclude those potential customers who may not have been educated in astronomy previously:

> [for] Those who have not learned these sciences… it requires no extra ordinary capacities to understand what is here shewn; for with the assistance of one of these clocks, by observing its motions, and comparing them with those they represent in the heavens, they may from hence acquire a general knowledge of both of astronomy and geography.[120]

The second part of this paragraph reveals that users were expected to observe the heavens themselves and then compare their observations with the information indicated on the clock. Presumably the user was also expected to own a telescope in order to make comparative observations of the sky. I have already identified the user of an astronomical clock such as this as a wealthy gentleman with an interest in science and astronomy, so it is logical that such a person would own both an expensive clock and a telescope.

As noted above, there were of course other instruments that were used for teaching purposes in the period and which were made by other makers who were successful at marketing their wares such as Ferguson's *The Use of a New Orrery* of 1746.[121] However, Jenkins claimed that the astronomical clock was a more effective learning device than these others types of instrument: "Maps and globes are undoubtedly of great use. But if several bodies of the same quality and distance be within view, and one amongst them be in motion [as in the case of the astronomical clock], that will first engage the attention of the eye."[122] This might be the first published argument that clocks were a better form of teaching aid than other instruments.

It is significant that in the description of the clock made in 1759 he emphasised that, in addition to indicating the motion of the planets, it also represented the way in which Venus appeared to people on Earth. [123] The year of construction was only two years before the first transit of Venus of the eighteenth-century, which took place in 1761.[124] There was great interest in this astronomical event, which only occurs once in every century and takes

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[119] Ibid.
[120] Ibid.
[121] Ferguson, J. 1746. *The Use of a New Orrery.* London.
[122] Jenkins, H. 1778. *A Description of Several Astronomical and Geographical Clocks.* London.
[123] Ibid.
[124] The second transit took place in 1769.

the form of two transits separated by eight years. Jenkins conceivably made this astronomical clock in 1759 in preparation to sell to customers in 1761. In fact people would have continued to be interested in the clock in 1769 amid the great interest surrounding Captain Cook's voyage to Tahiti to observe and record the transit from there, which received support from the Royal Society and King George III. Gentlemen interested in how Venus could be seen in front of the Sun, why transits only took place every century and why there were two transits separated by eight years on each occurrence, would have found an astronomical clock as useful as an orrery for answering these questions. Similarly to Watson, Naylor, Bridges, and Davies, by emphasising use and making reference to topical interests, Jenkins was distancing himself from the by-then outdated astrology with which earlier multi-function dials with astronomical indications were associated.

Taken together, the writing of these four clock-makers and a retailer represented a justification of the various functions on the clock in response to wider criticism, which Jenkins expressly stated as his reason for writing. Given the era in which they were written and that they did not appear before the late-seventeenth century, despite a proliferation of multi-function dials, it is conceivable that they were published in a period when readers and users were potentially distrustful of functions considered to be useful for astrology. Indeed, this was less than thirty years after natural philosophers such as Robert Boyle were distancing themselves from the natural magic tradition when describing their experiments, as Robertson reveals.[125]

This act of distancing and doing so by associating clockwork with natural philosophy was also apparent in Thomas Hatton's *Introduction to Clock and Watch Work* of 1773.[126] Very much in keeping with the genre of pamphlets written by clock-makers, Hatton offered a technical explanation of clock-making.[127] In his preface he claimed: "That the business of clock and watch-work, is a business of science is evident to any man of reason, for it is no less than an attempt to measure time…'[128] This was a bold statement designed to associate clock-making with trustworthy science. Indeed, the tone of the entire work is one which emphasises the mechanical process and the association with science. On the title page he said that the work was very useful for the working mechanic or 'gentlemen mechanically inclined'.[129] I argue that it was for the latter given that any practicing craftsmen would already know everything he discussed within its pages, having served a seven-year

[125] Robertson, H.E. 2015. *'Imitable Thunder': the Role of Gunpowder in Seventeenth-century Experimental Science*. thesis, University of York.p.71.
[126] Hatton, T. 1773. *An Introduction to the Mechanical Part of Clock and Watch Work.* London.
[127] Ibid.
[128] Ibid.p.vii.
[129] Ibid.p.i.

apprenticeship and several years as a journeyman before starting his own business. Hatton was himself a watch-maker and would have been aware of this. Its real role, I argue, was to position the craft of clock and watch-making within the community of natural philosophy in the eyes of the gentlemen who were its target audience.

Hatton used three different methods for associating clocks and watches with natural philosophy. First he explicitly linked horology with geometry and the laws of mechanics when he stated that to learn about the first required knowledge of the second two.[130] The second method he used was to associate clocks and watches with known men of early science. He name-dropped the following: 'Mr Huygens' (Christiaan Huygens), 'Dr Hook' (Robert Hooke), 'Mr Durham' (William Derham), 'Mr Martin' (Benjamin Martin), 'Mr Cumming' (Alexander Cumming), 'Mr Emerson' (William Emerson), 'Sir I. Newton' (Isaac Newton), 'Mr Harrison' (John Harrison), 'Mr Fromantil' (Ahasuerus Fromanteel), and 'Mr Tompion' (Thomas Tompion) and referred to their various mathematical or technological contributions to the development of clocks and watches.[131] Hatton mentioned some other names, but he focussed on these ten. As a combination they represent a significant group of natural philosophers and eminent clock-makers at the top of their respective fields.

The third method he used was to offer a brief history of timekeeping in which he contrasted pre-pendulum timepieces with post-pendulum work. He thereby associated the clocks of the post-pendulum period with early science and, in effect, denied any link with pre-pendulum clocks and early science. He even referred to Watson's clock, discussed above, and said: "It may be questioned, whether those machines were common or not: I believe they were rarities then, as well as Mr. Watson's and others are accounted now."[132] Though he did not mention astrology, he was clearly distancing himself and clocks from it by not mentioning it and describing horological history in this pre- and post-pendulum manner. It is from this pamphlet that modern historians of horology have set up their work in terms of a pre- and post-pendulum dichotomy. As mentioned in chapter one, this angle of approach and interpretation has not changed until now. It must be remembered that Hatton had an agenda for writing in the way that he did and we must not judge timepieces of the past according to his words only.

In this section I have shown that the links between lectures on astronomy and eighteenth-century astronomical clocks demonstrate the use of these clocks as learning aids, which I have shown is supported by the words of the makers themselves. Indeed, the way in

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[130] Ibid.p.viii.
[131] Ibid.p. viii; ix; xi; xiii; 11; 15.
[132] Watson, S. 1690. *A Chronological Automaton or, Self-Moving Ephemeris of the Cælestial Motions.* London.

which published versions of lectures were written was very similar to the way in which clock-makers wrote about their astronomical clocks. Both used evocative language to entice the reader. Keill described the: "…sublime speculations…"[133] which: '"…wonderfully please and recreate the mind."[134] Similarly, Jenkins referred to the: "…sublime sciences…" the knowledge of which the astronomical clock's indications served to convey and which equated to an: "…agreeable entertainment for the eye." [135]

Astronomical clocks, such as those discussed in this section, were fashionable as learning aids from the late-seventeenth to the mid-eighteenth century with a few exceptions in the late-eighteenth century, but were a specialist learning device and did not become part of the standard format dial in 1770. Instead, they serve as an example of the revival of astronomical representation on clock and watch dials beyond the decline of astrology and for a new purpose. In one sense the original mnemonic use of the astronomical function, which declined during the early-seventeenth century as noted in section 7.2, was revived at the end of the seventeenth century when astronomical clocks were made for teaching. They were a moving aid which assisted learning and the acquisition of knowledge.

7.4 Conclusion

At the beginning of this chapter I distinguished between astronomical indications on clock and watch dials for astrological and mnemonic use up until the early-seventeenth century and astronomical indications on dials for teaching purposes from the late-seventeenth to the early-mid eighteenth century. I argued that these were both different contexts of use where the dial provided the user with astronomical knowledge. By approaching the astronomical function in this manner, I provide the final parts of the answers to the main thesis research questions, which could not have been attained in any other way.

In section 7.2 I offer a substantial part of the answer to the question as to the extent of the relationship between dials and astrological and mnemonic practice up until the mid-late seventeenth century. I have demonstrated that the astronomical indication had been a feature from the earliest clock and watch dials of the late-sixteenth century right up until the early-seventeenth century when it went into decline and was out-lived by the calendar and lunar functions. The early dials were clearly useful in terms of the mnemonic method as their similarities in terms of information indicated and style of representation with

[133] Keill, J. 1760. *An Introduction to the True Astronomy or Astronomical Lectures.* London.
[134] Ibid.
[135] Jenkins, H. 1778. *A Description of Several Astronomical and Geographical Clocks.* London.

almanacs, astronomical diagrams and mnemonic image making shows. While present on multi-function dials, astronomical indications such as the positions of the Sun and the Moon in the zodiac using symbols and stylised pictures were used for astrological and mnemonic purposes, being present in books of symbols from Romberche to Bruno, along with the lunar and calendar functions.

