The Changing Face of Early Modern Time, 1550–1770

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For my family

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CHAPTER 1

Introduction

The late-eighteenth-century user of the watch made by John Arnold & Son shown in Fig. 1.2 would have had very little use for the dial of the clock made by Nicholas Vallin shown in Fig. 1.1. It did not tell them the minutes or seconds. Conversely, the late-sixteenth-century user of Vallin's clock would have found Arnold's watch dial 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. Despite changes in the use and appearance of dials in this period, Arnold's watch dial, which exemplifies a kind of standard format that emerged around 1770 and enjoyed continued popularity over the course of the next century, primarily owed its design to dials such as that made by Vallin. While the availability of materials and the increasing machine capacity to reproduce this form would also have played a role, these factors do not sufficiently explain the longer-term influences which led to the emergence of this design. Nor does the continued production throughout the period of single-function dials that only represented the time of day. The standard format was as much a product of hitherto declined theories and practices, present on the earlier multi-function dials, as it was of those prevalent around 1770 when it rose to popularity.

The changing face of early modern time, or the journey of dial development from the type shown in Fig. 1.1 to the type shown in Fig. 1.2, is

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Fig. 1.1 Table clock by Nicholas, London, c.1600. Object no. 1938-429 (Photograph courtesy of Science Museum/Science & Society Picture Library)

a rich and fascinating one and forms the overarching narrative of this book. It is not known who the original owners or users of the dials made by Vallin or Arnold were. We know approximately when they were made and that they were made in London, but their dials were not unique to England. They are tantalising and powerful evidence of past use and connections to the wider context of knowledge transmission, but unlocking their meaning is challenging. This book is committed to overcoming these challenges and revealing that meaning. As we shall see in the chapters which follow, the most productive way to do so is through a close comparison of dials with a special combination of printed paper sources. These comparisons enable the identification of the knowledge and communication traditions which clock- and watch-makers drew upon when designing dials, which were essentially a mechanised form of diagram. Decisions made in terms of what to include, 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. Dials were the faces of the kind of time that users wanted. These changing needs are evident in printed paper sources, such as

Fig. 1.2 Pocket watch by John Arnold & Son, London, 1794. Object no. WCC.429 (Photograph courtesy of the Worshipful Company of Clockmakers and Clarissa Bruce)

almanacs, where the decline of astrology during the mid-late seventeenth century was noticeable from the reduction of predictions based explicitly on planetary influences. Similarly, comparison of dials with printed paper sources enables the identification of changing uses of indications on dials that may at first seem to have changed very little throughout the period, such as the pictorial representation of the changing lunar phase. Almanacs up until the mid-late seventeenth century provided weather, health and farming advice based almost entirely 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 rural areas from the early-eighteenth century, planned nighttime 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.

1.1 Foundations

Clock and watch dials have received a disproportionately low level of scholarly attention compared with the mechanical development of the timepiece and the printed paper sources noted above, which makes the foundation on which to build a new interpretation of dials challenging to locate. There are, however, three bodies of literature that provide a useful springboard for progressing a discussion of dials. 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 of natural magic and nascent science). The historians who have contributed to these topics have provided critical information that will form the main points of reference throughout the subsequent chapters and are summarised in turn below.

The only book-length works which concentrate purely on dials are Tennant's accounts of dial conservation[1] and Loomes' volumes[2] which helpfully map the changes in numeral size and dial decoration in a catalogue-style approach, but do not interrogate contexts of use. This has left an immense gap in the historical record. The complexities of the journey of dial development from the multi-function dials of the mid-sixteenth century to the standard format that emerged in 1770 require a book-length work to untangle sufficiently. Beyond the work of Tennant and Loomes, historians of horology such as Thompson,[3] Bruton[4] and others[5] approach the history of clocks and watches according to a convention which was established during the late-nineteenth-century writer, Britten,[6] and mid-twentieth-century writers, Baillie[7] and Clutton.[8] These three authors provided a catalogue-style approach to clock and watch history, helpfully mapping and describing every detail of a clock or watch, but with extremely little contextualisation beyond horology and no discussion of the wider significance of the elements they described.

Their focus was on the development of precision timekeeping, and consequently, they wrote in terms of a pre-pendulum and post-pendulum dichotomy, where everything in the former era was thought of as a stopgap until the pendulum was developed. Subsequent historians of horology followed the same approach when describing timepieces—beginning with the casing, moving past the dial and going through each component of the movement.[9] Many historians merge all indications other than the hour of the day into one group of 'other'.[10]

One of the challenges with trying to use the traditional horological literature to find out more about dials and changing uses seems to have arisen from their perceptions of museum objects or items from private collections. The authors appear to have been guided by the modern identity granted to them as 'museum objects' once acquired by an institution or collector. Gauvin is sceptical about the power of objects once they appear in a museum[11] and he is not alone in this.[12] For him once in this context, they lose their functional identity and this point helps us to understand the findings of previous horological histories that have overlooked important parts of the original function of clock and watch dials. To fully understand dial use we must contextualise them beyond the world of horology. While Gauvin was right to question the identity of museum objects, his criticism of Dudley's account of being 'utterly spellbound'[13] by an encounter with an ancient Chinese horse statue overlooks her point that objects are powerful because they were made for a specific reason and were used by people in the past. Looking at and contemplating them can give us a sense of this, however small.

Consequently, the limitations of many social histories of time, such as those by Adam,[14] Landes[15] and Birth,[16] are a result of their complete reliance upon the histories of horology noted above for their interpretation of clocks and watches. They accept the marginalisation of the functions other than the hour initiated by traditional histories of horology without realising that this was due to other priorities and base their own arguments solely on the clock as a communicator of the hour and the 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 connection made in the chapters of this book between dials and the mnemonic tradition.[17] This was surely the result of his focus having been on the human mind and its construction of the concept of time, rather than instrument use. While other historians such as Dohrn-van Rossum[18] and Glennie and Thrift[19] similarly do not question previous horological

histories, their work on the proliferation of clocks from the thirteenth century onwards provides some valuable context for this investigation. While Mayr[20] has made a promising start in thinking about clocks in a different way, 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 is based on an overview of the clock and what it signified as a whole, rather than the changing indices and their use.

Most authors whom engage with the topic of early modern knowledge transmission, such as Lefevre[21] and others,[22] base their claims on printed paper sources. While this is perfectly reasonable and informs this investigation also, it leaves a gap with respect to the role played by instruments which were also designed to convey information. Franklin, for example, correctly claims that diagrammatic forms of representation were created as a form of language that would be easily interpreted by the reader,[23] but his focus on printed paper sources has meant that he has been unable to consider other forms of communication. Both dials and printed paper sources were embedded with signs of early modern perceptions of what constituted an effective method of communication, not just the latter. Clock and watch dials were a form of mechanised diagram, sharing both content and format with their printed paper counterparts and were used by many of the same people. They must not be overlooked as they played an important role as the earliest forms of mechanisations of knowledge. Dials were influenced by printed paper sources and influenced them in their turn as we shall see.

Eisenstein has rightly drawn attention to the changes brought about through printing in terms of the new knowledge that was disseminated throughout Europe and the influence of the printers over what would become available to readers.[24] Again, she did not include technological devices or instruments as they were beyond her scope, which has left a gap in our appreciation of the reach of printing. Dial designs, like printed paper sources, transcended national boundaries. Clock- and watch-makers, like authors, were heavily influenced by printing which is evident in their dial designs. One assumes therefore that clock and watch users experienced dials similarly to the way in which they experienced books and pamphlets as readers. Historians of reading practices such as Finkelstein and McCleery argue that in terms of the roles of author and reader within the reading experience, the example of the annotated book is evidence of a dialogue between reader and author.[25]

Almanacs, which are a key type of text that is compared with dials in this book, were often annotated. Yet, with respect to dials, the experience of reading and interpreting information was not a dialogue because the author, or maker, could not respond. With dials, the clock- or watch-maker, like the author of a text, formed the content and the format of the piece and then sent it out into the world. It was then used by the owner of the timepiece, like the reader of an author's text, who, in the case of the reader could annotate it, but in the case of the clock or watch user had to hold onto 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. By comparing the two media, we can appreciate the benefits and limitations of dials as a communication device, rather than only admiring their aesthetic qualities. Similarly, Darnton argues that there was a communication circuit of influence on printed books,[26] but mechanical timepieces can be added to two stages of his circuit. Whereas Darnton's circuit ends with the reader,[27] the dial circuit ends with the user, who is also a reader and is thus 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.[28] In the example of dials, the addition of 'non-survival' or 'decline' would also need to be made, which neither of these authors include. Throughout this book, we will see that decline and partial continuity was a significant facet of the journey of dial development.

Historians of early modern epistemology can also help us to interpret dials differently. Gunpowder, the printing press and the magnetic compass were cited by Francis Bacon as the three great inventions of the Renaissance. Henry correctly says that they thoroughly changed ways of life,[29] but clocks and watches were the fourth device of similar importance. While technically an earlier invention, the new availability of domestic timepieces to those that could afford them was significant. They were a mechanised form of knowledge tool, which were adapted to changing use throughout the period. The chapters in this book demonstrate 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. Henry[30] and Eamon[31] correctly argue that technology was perceived as a form of mathematical magic in the sixteenth- and early-mid-seventeenth century. Yet, clocks and watches have not been considered from the perspective of the natural magic tradition. This is 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.[32] This is perhaps one reason why there is a lack of archival records left behind by clock- and watch-makers of the early period. Dials acted as an aid to natural magic up until 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[33] and Webster,[34] agree that prophecy was an important part of early modern life. Yet, technological devices and instruments are also beyond their scope. 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 when astrology experienced its main wave of decline. Since dials have not as yet been considered in sufficient detail, the subtle differences between the calendar, lunar and astronomical functions in terms of the way in which they were used have not been identified. In the late-sixteenth and early-seventeenth centuries, multi-function dials also 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 that the user wanted to remember. It was thought that this would help them to get closer to God. The work which Yates began fifty years ago[35] provides a useful foundation for thinking about these issues. Those who have criticised her work for the extent of her arguments about the hermetic nature[36] of the art of memory have overlooked the value of her wider findings. Her discussions of image construction, that the mnemonic method was a search for signs and symbols to use,[37] and *loci*[38] (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 multi-function dials with sets of concentric rings or subsidiary dials provided numerous *loci* for users to remember, as will be demonstrated in subsequent chapters.

Historians such as Henry[39] and Clark[40] correctly argue that nascent science drew from different aspects of 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 concerning the nature of the period often referred to as 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.[41] However, his focus on the development of the mechanism rendered dials beyond the scope of his research. Dials in fact show that in many respects the story of horological development was one of incremental change in response to changing user needs, rather than complete, over-night change.

1.2 Forging a New Interpretation: Evidence from Dials

While the three bodies of historical literature described above have provided some groundwork on which a new discussion of clock and watch dials can be built, their respective approaches are not appropriate for this book. As the user-facing part of a timepiece, the dial's 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. 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 conveying that information. This book is about uncovering these 'hidden', or not immediately obvious, meanings and will do so by concentrating on the changing contexts of use. 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 included. Multi-function dials, which represented complex combinations of information, were popular up until the mid-late seventeenth century, but then went into 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. Those that continued to be made were designed for their aesthetic and nostalgic appeal, rather than their utility. 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. Each of these contributed to the making of the standard format which emerged by 1770. 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.

There are four key issues that help us to get closer to understanding the reasons for dial change in this period and will underpin the narrative of this book and which have not been adequately discussed previously. The first is the close relationship between dials and printed paper sources—the influence of conventions in communication of information and perceptions of effective knowledge acquisition. The second is the use of dials for astrological and mnemonic purposes and the influence of the decline of these theories and practices. The third is the extent to which dials mirror contemporary perceptions of knowledge transfer and creation. The fourth is the influence of users' emotions on the decisions made by clock- and watch-makers when they were making dials. In order to discuss the complexities of these four issues, careful parameters have been established and supportive sources strategically sought—each element of which is outlined below. The temporal parameters for this book 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 discuss the effect of the decline of astrology on dials, the wider period in which these ideas and practices were at their height and after their decline must be discussed. To solely examine the period in which they went into decline is insufficient. Therefore, throughout the book dial change is discussed in terms of the period in which change occurred for example the 'early-seventeenth century' or the 'late-sixteenth century', rather than specific dates as it is rarely possible to be more precise. The exception being several isolated cases such as references to the introduction of the pendulum for clocks in 1657. The focus of the book is the clock and watch dials of Britain, but with extended comparison with European dials from Germany,[42] France, Italy, Denmark and the Netherlands. As will be demonstrated throughout the subsequent chapters, the issues discussed 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.

One of the most probable reasons for the prior lack of contextualisation of clock and watch dials and one of the major challenges in writing this book is the lack of direct archival evidence of clock and watch dial use for the period under investigation. There are few, if any, first-hand accounts of clock and watch use and very few clock-makers' 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 evidence in their own right. With respect to interpreting objects, Baird claims that we read books, but 'examine' instruments.[43] Yet, clock and watch dials were designed to be 'read' in a similar way as printed paper sources. He correctly 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.[44] Meaning can indeed be drawn from clock and watch dials, but only by employing a new approach. The methodology used in this book consists of an interdisciplinary approach to dials. Given the difficulties presented by a lack of definitive archival evidence relating to clock and watch usage or design decisions, this information must be strategically sought from alternative sources. There is no single type of source that yields enough information, but a range of sources presents a fuller picture. Glennie and Thrift experienced a similar difficulty finding archival sources to answer their questions about how the experience of the hour influenced 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.[45] While this statement is also applicable here, the user experience of dial format and content 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 reveal the full story.

Similarly, there is no one dial that can reveal everything. The findings revealed in the subsequent chapters have been derived from an examination of over two-hundred-and-fifty clock and watch dials from different museum collections. Their format and content have been deconstructed

and compared with printed paper sources in order to identify patterns of change and continuity. This book is object-rich and in order to guide the reader through the central arguments thirty-five carefully selected images have been provided throughout. Images are necessary for understanding the subtle changes in different components of dial format and content. The eighteen carefully selected dial images are key examples which are representative of wider groupings and references are made throughout to many other clocks and watches. One-off examples that were not part of wider trends are not commented upon. The majority examined are held in the collections of the British Museum, this is one of the largest collections in the world, but also include objects from the Science Museum, the Museum of the Worshipful Company of Clockmakers, the Wallace Collection, 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 museum collections is problematic given that, in his opinion, one should not view museum pieces as representative of those owned by everyone.[46] Yet, the reader must be gently reminded that the overall aim of this book is to explain the reasons 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.[47] Although timepieces became increasingly more affordable as the period progressed, they remained objects owned by the wealthiest sections of European society. The subject of clock and watch dial research has the potential to be vast. Indeed, the standard format which emerged around 1770 enjoyed a long life into the nineteenth century, but its longevity is beyond the scope of this book. The focus here is explaining why it appeared the way that it did. Similarly, clock and watch case decoration is also beyond the scope. Much work has been conducted on the allegories depicted on cases and their links to the history of art, literature and religion.[48] Allegorical or decorative images on dials, such as ships, windmills, and flowers, are not discussed here.

1.3 Forging a New Interpretation: Evidence from the Archives

An essential feature of the new approach employed in this book is the combination of archival sources from which evidence is drawn. The vast majority of which have not been compared with clocks and watches by historians before and none have been compared with dials specifically. In all, there are seven main categories of archival source that have been used. While some historians would group these sources differently, in this book, they are grouped in terms of their original purpose and use. Inspiration for this mode of categorisation came from Wyatt[49] and Lindsay,[50] who approach technology from a user, potential user and non-user perspective, and Briggs,[51] who divided his work on technology and consumption into chapters on type of thing in order to discuss users' relationships to it. While these authors concentrate on twentieth- and nineteenth-century technology, respectively, and have more archival sources on which to base their conclusions, there is very little in the way of direct archival evidence of clock and watch use and thus a range of different sources must be brought together to make conclusions. 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.

The first are almanacs and calendars. Throughout the period covered by this book, 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 renders them a key source for each of the chapters, with the exception of chapter three on trust which is approached from a slightly different perspective. The extent to which they were used for the same purposes and by the same kinds of people is explored.

The second is the range of craft books which were published throughout the period. The sixteenth and seventeenth centuries experienced a proliferation of small pamphlets, which are often referred to as 'craft books' which acted as guides or manuals to different crafts and practices.[52] 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 application of

some dial content and thus provide clues to perceptions of knowledge in the period.

The third 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 2 on Communication Methods.

The fourth are artworks, including prints and paintings which are utilised in order to contextualise in several chapters. Artworks 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 4 which concentrates on different contexts of enablement, and Chapter 6 which focusses on the lunar function.

The fifth are diaries, which are selectively used where possible to provide further support for 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 few surviving diaries that contain relevant material, but a few examples do help strengthen Chapter 3 on trust.

The sixth is a single clock-maker's notebook. While its author is unknown, 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 watch-making', there are virtually no surviving notebooks or archive material relating to his business except a few receipts.[53] 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.[54] Indeed, for these reasons individual clock- and watch-makers are not the main focus of this book. We don't know enough about the individuals for them to play a major role in this particular inquiry. More importantly, they were as

much a part and a product of the wider culture evident in printed paper sources as anyone else.

The seventh and last are selected archival material from the Worshipful Company of Clockmakers. 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 Company over clock- and watch-making in London in the period. While this London Livery Company is noted 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 contemporary material enable the placement of clock and watch dials within the wider context of early modern ideas and practice. As a set they enable the identification of 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.

1.4 Forging a New Interpretation: Clock and Watch Users

The difficulty in trying to identify specific users of clocks and watches is similar to that with trying to identify and distinguish specific dial makers from the clock- and watch-makers who made the movements. It would be valuable to know who these people were and the influences on them. In some instances, 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. Yet, 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 unlawfully engraving in February 1683.[55] 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 a guild. Again, the challenge is a lack of supporting archival material, but can be overcome using the range of primary sources identified above.

As previously stated, clock- and watch-makers are not the main focus of this book. 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 on the movement of the timepiece. In some instances, much is known about the biography of a clock- and watch-maker such as Thomas Tompion or Ferdinand Berthoud, but in other cases only their active working dates and place of making is known.[56] This is another reason why an extended timeframe is utilised here as extant clocks and watches can often only be dated to an accuracy of within fifty years.[57] Maker information can help to determine the types of customers makers might be selling to. Although client lists have not survived, there are several armorial engravings on cases which act as an identifier.[58] Yet, in most cases the ideas embedded within the dial transcend the work of individual makers. The similarities that are identified between the products of makers from different countries will show this to be true. Makers were as much a product of their time as anyone else and it is the wider context that is more revealing about dial use and influence on dials than information about individual makers. Some historians of horology unwittingly imply, through their lack of contextualisation, that the creations of the clock- and watch-maker were made in horological isolation, but the subsequent chapters will demonstrate 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.[59] This may be why many historians of horology generally overlook the issue of who the users actually were and only refer to them by saying that a specific clock or watch was clearly made for a wealthy customer. It more than likely was, but this is not very helpful. Partial evidence can be derived about the identity of users from the prefaces of various pamphlets written by clock-makers in the period. Both John Smith in his *Horological Disquisitions*[60] and Clay in his *An Explanation of the Nature of Equation of Time*[61] identified their readers as 'gentlemen'. It will be remembered that neither of the original owners or users of the dials featured at the beginning of this chapter in

Figs. 1.1 and 1.2 are known. However, to compensate for this the different types of user who would have owned and used the dials considered here have been identified. These identifications are based on a body of work conducted by historians of consumption and the economy of early modern Europe and London such as Weatherill,[62] Earle,[63] Brenner,[64] Brewer and Porter.[65] 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, aldermen, successful craftsmen and professional people such as lawyers, doctors and leaders of civil and military life. This is supported by advertisements 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[66]; a French watch made of gold lost by a Major General near Whitehall[67]; and an attorney's clerk stealing a gold watch from his master's premises near the Strand.[68] 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 and did not solely refer to the landed gentry.[69] 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 late-seventeenth-century examples have been included, they were typical of the period under discussion here.[70]

This information informed the selection of the kinds of printed paper sources, outlined above, which are 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 mathematical ideas.[71] 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[72] and De Vries[73] 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 indicate that certain individuals owned clocks and watches, which is helpful, but offer nothing further concerning 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. This 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 considered here 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 considered here are virtually non-existent. We often know who made clocks and watches in museum collections, but they have historically been separated 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.