The planetary aspects were an important part of the advice given in almanacs. On dials of the sixteenth and very-early-seventeenth centuries the lunar aspect diagram was a common feature of many multi-function dials. The presence of the aspect diagram is indicative of mnemonic use. The aspect diagram served as a memory prompt for information about planetary aspects read in almanacs and associated astrological advice. It also served as a template for users to remember information they had associated with the planetary aspects. Astronomical representation on multi-function clocks also served as a representation of the higher knowledge which some early modern people strove to attain.

In both sections 7.2 and 7.3 I offer a substantial part of the answer to the related question as to the extent of the relationship between dials and the decline of astrology and mnemonics. The astronomical function on dials declined just before the general decline in astrology. I argued that it was more useful as part of the mnemonic art and it declined in the same period as pamphlets on the art of memory. In section 7.2 I argued that astrolabes and astrolabic dials declined in the same period, during the early-seventeenth century. Astrolabes were used for astrological purposes as were multi-function dials, but once the multi-function dial took hold, the astrolabe was no longer needed. The multi-function dial used for astrological purposes survived until the mid-seventeenth century, which may have been only twenty-five to fifty years longer, but its decline was the result of the general decline in astrology whereas astrolabes declined before astrology. This point expands instrument histories such as Morrison's work on astrolabes.[136] Like many other instrument historians, Morrison concentrated on one type of instrument rather than comparing different types.

In section 7.3 I discussed the second part of the life of the astronomical function on British clocks that were used for astronomical teaching and demonstration from the late-seventeenth to the early-eighteenth century. I argue that the new genre of pamphlets written by clock-makers, constitute a distancing from astrology which was part of a wider trend from the late-seventeenth century. This was the only other example of national difference found in the thesis. All other representations on dials transcended national

[136] Morrison, J. E. 2007. *The Astrolabe*. Delaware: Janus.

boundaries The astronomical function for teaching declined during the early-mid eighteenth century in the same period as the decline of public demonstration of natural philosophy generally, which peaked during the 1750s. In one sense, the astronomical indication retained its mnemonic function in a pedagogic context. Moxon's astronomical playing cards, along with the astronomical clocks, lectures and pamphlets, were part of a large package of information available to people from the late-seventeenth to the mid-eighteenth century when teaching of natural philosophy, of which astronomy was a major part, was popular. Only the wealthy were able to afford to take advantage of all of the components, but the buyers of clocks would certainly have been able to indulge in the other components. These points position clock and watch dials within the history of natural philosophy demonstration, such as the work of Stewart,[137] Morton and Wess,[138] for the first time thereby expanding both the history of horology and the history of science teaching.

In section 7.2 I offer part of the answer as to what the relationships between dials and printed paper sources were in the period. I argued that new astronomical ideas, such as the Copernican heliocentric theory, did not make an immediate impact on dials, but over the course of sixty years a certain degree of difference was noticeable, such as the disappearance of anti-clockwise progression zodiac ring for example.

In section 7.3 I offer part of the answer as to the extent of the relationship between dials and perceptions of effective knowledge transmission in the period. I argued that astronomical clock dials functioned in a similar way to instruction texts or lecture notes. Users could learn about the heavens and the place of the Earth from either medium. The dial was a self-moving version.

In section 7.3 I offer part of the answer as to the extent that users' emotions influenced dial development. I argued that the clocks made for astronomical teaching from the late-seventeenth century were indeed different from the multi-function dials that had come before. They were accompanied for the first time by pamphlets written by clock-makers which explained their pedagogic characteristics in great detail. They were very much a part of the wider culture of public demonstration of knowledge, which by then included astronomy. Furthermore, as mentioned above, I argue that clock-makers, similarly to others in the period, tried to distance themselves and their work from the by-then outdated astrology which astronomical indications had become synonymous with.

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[137] Stewart, L. R. 1992. *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain 1660-1750.* Cambridge: Cambridge University Press.

[138] Morton, A. Q. and Wess, J. A. 1993. P*ublic & Private Science: the King George III Collection*. Oxford: Oxford University Press in association with the Science Museum.

There were no signs of astronomical indication, for any context of use, on the standard format which emerged by 1770. Again, its lack of presence was an indication of both its past prominence and the demise of its resurgence in the mid-eighteenth century. This chapter on astronomical knowledge completes the set of three chapters which focus on dial content. It provides the final contribution towards improving our understanding of dials and answering the main thesis research questions. I now move to chapter eight where I will make my final conclusions to the thesis.

Chapter 8

Conclusion

8.1 Introduction

The most important achievement of this thesis is to demonstrate that while dials are indeed aesthetically appealing, they are considerably more significant in terms of their historical change. They are embedded with a wide variety of meanings and their format and content changed during the period according to changing uses. The standard format of 1770 was not a random, minimalist design; it was the culmination of huge changes in thinking and practices. Until now this has been overlooked by historians, due to alternative priorities and the challenges posed by the existing archival evidence. My novel methodology demonstrates that despite the challenges posed to an investigation of this nature, there are ways of unlocking meaning from objects left to us by makers and users of the past, when associated references to them on paper have not survived.

The version of the standard format that I discuss here, which emerged by 1770, was as much a product of hitherto declined theories and practices as it was of those prevalent in the period in which it rose to popularity. The preceding chapters each provide different parts of the answers to the main thesis research questions, as I demonstrate below. They also each play a role in the unfurling of the underlying narrative concerning the factors which influenced the appearance of the standard format. I use the chapters as a set to argue that the standard format, in terms of both form and content, came into being as a consequence of the conventions established in early dials and the decline of other aspects of format and content that did not become conventions. Each component of the dial was useful in the particular period in which it was made. Aside from components which became part of the standard format, every other aspect disappeared once it was no longer useful. Throughout the period, clock and watch-makers provided users with dials that were genuinely the faces of the kinds of time that their owners could make most use of.

In chapter one I claimed that clocks and watches were a fourth invention which changed ways of life in the early modern period, expanding Henry's reference to Bacon's three: gunpowder, the printing press, and the magnetic compass.[1] Throughout the preceding chapters I have referred to examples of the dial as a mechanised knowledge tool. From the way in which it enabled users who were otherwise disabled by traditional dials,

[1] Henry, J. 2012. *A Short History of Scientific Thought.* Basingstoke: Palgrave Macmillan.p.51.

discussed in chapter four, to its capability of providing users with a prompt for recalling astrological advice, discussed in chapters five to seven, dials not only made users' lives easier, but demonstrated the capability of clockwork for acquiring combinations of knowledge.

8.2 Fluid boundary between dials and printed paper sources

An important achievement of this thesis is to demonstrate that the true significance of clock and watch dials can only be revealed through a comparison with printed paper sources. As I have shown across the thesis, there is a fluid boundary between text, diagram and instrument. Historians of horology such as Thompson[2], Bruton[3] and Loomes[4] have generally focused on the development of precision timekeeping, which necessarily prioritises the mechanism over the dial. However, over the course of the preceding chapters I have shown that dials are a rich source of evidence for increasing our understanding of the interplay between instrument and printed paper sources within the context of knowledge sharing. Dials were a conveyor of knowledge, comparable to texts and diagrams, and were used for similar purposes in the period.

I show that the most effective method for using clock and watch dials as a historical resource is to compare them with texts which contain similar information. This is not a random comparison of any printed paper source; to be meaningful I made a careful selection, as outlined in chapter one. As I show in chapters two on communication methods, five on calendrical insight, six on lunar wisdom and seven on astronomical knowledge, our understanding of dials is much improved when the link is made between astronomical symbols on dials with those in schematic diagrams of the heavens and almanacs from the period. I argue that the use of symbols and pictures as notation demonstrated a form of symbol literacy among readers and users. Symbols were prevalent on both media from the mid-sixteenth to the early-mid seventeenth century, when they began to decline. Furthermore, in chapter five I identify a similarity between the number of co-ordinates of calendrical information presented in almanacs and on dials. Up until the mid-late seventeenth century there were up to five, but the number declined in both media during the late-seventeenth century. By the early-eighteenth century the number had diminished

[2] Thompson, D. 2004. *Clocks.* London: British Museum Press, Thompson, D. 2007. *Watches.* London: British Museum Press.
[3] Bruton, E. 2000. *The History of Clocks and Watches.* London: Little, Brown.
[4] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club, Loomes, B. 1981. *White Dial Clocks: the Complete Guide.* Newton Abbot: David & Charles.

to one. I argue that this was the result of changing ideas such as the decline of astrology, discussed in the next section, but it also shows the extent of the relationship between the two media.