The selection of clocks and watches referred to in this book comprises clocks and watches that were made in Britain, Germany, France, the Netherlands, Denmark, 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 seven 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. A clock-making centre in the early modern period that was solely clock-making and nothing else has yet to be identified. 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 referred to here.

1.5 Capturing a New Interpretation

A set of six core chapters bring together all of the elements outlined above to reveal the complexities of the journey of dial development from the multi-function dials of the mid-late sixteenth century towards the standard format that emerged by 1770. Each chapter is relatable to one of the two basic components of a dial, which are format and content. Chapters 2–4 concentrate on dial format, the way in which information was arranged on the dial. Chapters 5–7 focus on dial content, which other than the hour and its subdivisions encompassed calendrical, lunar and astronomical information. Until now they have been grouped together by historians of horology[74] as 'other', but they must be considered separately in order to improve our understanding of the dial as a knowledge tool.

We begin with Chapter 2, which sets the scene for the rest of the book in terms of establishing the dial as a form of text or diagram. Here, we explore the different methods of communication that were used by makers to convey knowledge to users, such as concentric rings and subsidiary dials. This chapter will consider the act of looking and the pathways that were created for the eye to follow and will use this to discuss the creation of knowledge hierarchies and perceptions of effective knowledge transmission. It will identify languages of symbolism that were shared by both dials and printed paper sources in the period and consider the usefulness of this within the context of the art of memory. Understanding how and why information was arranged in certain ways and how this changed throughout the period will help us to understand why the standard format appeared the way that it did by 1770.

Chapter 3 will consider the ways in which the trust relationship between clock- and watch-makers and their users, through the timepiece itself, influenced changing dial formats in the period. It will explore four important moments within the history of horology where format was

used to either generate or maintain trust in a timepiece. Firstly, this will be the representation of alternative hour schemes during the mid-sixteenth century to the early-seventeenth century. Some countries used the 1–24 schemes, whereas other preferred I–XII or even I–VI. Secondly, it will be the coexistence of quarters and minutes on dials in the late-seventeenth century. Thirdly, the changing relationship of dependence between the sundial and the mechanical timepiece as evidenced through the dial. Lastly, it will consider the influence of precision-timepiece dials through the process of imitation. These four moments will help us to understand the role played by trust in the emergence of the standard format by 1770.

Chapter 4 will explore two different ways in which makers used dial formats as a method of enabling users who were excluded from using traditional clock and watch dials. Here, dial formats will be considered from the perspective of the cultural view of disability. The first example is the touch-pin which was present on dials from the mid-sixteenth century to the early-seventeenth century. Touch-pins were small, rounded protrusions located at each numeral of the hour index. Dials with touch-pins will be considered within the context of changing perceptions of blind and partially sighted people and the increase in the use of spectacles with sides. The second example is the illuminated night clock which was used from the mid-late seventeenth century to the early-eighteenth century. These clocks were fitted with a lamp behind a rotating dial with transparent numerals. Night clocks will be considered within the context of early modern domestic lighting and changing perceptions of the night. Understanding why these adaptions went into decline will help us to understand why they were not part of the standard format by 1770.

The first of the three chapters that concentrate on dial content, Chapter 5 will reflect upon the changing use of the calendar function throughout the period. It will consider indices such as the period of the day, the seven days of the week, day of the month, the twelve months of the year and the four seasons as calendrical locating co-ordinates for users to locate themselves according to the astrological advice read in almanacs and other calendrical texts. It will explore the effect of the decline of astrology on the calendar function in the mid-late seventeenth century and analyse the survival of some of the co-ordinates for other uses. Surviving co-ordinates will be considered within the context of key religious and financial dates and the multi-stage reform of the calendar dependent on country and region that took place between 1582 and 1752.

Chapter 6 will focus on the changing use of the lunar function. The lunar phase, often represented with a lunar calendar index, was present on dials throughout the period and initially appears to have changed very little, but this chapter will explore the subtle differences that became apparent over time and compare these with parallel changes in print. It 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. It will explore the use of the dial as a memory prompt for astrological advice acquired elsewhere and discuss the influence of the decline of astrology during the mid-late seventeenth century. It will examine the survival of the lunar function such as for use during the night in areas without street lighting and within the context of renewed interest in tidal reckoning in the late-seventeenth century due to the growing interest in the measurement of natural phenomena.

Chapter 7 will consider the changing use of astronomical indications throughout the period. Here, we will explore the two different contexts of use for astronomical clocks. The first is the use for astrology and memory in the period from the mid-sixteenth century to the early-seventeenth century. This chapter will reflect upon the relatively shorter lifespan of the astronomical function compared with the calendar and lunar functions and consider the effect of the first wave of astrological decline in the early-seventeenth century. The second context of use is the renewed representation of astronomical indications for teaching astronomy during the late-seventeenth century and early-eighteenth century, as part of the wider context of public demonstration of natural philosophy. Four astronomical clocks will be explored alongside pamphlets written by their makers which will include a discussion of makers as authors within the wider context of public science demonstration.

In the concluding chapter, we will return to consider the four key issues identified at the beginning of this chapter, which underpin the narrative of the book. Making references to relevant chapters, we will reflect upon the extent to which there was a fluid boundary between dials and printed paper sources. The chapter will discuss the influence of astrology and the art of memory on the development of dials, but also its decline. It will consider the extent to which dials were designed to be effective communication devices, based on perceptions of knowledge acquisition in the period. It will contemplate the influence of users' emotions on dial designs and reflect upon the idea that dial change rarely took

place immediately and there were often periods of transition, rather than immediate change. By the end of these chapters, we will have a much better understanding of why the standard format that emerged by 1770 appeared the way that it did.

Notes

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37. Ibid., p. 378.
38. Ibid., pp. 84–93.
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50. Christina Lindsay, 'From the Shadows: Users as Designers, Producers, Marketers, Distributors, and Technical Support', in *How Users Matter: The Co-Construction of Users and Technology*, ed. by Trevor Pinch (Cambridge, MA: The MIT Press, 2003), pp. 29–50.
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52. For more information see Eisenstein, pp. 46–48.
53. Jeremy Evans, *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, 2006), p. 40. The receipts are not even known to be in Tompion's own handwriting.
54. The archives of the Worshipful Company of Clockmakers holds one work ticket by the maker Benjamin Vulliamy MS3988B/1, 'Ticket by Benjamin Vulliamy' (Worshipful Company of Clockmakers, 1778); the Jump family records MS15189, 'Jump Family Scrapbook' (Worshipful Company of Clockmakers). Tennant refers to the James Wilson family business records of 1777 onwards, Mary Frances Tennant, *Longcase Painted Dials* (London: N.A.G., 1995), pp. 30–31.
55. MS3975. *Index of and Abstracts to Journals and Ordinanaces*, Worshipful Company of Clockmakers.
56. Historians have thoroughly researched the names, active dates and locations of many different clock and watch-makers and published extensive lists.

57. Many clocks and watches in every museum are dated as 'mid-sixteenth century' or 'early-eighteenth century'.
58. For example British Museum object number 1856,0429.1.
59. 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.
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68. Anonymous, 'Advertisements', *The London Gazette*, 20 October 1673, p. 2, https://www.thegazette.co.uk.
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74. Bruton, *The Longcase Clock*, pp. 104–119.

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-century and seventeenth-century clocks and watches 'told' their users a great deal of temporal information from

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_2

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. The work of Rossi[3] and others[4] on the early modern art of memory provides a useful foundation on which to build an understanding of dials as memory prompts.

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 been dramatically reduced. 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 view contrasted with the sixteenth-century and early-seventeenth-century perception of mechanical devices as magical, according to Eamon's definition,[5] which also provides a foundation for improving our understanding of 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 those associated with the natural magic tradition. Indeed, as Henry correctly states, proponents of nascent science from the late-seventeenth century onwards were keen to separate naturalistic elements from the magic tradition and discard elements they no longer wanted.[6] Clocks and watches improve our understanding of this practice. Duncan's subsequent assertion using the phrase 'we never imagine', while seeming logical to a modern reader, indicates that there was indeed a prior view, if almost fully declined by 1770, that the mechanical instrument was an interpreter of information for the user, which some people had believed.

Communication is a timeless concern, and many different media have been used over the centuries to share information from one person or group to another. Regardless of the medium, communication requires certain methods to be effective. 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, communication 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. By interrogating the clock and watch dial as a form of text and diagram, the numerous and evolving components of dial format can be restored to their rightful position within the history of perceptions of knowledge communication. Crucially, dials were designed to convey meaning and transmit knowledge through specific notation and arrangements of information in a manner virtually identical to printed paper sources.

The products of the printing press exerted the greatest influence on the arrangement of information on dials, and the characters chosen to represent that information. The work of historians of the book and of printing such as Eisenstein[7] and others[8] provides a foundation for understanding the issue of communication through instruments and the ways in which printed paper sources and instruments influenced each other. This influence was much stronger than the attempt to provide a purely aesthetically pleasing object for a wealthy client as historians of horology such as Landes[9] and Thompson[10] have previously suggested, though of course clocks and watches were undoubtedly beautiful. Glennie and Thrift, the only authors of a work on clocks to refer to user comprehension, correctly emphasise 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 both 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. 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 with in order to make good use of both media. Dials were not made in horological isolation; to understand them fully, they must be reinterpreted within the wider context of knowledge communication and representation.

Johns emphasises the role played by the controllers of the printing presses in deciding which publications would be disseminated by their presses, for example the Stationers' Company in London.[14] As dials were influenced by print culture, those in control of the printing presses

indirectly influenced dials. He briefly mentions that those working in the printing presses set conventions, but does not elaborate. Taking this line of thought further and given the extent of the components of a page of astrological text such as an almanac, this must have involved the selection of the typeface, point size, language, numeral type and symbols that had been determined the most efficient for selling 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 in time become accustomed to. Indeed, Eisenstein correctly 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.[15] Eisenstein's work provides a foundation on which a discussion of instruments including clocks and watches can be constructed. Dials not only formed part of this process of convention establishment, but as they were a moving form of information indicator, they represent an automated form of information ordering and as such a memory trigger.

There were three essential ways in which dials communicated information in the period, and these will be considered in turn. Firstly, the formatting of the information on the dial was intended to create pathways for the eye to follow. Secondly, the information presented, and more importantly, the way in which it was formatted was according to a pre-ordered hierarchy of knowledge. Thirdly, dial formats were a tool designed to enable the effective transmission of knowledge to the mind and long-term memory in particular.

2.2 Pathways for the Eye

The methods chosen to communicate information on clock and watch dials created pathways for the eye to follow. These pathways can only be identified by considering dials as diagrams. The argument of historians who have written about the early modern diagram, such as Lefèvre[16] and others,[17] provides a foundation from which we can better understand the communication methods used in diagrams. These authors have not extended the investigation far enough, but provide a useful starting point for introducing an in-depth evaluation of working, three-dimensional instruments so that both dials and diagrams can be better understood. The approach shared by these authors represents a relatively new research priority in the history of science which moves beyond the

printed or written word in the search of evidence for ideas. Nevertheless, their commitment to printed diagrams has become a limitation, which can be corrected 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 their central argument is accurate 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 insufficient discussion of the ways in which people in the period believed knowledge was acquired through the physical viewing and reading of these various formats. While Edgerton's approach to scientific illustrations[18] has been criticised as teleological by other historians,[19] this does not detract merit from his important assertion, after the philosopher Gadamer,[20] that diagrams can reveal profound truths about the society which produced them.

While it is easily inferred from the work of several historians that they are in agreement with this notion, it is not explicitly stated but it must be if analysis of dials in this instance, and diagrams more generally, in sufficient detail is to take place. Indeed, historians such as Hall,[21] Dolza,[22] Lüthy[23] and Franklin[24] find potential in diagrams through their inherent codification and conventions. From this, it can be inferred that these authors acknowledge the need for the reader to possess prior knowledge of the language of the diagram, but this is most accurately described as 'diagram literacy'. Yet, although it remains important to identify these codes and conventions and is something undertaken in this chapter 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 gap 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 level of detail can a deeper understanding of communication methods be achieved and judgements of effectiveness made.

The main focus of this chapter is the multi-function dial made and used up until the mid-late seventeenth century (see Figs. 1.1, 2.2, 2.5 and 5.1). From the late-seventeenth century, the number of format components such as concentric rings and subsidiary dials went into decline. Yet, the two concentric rings and single subsidiary dial of the standard

format which emerged by 1770 (see Fig. 1.2) were a product of the conventions established during the era of the multi-function dial and the first phase of its decline. Contrast and the circular method were the two core components of dial legibility and will be considered in turn.

2.2.1 Visual Contrast

Contrast was and still is 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 dials as it was 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 fully white backgrounds until the first decades of the eighteenth century. The challenge with metallic dials was to provide a sufficiently light background with adequately dark engraved numerals and characters to create sufficient contrast for the engraving to be immediately legible.

From the mid-sixteenth century, dial backgrounds were brass and either gold- or silver-gilded (see Figs. 1.1 and 2.2) until the white dials of the eighteenth century (see Fig. 1.2). These metallic surfaces provided a light-reflecting background that was ideal for the low-level lighting that was part of the early modern domestic setting. This assisted legibility by giving the appearance of a lighter background than there was in reality, and inscriptions were filled with dark wax,[25] which provided a similar effect as dark print on light-coloured paper. On some multi-function dials, several indices were differentiated by their background colour, such as using silver for the lunar index ring on a gilded dial (see Fig. 1.1). This practice is indicative of a hierarchy of knowledge, discussed in detail below. Furthermore, gold and silver had a symbolic role indicative of the celestial and terrestrial structure created by God. Henry informs us that in God's hierarchy, which appeared in various published works, silver was the second metal after gold and corresponded to the Moon and queens. Gold corresponded to the Sun, kings and princes.[26] This made the different coloured rings on multi-function dials ideal in the period for contemplating God's hierarchy.

One of the few historians of horology to comment on colour contrast is Betts who helpfully informs us that the original purpose of the

silver-coloured dial was to enable it to be read and that as more silvering appeared, with the addition of blued steel hands, dials became even easier to read.[27] Betts does not elaborate on this point, but his statement that silvering enabled legibility is certainly correct. In fact, all dials in the period, whether they were the earlier metallic type or the later white-enamelled type, provided the necessary contrast for legibility within the context in which the timepieces were used. White enamel dials were not necessarily easier to read than the earlier metallic dials.

McKenzie[28] and Hunter[29] both provide a scientific insight into 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. They may not have realised the reasons why it was effective, but they recognised that it worked.

McKenzie informs us that colour should be understood in terms of its hue, saturation and luminosity.[30] 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 book. In terms of luminosity, if used in candlelight or firelight, then the metallic surfaces could create a greater intensity of reflected light for 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 within the context of 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 must be noted that there are some surviving examples of dials with red wax instead of black from the mid-seventeenth century to the early-eighteenth century, but these were the minority.[31] 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 very dim lighting red and purple along with violet and black is

nearly indistinguishable.[32] This is an extreme example, but demonstrates that some colour combinations worked better than others in the context of different lighting conditions.

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,[33] 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 1. As Hunter points out, similarly to McKenzie, there is more going on with our perceptions of objects due to light than we realise. He informs us of the six attributes that 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.[34] 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 period under investigation, users would be viewing their dials in daylight and by fire and candlelight in the evenings.[35] 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 candlelight and then accidentally putting the candle out.[36] 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 John Clayton reported his experiments with coal gas for lighting to the Royal Society.[37] 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, as discussed

in Chapter 4, 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 plain white backgrounds, which rose to popularity just a few years earlier in the first decades of the eighteenth century, were easier to read than in the low lighting of candlelight. This is one reason why the white enamel dial generally superseded the metallic dial, with only some exceptions,[38] during the eighteenth century.

At the most fundamental level, the dial mirrored the book in the way that it was presented to the user as a medium designed to be read. These were undoubtedly aesthetically pleasing objects, as emphasised by many historians,[39] 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

As noted earlier, the components of the mid-sixteenth-century to the mid-late seventeenth-century multi-function dial must 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, archival references to the ways in which makers engaged the eye are 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 within the context of knowledge acquisition in the early modern period, refer to the eye and the process of 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[40] helpfully provides 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 one of the few historians to describe the way in which the viewer is intended to follow round the parts of the diagram and then

infer meaning from it.[41] His 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 raises a further question about the intended sequence of reading and thus the hierarchy of information presented. 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 it is significant.

For writers such as Lefèvre,[42] it is sufficient to distinguish diagrams from technical plans and then move on. Lüthy,[43] Franklin[44] and Maclean[45] define different types of diagram on the basis of shape or arrangement of information, for example circular or square arrangements. Following the example of these four authors enables the identification of similarities between printed diagrams and dials such as arrangement of information, numeral type, words, symbols, colour contrast, method of indication and motion. Yet, this method is not sufficient for the purposes of this book because 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 representing contrary relationships between terms, their limited deconstruction of diagram format means that they then move on to other issues. However, there is more to say.

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 from which the user acquired 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…",[46] 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 with respect to the human body was significant in this period. Banister also alluded to the importance of creating a visual pathway for the eye when he referred 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 informs us that book frontispieces were intended to be used to acquaint oneself with the contents of the work before reading it,[47] but 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. The dial shown in Fig. 2.2, for example, which was made by Nicolas Forfaict in Paris, provides a lunar and calendrical overview of the day in question. The indication seen in the figure shows the thirteenth day of the month, the sixteenth day of the lunar calendar, a waning face of the Moon, an aspect position between opposition and sextile, and the changing hours.

Despite the mechanical necessity for the circular method, produced by a movement with turning gear wheels and pinions, this arrangement of information was drawn from a genre of diagrams in print and paper instruments (or volvelles). These diagrams represented temporal information, schematic representations of the universe (see Fig. 2.1) which were found in examples such as Robert Recorde's *Castle of Knowledge*,[48] Petrus Apianus' *Cosmographia*,[49] Johannes Honterus' *Rudimenta Cosmographica*[50] and mnemonic diagrams (see Fig. 2.3). Figures 2.1, 2.2 and 2.3 demonstrate the influence of print on dials from the mid-sixteenth century 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.[51]

Historians agree that the mnemonic genre was widespread in the sixteenth century and early-seventeenth century.[52] The multi-function dial was at the height of popularity in this period. It is significant that notable contributors to the mnemonic art such as Ramon Lull[53] and Giordano Bruno[54] utilised the circular method. Given the aim was to provide readers with a method for retaining information in the memory, the circular arrangement 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 acquire total knowledge in the period.[55] Yet, it was not only achieved in paper form. Clock and watch dials were designed using similar formats (see Fig. 2.2) and were a part of this mnemonic tradition.

Fig. 2.1 *Cosmographia* by Petrus Apianus, 1550 (©The British Library Board (C_114_e_2_(2)_plate_scheme_praemissa))

Fig. 2.2 Pocket watch by Nicolas Forfaict, Paris, 1580–1610. Object no. 17.190.1607 (Photograph courtesy of the Metropolitan Museum of Art. Gift of J. Pierpont Morgan, 1917)

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, not just those between the sixteenth century and mid-late seventeenth century, 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.

Fig. 2.3 *Ars Brevis Illuminati* by Ramon Lull, 1514 (©The British Library Board (719_e_27_(1)_faviiir))

2.3 Knowledge Hierarchy

Decisions made by clock- and watch-makers to layer information on the dial equated to decisions made to order knowledge and thus create hierarchies. This was achieved in several ways throughout the period, including concentric rings, subsidiary dials and apertures, and typeface. While layering was by no means new nor was it limited to one area of knowledge, it was an essential part of the art of memory in the sixteenth century and early-seventeenth century. It was used by compilers of genealogy, by Nicolaus Copernicus to convey his new ideas about the solar system and by writers of mnemonic works—all of whom used layering to improve the reader's experience by aiding the memory. 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 because their indications were self-moving. Combinations of information on multi-function dials enabled users in this period to order knowledge according to the hierarchies provided by the dial's indices of numerals and symbols. Users first had to associate facts and concepts with indications on the dial and were then able to contemplate them in an ordered manner. Taking the example of the watch in Fig. 2.5 (which was made by James Nellson in London), a user had two subsidiary dials, one of which contained four concentric rings and four apertures that could be used as a ready-made combination of numerals, symbols and words to which memorable information could be assigned and then recalled using the dial as a prompt.