I show in chapter two that analysing the dial as a form of diagram is the most effective method for understanding the significance of dial format differences and changes. Dials and diagrams with the same symbols and numerals presented similar visual hierarchies to users and readers. I identify a similarity between the two media in terms of use of the circular method of arranging information over concentric rings throughout the period, but where the number of rings declined from the early-seventeenth century. Similarly, I identify the use of subsidiary dials from the early-seventeenth century as comparable to tree diagrams and tables in print. The number of subsidiary dials declined during the mid-late seventeenth century, which I argue was comparable with the tabulated information in almanacs becoming plainer in appearance and inclusive of less information. Again, I argue that this was the result of changing ideas, but also demonstrates the connections between the two media. This was something historians who have written about the diagram such as Lefevre[5] and others[6] do not mention, despite their focus on diagrams. They compare different diagrams, but do not push the boundaries of diagram definition. My thesis expands these boundaries and positions the dial within the historical account of diagrammatic representations of knowledge.

I demonstrate throughout the thesis that clock and watch-makers were not only influenced by the authors of printed paper sources, but were also agents of inspiration. Dials were both an outward sign of receptiveness to wider convention and an influence upon diagrams and texts. In chapter two I demonstrate that both in terms of the arrangement of information and notation, dials were not created in horological isolation; they reflected established methods of communication. However, by providing the first in-depth deconstruction of dial formats I reveal that dials also influenced printed paper sources by playing an active role in validating existing communication methods and establishing new ones. Until this thesis, the different components of the dial have not been identified in the level of detail necessary to expose these points. Historians of horology such as Thompson,[7]

[5] Lefèvre, W., Renn, J. and Schoepflin, U. eds. 2003. *The Power of Images in Early Modern Science.* Basel and Boston: Birkhäuser.
[6] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In: Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.pp.53-97.
[7] Thompson, D. 2004. *Clocks.* London: British Museum Press.

Bruton[8] and Loomes,[9] use a catalogue-like approach and list dial indices, but their lack of contextualisation means that they have missed these highly significant connections.

In chapter four on enablement devices I argue that the illuminated night clock was a religious or devotional aid for users during the night. I likened this function to religious texts such as the earlier books of hours. In the three chapters which focus on content, I show that dials represented similar types of information as almanacs and mnemonic works in the early modern period. The decline of which was reflected in both dials and printed paper sources. However, I also show that dials influenced these texts and diagrams. In chapter six, for example, I show that one of the three forms of representation of the lunar calendar on dials was replicated in almanacs. In chapter three on trust I demonstrate that at different moments in the period, dials influenced printed paper sources. The addition of minutes to dials on clocks from 1657 was readily accepted by some users and was reflected in their writings. Samuel Hartlib is just one example of a writer who referenced the quarters of the hour prior to the introduction of minutes to clocks, and from 1657 referenced the minutes. Elsewhere in the chapter I show that, from the late-seventeenth century, equation-of-time tables were provided in almanacs in order to provide users of clocks and watches with information relating to the functioning of their timepieces. These examples demonstrate the reciprocal nature of the relationship between dials and printed paper sources in the period. Each medium influenced the other and was consumed by the same people. This greatly expands the parameters of social histories of time such as those of Sherman[10] and Landes.[11] Sherman inadvertently hints at the possibility of a relationship between dial and text in his consideration of watches and diaries. However, his approach of considering one medium at a time rather than comparing the two, means that he has missed the opportunity to make the links that I do. Landes' approach, typical of many historians of time, also led him to miss the significance of the dial as a result of his over-reliance on the work of historians of horology. They dismiss the dial as unimportant beyond the context of aesthetic appeal.

In chapter seven I show that early clock and watch dials, with astronomical indications, constituted an articulation of the complex concept of early modern astronomy as astrological prediction, star mapping and mathematics. The work of Copernicus, Brahe and Kepler did not have a major effect on the content or use of almanacs or dials. Yet, by

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[8] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.
[9] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club.
[10] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[11] Sherman, S. 1996. *Telling Time: Clocks, Diaries, and English Diurnal Form 1660-1785.* Chicago: University of Chicago Press.

considering the subtle changes such as the direction in which the indices progressed from the perspective of its role in knowledge transmission, I thereby reposition the clock and watch within the existing work on early modern astronomy, such as that by North.[12] I expand the debate from minimal references to observatory clocks to representations of astronomical thought on dials.

In chapter six I argue that the representation of the lunar phase using the man-in-the-moon from the early-mid seventeenth century was significant in terms of representing discussions about the inhabitable Moon from the mid-seventeenth onwards. These were discussions involving natural philosophers, the clergy, and clock-makers.

8.3 Astrology and memory

A significant accomplishment of this thesis is to demonstrate that dials were used for astrological purposes from the late-sixteenth to the mid-late seventeenth century. Furthermore, to demonstrate that the decline in astrology, from the mid-late seventeenth century, led to the decline of certain aspects of dial representation, but notably the survival of others.

A consideration of dial format in the three chapters in part one yields important results. In chapter two on communication methods I show that the various arrangements of information on dials were similar to those in almanacs and mnemonic diagrams up until the mid-late seventeenth century. Information presented included similar ranges of information, which formed the basis of astrological advice, and were represented using the same symbols and images. I demonstrate that from the mid-late seventeenth century both dials and almanacs became plainer in appearance due to the reduction of information presented on them. I argue that this reduction was a consequence of the decline of astrology. The level of calendrical and lunar information was no longer needed, so it was removed accordingly. In chapter four on enablement devices I argue that the illuminated night clock provided the time for users who needed to know the hour at night in order to carry out tasks advised by the almanac. This included the planting of seeds and health-related tasks. Its arrival during the decline of astrology was one of several reasons for the decline of the night clock in the early-eighteenth century.

In chapters five to seven in part two on content I reveal that dials were useful as a memory prompt for astrological advice, previously read in the almanac, up until the mid-late

[12] North, J.D. 2008. *Cosmos: an Illustrated History of Astronomy and Cosmology.* Chicago: University of Chicago Press.

seventeenth century. Users could refer to their timepiece to recall astrological advice from almanacs concerning auspicious moments to conduct certain activities. The calendar function, discussed in chapter five, provided the calendrical location coordinates necessary for users to locate themselves temporally. The lunar function, discussed in chapter six, provided users with a device which prompted their existing lunar wisdom. The astronomical function, discussed in chapter seven, also provided a prompt to advice read in the almanac, but primarily served a mnemonic purpose for recalling information which the user had associated with the zodiac symbols and combinations.

By making these connections I challenge historians of horology such as Thompson,[13] Bruton[14] and Loomes[15] and historians of time such as Landes,[16] who dismiss the early modern dial as insignificant. By deconstructing the dial and closely comparing with texts from the period I position dials within the history of astrology and mnemonics for the first time. I thereby expand the parameters of existing scholarship on the history of astrology and memory, most notably Curry[17] and Rossi[18] who focus solely on textual sources. I contribute a redefinition of what an astrological and mnemonic text is by introducing the dial as a self-moving astrological diagram.

I reveal that functions other than the hour continued to be useful after the decline of the art of memory, from the early-seventeenth century, and the decline of astrology, from the mid-late seventeenth century onwards. The calendar and lunar functions survived while they continued to serve a purpose. In chapters five to seven, I show that the calendar, lunar and astronomical functions developed differently. In chapter five, I show that the calendar function survived, given that it served a religious and financial purpose in helping users to remember the date for Easter and dates for paying taxes. The change from the Julian to the Gregorian calendar, at separate moments in different European countries, stimulated a need for the calendar function on dials up until the mid-eighteenth century for the purposes of cross-referencing between the two types of calendar. These points greatly contribute to existing histories of the calendar such as the work of Blackburn and Holford-Strevens[19] as I position the clock and watch into the debate for the first time and consider the use of instruments alongside paper calendars.

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[13] Thompson, D. 2004. *Clocks.* London: British Museum Press.
[14] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.
[15] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club.
[16] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.
[17] Curry, P. 1989. *Prophecy and Power: Astrology in Early Modern England.* Cambridge: Polity.
[18] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.
[19] Blackburn, B.J. and Holford-Strevens, L. 1999. *The Oxford Companion to the Year.* Oxford: Oxford University Press.

In chapter six I show that the lunar function continued to be useful as a tidal indicator in the late-seventeenth century. The tidal indication appeared on dials in the same period as pamphlets on tidal reckoning, from the mid-late seventeenth century, and when models were being made to teach tidal motion, from the late-seventeenth century. In making this connection for the first time I argue against historians of horology and social historians of time who dismiss the dial as insignificant and argue instead that it is demonstrative of clock and watch-makers responding to the knowledge needs of their users. Of the three different methods of representing the lunar calendar on the dial, the lunar phase was the last to survive. This was due to its use throughout the period as a tool for planning night-time travel in areas where there were no street lights. Works on lunar knowledge specifically are extremely rare beyond histories of the calendar, meaning that these points have reopened the subject for further research. Even Koslofsky,[20] writing about the experience of the early modern night, and Maczak,[21] writing about early modern travel, did not mention the role of the Moon. This thesis expands those histories by positioning the lunar function on dials at the centre of those experiences.

In chapter seven I show that astronomical indication declined during the early-seventeenth century and was survived by the calendar and lunar functions. For the first time I make the link between astrolabes and astrolabic dials declining almost simultaneously during the early-seventeenth century. Astrolabes were used for astrological purposes as were multi-function dials. However, once the multi-function dial took hold, the astrolabe was no longer needed. This point expands instrument histories such as Morrison's work on astrolabes.[22] Like many other instrument historians, Morrison concentrated on one type of instrument, rather than comparing different types. Elsewhere in the chapter I also reveal that the astronomical clocks of the late-seventeenth and early-eighteenth century were used for teaching. I make the link between these clocks and texts, such as Moxon's *Astronomical Playing Cards*, and argue that this is an indication of the astronomical indication retaining its mnemonic function in a pedagogic context. Moxon's cards offered users the opportunity to learn about astronomy through traditional playing cards and astronomical dials offered a self-moving teaching device.

As a set the three chapters in part two on content show that the memory function survived, although not as part of the traditional art of memory, which serves to expand

[20] Koslofsky, C. 2011. *Evening's Empire: a History of the Night in Early Modern Europe.* Cambridge: Cambridge University Press.
[21] Maczak, A. 1995. *Travel in Early Modern Europe.* Cambridge: Polity Press.
[22] Morrison, J.E. 2007. *The Astrolabe.* Delaware: Janus.

discussion by historians such as Yates[23] and Rossi[24] by introducing clocks and watches as part of the continued legacy of the art. In chapter two on communication methods I show that early astrological and mnemonic arrangements of information became conventions which survived the decline of astrology in the mid-late seventeenth century. They were not the random invention of an eighteenth-century clock-maker and had a longer pedigree. By making these points I contribute to histories of the origins of the scientific revolution such as Henry[25] and Dear.[26] I position clocks and watches as support for the argument that strands from the older natural magic traditions of astrology and memory continued into the era of early science from the mid-late seventeenth century onwards. Two concentric rings and a single subsidiary dial were signs of this influence and which became conventions that survived to become part of the standard format dial in the late-eighteenth century.

8.4 Knowledge transfer and knowledge creation

Another important achievement of this thesis is its demonstration that dials were a device for both transmitting and creating knowledge. I show throughout the preceding chapters that dials were designed to be effective communication devices, based on perceptions of knowledge acquisition in the period. I argue against historians of horology, such as Thompson,[27] Bruton[28] and Loomes,[29] and historians of time, such as Landes,[30] who effectively dismiss dial variation as merely an aesthetic consideration. I argue that dials were embedded with meaning that can only be adequately revealed when contextualised, which is something that has not been undertaken until this thesis. In each chapter I demonstrate that the dials and the printed paper sources I have compared them with were consumed by the same types of people. They were wealthy, literate and familiar with the latest publication of almanacs and books of astronomy, mathematics, astrology and memory.

Each of the three chapters which focus on format provide a different perspective for understanding dials as aids of knowledge transfer. In chapter two on communication methods I show that the various arrangements of information on dials were conducive to

[23] Yates, F.A. 1966. *The Art of Memory.* London: Ark Paperbacks.
[24] Rossi, P. 2000. *Logic and the Art of Memory: the Quest for a Universal Language.* London: Athlone Press.
[25] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.
[26] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.
[27] Thompson, D. 2004. *Clocks.* London: British Museum Press.
[28] Bruton, E. 1976. *The Longcase Clock.* London: Hart-Davis MacGibbon.
[29] Loomes, B. 1998. *Brass Dial Clocks.* Woodbridge: Antique Collectors' Club.
[30] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.

the mnemonic method of creating mental hierarchies by providing pathways for the eye. Concentric rings bore relation to schematic diagrams of the heavens and circular mnemonic diagrams. There was also a mimetic principle behind these arrangements as it was believed that, as the human eye consisted of concentric rings, the most effective method by which to assist information entering the eye was to arrange it in a similar way. Subsidiary dials resembled tree diagrams of the art of memory and books of knowledge. Combinations and hierarchies on dials were useful for the early modern pursuit of higher knowledge. The attainment of which was perceived as a means of coming closer to God. Furthermore, it was believed up until the early-mid seventeenth century that knowledge reached the long-term memory through a three-step process and I argue that concentric rings and subsidiary dials were conducive to this. In chapter three on trust I argue that alternative hour schemes and the representation of minutes and quarters together were different ways that layers of information were represented to enable cross referencing in the late-sixteenth to early-seventeenth century and late-seventeenth century respectively. The plainer dials and printed paper sources from the mid-seventeenth century onwards, mentioned in section 8.2, were outward expressions of the decline of this perception of knowledge communication, which was linked to the decline of the art of memory. Historians of horology such as Thompson[31] and Bruton[32] refer to medieval clocks as useful for religious purposes, but do not discuss multi-function dials or night clocks as a religious aid. I thereby further expand the history of horology by introducing these examples.

Furthermore, I show that representation of information drew on widely accepted and recognisable forms of communication. The most common form of representation of the lunar calendar on dials, for example, featured an aperture and a moving image of the Moon, which showed the lunar phase in the same manner as it appeared to the human eye from Earth. This was immediately recognisable. For the first time, I position the clock and watch into debates about perceptions of knowledge transmission in the period. I thereby contribute to not only horological history, but also expanding an area of epistemological history such as the work of Kusukawa.[33]

In chapter four on devices of enablement, I argue that clock-makers used touch as an alternative sense to sight, in order to follow the same conventions of communication that were used to communicate information to sighted readers. Dials and text were similar, even

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[31] Thompson, D. 2004. *Clocks*. London: British Museum Press.
[32] Bruton, E. 2000. *The History of Clocks and Watches*. London: Little, Brown.
[33] Kusukawa, S. 2012. *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-century Human Anatomy and Medical Botany.* Chicago: University of Chicago Press.

when a user could not see, because reading by touch was a positional form of reading which gave the user an active role. In the early modern period, touch was also perceived as an important part of multi-sensory knowledge acquisition. Feeling and looking were considered to improve memory acquisition and attainment of higher knowledge, which meant that partially-sighted users were not excluded from this pursuit. Furthermore, it was believed by some that spectacles were harmful to health, which was another reason why some partially-sighted users would have preferred touch-pins over spectacles. I argue that touch-pins disappeared from use once spectacles, especially those with sides, became more widespread in the early-seventeenth century and negative attitudes to spectacles declined. These points expand existing discussions about knowledge acquisition such as the work of Clark[34] and Franklin[35] who do not mention the disabled. In terms of the cultural view of disability history, these points expand the discussions initiated by Hobgood and Houston Wood[36] by introducing clocks and watches to their text-based consideration of the ways in which people are disabled by their environment, rather than their bodies. Clocks and watches were thus positioned into discussions about responses to disability in the early modern period for the first time.

In chapter six on lunar wisdom I argued that the tidal indication, related to the lunar phase, was revived on dials in the same period as pamphlets on tidal reckoning and when models were being made to teach tidal motion during the mid-late seventeenth century. Tidal indication had existed on late-sixteenth century dials, but enjoyed increased popularity from the mid-late seventeenth century. Both tidal indication on dials and pamphlets on tidal motion, aimed at a wide audience, declined by the early-eighteenth century. This enabled the lunar function to survive the decline of astrology in the mid-late seventeenth century, providing it with a boost, but not enough to secure its inclusion on the standard format.

I demonstrate throughout the thesis that dials were an effective aid for practicing religion. In chapter five on calendrical insight I show that dials were useful for ascertaining the date of Easter. This was particularly useful during the change from the Julian to the Gregorian calendar. That this took place in 1582, 1700 and 1752 in different parts of Europe created a need for cross-referencing between systems. It stimulated the continuation of the calendar function beyond the decline of astrology in the mid-late seventeenth century.

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[34] Clark, S. 2007. *Vanities of the Eye: Vision in Early Modern European Culture.* Oxford: Oxford University Press.p.14-15.

[35] Franklin, J. 2000. Diagrammatic Reasoning and Modelling in the Imagination: the Secret Weapons of the Scientific Revolution. In Freeland, G. and Corones, A. eds. 2000. *1543 and All That: Images and Word, Change and Continuity in the Proto-scientific Revolution.* London: Kluwer Academic.p.86-97.

[36] Hobgood, A. and Houston Wood, D. 2013. *Recovering Disability in Early Modern England.* Columbus: Ohio State University Press.p.5.