Unlike paper volvelles, users could not manipulate the indications on the dial whenever the need arose; instead, they had to mentally 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 and how to relate them to each other. An obvious source of inspiration for makers was the printed works they and their readers were familiar with. Works on the art of memory from the sixteenth century to the early-seventeenth century, such as Bruno's *Umbris Idearum*,[56] provided advice to readers on how to order information. During the mid-late seventeenth century, advice concerning categorisation came instead from the movement to create encyclopedias of knowledge and universal languages. The reason for categorisation had changed, but the process at its most basic level had not.

Many of the authors who utilised the circular method, especially in the sixteenth and seventeenth centuries, were mathematicians, astronomers and astrologers. As Dear[57] and Clark[58] remind us, people in the sixteenth century and early-seventeenth century did not distinguish between these different occupations (as we might call them); they were all part of the natural tradition. The early-seventeenth-century proponents of which were seeking to distance themselves from spiritual mmagicagic. Dials were very much part of the outward expression of this separation. Clock- and watch-makers from the mid-sixteenth century to the early-seventeenth century drew on these branches for inspiration regarding format and content,[59] but not the spiritual branch. Henry[60] and Eamon[61] agree that it was through mathematics that machines were perceived to be part of the magical tradition known as 'mathematical magic' in this period. Indeed, mathematics, and specifically mathematical hierarchy, was well represented on the dial.

Alongside numerical indices, geometrical shapes were an important component of sixteenth-century and early-seventeenth-century dials. The most obvious were the overall circular shape of the dial perimeter, the subsidiary dials and concentric rings. Many dials from the mid-sixteenth century 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 Figs. 1.1 and 2.2). These indicated the position of the Moon in relation to the Sun, expressed in terms of opposition, trine, quartile and sextile.[62] Each aspect was meaningful in terms of astrology. These aspects were cited in sixteenth-century and early-seventeenth-century almanacs (see Fig. 6.3), 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. Beltramini and Gasparotto[63] inform us that the platonic solids featured in artworks, indicative of their symbolic significance, but this can be expanded by emphasising that they also featured on dials of the period. It could be imagined that the wealthy owner of a painting[64] 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.

Historians of mathematics and its application in the period, such as Merzbach and Boyer[65] and Bennett,[66] emphasise the increased demand for Euclid's *Elements*[67] in the vernacular after the invention of printing. While dials and diagrams were beyond their scope, the renewed and

increased interest of which they wrote influenced both media. Building on Barrow-Green's emphasis on the 'groundplat' in John Dee's preface to Henry Billingsley's edition of Euclid's *Elements*,[68] both Dee and clock- and watch-makers drew on the tradition of the tree diagram as a method that had been perceived for centuries to be effective for ordering knowledge.

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* was about the interrelations between spatial parts, not just a catalogue of shapes, is a useful foundation for considering diagrams and dials.[69] 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 the index on each ring displayed a different temporal unit, the relationship between each ring represented an overall concept of time and the consequent manner in which time was divided. How a society or group of people divide time depends on the way in which they use it. The dial shown in Fig. 2.2, for example, represents the hours, the lunar calendar, the lunar aspects and the civil calendar as its components of an overall concept of time. Where some rings also included astronomical information, such as that in Fig. 1.1, the relationship between them represented the concept of our place in the hierarchy of the Great Chain of Being[70] along similar lines to the schematic representations of the universe, such as that shown in Fig. 2.1 which was made by Apianus. Apianus' astronomical diagrams, though not unusual in terms of format, have been remembered as being some of the most visually striking.

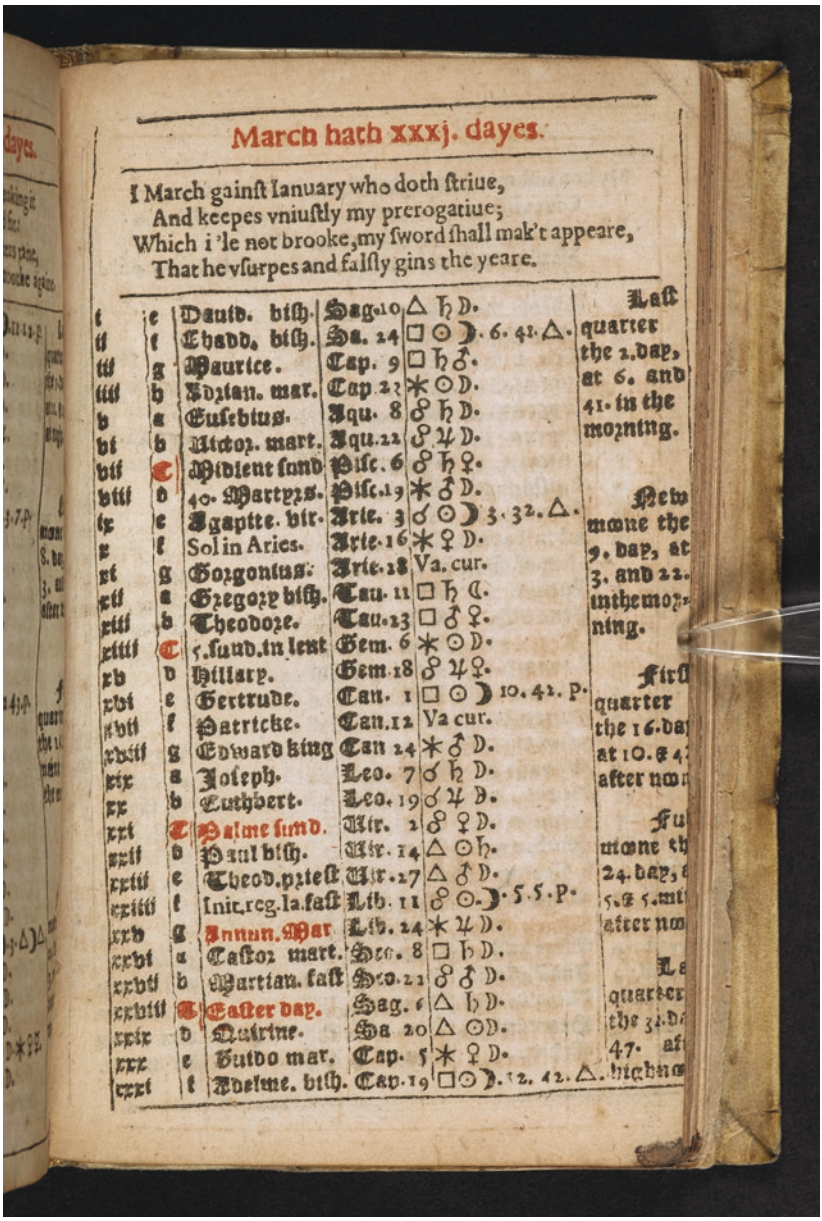
Thus, to create hierarchies of information on dials in the late-sixteenth and early-seventeenth centuries, makers used concentric rings to represent different indices and thus provide different functions on the dial. This was a format which survived the arrival of the pendulum in 1657, with its introduction of the minute index, and became part of the standard format that emerged by 1770. At a basic level, there might be two concentric rings. However, from the mid-sixteenth century 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 (see Figs. 1.1 and 2.2). The equivalent response in printed diagrams was colour contrast. Almanac writers and publishers often used red ink instead of black to distinguish full Moons from new

Moons. Kusukawa informs us that variation in text colour was significant in that it was used as a differentiation or signalling technique in law books, almanacs and liturgical works,[71] but it was equally significant on dials, and there was a parallel between the two media. Coloured Moons in almanacs and the changing lunar phase on dials were 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 example is further evidence 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, in the sense that circular movement was mandatory, makers utilised combinations of subsidiary dials and apertures as comparable methods to achieve the kinds of results that printers created with tables or tree diagrams (see Fig. 2.5). Bruno's mnemonic works, for example, utilised a range of different diagrammatic communication methods, one of which was the use of smaller parts within an overall shape.[72] The composition of the page in emblem books involved the placement of a title at the top, an image in the main position, along with an epigram positioned either around the sides or below the image. Similarly, almanacs throughout the period utilised tables as a method for presenting calendrical, lunar and astronomical information. Layers were represented using multiple columns (see Fig. 2.4). Again, it is clear that there was a mutual consideration of legibility and ease of comprehension and a mnemonic and astrological intention written into dial formats.

Of the authors who have commented on diagrams, Lüthy[73] and Dolza[74] have not considered formats in sufficient detail to be able to describe the layers of information they provide. One of the few authors to have come close is Franklin who has remarked on the complexity of Lullian wheel diagrams as representing parallels between the seven Beatitudes and gifts of the Holy Spirit,[75] but he does not expand the point and moves on to describing other types of diagram. Similarly, Maclean defines different types of diagram, but his chronological approach which has led him to say that 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.[76] Yet, dials are better understood by considering the more complex issue of formats that vary according to their



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.

i	e	Dauid. biſh.	Sag.10	△ ♄ ☽.	Laſt
ii	f	Chadd. biſh.	Sa. 24	□ ☉ ☽. 6. 41. △.	quarter
iii	g	Maurice.	Cap. 9	□ ♄ ♂.	the 2. day,
iiii	b	Adrian. mar.	Cap. 27	✶ ☉ ☽.	at 6. and
v	a	Euſebius.	Aqu. 8	♂ ♄ ☽.	41. in the
vi	b	Victor. mart.	Aqu. 22	♂ ♃ ☽.	morning.
vii	c	Violent ſond	Piſc. 6	♂ ♄ ♀.	
viii	d	40. Martyrs.	Piſc. 19	✶ ♂ ☽.	
ix	e	Agapite. bir.	Arie. 3	♂ ☉ ☽. 3. 32. △.	New
x	f	Sol in Aries.	Arie. 16	✶ ♀ ☽.	moone the
xi	g	Gorgonius.	Arie. 28	Va. cur.	9. day, at
xii	a	Gregory biſh.	Tau. 11	□ ♄ ☾.	3. and 22.
xiii	b	Theodore.	Tau. 23	□ ♂ ♀.	in the morn-
xiiii	c	5. ſund. in lent	Gem. 6	✶ ☉ ☽.	ning.
xv	d	Hillary.	Gem. 18	♂ ♃ ♀.	
xvi	e	Gertrude.	Can. 1	□ ☉ ☽. 10. 42. p.	Firſt
xvii	f	Patricke.	Can. 12	Va cur.	quarter
xviii	g	Edward king	Can 24	✶ ♂ ☽.	the 16. day
xix	a	Joſeph.	Leo. 7	♂ ♄ ☽.	at 10. & 4.
xx	b	Cuthbert.	Leo. 19	♂ ♃ ☽.	after noon
xxi	c	Palme ſund.	Vir. 2	♂ ♀ ☽.	
xxii	d	Paul biſh.	Vir. 14	△ ☉ ♄.	Full
xxiii	e	Theod. priеſt	Vir. 27	△ ♂ ☽.	moone the
xxiiii	f	Init. reg. la. faſt	Lib. 11	♂ ☉. ☽. 5. 5. p.	24. day, at
xxv	g	Annun. Mar	Lib. 24	✶ ♃ ☽.	5. & 5. mi-
xxvi	a	Caſtor mart.	Sco. 8	□ ♄ ☽.	after noon
xxvii	b	Martian. faſt	Sco. 21	♂ ♂ ☽.	
xxviii	c	Eaſter day.	Sag. 6	△ ♄ ☽.	Laſt
xxix	d	Quirine.	Sa 20	△ ☉ ☽.	quarter
xxx	e	Guido mar.	Cap. 5	✶ ♀ ☽.	the 31. day
xxxi	f	Balme. biſh.	Cap. 19	□ ☉ ☽. 12. 42. △.	47. af-
					highing

Fig. 2.4 *An Almanacke and Prognostication* by George Hawkins, 1624 (©The British Library Board (C_28_a_3_(14)_march_xxxi))

Fig. 2.5 Pocket watch by James Nellson, London, c.1638–1645. Object no. WCC.36 (Photograph courtesy of the Worshipful Company of Clockmakers and Tony Gray)

context of use, the different layers of information represented on them and equivalent methods for 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, usually with examples of between two and four subsidiary dials and 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, demonstrating the legacy of the original subsidiary dial.

Whereas Lüthy and Smets[77] refer to the fluid boundary between image and text in the period and claim the tree diagram is an example of text becoming image, there was also a fluid boundary between diagrams in books, pamphlets 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, parallels can be drawn between tree diagrams and dials. If tree diagrams such as those of Robert Fludd[78] (see Fig. 2.6) represented ever smaller or more distinct units of information as the viewer reads along the branches, then similarly dials with subsidiary dials also represent ever smaller temporal units. This apparent similarity in format, 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 with the tree diagram, the larger dial, or the largest of the set of subsidiary dials or apertures, is the dial 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. Taking the example of the dial in Fig. 2.5, the civil calendar of days 1–30/31 is the equivalent of the top-left position of the tree diagram, in this case a temporal tree diagram. Successive temporal units can then be followed on the dial until the user reaches the hours and the quarters, an example indication might be the 24th of March, in the zodiac sign of Aries, which was a Saturday, the night of the new Moon, the 29th day of the lunar month, and the time ten hours and one-quarter.

The publication of works such as Petrus Ramus' *Compendium of the Art of Logic and Rhetoric*[79] confirms the importance of knowing how to

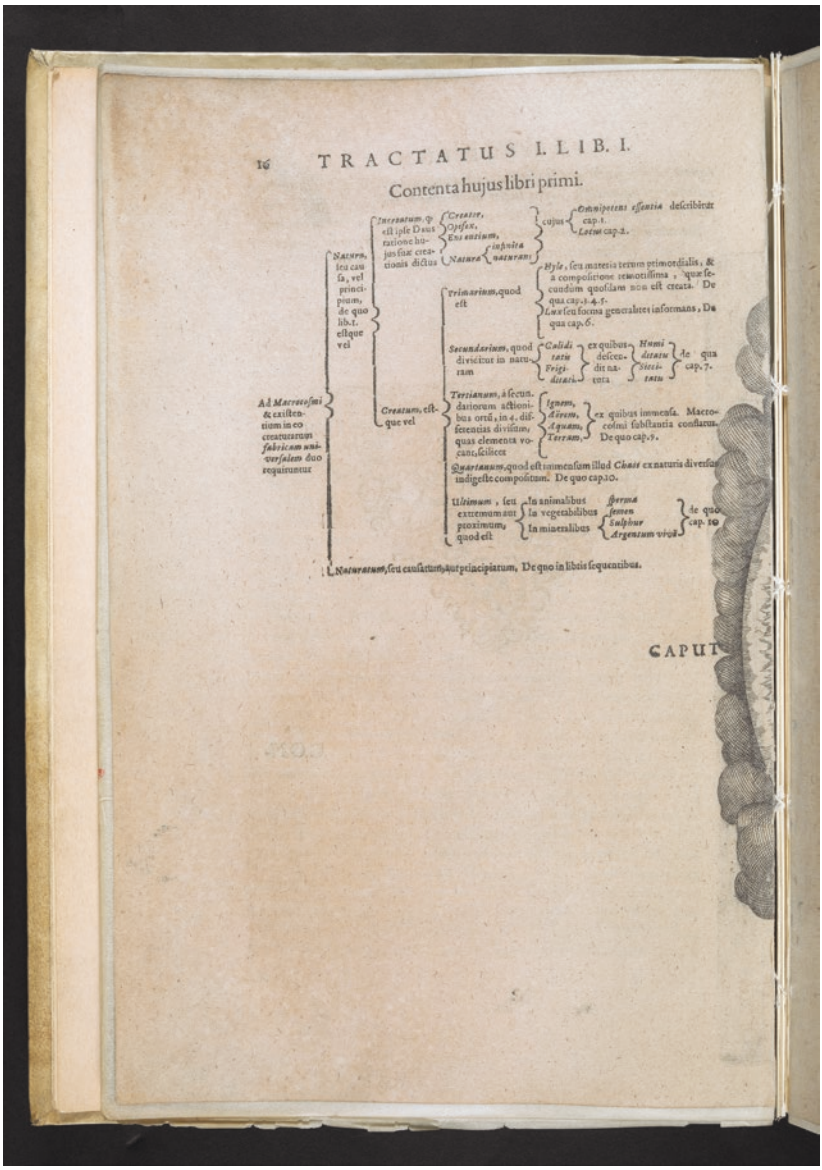


Fig. 2.6 *Utriusque Cosmi* by Robert Fludd, 1617 (©The British Library Board (30_g_9_p016))

order and divide information in the early modern period. Located within the genre of the instruction book and drawing on the long-standing tradition of categorisation using a hierarchical structure, it provided the reader with the categorisation process required to create 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[80] to the world beyond text using the example of subsidiary dials and apertures. While Rossi helpfully informs us that during the mid-late seventeenth century, these techniques were applied to the pursuit of *pansophia* and the creation of an encyclopaedia of knowledge,[81] 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 some of these meanings before they went into decline during the mid-late seventeenth century. The user of the dial in Fig. 2.5, for example, had in the palm of their hand an indication of calendrical, lunar and zodiac information and the hours, which in one sense was a representation of the temporal sequences created by God for people in this period.

By the eighteenth century, clock- and watch-makers were dedicated to making dials as simple as possible. Alexander Cumming, in an unpublished manuscript entitled *Remarks on a Clock*, criticised an astronomical clock[82] for an overly complex dial, saying that it would have been: "… equally complete…", 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".[83] Cumming's views on dial formats were clear: they should not be cluttered, but nor should information be removed.

Texts and dials conveyed ordered knowledge throughout the period using different-sized letters and numerals. While Carter et al. cite the importance of the proportions of individual letters in today's typography,[84] this sentiment can also be applied to the period under discussion here. This means that using varying typefaces for each index on a dial, for example, would provide immediate contrast and thus aid legibility. In text, different sizes of lettering 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 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 1550–1770, 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 that 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 from the late-seventeenth century onwards. This is indicative of the gradual decline of the dial as a communicator of knowledge that was 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 those dials throughout the period that 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[85] for clocks and 1675[86] for watches, the hour 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 the hour numeral to demonstrate that it was intended to be 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’,[87] which according to Cole was a further example of revival in the period.[88] This view provides a useful foundation for achieving a better understanding of dials. 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 were clearly important, but equally significant was the proportional size of the characters on each index of the multi-function dial. They were harmoniously proportioned to reflect information hierarchies, and this became a consideration that survived the decline of this notation.

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 name of the child for whom the horoscope was being created.[89] 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 the example seen in Albrecht Durer's *Melancolia*[90] represented the perceived relationship between Arabic numerals, the notation of choice for mathematical texts, when arranged in an order where the sum of any row or column is equal to that of any other row or column. 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.

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 do not appear to have been any examples that used Roman numerals. Where they co-existed on dials, Arabic numerals were smaller than Roman numerals throughout the period. Yet, 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 for the hours in the pre-pendulum context were generally

of larger proportion to the Roman numeral used for the hours 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 as the Roman hour numerals. 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 an additional interpretation of the hour numeral, but instead represented 15 minutes past the hour that was indicated by the Roman hour numeral. Makers of this period 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. 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,[91] and Cheney Culpeper,[92] among others, suggested schemes which associated Arabic numerals with concepts. This was their answer to Francis Bacon's earlier call for real characters.[93] 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,[94] 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,[95] but do not say anything else. Yet, 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.

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 which emerged by 1770.

2.4 Knowledge Transmission

Having explored the components of information arrangement on dials, 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 with reference to the ways in which people believed that knowledge was transferred to the mind in the early modern period. Contemporary material that discussed perceptions of the role of sight, relative to the other senses, helps improve our understanding of communication methods used on dials.