In chapter seven on astronomical knowledge I also demonstrate that dials were used for pedagogical purposes in the late-seventeenth and early-eighteenth century, which is evident from the tone of the pamphlets written about them by clock-makers. Historians of horology, in their merging of all indications other than the hour of the day into one group of aesthetically-pleasing decorations, have missed the fact that the astronomical function on dials experienced these two periods and contexts of use. The pedagogical use was clearly a form of knowledge transmission, which drew on the earlier tradition of the art of memory. This point positions clocks and watches within the history of natural philosophy demonstration for the first time, and expands the work of Stewart,[37] Morton and Wess[38] thereby expanding both the history of horology and the history of science teaching. It also provides further support for the work of Henry[39] and Dear[40] regarding the strands of continuity which fed in to nascent science from the older traditions.

8.5 Emotional influences

The final, but by no means least significant, achievement of this thesis is to show that users' emotions also influenced dial design throughout the period.

I demonstrate throughout the thesis that dial change rarely took place overnight. It sometimes took thirty years for a new type of representation to be accepted by users. There were also periods of transition, rather than immediate change. Over the course of three chapters I demonstrate that some users preferred older formats and older types of numeration, or points of reference, for example. In chapter three on trust I identify several examples where clock and watch-makers provided users with reassurance through dials. The provision of alternative hour schemes, up to the early-seventeenth century, enabled users to cross-reference the scheme they preferred with less familiar schemes in use in other countries. Elsewhere in the chapter I reveal that the co-existence of minutes and quarters on different dials was not random. They were not isolated examples designed as novelties, as historians of time such as Landes[41] suggested, but in effect a representation of a period of transition between the old and new systems. In this situation, the clock-maker

[37] Stewart, L.R. 1992. *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain 1660-1750.* Cambridge: Cambridge University Press.
[38] Morton, A.Q. and Wess, J.A. 1993. *Public & Private Science: the King George III Collection.* Oxford: Oxford University Press in association with the Science Museum.
[39] Henry, J. 2008. *The Scientific Revolution and the Origins of Modern Science.* Basingstoke: Palgrave Macmillan.
[40] Dear, P. 2001. *Revolutionising the Sciences: European Knowledge and its Ambitions 1500-1700.* Basingstoke: Palgrave.
[41] Landes, D.S. 2000. *Revolution in Time: Clocks and the Making of the Modern World.* London: Viking.

played the role of teacher, gradually exposing his users to the new minute indication which they eventually had to accept. This link has not been made before, but is very important as a contribution to histories of technology users. It serves as a contribution to the work of Gooday[42] on trust by introducing clock and watch dials to the discussion and expanding the temporal boundaries of trust debates. Furthermore, whereas historians such as Wyatt[43] have begun the discussion of reluctance to change as a stimulus to the continued use of technology in the twentieth century, I demonstrate that early modern makers responded to similar emotional responses to time by continuing to use by-then old-fashioned indices such as the quarter.

Similarly, in chapter five on calendrical insight I show that the zodiac calendar was preferred as a form of calendrical reference during the late-sixteenth century, evident from dials of this period and texts such as Recorde's *Castle of Knowledge*. I argue that this was significant in the years after 1582 when the Catholic countries in Europe began using the Gregorian rather than the Julian calendar. In this context, the zodiac calendar on dials was an unchanging constant, likely to have been perceived as more reliable and comfort-inducing than the civil calendar which was undergoing such dramatic change. These points contribute to the work of Wyatt[44] and Lindsay,[45] who discuss users and non-users of twentieth-century technology, by expanding the temporal parameters of the discussion to include users of early-modern technology.

I demonstrate throughout the thesis that the clock and watch-makers' voice emerges only at moments when users required reassurance about their timepieces. The dial was the user-facing part of the timepiece, so it was to the dial that a clock and watch-maker's comments were often directed. Throughout the thesis I have been challenged by a lack of archival evidence left by makers. Clock and watch-maker publications for the period under investigation are rare, but some survive from the late-seventeenth century onwards. In chapter three I show that some of these reveal information about the relationship between the maker and the user. I argue that clock and watch-makers wrote pamphlets, explaining the equation of time, to reassure users that they could trust the time displayed on their clocks and watches more than the sundial. Up until the development of the pendulum

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[42] Gooday, G. 2004. *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press.

[43] Wyatt, S. 2003. Non-Users Also Matter: the Construction of Users and Non-Users of the Internet. In: Oudshoorn, N. and Pinch, T. eds. 2003. *How Users Matter: the Co-Construction of Users and Technology* Cambridge Massachusetts: The MIT Press.pp.67-80.

[44] Ibid.

[45] Lindsay, C. 2003. From the Shadows: Users as Designers, Producers, Marketers, Distributors, and Technical Support. In: Oudshoorn, N. and Pinch, T. eds. 2003. *How Users Matter: the Co-Construction of Users and Technology.* Cambridge Massachusetts: The MIT Press.pp.29-50.

for clocks in 1657 and balance spring for watches in 1675 the sundial was perceived to be more accurate than the mechanical watch. The equation of time was in effect a period of transition between user preference for the sundial and user preference for the mechanical timepiece. Clock-makers stopped writing about it at the beginning of the eighteenth century because users no longer needed the reassurance of the explanation.

In chapter seven on astronomical knowledge I reveal that clock-makers wrote lengthy descriptions about astronomical teaching clocks in the late-seventeenth and early-eighteenth centuries where they strongly emphasised the practical value of the clocks. I argue that this was to distance themselves from the by-then out-dated multi-function dials used for astrological purposes before the mid-late seventeenth century. Until this thesis, historians of horology have not considered any form of emotional influence on clock and watch development. Their focus on mechanical development has marginalised the role of the user, whereas my approach puts the user at the forefront and has enabled me to make these connections.

8.6 Epilogue

The answers I have provided to the main thesis research questions would not have been possible without comparing dials to printed paper sources. Objects left to us by the past are powerful and laden with meaning, but require a careful process of deconstruction and contextualisation, as I have shown here, to unlock those meanings. Subtle differences to otherwise unchanging representations on dials such as the addition of the man-in-the-moon to the lunar phase would appear insignificant if the objects were considered in isolation.

My interrogation of dials as a source for understanding different aspects of knowledge transmission in the period has not only enabled a reinterpretation of dials within the field of horology and material culture, but has made large contributions to histories of early modern knowledge transmission, namely histories of printing and reading, and histories of early modern epistemology, namely natural magic and nascent science. I have shown that an inter-disciplinary approach to instrument research is a beneficial one that can help to reveal new information about historic objects.

This thesis marks the beginning of research into clock and watch dials and their users. I hope my reinterpretation of dials based on my novel approach, will inspire further research in to both timepieces and scientific instruments more generally. I have shown throughout the preceding chapters that despite challenges posed by a lack of immediately

obvious primary sources, it remains possible to ask and answer new questions of objects. There is scope for many angles of future research. One of which would be to expand the temporal boundaries of the investigation and to consider dials made in the nineteenth and twentieth centuries. The standard format I consider here enjoyed a long life throughout the nineteenth century and it would be a valuable pursuit to explore the factors which made this possible. An enquiry into the effect of the railways on dial production would make a valuable contribution, given the increased demand for not only accurate, but legible time reckoning at a distance on railway platforms. Another would be to explore the effect of the two world wars on dial production, given the demand for legible dials in various combat conditions such as in the dark, on the move, and while operating other instruments and technology. Increased optical knowledge and improved mass production techniques would have been important. Yet, similarly to the period under investigation here, it is very likely that dials reflected the needs of users in specific user contexts.