It may be obvious to Hall[96] that seeing, or 'seeing as' according to Coliva's distinction between looking and comprehension,[97] 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. Nevertheless, 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…".[98] Great power is not ascribed to the eyes here, but a distinction is made between different parts of the mind by the identification of an understanding part. If

subscribing to this view, clock- and watch-makers would have intended their formats to transfer temporal information to the understanding part, rather than a quick-reference part, indicative of deeper-level contemplation of information represented on dials. Hall's semi-dismissive remark that 'seeing involves many parts of the brain' is insufficient for further consideration of the reasons why early modern makers made the decisions they did regarding dial and diagram formats.[99] Surphlet's use of the terms 'enter into' and 'pass through' confirms the process by which knowledge was perceived to be acquired.

Hall refers to the modern research on the brain by Zeki,[100] 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 for understanding how the eye functions and reveals the reason 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 were unaware of the science that underpinned their legibility. 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.[101] Motion and colour were the most distinct,[102] 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.[103] Bruno's identification of these four key ingredients for an effective mnemonic image was based on his understanding of how knowledge was transferred to the mind. While of course very different to Zeki's modern understanding, Bruno's work provides further evidence of early modern writers and makers arriving at effective communication methods that can still be viewed as such today, but explained differently.

For Clark,[104] Dolza[105] and Akbari,[106] contemporary material 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,[107] the viewing of a multi-function dial that represented the celestial realm 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…",[108] he suggested that what is seen feeds directly into the mind and has the capacity to alter it, a power he did not ascribe to the other senses. Though a serious meaning was intended 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 from getting lost en route, he recommended that the reader should perform exercises which would stimulate the senses.[109] 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.[110] 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. By Clark's definition,[111] 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 (such as the ten indices visible on the dial shown in Fig. 2.5), 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.

In 1622, when Richard Banister said that: "…seeing beames come from the eye…",[112] he was writing in the tradition of thirteenth-century thinkers Roger Bacon and Thomas Aquinas who, as Clark informs us,

understood the mechanics of vision according to a theory of species.[113] According to this view, which did not decline until the mid-seventeenth century, objects produced species which radiated out into the surrounding air, physically transmitting likenesses of themselves 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, for example the full Moon on the fifteenth day of the lunar calendar.

Expanding both Clark[114] and Franklin's[115] 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.[116] Although expressed in a different order, this agreed with Francis Bacon's emphasis on sense, memory, imagination and reason. For others such as Pico della 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. It is conceivable that concentric rings and subsidiary dials, as a device for layering information, were also the form in which it was thought that knowledge was arranged in the imagination before being retained in the long-term memory.

2.4.1 Indication

The way in which information was indicated to users on dials and diagrams 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 more effective method by which to transmit that knowledge to the mind. The user did not need to find the information as the indication was made for them. The more indices were present on multi-function dials such as Fig. 1.1, the more important it was to find

a way of indicating values on those indices without confusing the user. Similarly, the task was not something that could be taken for granted once the range of indices was reduced. As a users' needs for more accurate timekeeping increased after the introduction of the pendulum in 1657 and the balance spring in 1675, the need to be able to precisely pinpoint values continued to be important, but now this related to the minute and seconds indices of dials such as that shown in Fig. 1.2.

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'.[117] Use of a hand, or pointer, was a convention established by the first mechanical clocks to be fitted with dials in the late medieval period[118] 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.[119] While circular motion was predetermined by the gearing, the direction of that motion was not. Most dials in the period indicated information using clockwise motion. However, there were examples of anticlockwise indication, which existed on particular rings within a dial with concentric rings or on timepieces which had a front and rear dial.[120] In both cases, particularly the former, the choice of which type of information was to be indicated in an anticlockwise direction was significant. It was rarely the hours[121] and was usually calendrical information. Clocks and watches were not alone. Apianus' *Cosmographia*[122] provided a printed example of a circular calendrical diagram, with no moving parts, where the index progresses in an anticlockwise 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,[123] human hands were perceived as mediators between the heavens and the Earth in the early modern period, and this provides a useful way to think about dial indicators. 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.[124] In works of art, figures depicted with an extended index finger, usually the right, to point to something were usually indicating divine truth. Index fingers in art were also sometimes used to represent seeing or telling.[125] In Richard Sanders' *Chiromancie* of 1653, he associated the index finger with the planet Jupiter and said it was the indicative or demonstrative finger.[126] 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 to highlight parts the author wished to draw attention to. In the context of timepieces, 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 indicates a combination of information. While texts and artworks no longer represented 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 rendered the combinations of information and the associated combinations of hands and pointers that made the indications no longer significant in the same way. In the late-seventeenth and eighteenth centuries, it was the shape of the indicator, or hand, that became more important. A hand with a pointed tip that could clearly distinguish between one minute and another on the index was increasingly important to users.

2.4.2 Symbol Recognition

Almanacs, volvelles, frontispieces and mnemonic works including emblem books utilised symbols and pictures to convey meaning, both individually and in combination. They were part of a wider European language of symbolism, recognisable to the book-buying public of the sixteenth and seventeenth centuries, which included makers themselves. Clock- and watch-makers drew on this tradition for their representation of symbols and in their turn influenced writers of emblem books and mnemonic works. Dials thus represent a symbolic and pictorial language that was shared with printed paper sources. The symbols and images that formed the words and concepts in this language played an important role in perceptions of knowledge transmission up until the mid-late

seventeenth century, when emblem books and the majority of the symbols on multi-function clock and watch dials had declined.

The words and concepts that dials and printed paper sources shared in symbol form were the Sun, Moon, stars and the zodiac. Some multi-function dials provided layers of symbolic representation. The lunar phase, represented pictorially on dials such as that shown in Fig. 2.2, almanacs and in mnemonic works including emblem books, 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.[127] In the period up until the early-mid-seventeenth century, it shared a use with mnemonic works. In his mnemonic work, Bruno provided seven images of the Moon and images of the twenty-eight mansions of the Moon,[128] and in emblem books such as those of George Wither, there were images of the changing Moon with a message about renewal.[129] 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. The life-like representation of the Moon, which may have begun life as an attempt to convey similitude, survived beyond the decline of that perception. The reasons for which will be discussed in detail in Chapter 6, but the important point here is the legacy of the belief in similitudes.

Some multi-function dials, such as that shown in Fig. 1.1, represented the Sun, Moon, lunar aspects and the zodiac in their indices and pointers, which would enable a user to utilise the mnemonic potential associated with these images. Mnemonic works such as those of Bruno[130] and emblem books such as those of Geffrey Whitney,[131] Thomas Combe[132] and Francis Quarles[133] include all of these emblems and accompany them with short narratives in epigram form to give inspiration to the user. Quarles and others believed that God made Himself known through objects such as animals and plants, which gave symbolic meaning to them and suggested that one could get closer to Him by improving their knowledge of symbols.[134] In this context, it could easily be imagined that a user who was familiar with mnemonic works and books of emblems would enjoy making use of a multi-function dial that offered some of the same symbols. In combination, these characters were at their most meaningful and made the dial a symbol itself. These picture groupings provided a pictorial overview of a specific point in time, which in the case of Fig. 1.1 is a lunar one with astronomical, and thus astrological, associations.[135] These groupings were conceivably intended to efficiently

transfer this temporal and astrological knowledge to the mind, which would help users to get closer to God.

Representation of duration, or the passing of time on either a large or small scale, though not new in this period, continued to feature in works of literature (especially in journeys), mnemonic works (including emblem books) and almanacs. Devices used to measure time were clearly connected to these representations, given that they often appeared in works of art designed as *memento mori*.[136] Works such as those of Wither and others were intended to serve a similar purpose when they represented the passing of time with an image of Father Time along with either a sandglass or armillary sphere.[137] Accompanying epigrams helped to secure the image in the memory. Quarles assigned the following verse to his image of Father Time: "If fortune hale, or envious Time but spurn, The world turns round; and the world we turn; When fortune sees, and Lynx-ey'd time is blind, I'll trust thy joys, O'world; till then, the wind".[138] Associating duration with the endless turning of the Earth and the limited nature of human happiness was a common and clever device that surely triggered an emotional response in readers. We can all appreciate the relative shortness of life and differentiate between things that should be priorities for us and those that are unimportant. The moral message relevant to this period was not to throw caution to the wind and enjoy oneself, but to contemplate one's religious teachings and try to live a purer life. In works of literature such as Samuel Johnson's *Rasselas* or Jonathan Swift's *Gulliver's Travels*, duration was represented by a journey from one place to another.

Clocks and sundials began to be used as symbols themselves from the very early-seventeenth century. Rossi informs us that within the mnemonic tradition images of certain material objects came to acquire widely understood meanings such as the balance for justice (though not new in this period) and the astrolabe for astrology.[139] Yet, if the astrolabe had this association, then the multi-function dial must have had also. Indeed, it is significant that Giordano Bruno,[140] Johannes Romberch[141] and Robert Fludd[142] each used an image of a clock in their mnemonic works (see Fig. 2.7) and the emblem book writers Thomas Combe,[143] Francis Quarles[144] and John Hall[145] each featured sundials or clocks, which were usually of the wall-hung or upright table variety suggestive of domestic use, in their emblem catalogues. While Yates said that practitioners of the art of memory searched for signs and symbols to use in the art, this warrants expansion in order to pinpoint which bodies

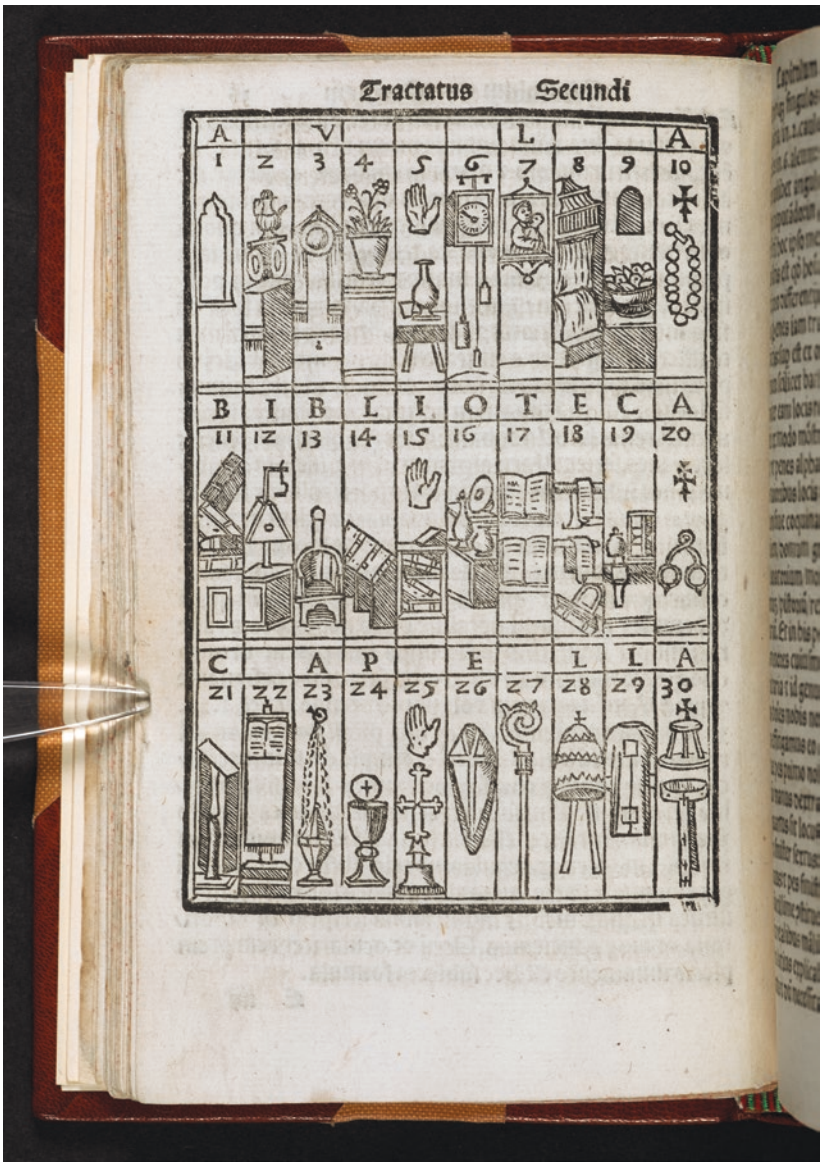


Fig. 2.7 *Congestorium Artificiose Memorie* by Johannes Romberch, 1533 (©The British Library Board (1030_a_3_plate_opp_p037))

of knowledge authors drew upon.[146] One was clearly religion, another was astrology, and a further was the world of material culture, which included clocks. Indeed, Freeman correctly pointed out that seventeenth-century writers of emblem books drew on new material for their lists of emblems.[147] Timepieces were beginning to be acquired by more, and more people in the seventeenth century and their entry, which even included epigrams about watch-makers themselves,[148] into emblem books and mnemonic works are a testament to their significance within that context.

Individually and in combination, these examples of symbol use indicate the wide extent of symbol literacy in the period in which they appeared from the mid-sixteenth to the mid-seventeenth centuries. In fact, their presence on dials demonstrates the influence of the wider culture of communication on clock- and watch-makers.

2.5 Conclusion

Through the epigraph, it was shown that users of clocks and watches at both the beginning and end of the period 1550–1770 were in agreement that dials were a 'telling' device. The context in which the two authors 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 Duncan's world it was unimaginable that a dial could interpret information for a user, they did that part themselves. In this chapter, it has been shown that dial formats were methods of communication that were selected by clock- and watch-makers through which information was presented, layered and indicated. Dial formats were therefore highly significant. Returning to the overarching narrative of dial development from the multi-function dial of the mid-late sixteenth century to the standard format dial that emerged by 1770, this chapter has revealed three facets that improve our understanding of that complex journey.

Firstly, this chapter has shown that there was certainly a fluid boundary between dials and printed paper sources. The circular method of arranging information was shown to be similar to schematic representations of the universe and mnemonic diagrams. The early-seventeenth-century use of subsidiary dials, part of which became a component of the design of the standard format by 1770, was closely linked to the tree diagrams

which were popular in mnemonic works of the period. In some instances, a component that began as a mirror of text became a convention of dials, such as the subsidiary dial of the early-seventeenth century that became a key part of the standard format by 1770 and the representation of the Roman numeral IIII, which became a convention unique to dials by the mid-seventeenth century. 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. Clocks began to be used as symbols themselves in books of emblems, demonstrating the way in which each media influenced the other.

Secondly and related to the above, dials were in one sense a mirror of perceptions of knowledge transmission. We have seen that the way in which information was arranged on dials and the very fluid boundary between them and text was intended to aid that transfer. The standard format's concentric rings and single subsidiary dial were a legacy of a much different perception of knowledge transfer in the earlier period. Concentric rings, subsidiary dials and proportional sizes of Roman and Arabic 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. Makers designed dials according to the sixteenth-century 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. A sharp contrast between the landscape and the inscribed characters provided the backboard onto which the pathway for the eye was carved, which was achieved through a process of trial and error. The background colour of dials only changed with improvements that were made to domestic lighting technology.

Thirdly, the practices of astrology and the art of memory clearly influenced dial layouts and dials also influenced contemporary mnemonic material. Similarities in format between dials and almanacs demonstrate that dials were a mechanised version of the almanac and the mnemonic diagram. 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. 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 astrology, books of symbols and the art of memory.

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-century 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.

Notes

1. Robert Greene, *Ciceronis Amor* (London, 1589).
2. William Duncan, *The Elements of Logick* (London, 1770).
3. Paolo Rossi, *Logic and the Art of Memory: The Quest for a Universal Language* (London: Athlone Press, 2000).
4. Frances Amelia Yates, *The Art of Memory* (London: Ark Paperbacks, 1966).
5. William Eamon, 'Technology as Magic in the Late Middle Ages and the Renaissance', *Janus*, 70 (1983), p. 172.
6. John Henry, *The Scientific Revolution and the Origins of Modern Science* (Basingstoke: Palgrave Macmillan, 2008), p. 57.
7. Elizabeth L. Eisenstein, *The Printing Revolution in Early Modern Europe* (Cambridge: Cambridge University Press, 1983).
8. Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago: University of Chicago Press, 1998); Robert Darnton, 'What Is the History of Books?', *Daedalus*, 111.3 (1982), pp. 65–83.
9. David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (London: Viking, 2000).
10. David Thompson, *Clocks* (London: British Museum Press, 2004); David Thompson, *Watches* (London: British Museum Press, 2007).
11. Paul Glennie and Nigel J. Thrift, *Shaping the Day: A History of Timekeeping in England and Wales 1300–1800* (Oxford: Oxford University Press, 2009), p. 253.
12. The specific use of the calendar, lunar and astronomical functions on dials is considered in depth in Chapters 5–7.

13. Many clock and watch-makers were very wealthy. They were a literate and numerate group of people and must have had their own libraries or access to publications.
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15. Eisenstein, p. 64.
16. Wolfgang Lefèvre, Jürgen Renn, and Urs Schoepflin, eds., *The Power of Images in Early Modern Science* (Basel and Boston: Birkhäuser, 2003).
17. Sachiko Kusukawa and Ian Maclean, eds., *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe* (Oxford: Oxford University Press, 2006); Guy Freeland and Anthony Corones, eds., *1543 and All That: Images and Word, Change and Continuity in the Proto-Scientific Revolution* (London: Kluwer Academic, 2000); and Martin Kemp, *Visualizations: The Nature Book of Art and Science* (Oxford: Oxford University Press, 2000).
18. S. Y. Edgerton, 'The Renaissance Development of the Scientific Illustration', in *Science and the Arts in the Renaissance*, ed. by John William Shirley and David F. Hoeniger (Washington, DC: Folger Books, 1985), pp. 168–197.
19. M. S. Mahoney, 'Drawing Mechanics', in *Picturing Machines 1400–1700*, ed. by Wolfgang Lefèvre (Cambridge, MA: MIT Press, 2004), p. 305.
20. Hans-Georg Gadamer, *Truth and Method*, 2nd ed. (London: Continuum, 2004).
21. Bert S. Hall, 'The Didactic and the Elegant', in *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science*, ed. by Brian S. Baigrie (London: University of Toronto Press, 1996), p. 10.
22. Luisa M. Dolza, 'Reframing the Language of Inventions: The First Theatre of Machines', in *The Power of Images in Early Modern Science*, ed. by Wolfgang Lefèvre, Jürgen Renn, and Urs Schoepflin (Basel and Boston: Birkhäuser, 2003), p. 98.
23. Christoph Luthy, 'The Invention of Atomist Iconography', in *The Power of Images in Early Modern Science*, ed. by Jürgen Renn, Wolfgang Lefèvre, and Urs Schoepflin (Basel and Boston: Birkhäuser, 2003), p. 117.
24. James Franklin, 'Diagrammatic Reasoning and Modelling in the Imagination: The Secret Weapons of the Scientific Revolution', in *1543 and All That: Images and Word, Change and Continuity in the Proto-Scientific Revolution*, ed. by Guy Freeland and Anthony Corones (London: Kluwer Academic, 2000), pp. 53–97.
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27. Jonathan Betts, *The National Trust Pocket Guide to Clocks* (London: Octopus Books, 1985), p. 36.
28. Arthur Edward Ellard McKenzie, *A Second Course of Light* (Cambridge: University Press, 1965).
29. Richard Sewall Hunter, *The Measurement of Appearance* (Washington: Hunter Associates Lab, 1973).
30. McKenzie, p. 190.
31. For example British Museum object number 1862,0801.1. It is unknown whether or not the coloured wax is original to the seventeenth century.
32. McKenzie, p. 193.
33. Hunter, p. 3.
34. Ibid., p. 49.
35. The lighting context is discussed in greater detail in Chapter 4.
36. William Thomas O'Dea, *Making Fire* (London: Science Museum, 1964), p. 6.
37. William Thomas O'Dea, *Lighting 2: Gas, Mineral Oil, Electricity* (London: H.M.S.O, 1967), p. 3.
38. The exceptions were mostly provincial longcase clocks such as British Museum object numbers 2010,8029.6, 2010,8029.39 and 2010,8029.48.
39. Eric Bruton, *The Longcase Clock* (London: Hart-Davis MacGibbon, 1976); Thompson, *Watches*, pp. 104–119.
40. Stuart Clark, *Vanities of the Eye: Vision in Early Modern European Culture* (Oxford: Oxford University Press, 2007), pp. 10–11.
41. Franklin, 'Diagrammatic Reasoning and Modelling in the Imagination', p. 55.
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48. Robert Recorde, *The Castle of Knowledge* (London: R. Wolfe, 1556).

49. Petrus Apianus, *Cosmographia* (Vaeneunt G. Bontio: Antuerpiæ, 1550).
50. Johannes Honterus, *Rudimenta Cosmographica* (Zurich, 1546).
51. Henry, *Knowledge is Power*, p. 57.
52. Rossi, p. 1.
53. Ramon Lull, *Ars Brevis Illuminati* (London, 1514). Although a thirteenth-century writer, Lull's work enjoyed a revival in the early modern period.
54. Giordano Bruno, *De la Causa, Principio, et Uno* (Venice, 1584).
55. Yates, *The Art of Memory*, p. 369.
56. Scot Gosnell, trans., *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582* (United States: Huginn Muninn & Co., 2013), p. 107.
57. Peter Dear, *Revolutionising the Sciences: European Knowledge and Its Ambitions 1500–1700* (Basingstoke: Palgrave, 2001), pp. 17–18.
58. Stuart Clark, *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe* (Oxford: Clarendon Press, 1997), pp. 214–215; 218.
59. Dial content is discussed in detail in Chapters 5–7.
60. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 58.
61. Eamon, p. 197.
62. Opposition was represented by a straight line, trine by a triangle, quartile by a square and sextile by a hexagon.
63. Guido Beltramini and Davide Gasparotto, *Aldo Manuzio: Renaissance in Venice* (Venice: Marsilio, 2016), p. 28.
64. For example Jacometto Veneziano, *Portrait of Luca Pacioli and Guidubaldo da Montefeltro*, 1495, Museo di Capodimonte, Naples.
65. Uta C. Merzbach and Carl B. Boyer, *A History of Mathematics*, 3rd ed. (Hoboken, NJ: John Wiley, 2011), p. 119.
66. Jim Bennett, 'Instruments and Illustrations in Eighteenth Century Astronomy', in *Science and the Visual Image in the Enlightenment*, ed. by William R. Shea (Canton, MA: Science History Publications, 2000), pp. 137–142.
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69. Franklin, p. 53.
70. Henry, *Knowledge is Power*, p. 57.
71. Sachiko Kusukawa, *Picturing the Book of Nature: Image, Text, and Argument in Sixteenth-Century Human Anatomy and Medical Botany* (Chicago: University of Chicago Press, 2012), p. 69.
72. Giordano Bruno, *De Monade Numero et Figura* (Frankfurt, 1591).
73. Luthy, 'The Invention of Atomist Iconography', pp. 117–128.
74. Dolza, pp. 89–98.

75. Franklin, pp. 58–59.
76. Maclean.
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78. Robert Fludd, *Utriusque Cosmi* (Oppenhemii, 1617).
79. Petrus Ramus, *Compendium of the Art of Logic and Rhetoric* (London, 1651).
80. Maclean, pp. 137–140.
81. Rossi, p. 38.
82. The identity and location of this particular clock are unknown. MS3964, Alexander Cumming, 'A Folio Volume Containing Memoranda, Descriptions, Observations, and Correspondence Relating to Various Matters, Mostly Mechanical', 1766–1812.
83. Ibid.
84. Rob Carter and Sandra Maxa, *Typographic Design: Form and Communication* (Hoboken, NJ: John Wiley, 2007), p. 32.
85. The pendulum was first applied to clocks in 1657 and enabled the representation of minutes rather than quarters.
86. The balance spring was first applied to watches in 1675 and enabled the representation of minutes.
87. Beltramini and Gasparotto, p. 28.
88. Alison Cole, *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, 1994), p. 30.
89. Richard Roussat, *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* (London, 1562).
90. The magic square is situated in the top right-hand corner of the painting.
91. Rossi, pp. 160–161.
92. Rhodri Lewis, *Language, Mind and Nature: Artificial Languages in England from Bacon to Locke* (Cambridge: Cambridge University Press, 2007), pp. 46–47.
93. Ibid., pp. 13–14.
94. Ibid., p. 62.
95. Brian Loomes, *Brass Dial Clocks* (Woodbridge: Antique Collectors' Club, 1998); Granville Hugh Baillie, *Watches: Their History, Decoration and Mechanism* (London: N.A.G. Press, 1929), p. 38.
96. Hall, p. 10.
97. Annalisa Coliva, 'Human Diagrammatic Reasoning and Seeing-As', *Synthese*, 186 (2012), pp. 121–148.

98. Richard Surphlet, *A Discourse of the Preservation of the Sight*, trans. from the French (London, 1599).
99. Hall, p. 10.
100. Semir Zeki, 'The Visual Image in Mind and Brain', *Scientific American* (1992), pp. 69–76.
101. Ibid., pp. 70–71.
102. Ibid.
103. Giordano Bruno, *De la Causa, Principio, et Uno* (Venice, 1584).
104. Clark, *Vanities of the Eye*, p. 9.
105. Dolza, p. 89.
106. Suzanne Conklin Akbari, *Seeing Through the Veil: Optical Theory and Medieval Allegory* (Toronto: University of Toronto Press, 2004), p. 3.
107. Ibid.
108. Richard Brathwaite, *Essaies Upon the Five Senses* (London, 1620).
109. Gosnell, pp. 14–15.
110. Robert de Lucca, and Richard J Blackwell, eds., *Giordano Bruno: Cause, Principle and Unity* (Cambridge: Cambridge University Press, 1998), p. 138.
111. Clark, *Vanities of the Eye*, p. 10.
112. Banister.
113. Clark, *Vanities of the Eye*, p. 15.
114. Ibid., pp. 14–15.
115. Franklin, pp. 86–97.
116. Clark, *Vanities of the Eye*, p. 15.
117. The term *hand* was applied to clock dials in the nineteenth century.
118. The first medieval turret clocks did not have dials and measured time by bells.
119. Wheels and pinions necessitated circular motion. Shaped cams enabled motion in other forms and were used for automata, but not for motion on clock and watch dials.
120. For example British Museum object number 1958,1201.837.
121. The only exception being some extremely rare Jewish timepieces. For more information, see John A Robey, 'A Large European Iron Chamber Clock', *Antiquarian Horology*, 33.3 (2012), pp. 335–346.
122. Apianus.
123. Sachiko Kusukawa, 'A Manual Computer for Reckoning Time', in *Writing on Hands: Memory and Knowledge in Early Modern Europe*, ed. by Peter M. Lukehart (Seattle: University of Washington Press, 2001), p. 28.
124. John Dee used images of the index finger to point to particular passages in his preface to Billingley's edition of Euclid's Elements. Henry Billingsley, *The Elements of Geometrie of Euclide* (London, 1570).

125. Matilde Battistini, *Symbols and Allegories in Art* (Los Angeles: Getty Press, 2005), p. 118.
126. Richard Sanders, *Physiognomie, and Chiromancie, Metoposcopie the Symmetrical Proportions and Signal Moles of the Body* (London, 1653).
127. The representation of the lunar phase and the use of lunar knowledge on dials are considered in depth in Chapter 6.
128. Gosnell, pp. 176–182.
129. George Wither, *A Collection of Emblemes* (London, 1635).
130. Giordano Bruno, *De la Causa, Principio, et Uno* (Venice, 1584).
131. Geffrey Whitney, *A Choice of Emblemes and other Devises* (London, 1586).
132. Thomas Combe, *The Theatre of Fine Devices* (London, 1614).
133. Francis Quarles, *Emblemes* (London, 1635).
134. Rosemary Freeman, *English Emblem Books* (London: Chatto & Windus, 1948), pp. 114–147.
135. The lack of a distinction between astronomy and astrology in the early modern period is discussed in detail in Chapter 7.
136. For example National Gallery object number NG1256, Harmen Steenwyck, Still Life: An Allegory of the Vanities of Human Life, c.1640. Watches in this period were also made in skull-shaped cases as a further symbol such as British Museum object number 1888,1201.199.
137. Wither; Quarles.
138. Quarles.
139. Rossi, p. 27.
140. Gosnell, p. 147.
141. Johannes Romberch, *Congestorium Artificiose Memorie* (Venice, 1533).
142. Fludd.
143. Thomas Combe, *The Theatre of Fine Devices Containing 100 Moral Emblemes* (London, 1614).
144. Quarles.
145. John Hall, *Emblems with Elegant Figures* (London, 1658).
146. Yates.
147. Freeman.
148. John Bunyan, *A Book for Boys and Girls or Divine Emblems* (London, 1686).

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

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 everyday life, for at least the wealthier sections of society. They were, for that very reason, an obvious point of reference for Pope when he decided to make an analogy between an individual's opinions and a material object. 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 any other. Indeed, the as-yet unidentified gentleman portrayed with his pocket watch in the portrait in Fig. 3.1, painted one hundred and fifty years before Pope wrote this line, was making a statement about ownership, deliberately identifying this watch as one of his most significant possessions. Such images have traditionally been interpreted[2] as examples of sitters demonstrating their wealth to others, which this man is undoubtedly doing, but he is also identifying this particular watch as a representation of his personal qualities. Mayr's claim that sixteenth and early-seventeenth-century multi-function clocks were, in a sense,

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_3

Fig. 3.1 *Man Holding a Watch*, attributed to Tommaso Manzuoli, Italy, 1558–1560. Object no. 1976-13 (Photograph courtesy of Science Museum/ Science & Society Picture Library)

representations of the universe in miniature[3] is useful for thinking about perceptions of timepieces. Yet, while he bases his argument on references to clocks and watches in literature, paintings can offer more information by providing a visual expression of these perceptions in addition to the identification of an individual user, or type of user. By holding this watch, the sitter also represents himself as the holder of knowledge.

Sitters of this period also achieved this statement-of-self by choosing to be portrayed with the notebook, or commonplace book, in which they had transcribed significant passages and made notes.[4] These books were accumulations of knowledge, which they believed were an important part of getting closer to God. Multi-function clocks and watches of this period served a similar purpose. The sitter in Fig. 3.1 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. Both Pope's analogy and the painting of the gentleman with a watch demonstrate that trust in one's timepiece continued to play a significant cultural role throughout the period 1550–1770. As previously stated, dial formats both reflected and stimulated changes in the wider context of textual and pictorial communication. 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[5] accuracy or inaccuracy of the timepiece.

The role of trust within the history of science and technology has been explored by Gooday,[6] Porter[7] and Shapin,[8] but it has not yet been fully addressed within the history of horology. Dials are key to drawing this out. Trust has played a significant role in horological developments and clock and watch dials bear signs of the relationship that makers established with their customers. Shapin claims that there is no limit to the considerations that might be relevant to securing credibility.[9] This phrase can also be reversed—there is also no limit to the considerations that might be relevant to losing credibility. Clock and watch-makers worked hard to maintain trust. Both Gooday and Porter question the criteria by which trust judgements were made and the factors which influenced those criteria. Until now, neither historians of horology nor of the social experience of time have had scope to ask these questions of timepieces. Gooday's approach is the most useful starting point for thinking about timepieces, given that he focusses on trust between people and objects whereas Porter's approach is to focus purely on trust between people. In the case of clocks and watches, similarly to the electrical meters which Gooday discusses,[10] 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 is not appropriate for dials.

Given that dials are a form of diagram, as demonstrated in Chapter 2, 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. There were several 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[11] have explored the issue of a writer's authority in texts. They inform us that the author's status improved from the sixteenth century onwards.[12] One reason for this, they say, was the new trend of attaching names to printed works.[13] Due to the reproducibility enabled by the printing press and the increasing distribution networks for texts, authors could quickly become known throughout Europe. There is a clear correlation between clocks, watches and other instruments and texts in terms of this trend for increased 'author authority' given that timepieces were increasingly engraved with their makers' signatures at this time.[14]

In the period 1550–1770, there were four key moments within the history of horology which capture the changing relationship of trust between makers and users. These were: the use of alternative hour schemes in different countries in Europe from the mid-sixteenth to the early-seventeenth century; the coexistence of both quarters and minutes in the mid-late seventeenth century; the changing relationship between the sundial and the mechanical timepiece in the late-seventeenth and early-eighteenth centuries; and the imitation of precision timepieces in the mid-late eighteenth century. These will each be explored in turn.

3.2 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. These differences were mirrored in contemporary literature. In English stage plays, for example, temporal references were

to the twelve-hour scheme. Robert Greene's character in *Looking Glass for London* asks: "…what is this o'clock, four?" when trying to work out if he was late for an appointment one afternoon.[17] Despite prior scholarly attention, the significance of these different hour schemes for users who travelled between countries and the reasons for the decline has not been discussed. Yet, it is an important issue which must be addressed. In Chapter 2, it was noted that different numerals were used to distinguish between indices including different hour schemes. While the focus there was on legibility and numeral hierarchy, here the focus is on what these hour scheme differences reveal about trust.

When clock-makers in different countries designed and made 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 at least four others, unless they made timepieces for export elsewhere.[18] This decision by the makers to reflect local needs generated trust in them and their timepieces for their users. The maker of timepieces which represented multiple hour schemes[19] 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 indicative of both the user's trust in their own hour scheme and distrust of other schemes and a further example of makers responding 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,[20] 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 travelling with their own watch or small clock, as Pope's sentiment in the 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 and recorded that he set out from Nuremberg: "…at 23 hours as it strikes at Venice".[21] 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 late-sixteenth-century dial which represented multiple hour schemes. On these dials,[22] similar in format to Fig. 4.1, there were between two and four concentric hour rings, each of which represented a different hour scheme of I–XII, 1–24, I–VI. When describing such clocks, historians have identified the indications on the dial,[23] which is extremely helpful, but have not explained or referred to the wider significance. It is noteworthy that such a dial would have 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.

Critics might argue that such clocks were unique commissions, designed for wealthy individuals as an over-the-top device to demonstrate wealth to associates. However, in the context of different hour schemes and examples such as that of Krause, mentioned above, the utility is clear. At a glance, the user of this clock could interpret a given time or articulate the time to someone else according to a different hour scheme. Further evidence is clear from the existence of other clocks from this period designed along the same lines which indicate two hour schemes I–XII twice and 1–24.[24] Comparing these two dial formats suggests one type of user who visited many different countries in Europe, possibly including England, France, the Netherlands, Germany and Italy, and another type of user who visited fewer countries but nevertheless travelled between England or France and Germany. It is only through a focus on trust that suggestions such as these can be made. If we only think about late-sixteenth-century clocks as status symbols, then it prevents us seeing them within their wider context of use.

Another, less common, response from clock-makers was the dial with an interchangeable hour ring, which would have been useful in different countries. In this example, one ring represents the hours as two sets of 1–12 and the reverse represents 1–24.[25] 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. Having a dial such as this one, or travelling 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 most clocks and watches made in Germany, France and England represented the I–XII hour scheme only. This scheme had been favoured in the Netherlands and by some in England and France previously. The 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, and this was the first step towards the standard format of 1770. The presence of the hour sequence I–XII would have been taken for granted in 1770, but its appearance was not inevitable and in part owed its existence to issues of trust and the decline of the other hour schemes. 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 many 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,[26] which demonstrates that the invention of the pendulum did not determine the lifespan of the alternative hour scheme. The main reason for the change 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.

The way in which hours were represented on late-sixteenth and early-seventeenth-century dials may at first seem to be a novelty of geographical difference, but it is only when we compare them, particularly with dials which represent multiple hour schemes, that issues of trust are revealed. Provision of indices that were preferred by users was just one example of makers responding to users' needs in the period, and we can now move on to consider the effect of the introduction of minutes to clock and watch dials in the late-seventeenth century.

3.3 Quarters and Minutes

Users of dials throughout the period 1550–1770 wanted to know the hour, but also the smaller temporal units of its subdivisions. In the era before the pendulum, this was the four quarters of the hour and

afterwards the sixty minutes of the hour (and later seconds). It would be untrue to say that people were not interested in minutes until the pendulum was applied to clocks in 1657. 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 daily life. It was a convention of recording astronomical data. Minutes were not reliably or often represented on clocks before the introduction of the pendulum in 1657 or on watches before the introduction of the balance spring, although there were some examples.[27] Once established minutes were represented using two concentric rings and two centrally pivoted hands (this arrangement can be shown in Fig. 3.5). 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. Hands had been used as an indication device on multi-function dials since the mid-sixteenth century.[28] Before 1657, most dials either indicated the hour and each quarter using a single hand as can be shown in Fig. 4.3 (although a pendulum was added to this clock at some point after 1657) or featured a subsidiary dial which represented the four quarters.[29]

Dials influenced the recording of temporal references in diaries in which event times were not recorded in minutes until several years after the application of the pendulum in 1657, once the new technology had become more widely known. By way of example, Roger Lowe's diary references of 1663,[30] six years after the pendulum was introduced, referred to the nearest hour whereas those of the West Country Physician, Claver Morris, after 1684[31] referred to minutes, some twenty-seven years after the invention. This is also evidence of the varying needs for temporal accuracy appropriate to 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.[32] Representation of the minute unit on the dial followed existing conventions, which helped maintain trust in timepieces for some users through the provision of a sufficient number of familiar features. Most users trusted minutes relatively quickly, which is evident from references in diaries, as mentioned above, in records of early experiments in natural philosophy, and the

prevalence of older clock mechanisms which were routinely converted to pendulum operation.[33] However, some users distrusted minutes and required a certain degree of reassurance from makers. These users preferred using quarters as their point of reference. Users had not only become used to them, but money had depended upon them, which is evident in contemporary literature such as Greene's character in *Looking Glass for London* who claims a distinction between the time shown on the moneylender's clock and the city's public clocks which led to late payments and associated fines.[34] 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 historiographical record is silent regarding the coexistence of quarters and minutes on clock and watch dials, but this coexistence represents a key moment within the story of dial change and can only be fully appreciated by considering its significance within the context of the trust relationship between makers and their customers. For both historians of horology, such as Thompson[35] and Bruton,[36] and some social historians of time, such as Landes[37] and Whitrow,[38] the introduction of minute indication marked a watershed in the history of clocks and watches and the way in which time was experienced. Collectively, these authors unwittingly give the impression that the transition from the indication of hours and quarters to hours and minutes on clocks and watches took place immediately in 1657 and 1675, respectively. While these were undoubtedly hugely significant moments in terms of horological development, this view does not leave 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 coexistence.[39] 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.[40] He accepts 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.[41] Most historians of temporal experience have relied on historians of horology for their information about clocks and watches, which is why they have not progressed this particular discussion.

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 rather than getting to know something new[42] can be extended to the realm of timekeeping and the late-seventeenth century. 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 temporal 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 unfamiliar to the user.

Evidence for late-seventeenth-century reluctance in this area emerges from 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 (see Figs. 3.2 and 3.3). The second source consists of a new genre of literature which included instructions that were 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 sufficient attention from historians, 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'[43] and 'sun-and-moon'[44] watches might indeed exist as evidence of the attempt to offer a more aesthetically interesting display. Landes described them as 'lively layouts'[45] and Thompson as 'a means of attracting new customers',[46] but they are more significant as evidence of an intermediary period[47] 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 shown in Fig. 3.2, made by Thomas Tompion who has is remembered as the father of English watch-making.[48] The hour is indicated by the Roman numeral which moves along the semicircular aperture. The position of the numeral in the aperture indicates the minutes at the top and the quarters 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.

Fig. 3.2 Pocket watch by Thomas Tompion and Edward Banger, London, 1701–1750. Object no. 1954-189 (Photograph courtesy of Science Museum/ Science & Society Picture Library)

In the relevant entries for clocks and watches in his two catalogues, Thompson does not mention the coexistence of quarters and minutes. While this was probably due to his focus on documenting the development of precision, it feels like a missed opportunity. Of a wandering-hour watch by Bushman, for example, Thompson comments that the watch came from a period where makers designed 'unusual' dials, but offers no further comment.[49]

The relatively short lifespan of the wandering-hour dial strongly suggests that by the time they disappeared around 1700, they were no longer needed because reluctant users had been persuaded to accept the new

Fig. 3.3 Bracket clock by Edward East, London, c.1665. Object no. 64.101.860 (Photograph courtesy of the Metropolitan Museum of Art. Gift of Irwin Untermyer, 1964)

temporal unit. Had this design been made at any other time then perhaps it could be considered 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. Business was booming in London, Paris and Amsterdam. There was no urgency to create novelties to keep business going, though of course businessmen always look for new ways to attract customers. Furthermore, as with the majority of the conventions and changes discussed throughout this book, 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.[50]

It is noteworthy that Baillie refers to an example of a wandering-hour dial made by Ahasuerus Fromanteel.[51] 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, Landes dismissal of the importance of wandering-hour dials can be quickly refuted. Landes 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.[52] 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 produced wandering-hour dials is evidence that they were significant. Other master makers such as Thomas Tompion and Daniel Quare also made wandering-hour dials and, along with makers such as Edward East (see Fig. 3.3), experimented with representation of minute indication, which is further evidence of a period of transition, rather than the overnight change that Thompson suggests. It is not surprising that high-end makers such as these played the role of persuaders to gain trust from reluctant users through their dial formats.