Appendix One: Clock and Watch Dials Examined

Museum Collection

BM – British Museum
ScM – Science Museum
Louvre – Musée du Louvre
DU – Deutsches Uhrenmuseum
MHS – Museum of the History of Science, Oxford
MPS – Mathematisch Physikalischer Salon, Dresden
DM – Deutsches Historisches Museum
WCC – Worshipful Company of Clockmakers' Museum

Functions

C – calendar
CR – concentric rings
L – lunar
SD – subsidiary dials
A – astronomical
Ap - apertures

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
1856,0429 .1	Watch	H. Roberts	London	1600-10	BM	Multi-function A, C, L (with aspects) CR
1874,0718 .21	Watch	Du Pont	Castres	1615-25	BM	Multi-function A, C, L CR, Ap
1874,0718 .23	Watch	William North	London	1640-50	BM	Multi-function C, L SD
1874,0718 .51	Watch	Jan Janssen Bockelts the Younger	The Hague	1625-35	BM	Multi-function L Ap
1874,0718 .62	Watch	Sampson Shelton	London	1645-48	BM	Multi-function C CR
1874,0718 .66	Watch	Louis Arthaud	Lyon	1645-55	BM	Multi-function C, L (with aspects) SD
1881,0802 .6	Watch	A Bernard	Paris	1630-40	BM	Singular
1888,1201 .102	Table clock	Unknown	Germany	1575-85	BM	Singular with four alternative hour schemes. CR
1888,1201 .103	Table clock	Josua Grunner	Bern	1630-40	BM	Multi-function touch-pins C SD
1888,1201 .105	Table clock	Unknown	Nuremberg	1530-40	BM	Multi-function A, C, L (with

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
						aspects) CR
1888,1201 .130	Clock	Unknown	Augsburg	1595- 1605	BM	Singular
1888,1201 .150	Watch	Unknown	Germany	1550- 75	BM	Singular with hours I-XII and 13-24 and touch-pins
1888,1201 .175	Watch	Benjamin Hill	London	1650- 60	BM	Multi-function C, L SD
1888,1201 .177	Watch	Jean Vallier	Lyon	1625- 35	BM	Multi-function C, L (with aspects) SD
1888,1201 .213	Watch	Jean Gaspard Girod	Geneva	1645- 55	BM	Multi-function C, L SD
1888,1201 .229	Watch	Jean Baptiste Duboule	Geneva	1645- 55	BM	Multi-function. C, L SD
1888,1201 .265	Watch	Unknown	Paris	1770- 80	BM	Singular
1890,1215 .1	Watch	Georg Seydell	Cologne	1635- 45	BM	Multi-function C, L SD
1893,0601 .328	Watch	Matthias Hintsche	Strasbourg	1680- 1700	BM	Multi-function C, L CR, Ap
1894,0215 .1	Table clock	Unknown	Germany	1570- 80	BM	Singular with dark and light aperture
1905,0418 .2	Watch	Daniel Quare	London	1705- 15	BM	Singular
1928,0607 .1	Clock	Thomas Tompion	London	1676- 78	BM	Singular
1958,1006 .1966	Bracket clock	Unknown	Netherlands	1655- 65	BM	Multi-function L Ap
1958,1006 .2047	Illuminated night clock	Joseph Knibb	London	1665- 75	BM	Singular
1958,1006 .2063	Astronomical clock	Thomas Starck	Augsburg	1620	BM	Multi-function A, C, L CR
1958,1006 .2078	Bracket clock with quarter repeat	Quare and Tompion	London	1705- 10	BM	Multi-function C SD
1958,1006	Bracket clock	Daniel	London	1685-	BM	Singular

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
.2079		Quare		95		
1958,1006 .2090	Clock	Unknown	Germany	1600-50	BM	Singular
1958,1006 .2095	Lantern clock	James Markwick	London	1665-75	BM	Singular
1958,1006 .2097	Clock	Jeremias Metzger	Augsburg	1580-1600	BM	Multi-function with astrolabic dial C SD
1958,1006 .2098	Longcase clock	Daniel Quare	London	1690-1700	BM	Multi-function C (and equation-of-time)
1958,1006 .2102	Bracket clock	Johannes Muys	Maastricht	1653	BM	Multi-function C, L CR
1958,1006 .2105	Clock	Giovanni Baptista de Albertis	Brescia	1685	BM	Multi-function C Ap
1958,1006 .2107	Clock	Unknown	Germany	1550-1600	BM	Singular
1958,1006 .2112	Table clock	Unknown	Germany	1555-65	BM	Singular with 24 hours and touch-pins
1958,1006 .2113	Table clock	Peter Grundel	Copenhagen	1576	BM	Multi-function A, C, L CR
1958,1006 .2128	Illuminated night clock	Campani	Rome	1683	BM	Singular
1958,1006 .2138	Bracket clock	Ulrich & Andreas Liechti	Winterthur	1599	BM	Multi-function L Ap
1958,1006 .2139	Bracket Clock	Nicholas Vallin	London	1598	BM	Singular
1958,1006 .2143	Bracket clock with quarter repeat	Joseph Knibb	London	1675-80	BM	Singular
1958,1006 .2152	Table clock	Hans Koch	Munich	1575-85	BM	Singular with dark and light aperture and touch-pins
1958,1006 .2191	clock	Unknown	Italy	1745-55	BM	Singular with hours I-VI
1958,1201 .1697	Watch	John Charlton	London	1625-35	BM	Singular
1958,1201 .1791	Watch	Louis Tavernier	Paris	1754-1840	BM	Multi-function with

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
						geographical function
1958,1201.1839	Watch with dumb repeat	John Arnold	London	1778	BM	Singular
1958,1201.2203	Watch	M.S	Germany	1550-70	BM	Singular with I-XII and 13-24 hours and touch-pins
1958,1201.2239	Watch	Unknown	Unknown	1675-85	BM	Singular with Turkish numerals
1958,1201.2338	Watch	Ferdinandus Zolling	Hamburg	1660-70	BM	Multi-function C, L SD
1958,1201.2375	Watch	Unknown	France	1695-1705	BM	Multi-function with Turkish numerals L SD
1958,1201.2381	Watch	Tompion & Delander	London	1688	BM	Singular
1958,1201.301	Watch	John Arnold	London	1780	BM	Standard format
1958,1201.535	Watch	Daniel Quare	London	1675-80	BM	Multi-function C, L (with tidal) SD
1958,1201.538	Watch	William Pybus	London	1788-94	BM	Singular
1958,1201.541	Watch	George Prior	London	1794	BM	Singular with Turkish numerals
1958,1201.837	Watch	Daniel Delander	London	1720-25	BM	Singular with front and rear dials
1967,0601.1	Clock	Unknown	Unknown	1500-50	BM	Singular
1967,0601.4	Clock	Unknown	Germany	1551-99	BM	Singular with rotating dial
1972,0404.1	Clock	HB	Davos	1688	BM	Singular
1977,0702.1	Watch	Thomas Mudge	London	1764	BM	Multi-function C, L CR, Ap
1980,1002.1	Illuminated night clock	Edward East	London	1670-80	BM	Singular
1985,1005.1	Clock	Joseph Naylor	Nantwich	1720-25	BM	Multi-function A, C, L CR

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
1986,0306.1	Travelling clock with quarter repeat	Thomas Tompion	London	1695-1705	BM	Singular
1988,1104.1	Watch	Thomas Mudge	London	1740-50	BM	Multi-function C (with equation-of-time) CR
1989,0914.1	Bracket clock	Veit Schauffel	Munich	1575-1600	BM	Singular with touch-pins
1991,1008.1	Bracket clock	Bernard J. Van Stryp	Antwerp	1655-65	BM	Singular
1992,1001.1	Clock	Henry Jenkins	London	1778	BM	Multi-function A, C, L CR
1994,0611.3	Watch with quarter repeat	Julien Le Roy	Paris	1745-55	BM	Singular
2010,8029.1	Longcase clock	William Northrop	Wakefield	1690-1720	BM	Multi-function C Ap
2010,8029.10	Longcase clock	Stephen Blackburn	Oakham	1735-45	BM	Singular
2010,8029.12	Longcase clock	Thomas Hill	Lambourne	1740-50	BM	Multi-function C, Ap
2010,8029.13	Longcase clock	Neddy Wells	Shepley	1740-50	BM	Multi-function L Ap
2010,8029.14	Longcase clock	Thomas Williams	Kings Sutton	1740-50	BM	Singular
2010,8029.16	Longcase clock	Benjamin Fieldhouse	Leominster	1750-60	BM	Multi-function C, Ap
2010,8029.17	Longcase clock	Henry Deykin	Worcester	1765	BM	Singular
2010,8029.18	Longcase clock	Edward Edwards	Bishop's Castle	1750-60	BM	Multi-function C, Ap
2010,8029.19	Longcase clock	Wilmshurst	Brighton	1755	BM	Singular
2010,8029.21	Longcase clock	David Collier	Gatley Green	1760-70	BM	Multi-function C, Ap
2010,8029.22	Longcase clock	Thomas Kefford	Royston	1760-70	BM	Singular
2010,8029	Longcase	Nathaniel	Wellington	1770-	BM	Multi-function

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
.23	clock	Plimmer		80		C, Ap
2010,8029 .24	Longcase clock	Robert Webster	Madeley	1770-80	BM	Multi-function C, Ap
2010,8029 .26	Longcase clock	William Porthouse	Penrith	1760-70	BM	Multi-function C Ap
2010,8029 .26	Longcase clock	William Porthouse	Penrith	1760-70	BM	Multi-function C, Ap
2010,8029 .27	Longcase clock	Samuel Roberts	Llanfair Caereinion	1765	BM	Multi-function C, Ap
2010,8029 .28	Longcase clock	James Roper	Shepton Mallet	1765-75	BM	Multi-function C, Ap
2010,8029 .29	Longcase clock	Eli Stancliffe	Honley	1770-80	BM	Multi-function C, L Ap
2010,8029 .30	Longcase clock	William Harris	Chippenham	1765-75	BM	Multi-function C, Ap
2010,8029 .33	Longcase clock	William Snow	Padside	1775-85	BM	Multi-function C, Ap
2010,8029 .34	Longcase clock	John Woolley	Codnor	1760-70	BM	Multi-function C, Ap
2010,8029 .36	Longcase clock	Benjamin Barlow	Oldham	1775-85	BM	Multi-function C, L Ap
2010,8029 .38	Longcase clock	Thomas Honeybone	Wanborough	1770-80	BM	Singular
2010,8029 .39	Longcase clock	Samuel Lawson	Keighley	1760-70	BM	Multi-function C, L Ap
2010,8029 .4	Longcase clock	Thomas Loftus	Wisbech	1710-15	BM	Multi-function C Ap
2010,8029 .40	Longcase clock	Jerom Murch	Honiton	1770-80	BM	Singular
2010,8029 .42	Longcase clock	G.Savage	Huddersfield	1775-85	BM	Multi-function L Ap
2010,8029 .43	Longcase clock	Richard Stedman	Godalming	1770-80	BM	Singular
2010,8029	Longcase	John	Dereham	1810-	BM	Singular

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
.44	clock	Wenham		20		
2010,8029.46	Longcase clock	John Fletcher	Barnsley	1770-80	BM	Singular
2010,8029.47	Longcase clock	George Hill	Lambourn	1780-90	BM	Singular
2010,8029.48	Longcase clock	William Hooker	Lewes	1780-90	BM	Multi-function C Ap
2010,8029.49	Longcase clock	Lister & Bromley	Halifax	1795-1801	BM	Multi-function C, L Ap
2010,8029.50	Longcase clock	James Ault	Belper	1825	BM	Singular
2010,8029.6	Longcase clock	Richard Bullock	Ellesmere	1760-70	BM	Multi-function C, L Ap
2010,8029.6	Longcase clock	Thomas Ogden	Halifax	1730	BM	Multi-function C, L Ap
2010,8029.7	Longcase clock	William Parslow	Stonehouse	1720	BM	Multi-function C Ap
2010,8029.8	Longcase clock	Joseph Butterworth	Cawthorne	1735-43	BM	Multi-function C, L Ap
2010,8029.9	Longcase clock	Richard Midgley	Ripponden	1735-45	BM	Multi-function C, L Ap
CAI.19	Watch	Thomas Blatchley	Bradford	1765-75	BM	Standard format
CAI.101	Watch	George Graham	London	1690-1700	BM	Singular
CAI.147	watch	Daniel Quare	London	1680-1720	BM	Singular
CAI.164	Name-dial watch	Thomas Saunders	Dorchester	1800-10	BM	Singular with letters representing hours
CAI.167	Watch	Joseph Smith	Bristol	1730-78	BM	Singular
CAI.168	Watch	Daniel Quare	London	1718-33	BM	Singular
CAI.185	Watch	Torin	London	1675-85	BM	Singular
CAI.187	Watch	Underwood	London	1795-1805	BM	Singular
CAI.203	Name-dial watch	Wightwick & Moss	London	1788-1836	BM	Singular with letters

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
CAI.222	Watch	Unknown	London	1700-1710	BM	Multi-function C, L SD
CAI.251	Watch	Thomas Harris	London	1735-45	BM	Singular
CAI.256	Watch	Thomas Windmills	London	1725-28	BM	Singular
CAI.257	Watch	Unknown	Austria	Unknown	BM	Singular
CAI.293	Watch	Benjamin Gray	London	1760-65	BM	Singular
CAI.294	Watch	William Skeggs	London	1756-71	BM	Singular
CAI.296	Watch	Berthoud	Paris	1756-62	BM	Multi-function C (with equation-of-time)
CAI.298	Watch	Unknown	Switzerland	Unknown	BM	Singular
CAI.347	Watch	Unknown	Unknown	Unknown	BM	Singular
CAI.349	Watch	James Woodgate	London	1767	BM	Singular
CAI.0373	Name-dial watch	John Wood	London	1762	BM	Singular with letters
CAI.394	Watch	Shaw Williamson	Dublin	Unknown	BM	Singular
CAI.406	Watch	Joseph Watson	London	1760	BM	Singular
CAI.407	Watch	James Warne	London	1767	BM	Singular
CAI.426	Watch	van de Sandt	Nijmegen	1695-1705	BM	Singular
CAI.428	Watch	Vallette	Paris	Unknown	BM	Singular
CAI.464	Watch	Unknown	London	1755-65	BM	Multi-function C, L CC, Ap Front and rear dials
CAI.469	Watch	J.Tennul	London	1778-1821	BM	Singular
CAI.492	Watch	John Shaw	Holborn	1707	BM	Singular
CAI.554	Watch	Peacock	London	1770	BM	Singular
CAI.601	Watch	Moilliet & fils	Unknown	1725-35	BM	Singular
CAI.607	Watch	T. Miller	London	1767	BM	Singular
CAI.632	Name-dial	John	London	1750-	BM	Singular

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
	watch	Maxfield		60		
CAI.656	Wandering hour watch	Jean La Chaumette	France	1680-90	BM	Singular
CAI.703	Watch	Adied Hielckert	Potsdam	1755-65	BM	Multi-function C CR
CAI.873	Watch	T. Butt	London	1745-55	BM	Multi-function C SD
CAI.1358	Watch	James McCabe	London	1855-65	BM	Singular
CAI.1435	Watch	Unknown	Neuchatel	1788-98	BM	Singular
CAI.1436	Watch	Vauchez	Paris	Unknown	BM	Standard format
CAI.1531	Watch	John Roger Arnold	London	1815-25	BM	Standard format
CAI.1537	Watch	Borgelin	Switzerland	1795-1805	BM	Multi-function C CR
CAI.1548	Watch	Breguet et fils	Paris	Unknown	BM	Singular
CAI.1553	Watch	Brockbanks	London	1791-1835	BM	Standard format
CAI.1554	Watch	Brockbank & Atkins	London	1815-35	BM	Standard format
CAI.1555	Watch half-quarter repeat	George Chauvel	London	1780-90	BM	Singular
CAI.1558	Watch	Alexander Cumming	London	1776-86	BM	Singular
CAI.1564	Watch	Thomas Earnshaw	London	1825-50	BM	Singular
CAI.1565	Watch	Thomas Earnshaw	London	1749-1829	BM	Standard format
CAI.1570	Watch	Ellicott	London	1759	BM	Singular
CAI.1623	Watch	George Graham	London	1743-44	BM	Singular
CAI.1639	Watch	Robert Hynam	London	1745-55	BM	Singular
CAI.1643	Watch	J. Leroux	London	1781-1808	BM	Singular
CAI.1839	Watch	John Arnold	London	1778	BM	Standard format
CAI.1839	Watch	John Arnold	London	1778	BM	Standard format
CAI.1878	Watch	Ellicott	London	1757-60	BM	Singular

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
CAI.2080	Clock	Unknown	Germany	1548	BM	Singular
CAI.2101	Astronomical clock	Henry Bridges	Waltham Abbey	1733	BM	Multi-function A, C, L CR, SD
CAI.2192	Clock	Claud Duchesne	London	1715-25	BM	Multi-function C SD
CAI.2251	Watch	Unknown	London	1610-20	BM	Multi-function C, L SD
OA.426	Watch	John Harrison	London	1785-95	BM	Singular
OA.434	Watch	J. Leroux	London	1781-1808	BM	Singular
OA.442	Watch	Edward Manley	London	1790-1800	BM	Singular
WB.222	Clock	Unknown	Italy	1500-1550	BM	Multi-function A, C, L CR
1989.2188	Clock	Unknown	Germany	1550-1600	DM	Multi-function A, C, L CC, SD
KG 2000.17	Longcase clock	Unknown	Unknown	1680-1750	DM	Singular
KG 2001.16	Clock	Unknown	Germany	1550-1600	DM	Singular
KG 2001.23	Clock	Unknown	Germany	1550-1600	DM	Singular
16-0014	Clock	Unknown	Germany	1750	DU	Multi-function C, L SD
70-0671	Clock	Unknown	Davos	1673	DU	Singular
2005-089	Clock	Unknown	Germany	1810	DU	Singular
2008-019	Clock	Unknown	Germany	1769	DU	Singular
K-0458	Watch	Unknown	Germany	1600	DU	Singular
M.21-1947	Longcase clock	Thomas Tompion	London	1675-80	Fitzwilliam Museum	Multi-function A, C (with equation-of-time)
OA.7016	Chamber Clock	Unknown	France	1600-1650	Louvre	Singular with touch-pins
OA.8282	Table clock	Unknown	Blois	1550	Louvre	Singular with touch-pins
OA.8302	Unknown	Henry Ester	Geneva	1640-50	Louvre	Multi-function C, L SD, Ap
OA.8313	Watch	Unknown	Paris	1690	Louvre	Multi-function C, L