Some watches not only kept the quarter indication but even introduced half quarters displayed alongside the quarters.[53] The attempt was to show increased accuracy for users of both temporal units. The early balance-spring watch by Tompion shown in Fig. 3.4 also shows experimentation with the new minute indication. This watch truly emphasises the minutes, which occupy the largest index on the outer ring and whose only labelled numerals are 15 and 45. The experimental aspect is evident from the hour index which is positioned as a subsidiary dial with six hours that progress in an anticlockwise direction and whose only labelled numerals are 2 and 4. The lower subsidiary dial indicates seconds and is located in what would become the usual place on the standard format dial. Minutes are allocated the prime position within the hierarchy, which in this case is the outer rim, normally reserved for the hours (as mentioned in Chapter 2). 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.[54] Both Quare and Tompion marginalised the hours on their experimental dials, by only giving space to six hours rather than twelve, in order to emphasise the new minutes.

Fig. 3.4 Pocket watch by Thomas Tompion, London, c.1675. Object no. 1985-1537 (Photograph courtesy of Science Museum/Science & Society Picture Library)

The powerful 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[55] and described how to look after a watch such as that in Fig. 3.5. It is worth noting that the dial seen in this figure was made by Tompion in 1688 and might be the earliest surviving example, or one of the earliest, of the format and content of the standard format, before it became a standard a little under one hundred years later. It is significant that this was some thirty years after the invention of the balance

Fig. 3.5 Pocket watch by Thomas Tompion, London, 1682–1683. Object no. 17.190.1489a, b (Photograph courtesy of the Metropolitan Museum of Art. Gift of J. Pierpont Morgan, 1917)

spring. This was not the overnight change that Thompson describes. 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-handed 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 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".[56] 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.[57] This is expandable with reference to 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. References within the archives of the Worshipful Company of Clockmakers to the seizure of 'bad dials' from various shops in the City of London[58] in 1635 and 1674 are evidence of the control the guild was willing to exert over which dials were made available to customers.[59] 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 4 May 1674 at Michael Barley's house in which dials were confiscated for having incorrect divisions engraved.[60]

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', for balance-spring watches.[61] For Baillie, this association with the pendulum by the provision of a small disc attached to the balance wheel: "…invested in the eyes of the public…" the same virtues as the pendulum.[62] This would convey the message to users that said watch was the equivalent of the pendulum clock, even if they could not 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…".[63] 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, one hundred and sixteen 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…".[64] 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 taken by Fellows of the Royal Society and their associates in new clocks and watches in terms of individual possession, but he does not discuss the role of trust.[65] The timepiece clearly played a role, alongside written notes and other instruments, in verifying 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, 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*[66] 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…".[67] 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,[68] 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".[69]

In his *A Defence of the Doctrine Touching the Spring and Weight of the Air*[70] 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.[71]

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.[72]

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*[73] 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…".[74] 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".[75] 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".[76] 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 introduced until 1675. As Boyle's reference indicates, there were watches that represented the minute before 1675,[77] 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 was introduced to 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 turning the Instrument. Bressieu's Invention judged but a bable".[78] The pendulum, which enabled minute measuring, had only just been invented making this a very early reference to minute measurement beyond the astronomical context.[79] 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…[80]

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

While Boyle and Hartlib could not be said to be representative of the wider population, they are nonetheless two prominent individuals in the context of early science. Their welcoming of the introduction of the new minute representation compared with the reluctance of others 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.

3.4 Sundials and Mechanical Timepieces

During the sixteenth and for much of the seventeenth century, sundials were the means by which users set and adjusted 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 itself, was judged as trustworthy or untrustworthy up until the late-seventeenth century. Indeed, in 1614 one of Ben Johnson's characters in the stage play *Bartholomew Fair* asked whether the watch should be set by the clock or the clock by the watch, which shows how unsure some people were of the performance of timepieces in this period.[81] Yet, by the early-eighteenth century the increased accuracy of the mechanical timepiece meant that this relationship of dependency was changing and eventually users were no longer compelled to rely on the sundial to set their timepieces. For many users, clocks and watches had become sufficiently trustworthy to not require verification by the sundial, and this was another key moment in the history of the trust relationship between clock and watch-makers and their customers. 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. Prior to this, a user doubtless wanted their timepiece to function correctly and some clock and watch-makers had better reputations than others, but increased accuracy raised new questions, or at least 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 the relatively high standard expected of it. Bad timekeeping had

consequences, which had an impact on a user's trust in their timepiece and its maker. In the eighteenth century, users could miss coaches or the best times to cross rivers[82] if they did not have the correct time.

The pendulum, balance spring and escapement refinements of the late-seventeenth and early-mid eighteenth centuries brought about greater accuracy, but evidence of improved mechanical capability in extant clocks and watches does not reveal user attitudes, aside from the fact that lots of people clearly owned them. One method of gauging the way in which people judged this improved 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.[83]

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 critiques of timepieces, and other instruments, in the form of a performance review that appears very familiar to modern eyes.

In 1665, he recorded testing his new minute-watch:

> 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.[84]

Though Pepys called his device a 'minute watch', as Boyle did, 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' could indicate 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 has 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 does not discuss the issue of trust as his focus is on the emergence of the private ownership of minutes that was enabled by watches.[85] 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 in the 1660s continued to judge their clock or watch by reference to a sundial. The sundial has 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 terms of generating trust in a timepiece. They were a form of verification. It is thought 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 perfectly logical, this view 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 that were 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.[86] 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.[87] Her qualification of the initial claim is accurate and needs to be stated. 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 inaccurately termed the 'horological revolution'.[88] 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 coexistence and co-ownership of both sundials and clocks reveal the complementary nature of the two instruments.[89] Yet, it is more accurate to say that their relationship was about dependency rather than complementarity. Sundials initially supported timepieces based on trust generation. That relationship then changed as timepieces began to outperform sundials within many contexts of use.

As mentioned earlier, archival references to dial use such as those seen in Pepys' diary are rare, and so further evidence must be sought 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. 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 thirty minutes per day,[90] 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 will always vary according to the date. There are just four dates in the year when the two agree: 15th April, 13th June, 1st September and 25th December. The difference could be explained by reference to the equation of time. Yet, 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, portions of a conversation between users and makers can be identified, in addition to the techniques used by makers to reassure users and defend their work in the light of user criticism. From these pamphlets, a picture can be constructed of some aspects of the complex trust relationship in the late-seventeenth and early-eighteenth centuries. There are several different pieces of writing which act as evidence of clock and watch-makers advising users and defending their work.[91]

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…".[92] In this sentence, Smith powerfully 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".[93] Here we find Smith, the clock-maker, acknowledging untrustworthy clock-makers, but also reprimanding some users. He did so 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 whom or what is responsible for errors: the instrument or the maker?[94] Smith included the user in what we can infer would have been his answer to this question and attempted 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 manage…" their clocks.[95] 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 adjust 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 demanded 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.[96]

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.[97]

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".[98] 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 since the introduction of the pendulum and nineteen years since the balance spring. The late-seventeenth and early-eighteenth centuries were 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 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….".[99] Smith then advised that: "…this adjustment is only to be done by the help of an exact Table of Equations".[100] This tells us that there were different qualities of equation tables. Smith recommended Parker's[101] and Salmon's[102] 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.

Critically, Smith claimed that these tables are useful if you: "…understand them rightly…", but from his experience: "…not many truly do".[103] 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 after 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".[104] 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' Company.[105]

In his preface to *An Explanation of the Nature of Equation of Time*,[106] 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…".[107] 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 or bear adjustments itself. Furthermore: "…it is impossible to 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".[108] 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".[109] 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…".[110] 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.[111]

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…".[112] 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".[113] 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 people thought the Sun 'can be guilty of mistakes' was a defence of the clock against criticism and a promotion of its performance in order to generate trust. It was also a criticism of the sundial.

3.5 Imitation of Precision

Clock and watch-makers from the late-seventeenth century onwards sought to imitate the dial formats of precision timepieces in order to generate and maintain trust in their work. This was another significant moment within the history of the trust relationship between makers and their customers in the period. Part of the reason why the standard format appeared the way that 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 arrangement used by John Arnold and Thomas Earnshaw, who initiated a commercial market for the marine

chronometer in the late-eighteenth century. These were two examples of precision timepieces used for professional purposes that 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 hallmark of quality. They influenced domestic-timepiece dials because users were desirous of 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,[114] but were used by astronomers and were considered to be the most accurate available in the late-seventeenth century. Howse correctly informs us 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.[115] Yet, he implies that this was the first time that 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.[116] 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 accurate instruments.

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 that was commissioned for Flamsteed, the first Astronomer Royal, for the Observatory at Greenwich in 1676[117] 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".[118] 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 that the clocks, watches and movements were trustworthy in a single sentence. 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 clients such as him did indeed take instruments back to their makers for minor adjustments.[119] This was a service high-end makers, such as Tompion, were committed to providing as it helped to 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. 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.[120] They provided their customers with a representation of trustworthy timekeeping.

The marine chronometer, developed from 1736 onwards by John Harrison and others, 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 product on a larger scale and thus into more widespread use, used the standard format for chronometer dials.[121] The dials present on their timepieces (such as Fig. 1.2) demonstrate that apart from their signatures, the dial arrangement used by both was identical and probably sourced from the same dial-maker.[122] 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.[123] Betts does not comment on the dials as this was not his focus, but by concentrating on dials, those used for chronometers can be identified 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 it to enjoy a long life from the late-eighteenth to the late-nineteenth century.[124]

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 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 movement 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 arrangement.[130] Again, the effect of the chronometer on domestic clocks and watches is beyond their scope. Yet, 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.

There have been discussions in the secondary literature about imitation, but none have discussed the practice in relation to trust and none have considered clock and watch dials within this context. 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 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 could not afford the high-end observatory clock or marine chronometer, but they did so in the belief that they were acquiring a hallmark of quality, rather than a cheap alternative. Through dial imitation, the maker was saying 'this clock or watch will perform as correctly 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 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] the subject of dials is of course 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.

A consideration of the influential role played by the observatory clock and the marine chronometer in terms of generating trust reveals that the observatory clock played a role in the adoption of the standard format through the process of imitation. Instead of playing a similar role, the marine chronometer in fact drew on the standard format and became part of the imitation or representation of accuracy itself. 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 eyes of users than a dial that looked completely different.

3.6 Conclusion

In the epigraph, we considered Pope's inclusion of watches in his construction of an analogy for human opinions in his epic poem. Pope said that each man believes his own watch. In the course of this chapter, we have expanded this gesture to the trust relationship between users and clock and watch-makers through instruments. The different ways in which formats were used to generate and maintain trust and repel distrust helps us to understand why dial formats changed in the period 1550–1770. Returning to the overarching journey of dial development from the multi-function dials of the mid-late sixteenth century to the standard format dial that emerged by 1770, this chapter has revealed two aspects that help us to understand that complicated journey.

First and foremost, this chapter has shown that users' emotions influenced the development of dial formats. Some users from the mid-late sixteenth century preferred the hour scheme in use in their home location and distrusted other hour schemes. Dials with multiple hour schemes provided such users with a reassuring method of cross-referencing while away from home. When the pendulum clock and the balance spring for watches enabled the representation of minutes in addition to hours from 1657 to 1675, respectively, some users were reluctant to accept the new indication and makers provided dials that indicated both quarters and minutes which acted as a form of transition between the two indices. Many users, including natural philosophers, welcomed the new indication of minutes and eventually all users were persuaded to accept it and the transition pieces disappeared. 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 not to continue adjusting their timepiece to agree with their sundial, is important for understanding the role of formats in the building of trust relationships. 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 decline in 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. 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.

Secondly, this chapter has shown that knowledge creation and transfer through dials was influenced by the trust relationship. 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. The exception to this was almanacs, which referred to minutes as a matter of astronomical convention in the era before the pendulum.

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 their customers' trust in timepieces. 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.

Notes

1. Alexander Pope, *An Essay on Criticism*, 4th ed. (London: W. Lewis, 1713).
2. 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. Geraldine A. Johnson, *Renaissance Art: A Very Short Introduction* (Oxford: Oxford University Press, 2005), pp. 91–92.
3. Otto Mayr, *Authority, Liberty & Automatic Machinery in Early Modern Europe* (Baltimore: Johns Hopkins University Press, 1986), p. 10.
4. Guido Beltramini and Davide Gasparotto, *Aldo Manuzio: Renaissance in Venice* (Venice: Marsilio, 2016), pp. 28–31.
5. Acceptable accuracy in the period, which was within fifteen minutes per day, was sufficient for the pre-pendulum context, but not afterwards.
6. Graeme Gooday, *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice* (Cambridge: Cambridge University Press, 2004).
7. Theodore Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton, NJ: Princeton University Press, 1995).
8. Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth-Century England* (Chicago; London: University of Chicago Press, 1994); Steven Shapin, *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: Johns Hopkins University Press, 2010).
9. Shapin, *Never Pure*, p. 21.
10. Gooday.
11. David Finkelstein and Alistair McCleery, *An Introduction to Book History* (New York, NY: Routledge, 2005), pp. 70–71.
12. Ibid., pp. 70–71.
13. Ibid., p. 71.
14. London's clock and watch-makers signed their work throughout the period, but were required to do so by law from 1789, MS 3940, volume 1, Worshipful Company of Clockmakers.
15. Eric Bruton, *The History of Clocks and Watches* (London: Little, Brown, 2000), pp. 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. Robert Greene, *A Looking-Glass for London and England* (London, 1594).
18. Some clock and watch-makers travelled through Europe and attended the major fairs such as that at Frankfurt to sell their wares.

19. For example British Museum object number 1888,1201.102.
20. See Chapter 1 for more information on the different types of clock and watch user.
21. Gerhard Dohrn-van Rossum, *History of the Hour: Clocks and Modern Temporal Orders* (Chicago: University of Chicago Press, 1996), p. 329.
22. For example British Museum object number 1888,1201.102.
23. David Thompson, *Clocks* (London: British Museum Press, 2004), p. 40.
24. For example British Museum object number 1958,1006.2113.
25. For an example see British Museum clock object number 1888,1201.105.
26. For example British Museum object number 1958,1006.2191.
27. For example British Museum object number CAI.2316.
28. As demonstrated in Chapter 2, dials followed existing conventions in communication methods making them more familiar to existing and potential users.
29. For example British Museum object numbers 1888,1201.103 and 1888,1201.130.
30. Roger Lowe and Ian G. Winstanley, *The Diary of Roger Lowe of Ashton-in-Makerfield, Lancashire, 1663–1678* (Wigan: Picks, 1994).
31. Claver Morris and Edmund Hobhouse, *The Diary of a West Country Physician 1684–1726* (London: Simpkin Marshall, 1935).
32. The horological term for the axle on which the motion work which control the hands is attached.
33. Some users in the late-seventeenth and eighteenth centuries 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. Figure 4.3 which is a sixteenth-century clock that has been fitted with a pendulum later in its life may have been one of these examples.
34. Greene.
35. Thompson, *Clocks*, p. 66.
36. Bruton, p. 68.
37. David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (London: Viking, 2000).
38. Gerald James Whitrow, *Time in History: Views of Time from Prehistory to the Present Day* (Oxford: Oxford University Press, 1988), pp. 122–123.
39. Bruton, p. 86.
40. Whitrow.
41. Paul Glennie and Nigel J. Thrift, *Shaping the Day: A History of Timekeeping in England and Wales 1300–1800* (Oxford: Oxford University Press, 2009), p. 140.
42. Gooday, p. 262.

43. A wandering hour dial is the name given to dials where the time is shown by a numeral figure that moves along an aperture as shown in Fig. 3.2.
44. A sun-and-moon dial is the name given to dials that use the format of the wandering hour dial, but instead of an hour numeral that moves along the aperture, an image of the Sun during the day and of the Moon during the night moves along the aperture. The figure indicates the hour against an index located along the outer rim of the aperture.
45. Landes, p. 139.
46. David Thompson, *Watches* (London: British Museum Press, 2007), p. 58.
47. Termed an intermediary period as perceived from a modern perspective.
48. Jeremy Evans 'Thomas Tompion' in the *Oxford Dictionary of National Biography*, online, www.oxfordnb.com.
49. Thompson, *Watches*, p. 58.
50. For example British Museum CAI.656.
51. Granville Hugh Baillie, *Watches: Their History, Decoration and Mechanism* (London: N.A.G. Press, 1929), p. 162.
52. Landes, p. 139.
53. For example British Museum object number CAI.147.
54. See Chapter 4 for an in-depth discussion of touch-pins.
55. Thomas Tompion, *An Exact Measure of the Roads from Bath to London* (London: J. Good, 1709).
56. Gooday, p. 262.
57. Shapin, *A Social History of Truth*, p. 8.
58. MS3975. 1632–1816. *Index of and Abstracts to Journals and Ordinanaces*, Worshipful Company of Clockmakers.
59. This is an example from London, but the experience was mirrored by guilds across Europe.
60. MS3975. *Index of and Abstracts to Journals and Ordinanaces*, Worshipful Company of Clockmakers.
61. Baillie, p. 212.
62. Ibid.
63. C. Clutton, ed., *Britten's Old Clocks and Watches and Their Makers*, 9th ed. (London: Bloomsbury Books, 1990), p. 142.
64. Thomas Hatton, *An Introduction to the Mechanical Part of Clock and Watch Work* (London, 1773), pp. 12–13.
65. Stuart Sherman, *Telling Time: Clocks, Diaries, and English Diurnal Form 1660–1785* (Chicago: University of Chicago Press, 1996), p. 83.
66. Robert Boyle, *Certain Physiological Essays and Other Tracts Written at Distant Times* (London, 1669).
67. Ibid.
68. Sandglasses were calibrated to measure hours and quarters.

69. Robert Boyle, *Certain Physiological Essays and Other Tracts Written at Distant Times* (London, 1669).
70. Robert Boyle, *A Defence of the Doctrine Touching the Spring and Weight of the Air* (London, 1662).
71. Ibid.
72. Ibid.
73. Robert Boyle, *New Experiments Physico-mechanicall* (Oxford: H. Hall, 1660).
74. Ibid.
75. Ibid.
76. Ibid.
77. For example British Museum object number CAI.2316.
78. Samuel Hartlib, *Ephemerides* [29/6/5B], 1657, https://www.hrionline.ac.uk/hartlib/.
79. Minutes had been used as a reference in astronomy for decades.
80. Samuel Hartlib, Letter, Benjamin Worsley To Hartlib, 22 June 1649, 26/33/1A-3B [26/33/2A], https://www.hrionline.ac.uk/hartlib/.
81. Ben Johnson, *Bartholomew Fair*, printed from the play of 1614 (London, 1631).
82. Tompion. At the back of this pamphlet are some instructions on how to calculate the best time to cross the River Severn. This is discussed in detail in Chapter 5.
83. Diary of Samuel Pepys, *Saturday 13th May 1665*, http://www.pepysdiary.com/.
84. Diary of Samuel Pepys, *Wednesday 13th September 1665*, http://www.pepysdiary.com/.
85. Sherman, p. 79.
86. A well-known example is John Blagrave, *The Art of Dyalling* (Simeon Waterson: London, 1609).
87. Hester Higton and Silke Ackermann, *Sundials at Greenwich: A Catalogue of the Sundials, Nocturnals, and Horary Quadrants in the National Maritime Museum, Greenwich* (Oxford: Oxford University Press, 2002), p. 24.
88. Landes.
89. Anthony John Turner, *Of Time and Measurement: Studies in the History of Horology and Fine Technology* (Variorum, 1993), p. 21.
90. This that was sufficient for users' needs prior to 1657.
91. Selected as examples of both the equation of time and advice to users.
92. John Smith, *Horological Dialogues* (London, 1675).
93. Ibid.
94. Gooday, p. 66.
95. Smith, *Horological Dialogues.*
96. John Smith, *Horological Disquisitions* (London, 1694).

97. The desire to share craft knowledge was very popular at this time and not unique to clock-making. For more information see William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, NJ: Princeton University Press, 1994).
98. Smith, *Horological Disquisitions.*
99. Ibid.
100. Ibid.
101. George Parker, *Mercurius Anglicanus or The English Mercury Being a Double Ephemeris for the Year of Our Lord 1694* (London, 1694).
102. William Salmon, *The London Almanac* (London, 1694).
103. Smith, *Horological Disquisitions.*
104. Ibid.
105. The Worshipful Company of Clockmakers regulated clock-making in London from 1631 onwards.
106. F. Clay, *An Explanation of the Nature of Equation of Time* (London, 1731).
107. Ibid.
108. Ibid.
109. Ibid.
110. Ibid.
111. Ibid.
112. Ibid.
113. Ibid.
114. The astronomical function is discussed in detail in Chapter 7.
115. Derek Howse, 'The Tompion Clocks at Greenwich', *Antiquarian Horology*, 7.2 (1971), p. 114.
116. John David North, *Cosmos: An Illustrated History of Astronomy and Cosmology* (Chicago: University of Chicago Press, 2008), p. 325.
117. National Maritime Museum object number ZAA0885.
118. N. Stephenson, *The Royal Almanack* (London, 1677).
119. 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.
120. For example British Museum object number 1928,0607.1.
121. The standard format was not used on Harrison's nor 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.
122. In Chapter 1, it was explained that it is extremely difficult to identify specific dial-makers in the period up to 1770.

123. Rupert T. Gould and Jonathan Betts, *The Marine Chronometer: Its History and Development* (Antique Collectors' Club Ltd., 2013), p. 105.
124. 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.
125. Richard Dunn and Rebekah Higgitt, *Ships, Clocks & Stars: The Quest for Longitude* (London: Collins, 2014).
126. Gould and Betts.
127. John Cronin, *The Marine Chronometer: Its History and Development* (Ramsbury: Crowood, 2010).
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-distance method.
130. Cronin, pp. 76–77.
131. Clive Edwards, '"Improving" the Decoration of Furniture: Imitation and Mechanization in the Marquetry Process in Britain and America 1850–1900', *Technology and Culture*, 53 (2012), pp. 401–434.
132. Ibid., pp. 428–430.
133. Ibid., p. 416.
134. Maxine Berg, 'From Imitation to Invention: Creating Commodities in Eighteenth-Century Britain', *Economic History Review*, 55.1 (2002), p. 3.
135. Ibid., pp. 6–7; 9.
136. Ibid., pp. 13–14.

CHAPTER 4

Tools of Enablement

4.1 Introduction

There were two commercially available dial arrangements that were designed as tools of enablement in the period 1550–1770. These arrangements helped users to read the time in circumstances in which they otherwise could not or certainly could not do so easily. The first of these tools was the touch-pin of the mid-sixteenth century to the early-seventeenth century (see Fig. 4.1) and the second was the illuminated night clock of the mid-seventeenth century to early-eighteenth century (see Fig. 4.2). These two formats were both created for those who might otherwise have been dis-abled[1] by traditional dials, either due to an absence of full sight in the case of those who were partially sighted or blind, or due to the absence of light during the night in the case of sighted users. Most sixteenth- and seventeenth-centuries dials and all eighteenth-century dials, including the standard format that emerged around 1770, required sufficient sight and light to be read.[2] These traditional formats excluded some users all of the time and others in certain situations.

While historians of horology, such as Thompson,[3] Bruton[4] and others,[5] have not discussed contexts of dis-ablement, due to their focus on technical development, it is vital that the touch-pin and the illuminated night clock are reinterpreted within the growing secondary literature that reassesses history from the perspective of people who were dis-abled by their environment and the society in which they lived. Historians such as Hobgood and Wood emphasise that the aim should not be to write 'disability histories',

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_4

Fig. 4.1 Table clock, Germany, 1545–1555. Object no. 1954-186 (Photograph courtesy of Science Museum/Science & Society Picture Library)

but to write more inclusive histories, which take into account multiple perspectives.[6] Along with others,[7] they have made considerable progress in reassessing the surviving written and pictorial evidence. However, they have not as yet ventured broadly enough into the context of material culture.

In response to Hobson and Wood's call to offer a more inclusive approach instead of focussing on disabled users, this chapter considers two contexts in which the user, able-bodied or otherwise, was dis-abled by either a sight or light requirement and thus excluded from using traditional dials and the responses of some clock- and watch-makers to enable 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. Dials with touch-pins and illuminated night clocks were therefore devices of enablement, provided by clock- and watch-makers to assist users.

Fig. 4.2 Illuminated night clock by Joseph Knibb, London, 1675–1685. Object no. 1981-1856 (Photograph courtesy of Science Museum/Science & Society Picture Library)

4.2 'Reading' the Time by Touch

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 was, or became if their sight was deteriorating, a non-user of clocks and watches. Yet, the provision of touch-pins as part of a dial's

format, used alongside the dial hand, gave such people a method for ascertaining the time by touch and enabled them to become active users. It also enabled active users to remain as such and not become excluded due to changes in their eyesight. The phrase 'absence of full sight' is used here to distinguish the specific need which touch-pins alone fulfilled in the period before the pull-repeat mechanism. This was to enable clocks and watches, from the mid-sixteenth century 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 potentially useful for the second context of use, considered later in this chapter, which is ascertaining the time in the absence of light. However, as we shall see, the touch-pin's primary use was for blind and partially-sighted users.

An absence of full sight encompasses a wide range of different degrees 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 diseases of the eye. 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,[8] the focus here is on the responses made by late-sixteenth century and early-seventeenth century-clock- and watch-makers to enable users. This follows the cultural model of disability,[9] which emphasises that people are dis-abled by their environment rather than their bodies. The makers of traditional clock and watch dials that required full sight to be read were guilty of dis-abling blind and partially-sighted users. Most makers catered for the majority, except in the case of one-off commissions, rather than offering a timepiece that would suit every type of user, a situation that continued through the centuries. Blind and partially-sighted 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. Many clock- and watch-makers of the period recognised this and provided the touch-pin as a device of enablement.

There were three reasons why touch-pins were provided as a tool of enablement for the partially sighted and blind. 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 sideless. Changes to these perceptions and the rise of spectacle use plus the introduction of sides were factors which led to the decline of the touch-pin. However, there was no one definitive reason.

4.2.1 Perceptions of Sight and Touch

Touch-pins and the dial hand constitute a positional form of reading by touch. See Fig. 4.1, for an example, the maker of which is unknown but is representative of a type that was very popular across Europe from the mid-sixteenth century to the early-seventeenth century. 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 is indicative of either a user who had experienced visual degeneration, possibly age-related, but had previously been fully sighted and accustomed to reading a dial, or a blind user who had learned to interpret objects by touch. If their environment did not dis-able them, then, they were no less able to attain and interpret information 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. It is only when this feature is not included on traditional dials that its users are considered as 'other'. They are not inherently different, but have been separated as 'other' by dials that were inadequate for their needs.

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. Blindness featured in the many emblem books of the period and always carried a moral message. One example was Robert Farlie whose emblem took the form of an elderly figure with a walking pole in one hand and a dog on a lead in the other with the inscription: "My light is darkness to thee",[10] whose message was that sight was not required to get closer to God because it was contemplation that was important. Another was Geffrey Whitney whose emblem was a figure with a walking pole carrying a person that struggled to walk on their own with a passage about how both helped each other, one walking and one guiding.[11] Chess informs us that the inclusion of blind characters in early modern plays was significant as they were not being ignored.[12] Referring to a play based on the biblical account of Jacob and Essau,[13] she says that Isaac's age-related blindness was intended to show the audience that it was neither unique nor avoidable; it was just a part of getting older.[14] 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 literature to the blind as miserable and suggests a link between increased circulation of texts, enabled by the printing press, leading to greater exclusion of the blind. Yet, texts were not new in the seventeenth century, their availability had gathered pace in the sixteenth century, so it might be more accurate to say that what had changed were public attitudes to the blind and this was conceivably one reason why the touch-pin disappeared from dials. People were becoming less concerned with inclusivity.

Taking inspiration from Wyatt, who distinguishes between users and non-users,[15] touch-pins can be understood as a useful tool for distinguishing between users, potential users and 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,[16] 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 that the sighted were. 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 users of the dial, both blind and partially sighted, to become active users. They could ascertain the time by touch whenever they chose.

Notwithstanding some passing references to the existence of touch-pins, historians of horology have not dwelt upon the issue of 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. In some examples, the pin located at the XII position was larger than the others, making orientation easy.[17] In examples, 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 Fig. 4.1) were more difficult to orientate, but were perhaps not re-positioned very often. Weight-driven clocks (see Fig. 4.3) were always upright and so did not need to be orientated. The hour hand

also had to be strong enough to be touched by the finger and pressed 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 potentially a devotional experience. Users may have used the pins to remember their prayers.

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 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] While Baillie claimed they were common until the mid-seventeenth century, in reality they had declined by the early-seventeenth century with just one late example made around 1640. Furthermore, by only providing examples of watches he implied that touch-pins were unique to watches, which is inaccurate (see Figs. 4.1 and 4.3). Britten, on the other hand, acknowledged their presence on table clocks, but did not mention upright clocks, but there are examples of these also (see Fig. 4.3).[22] The existence of these clocks is further evidence that there was a context of use for touch-pins other than during the hours of darkness. 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.[23]

Thompson accepts Britten and Baillie's interpretation by describing touch-pins in his own work as 'being located at each hour to allow the time to be found in the dark'.[24] Thompson's focus, similarly to Britten and Baillie, is the documentation of the development of precision timekeeping, which means that different contexts of use are beyond his scope and he does not comment on them elsewhere in his book, even where there were examples that provided the opportunity for doing so.[25] The use of touch-pins to ascertain the time in the absence of light cannot be denied and is discussed later, but the 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 geographical section headings that touch-pins were unique to Germany. However, this is also inaccurate given that there are existing examples

Fig. 4.3 Upright table clock, Germany, c.1575–1600. Object no. 29.52.16 (Photograph courtesy of the Metropolitan Museum of Art. Gift of Mrs. Simon Guggenheim, 1929)

from England, Italy and France made by indigenous makers in the same period.[26] 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 appear to be more examples

of German dials with touch-pins.[27] Throughout this book, various components of dial format and content are identified that transcended national boundaries throughout the period 1550–1770.[28] Other methods of enabling the blind and partially sighted are discussed later with reference to the work of Eriksson who also claims there were no geographical boundaries with the production of tactile images.[29] Dials were not alone.

Artworks composed in the period can help us to visualise the user, which is important given the lack of additional information on users (as discussed in Chapter 1). A clock dial such as that shown in Fig. 4.3 (whose maker is unknown but is representative of a type that was very popular in Germany and France from the mid-late sixteenth century to the early-seventeenth century) and a watch dial such as that shown in Fig. 6.1 (which was made by Jan Jansen Bockeltz who was originally from Aachen in Germany and then moved to Haarlem) 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 partially-sighted lady depicted in Fig. 4.4 would have a clock such as that shown in Fig. 4.3 and would get up to feel the time, leaving her spectacles on a table since they were sideless and had to be balanced on her nose to be used. Similarly, in Jan Lieven's painting *Scholar at Desk*,[30] it could easily be imagined that the watch depicted on the table of the scholar might be equipped with touch-pins to enable reading of the time. It looks similar to the small table clock shown in Fig. 1.1 or the watch shown in Fig. 2.2. Jan Lievens depiction of elderly sitters has been described as a 'sympathetic' one by Wheelock and Dickey,[31] who point out that his skill at rendering the chiaroscuro effects enabled him to portray his figures as being as close to the viewer as if they were in the same room.[32] It is for both of these reasons that one can imagine that the scholar is just about to put down his quill and feel the time on the pocket watch next to his hand, before searching for his sideless spectacles to enable him to continue writing, as he is struggling to see. Furthermore, it is known that Lievens painted portraits for merchants[33] and painted scholars for patrons such as civic leaders.[34] Wealthy individuals such as these were the types of clock and watch user identified in Chapter 1.

The vast majority of dials with touch-pins, with rare exceptions,[35] were made between 1550 and 1600. This represents a commercial lifespan of fifty years. The first watches appeared in the mid-fifteenth century,[36] but most extant examples in museum collections date from

Fig. 4.4 *Sight* by Hendrik Visjager, Amsterdam, 1683–1684. Object no. RP-P-1910-1546 (Photograph courtesy of Rijksmuseum/Rijksstudio)

the mid-sixteenth century onwards, suggesting that they became more widely available from this time and that touch-pins were part of these early formats and not a subsequent addition. Domestic clocks[37] were also not new in the mid-sixteenth century, but began to increase from this point onwards with new types becoming available, for example, table clocks (such as Fig. 4.1) and an increase in weight-driven chamber clocks (such as Fig. 4.3). Thus, touch-pins were part of the design of very early, if not the earliest, dials for domestic use. They were not present on all, but were on many. The overall disappearance of touch-pins from both clock and watch dials in around 1600, with rare exceptions, is more significant for understanding their use than their first appearance on dials. This raises the question as to what had changed by 1600. Allusion was made 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.

The different types of enablement device, of which touch-pins were a part, were a physical manifestation of 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.[38] He refers to the book of emblems and blind man carrying the one-legged man, such as that of Whitney mentioned above. This was a representation and moral of limitations being overcome. These images in emblem books and all of those instruments discussed in this section demonstrate that changing attitudes towards 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.[39] Yet, the provision of touch-pins on dials indicates that touch was perceived by many according to this concept during the mid-sixteenth century to the early-seventeenth century. Taking the clock in Fig. 4.1 as an 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.

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'.[40] However, by limiting her analysis to the simple relationship of person and non-specific object that is merely picked up and held, she is unable to consider objects which are genuinely 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.[41] Yet, differences within the human capacity to derive meaning from touch can be identified by comparing representations of touch in art with touch-pins on dials. Jusepe de Ribera's painting, *Sense of Touch*,[42] depicts a blind man feeling the face of a statue in order to identify the subject. Sanchez and Spinosa's claim that Ribera had a renowned skill at creating a sense of realism and heroism[43] 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 the sense of touch.[44] The painting undoubtedly shows the acquisition of knowledge through touch, 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 Fig. 4.1. Dials with touch-pins are tangible evidence of the way in which people from the mid-sixteenth century 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[45] on the one hand and the engraver Stradanus[46] on the other. The late-sixteenth-century and early-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*,[47] 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. The lack of any reference to spectacles is 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 existing sight. While there might not appear to be anything very unusual about this attitude, its significance becomes apparent within 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.[48]

Bartisch's use of the word 'harmful' is significant. It suggests that despite spectacles becoming more widespread, some people avoided them in the hope of preserving their existing level of sight. Devices such as touch-pins that enabled the partially sighted to manage would be valuable in this context. It might be 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 sixteenth-century dials and the disappearance of them around 1600 when attitudes such as Bartisch's disappeared and spectacles became more widespread. Indeed, Rosenthal's findings that spectacles were out of fashion with the wealthier sections of European society in the sixteenth century are indicative of the consequences of the fear that was generated by such pamphlets.[49] Moreover, Bartisch's insistence that 'two imperfect eyes were better than four' implies that he perceived spectacles to be devices that enhanced vision to a point where things were not seen as they truly were; spectacles compromised the ability to acquire truth. This was much the same as the negative response to telescopes and microscopes by some writers approximately a century later.[50] The implied risk was that neither objects nor truths would 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 were a tool of enablement for such a user.

An alternative view was expressed in a series of eighteen prints entitled *Nova Reperta* (New Discoveries) by Johannes Stradanus in 1590,[51] one depicts clock-making (see Fig. 4.5) and one depicts spectacles

Fig. 4.5 *Clockmaking* published by Philips Galle, Antwerp, c.1589–1593. Object no. RP-P-OB-6836 (Photograph courtesy of Rijksmuseum/Rijksstudio)

(see Fig. 4.6). 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 those of the Classical world.[52] This was indicative of a sentiment of optimism and a forward-looking focus in addition to a reverence for the Classical past. In the same period, spectacles began to appear in emblem books such as that of George Wither, who used an owl with spectacles balanced on its beak to represent poor sight.[53] Another example was Johannes Romberch who also included a pair of spectacles in his table of emblems.[54] The associated moral in John Bunyan's *A Book for Boys and Girls* informed readers that spectacles were not for show, but provided the poor sighted with the gift of vision.[55] In London, the Worshipful Company of Spectacle Makers was established in 1629 with the motto 'blessed be the aged', suggestive of the main customer base of the spectacle makers which was the elderly with degenerating vision.

Fig. 4.6 *Spectacles* published by Philips Galle, Antwerp, c.1590–1595. Object no. RP-P-2004-74-115 (Photograph courtesy of Rijksmuseum/Rijksstudio)

This spirit of optimism with regard to the capability of technology can be elaborated upon. The Latin caption beneath Fig. 4.6 can be translated as: "Eyeglasses have been invented which remove the more obscure diseases of the eyes".[56] 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 Fig. 4.6) 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 Fig. 4.6) 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.[57] 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 be able 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.

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.[58] 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 manage, 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…"[59] referring to engraved forms of letters on blocks of wood in the late-sixteenth century. Moon said that this attempt was unsuccessful because the text was not in relief form. If Moon's statement about 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 at around the same time that touch-pins went into a marked decline.[60]

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 (similar to Fig. 2.1).[61] While most volvelles were not constructed with the enablement of partially sighted

or blind people in mind, the tradition of providing information in a way that required user interaction was a tradition from which makers that included touch-pins on their dials 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 that the touch-pin 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.[62] This idea is most conceivable within the context of multi-function dials (such as Fig. 6.1). That touch-pins were not restricted to dials that only represented the hour indicates that they served different purposes on separate dials.

Touch-pins featured on both multi-function dials and single-function 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.[63] In other examples, they were used on subsidiary dials to indicate the quarter hours and sometimes the alarm-setting subsidiary dial.[64] It appears that touch-pins were not used to communicate other information such as calendrical or lunar information. It is probable 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. Multi-function dials with touch-pins suggest 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.

Further evidence against the criticism that spectacles were readily available in the late-sixteenth-century meaning that the partially sighted did not need touch-pins can be found in a pamphlet published at around the same time or shortly after the last dials were being made with touch-pins in the early-seventeenth century. It was entitled *A Sight of ye Transactions of these latter yeares Emblemized with engrauen plats which men may read without spectacles*.[65] 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 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 visually without reading the text. Its claim to be comprehensible without the need for spectacles is indicative of 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.[66] Fig. 4.4, which was published by Hendrik Visjager in the Netherlands who was responsible for the publication of many other life-like, non-embellished depictions of individuals that was typical of the Dutch style, depicts the way in which early spectacles were worn in the late-sixteenth century and early-seventeenth century. As noted earlier, they were either balanced on the nose or held up to the face.

In every-day use, sideless spectacles such as those in Fig. 4.4 were more difficult to use than those with sides, improvised versions of which began to emerge in the mid-seventeenth century.[67] Sideless 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 (if those clocks did not have touch-pins). Spectacles with sides on the other hand enabled the user to comfortably and efficiently move from one task to another. Additionally, as Ilardi claims, spectacles needed to be repaired regularly,[68] which is evidence that they were not always to hand when required. For the period in which they were made, from the mid-sixteenth century to the early-seventeenth century, touch-pins on dials served a similar purpose as pamphlets such as the graphic representation of the Civil War mentioned above. They enabled the partially sighted to read the indicated time without putting on spectacles. The emergence of sideless 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, discussed later, describes the process of feeling the time in the dark as only possible because of the poor timekeeping ability of pre-pendulum clocks and pre-balance-spring watches.[69] This is an 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 representing hours and minutes became common from 1657 and 1675 onwards, being able to touch the dial was made difficult by a more sensitive and fragile set of dial hands, which was Wadsworth's point. When white enamel dials, which were completely smooth, were first used from the early-eigthteenth century onwards reading by touch was not possible.[70] 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.