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
						SD, Ap
OA.8397	Table clock	Unknown	France	1550	Louvre	Singular with touch-pins
1999.48.2	Longcase clock	Thomas Tompion	London	1677-80	Metropol-itan Museum of Art	Multi-function C, L SD
39663	Clock	Unknown	Unknown	1600-1650	MHS	Singular
44795	Table clock	Unknown	Germany	1650	MHS	Singular
D iv a 136	Watch	Unknown	Berlin	1750-1770	MPS	Singular
D iv a 425	Watch	Unknown	Germany	1640-1650	MPS	Multi-function C, L SD
D iv b 153	Table clock	Unknown	Germany	1550-1600	MPS	Singular with touch-pins
D iv b156	Bracket clock	Unknown	Germany	1670-1700	MPS	Singular
D iv b118	Bracket clock	Unknown	Germany	1720	MPS	Singular
D iv b275	Clock	Unknown	Germany	1700-1750	MPS	Singular
D iv d 4	Clock	Unknown	Germany	1600	MPS	Multi-function A, C, L SD
NMM ZAA0885	Clock	Thomas Tompion	London	1676	National Maritime Museum	Singular
RCIN30260	Clock	Samuel Watson	London	1683-90	Royal Collection	Multi-function A, C SD
1915-408	Watch	Thomas Earnshaw	London	1795-1810	ScM	Standard format
1916-108	Watch	Thomas Taylor	London	1700	ScM	Singular
1916-110	Watch	George Graham	London	1673-50	ScM	Singular
1916-117	Watch	Thomas Mudge	London	1740-1794	ScM	Singular
1916-120	Watch	Graham	London	1740-50	ScM	Singular
1916-124	Watch	William Finch	Halifax	1755-70	ScM	Singular
1916-131	Watch	Le Roy	France	1740-60	ScM	Singular with Turkish numerals
1916-145	Watch	Larcum Kendall	London	1750-1790	ScM	Singular

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
1916-205	Watch	Unknown	Rotterdam	1675	ScM	Multi-function C Ap
1916-226	Watch with dumb repeat	George Graham	London	1687-1751	ScM	Singular
1916-260	Watch	John Martin	London	1670-1700	ScM	Multi-function C CR
1916-93	Watch	Daniel Quare	London	1700	ScM	Singular
1916-96	Wandering-hour watch	Tompion	London	1701-50	ScM	Singular
1918-187	Chrono-meter	Lewis Recordon	London	1780-1800	ScM	Standard format
1932-441	Clock	Ulrich Andreas Liechty	Zurich	1596	ScM	Singular
1938-429	Table clock	Nicholas Vallin	London	1598-1603	ScM	Multi-function C, L (with aspects) CR
1942-57	Table clock	David Weber	Augsburg	1600-40	ScM	Singular
1942-58	Table clock	Unknown	Unknown	1675	ScM	Singular
1949-232	Table clock	George Lucenberg	Germany	1630-60	ScM	Singular
1951-217	Lantern clock	Joseph Knifton	London	1640-62	ScM	Singular
1952-312	Clock	Unknown	Augsburg	1600-1700	ScM	Multi-function with astrolabic dial C SD
1953-379	Table clock	Unknown	Unknown	1600	ScM	Multi-function with touch-pins C CR
1953-380	Watch	George Graham	London	1748	ScM	Singular
1953-47	Watch	Johannes van Ceulen	The Hague	1690-1700	ScM	Singular
1953-48	Table clock	David Bouquet	London	1550-1600	ScM	Singular 12 hours with touch-pins.
1954-151	Watch	André Pichon	Lyon	1600-1700	ScM	Singular
1954-184	Clock	Unknown	Germany	1500-1600	ScM	Singular

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
1954-185	Clock	Camerini	Turin	1656	ScM	Singular
1954-186	Table clock	Unknown	Germany	1545-1555	ScM	Singular. 24 hours with touch-pins
1954-189	Wandering-hour watch	William Crayle	London	1670-1710	ScM	Singular
1954-458	Bracket clock	Isaac Thuret	Paris	1665-81	ScM	Singular
1954-579	Lantern clock	John Holloway	London	1611	ScM	Singular
1954-580	Bracket clock	Johannes van Ceulen	The Hague	1670-80	ScM	Singular
1962-263	Bracket clock	George Graham	London	1700-51	ScM	Singular
1963-165	Watch	George Margetts	London	1750-1810	ScM	Multi-function with geographical function
1963-303	Watch	Henry Jones	London	1685-1700	ScM	Singular
1964-164	Longcase clock	Tompion	London	1700	ScM	Multi-function C Ap
1964-232	Table clock	Geo. Cri.	Augsburg	1660	ScM	Singular
1964-331	Quarter-repeat Watch	Thierry	Caen	1685-95	ScM	Singular
1964-332	Watch	David Lestourgeon	Rouen	1655-65	ScM	Singular
1970-25	Clock	Samuel Watson	London	1690-1710	ScM	Multi-function A, C, L CR
1975-334	Watch	Thomas Tompion	London	1650-1700	ScM	Singular
1976-520	Clock	Benjamin Martin	London	1765-75	ScM	Singular
1980-108	Bracket clock	Saloman Coster	The Haugue	1657-59	ScM	Singular
1980-244	Longcase clock	Ahasuerus Fromanteel	London	1660-65	ScM	Singular
1981-1856	Illuminated night clock	Joseph Knibb	London	1675-85	ScM	Singular
1985-1537	Watch	Thomas Tompion	London	1675-79	ScM	Singular
LDSAL131	Table clock	Jacob Zech	Unknown	1500-1548	Society of Antiquar-ies	Multi-function A, C, L (with aspects) CR
L.1-1973	Watch	David	London	1620	V&A	Multi-function

Object number	Clock or watch	Maker	Location	Date	Museum	Multi-function or singular
		Ramsay				C, L SD
M.39: 1 - 6-1959	Clock	Francis Nowe	London	1588	V&A	Multi-function A, C, L (with aspects and tidal) CR
M.64:1, 2-1952	Watch	Edward East	London	1645	V&A	Singular
M.7-1931	Table clock	David Ramsay	London	1610-15	V&A	Singular with touch-pins
Unknown	Watch	Bell	London	1670-1700	WCC	Standard format
Unknown	Watch	Childe	London	1620-1640	WCC	Multi-function C, L (with aspects and tidal) CR
Unknown	Watch	Daniel Carre	France	1670	WCC	Multi-function C, L SD
Unknown	Watch	Gorg.	Lyon	1660-1700	WCC	Singular. Sun-and-moon dial
Unknown	Watch	Henrici	Unknown	1640-1650	WCC	Singular
Unknown	Watch	James Nelson	London	1660	WCC	Multi-function A, C, L SD
Unknown	Watch	Daniel Quare	London	1700	WCC	Singular
Unknown	Watch	Stamper	London	1700	WCC	Multi-function C CR

Appendix Two: Glossary of Technical Terms

Aperture	a small opening in which a numeral, symbol, or picture is displayed.
Balance spring	a device, invented in 1675, which brought a similar level of accuracy to watches as the pendulum had for clocks.
Bracket clock	an upright clock, spring-driven clock.
Canon arbor	the central axel in the mechanism which usually carries the hour hand.
Centre seconds	a dial which represents the seconds concentrically to the hours and minutes, rather than in a subsidiary dial.
Escapement	a device within the mechanism which regulates the release of the energy stored in the main spring or weights.
Going	the running of a timepiece.
Horizontal table clock	a small, cylinder-shaped clock.
Illuminated night clock	a clock which displays the hour using the wandering-hour method, but where the numerals are transparent. A lamp is placed behind the dial and the numerals are thus illuminated.
Lantern clock	weight-driven clock, shaped like a lantern, designed to be attached to the wall.
Longcase clock	a weight-driven clock where the weights and pendulum are concealed by a tall wooden case.
Movement	the mechanism of a clock or watch.
Name-dial watch	a watch in which the hour index is numerated with letters which spell a name, rather than numerals.
Pendant	the terminal ring on a watch case, often by which it was attached to a chain or other device.
Planetary aspects	the apparent angular separation of the planets as perceived from Earth, expressed in terms of opposition, conjunction, trine, quartile and sextile.
Quarter repeat	a mechanism by which the last hour and quarter struck on the bell could be made to repeat on demand.

Striking	the manner by which the bell is made to sound an alarm or the passing hours.
Subsidiary dial	a small dial located within the main dial.
Turret clock	a large clock, usually situated on a church or town building.
Wandering hour	a display used on some watches and night clocks, by which the hour is indicated using an aperture in which the hour numeral is seen to move across.
Weight-driven chamber clock	a clock designed to be attached to the wall.

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