4.3 Finding the Time at Night

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.[71] Over forty years later, this chapter offers three new angles of interpretation of the illuminated night clock through a focus on its role 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 (which would have been earlier in the winter months when candles would have already been burning for several hours from four o'clock in the afternoon). Thirdly, it was a tool of religious devotion. Yet, despite the three ways in which it acted as a tool of enablement, 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 improve our understanding of the combination of influences which led to its decline.

Historians of horology have not considered night clocks as a tool of enablement 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.[72] 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.[73]

Returning to the literature on the history of disability, this section concentrates on the way in which some 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,[74] mentioned above, a person is only dis-abled by their environment and the society in which they live. 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 shown in Fig. 4.2, which was made by Joseph Knibb, 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 was discontinued by the early-eighteenth century.

Mechanical timepieces were devices of enablement in and of themselves. Historians of horology, such as Christianson,[75] 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 be able 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 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 for 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.[76] 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.[77] 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 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. Indeed, Samuel Pepys described seeing one of these clocks in 1664:

> After dinner to White Hall; and there met with Mr. Pierce, and he showed me the Queene's bed-chamber, and her closett, where she had nothing but some pretty pious pictures, and books of devotion; and her holy water at her head as she sleeps, with her clock by her bed-side, wherein a lamp burns that tells her the time of the night at any time.[78]

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 (there were examples of oil lamps causing the wooden clock cases in which they were enclosed to catch fire) and continued as a means for ascertaining the time in the absence of light beyond the other two devices. 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 demonstrated above, was that the touch-pin was primarily designed for use by blind and partially-sighted users, although ascertaining the time at night was undoubtedly 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 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[79] and Bowers[80] reveal that once the household fires and candles had been extinguished for the night (which would have been much earlier in the winter months given that candles would have already been burning for several hours since four o'clock in the afternoon), 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 household budgets,[81] meaning they wouldn't have been wasted to solely check the time during the night.[82] We gain an insight into the impracticality of domestic lighting in the period from O'Dea who foregrounds his work on lighting the home with a chapter entitled 'bad light', on the first page of which he says that from 15,000 years before Christ until 1782: "…there was practically no

improvement in lighting at all".[83] The most important part of this statement is not its huge time span, but the year in which it ends, with the arrival of the Argand lamp. 1782 is twelve years beyond the temporal parameters of this book, so O'Dea's information gives us an indication of the lighting challenges faced by users of every dial considered in this book.[84] Yet, 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.[85] 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, night clocks provide 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.

Gerrit Dou's painting *Astronomer by Candlelight*[86] shows the way in which people used candles to work when it was dark in the early modern period. In this painting, Dou depicts an astronomer/astrologer[87] working during 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.[88] 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. It was common practice in this period for people to be paid for the number of hours worked and sandglasses and clocks were a useful way of doing so. This may have been sufficient for counting the number of hours worked 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 shown in Fig. 4.2 was a solution offered by clock-makers for wealthy clients (such as merchants who needed to work on their accounts).

Night clocks ceased to be made once their use was no longer required in the early-eighteenth century. Yet, 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[89] describe these clocks as purely used to physically see the time in the dark. Yet, 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 passing trends 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 give the impression 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[90] argue that the night clock was superseded by the quarter-repeating mechanism invented by Daniel Quare in the late-seventeenth century, which is considered below. This is an example of where an approach which considers purely the technical development of a technology in more or less isolation with only a few passing references to the wider context, restricts itself in terms of what it can reveal and sends mixed messages about specific types of clock. 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 Two Periods of Sleep

In Chapter 1, users were defined as encompassing wealthy merchants who travelled throughout Europe. While Maczak,[91] a historian of travel, informs us about 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 candlelight 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 travelling.

Whereas Maczak's work does not improve our understanding of dial use, historians of the night, another under-researched area, such as Koslofsky,[92] are more helpful. He informs us that up until the

eighteenth-century people in the early modern period often separated the night into two periods of sleep, balanced between a period of at least one hour of wakefulness in which they busied themselves with various tasks.[93] 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 for the purpose of managing their night. Night clocks would have been useful in this context. This evidence runs in contradiction (at least in the period) to O'Dea's statement that activity ceased once the Sun went down[94] 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 slepe make water yf ye fele your bladder charged, and then slepe on the left syde'.[95] 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[96] 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…".[97] Astrological works, such as almanacs, advised on the best times to conduct certain activities such as planting seeds in the night, discussed in detail in Chapters 5, 6 and 7. This was another reason that people needed to be able to ascertain the time in the dark. Thus, understanding night clocks helps us to appreciate the broader history of the night in the early modern period.

If a user had to rise in the night to pray or to 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, which is easy to do during long winter nights, then, they may have wanted 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 century 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.[98] 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 the artificial-light maker's) attempts to solve the challenges posed by the night represent challenges to these natural limits. In this sense, the night clock is a symbol of the way in which some people began to think of nature as something that could be harnessed by humans.

Koslofsky defines the process of increased activity during the night as the 'nocturnalisation of early modern life',[99] 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, such as Pepys', reveal that people possessed a temporal awareness of the night that was realised by the mechanical timepiece. In his diary, written in the late-seventeenth century, Roger Lowe 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…".[100] Lowe had at least one clock from the inventory of his estate,[101] 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. This would have required a pocket watch or the use of someone else's clock.

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

4.3.4 A Devotional Tool

Artworks are helpful here for improving our understanding of night clocks, 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 1635–1640 (see Fig. 4.7). The night was clearly a time for quiet contemplation. La Tour is known for the powerful silences that he created in his paintings.[102] This striking effect is comparable to the effect that would have been created by the illuminated numerals on the night clock in Fig. 4.2. The contemplative nature of a burning candle in the dark was also evident in emblem books of the period such as those of Quarles who included an image of a lady praying by the light of a candle along with a moral verse entitled: "Light mine eyes, O Lord, lest I sleepe the sleepe of death".[103]

The term 'night clock' is a modern horological one and it is not known how most people in the early modern period referred to them. Pepys referred to one as 'a clock wherein a lamp burned',[104] but the adjective 'illuminated' that is commonly used today captures the essence of the religious use of this type of clock. In this context, the night clock of the late-seventeenth century 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 3, 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. Touch-pins from the mid-sixteenth century to the early-seventeenth century also had a devotional use, as noted above, and the night clock conceivably provided a similar service during the late-seventeenth century 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 of sleep.[105] This act of private devotion during the night was 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

Fig. 4.7 *The Repentant Magdalen* by Georges de la Tour, Paris, c.1635–1640. Object no. A12399 (Photograph courtesy of the National Gallery of Art/NGA Images)

night clock in Fig. 4.2 are both indicative of the divine light that draws the eye and could bring the viewer one step closer to God.

The night clock did indeed have a religious origin. It was requested by Pope Alexander VII in 1655.[106] 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.[107] 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 contextualise 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, it is more likely that 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 in fact the result of a much larger issue of user reluctance to the new minute display as the discussion of it as a transition device to generate trust in Chapter **3** demonstrates.

For Brusa, as noted above, the decline of the night clock was a consequence of its high cost and that it was superseded by the quarter-repeat mechanism.[108] His argument is based 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".[109] 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…".[110] However, neither author commented on night clocks, which implies the claim that one function superseded another is based only on an approach that prioritises technical development. 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 inaccurately 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 at the same time,[111] suggesting that 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. Indeed, historians such as Robey are rightly sceptical that a half-asleep person would be able to keep track of the hour struck during the night.[112] 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 and would not wake others. Even if the quarter-repeat mechanism did supersede the night clock, it does not mean that we can simply 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. It was a symbolic and devotional tool as well as a practical 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 outlined above.

There were many reasons why the night clock disappeared from use. Users' needs for knowing the time in the dark changed, including for astrological purposes 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. Yet, 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 of use.

4.4 Conclusion

In this chapter, it was shown that dial formats were used to enable people who were otherwise excluded from using traditional dials. Touchpins and the illuminated night clock were two key examples in the period 1550–1770 which must be considered in terms of their contexts of use. Crucially, by employing the cultural approach to disability history, this chapter has demonstrated that dials played a vital role in the history of enablement devices. Returning to the overarching journey of dial development from the multi-function dials of the mid-late sixteenth century to the standard format dial that emerged in 1770, this chapter has revealed two aspects that help us to understand the complexities of this journey.

Firstly, this chapter has shown that format arrangements designed to enable users in the period mirrored perceptions of knowledge creation and transmission. The touch-pin of the mid-sixteenth century to the 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 when their lack of sides rendered them more challenging to use. This view was further supported by the 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 that would bring the user closer to God, 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. The illuminated night clock of the late-seventeenth to the 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 command of the night and a religious one in terms of assisting religious devotion during the night.

Secondly, the fluid boundary between dials and printed paper sources was evident in the illuminated night clock, which was demonstrated to be an aid to religious texts such as the earlier Books of Hours. They both figuratively and literally illuminated the hour. The comparison with the artwork in Fig. 4.7 helped to improve our understanding of this context of use. 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 seeds. Astrology was already in decline by this time, which is one reason 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. 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.

Notes

1. The term 'dis-abled' was deliberately chosen in order to distinguish it from 'disabled' to move the focus from the person to their environment according to the cultural view of disability.
2. The Braille reading system was not created until the early-nineteenth century and Braille dials were not common until the early-twentieth century.
3. David Thompson, *Clocks* (London: British Museum Press, 2004); David Thompson, *Clocks* (London: British Museum Press, 2004).
4. Eric Bruton, *The History of Clocks and Watches* (London: Little, Brown, 2000).
5. Brian Loomes, *Brass Dial Clocks* (Woodbridge: Antique Collectors' Club, 1998); Brian Loomes, *White Dial Clocks: The Complete Guide* (Newton Abbot: David & Charles, 1981).
6. Allison Hobgood and David Wood, eds., *Recovering Disability in Early Modern England* (Columbus: Ohio State University Press, 2013), pp. 3–11.
7. Yvonne Eriksson, *Tactile Pictures: Pictorial Representations for the Blind 1784–1940* (Acta Universitatis Gothoburg University, 1998).
8. Hobgood and Wood, p. 4.
9. Ibid., p. 5.
10. Robert Farlie, *Lychnocausia* (London, 1638).
11. Geffrey Whitney, *A Choice of Emblemes* (London, 1586).
12. Simone Chess, 'Performing Blindness: Representing Disability in Early Modern Popular Performance and Print', in *Recovering Disability in Early Modern England*, ed. by David Wood (Columbus: Ohio State University Press, 2013), p. 106.
13. Genesis 27: 1–40.
14. Chess, pp. 111–114.
15. Sally Wyatt, 'Non-users Also Matter: The Construction of Users and Non-users of the Internet', in *How Users Matter: The Co-construction of Users and Technology*, ed. by Trevor Pinch (Cambridge, MA: The MIT Press, 2003), pp. 67–80.
16. This is the horological term for the gearing that controls the striking of the hours in the clock or watch mechanism.

17. For example Musée du Louvre object number OA.8282.
18. Clutton, C., ed., *Britten's Old Clocks and Watches and Their Makers*, 9th ed. (London: Bloomsbury Books, 1990), p. 41.
19. Granville Hugh Baillie, *Watches: Their History, Decoration and Mechanism* (London: N.A.G. Press, 1929), p. 59.
20. Baillie, p. 41.
21. Ibid., p. 59.
22. For another example see British Museum object number 1989,0914.1.
23. Glennie and Thrift inform us that most early modern clocks were located in the bedroom, hallway and kitchen. Paul Glennie and Nigel J. Thrift, *Shaping the Day: A History of Timekeeping in England and Wales 1300–1800* (Oxford: Oxford University Press, 2009), p. 174.
24. Thompson, *Watches*, p. 15.
25. Ibid., pp. 16; 22; 28.
26. For example the dial shown in Fig. 6.1, British Museum object number 1958,1006.2105 and Musée du Louvre object number OA.8397.
27. For example British Museum object numbers 1888,1201.150 and 1958,1201.2203.
28. There is perhaps one exception which is the indication of high tide in the late-seventeenth century.
29. Eriksson, pp. 21–22.
30. See Jan Lievens, *Scholar at Desk*, Musée des Beaux Arts Montreal object number 2012.50.
31. Arthur K. Wheelock Jr. and Stephanie Dickey, *Jan Lievens: A Dutch Master Rediscovered* (New Haven, CT: Yale University Press, 2008), p. 120.
32. Ibid., p. 7.
33. Ibid., p. 164.
34. Ibid., pp. 186–187.
35. For example British Museum object number 1888,1201.103.
36. George White, *The Clockmakers of London*, 2nd ed. (London: The Worshipful Company of Clockmaker, 2018), p. 6.
37. As distinguished from public turret clocks.
38. Moshe Barasch, *Blindness: The History of a Mental Image in Western Thought* (London: Routledge, 2001), pp. 122–123.
39. Carla Mazzio, 'The Senses Divided: Organs, Objects, and Media in Early Modern England', in *Empire of the Senses: The Sensual Culture Reader*, ed. by David Howes (Oxford: Berg, 2005), p. 88.
40. Howes, p. 87.
41. Chess, p. 115.
42. Jusepe Ribera, *The Sense of Touch*, 1632, Museo Del Prado object number PO1112.

43. Alfonso E. Perez Sanchez and Nicola Spinosa, *Jusepe de Ribera 1591–1652* (New York: Metropolitan Museum of Art: Distributed by Harry N. Abrams, 1992), p. xii.
44. Ibid., pp. 97–98.
45. Georg Bartisch, 1535–1607, was a medical practitioner working in Germany.
46. Johannes Stradanus, active in 1590, was born in Bruges and moved to Italy.
47. Richard Banister, *A Treatise of One Hundred and Thirteen Diseases of the Eyes and Eye-Liddes. Translated from J. Guillemeau* (London: F. Kyngston for T. Mann, 1622).
48. Goerg Bartisch, '*Ophthalmodouleia Das ist Augendienst'* part translated in Richard Corson, *Fashions in Eyeglasses*, 2nd ed. (London: Peter Owen Ltd, 1980), p. 37.
49. William Rosenthal, *Spectacles and Other Visual Aids* (San Francisco: Norton, 1996), p. 40.
50. Margaret Cavendish, *The Description of a New World called The Blazing-World* (London, 1666).
51. Johannes Stradanus, *Nova Reperta*, p. 1590.
52. Alessandra Baroni Vannucci and others, *Stradanus 1523–1605: Court Artist of the Medici* (Turnhout: Brepols, 2012), p. 148.
53. George Wither, *A Collection of Emblems* (London, 1635).
54. Johannes Romberch, *Congestorium Artificiose Memorie* (London, 1533).
55. John Bunyan, *A Book for Boys and Girls or Divine Emblems* (London, 1686).
56. Translation kindly provided by Dr. Sophie Weeks, University of York.
57. Geraldine A. Johnson, *Renaissance Art: A Very Short Introduction* (Oxford: Oxford University Press, 2005), p. 78.
58. Eriksson, p. 21.
59. William Moon, *Light for the Blind: A History of the Origin & Success of Moon's System of Reading for the Blind* (London: Longman, 1873), p. 1.
60. D. V. Benito, *The Use of Spectacles* (London, 1623).
61. Petrus Apianus, *Cosmographia* (Vaeneunt G. Bontio: Antuerpiæ, 1550).
62. Christoph Luthy, 'Centre, Circle, Circumference: Giordano Bruno's Astronomical Woodcuts', *Journal for the History of Astronomy*, 41.3 (2010), pp. 311–327, 311.
63. For example British Museum object number 1888,1201.102.
64. For example British Museum object number 1958,1006.2105.
65. John Vicars and Wenceslaus Hollar, *A Sight of Ye Trans-Actions of These Latter Yeares Emblemized with Engrauen Plats Which Men May Read Without Spectacles* (London, 1646).

66. Richard Corson, *Fashions in Eyeglasses*, 2nd ed. (London: Peter Owen Ltd, 1980), p. 31.
67. For more information see http://www.college-optometrists.org.
68. Vincent Ilardi, *Renaissance Vision from Spectacles to Telescopes* (Philadelphia, PA: American Philosophical Society, 2007), p. 210.
69. Francis Wadsworth, 'A History of Repeating Watches Part 3', *Antiquarian Horology*, 5.2 (1966), p. 364.
70. Until the braille watches which became popular as an item of adaptive technology during the early-twentieth century and were routinely provided to injured servicemen in the First World War.
71. Giuseppe Brusa, 'Italian Night Clocks', *Antiquarian Horology*, 9.2 (1975), p. 167.
72. David Thompson, *Clocks* (London: British Museum Press, 2004).
73. Clutton, p. 103.
74. Allison Hobgood and David Houston Wood, eds., *Recovering Disability in Early Modern England* (Columbus: Ohio State University Press, 2013), p. 5.
75. David Christianson, *Timepieces: Masterpieces of Chronometry* (Newton Abbot: David & Charles, 2002), p. 9.
76. Ibid., p. 118.
77. Miller Christy, *The Bryant and May Museum of Fire-Making Appliances* (London: Bryant & May Ltd., 1926). See entry for Dowler's nocturnal vesta.
78. Diary of Samuel Pepys 24th June 1664, https://www.pepysdiary.com.
79. William Thomas O'Dea, *The Social History of Lighting* (London: Routledge & Kegan Paul, 1958); William Thomas O'Dea, *Lighting 1: Early Oil Lamps and Candles* (London: H.M.S.O., 1966).
80. Brian Bowers, *Lengthening the Day: A History of Lighting Technology* (Oxford: Oxford University Press, 1998).
81. Ibid., p. 16.
82. Oil lamps that produced much less light than candles would have been used by poorer households, but these were unlikely to have contained clocks or watches.
83. O'Dea, *The Social History of Lighting*, p. 1.
84. See Chapter 2 for a discussion of the implications of fire and candle light for dial contrast in the period.
85. William Thomas O'Dea, *Lighting 2: Gas, Mineral Oil, Electricity* (London: H.M.S.O., 1967), p. 2.
86. Gerrit Dou, *Astronomer by Candlelight*, c.1655–59, The J. Paul Getty Museum object number 86.PB.732.
87. See Chapter 7 for a discussion of the distinction between astronomy and astrology in the early modern period.

88. http://www.getty.edu/. See entry for *Astronomer by* Candlelight by Gerrit Dou.
89. Thompson, pp. 72; 78.
90. Brusa, p. 166.
91. Antoni Maczak, *Travel in Early Modern Europe* (Cambridge: Polity Press, 1995), pp. 41–44; 50–51; 54–62.
92. Craig Koslofsky, *Evening's Empire: A History of the Night in Early Modern Europe* (Cambridge: Cambridge University Press, 2011).
93. Ibid., p. 6.
94. O'Dea, *The Social History of Lighting*, p. 21.
95. Andrew Boorde, *The Boke for to Learne a Man to Be Wyse in Building of His Howse for the Health of Body* (London, 1550).
96. Francis Quarles, *Wisdom's Better Than Money or The Whole Art of Knowledge and the Art to Know Men* (London, 1698).
97. Ibid.
98. Koslofsky, p. 1.
99. Ibid., pp. 1–5.
100. Roger Lowe and Ian G. Winstanley, *The Diary of Roger Lowe of Ashton-in-Makerfield, Lancashire, 1663–1678* (Wigan: Picks, 1994), p. 80.
101. Ibid., p. 134. The clock is described simply as one clocke weights and case.
102. http://www.nga.gov/. See entry for *Repentant Magdalen* by Georges La Tour.
103. Quarles.
104. Diary of Samuel Pepys 24th June 1664, https://www.pepysdiary.com.
105. Koslofsky, p. 75.
106. Brusa.
107. Ibid.
108. Ibid.
109. John Smith, *Horological Dialogues* (London, 1675).
110. William Derham, *The Artificial Clock-Maker* (London: James Knapton, 1696).
111. For example British Museum object number 1958,1006.2143.
112. John A. Robey, 'Who Invented Rack-and-Snail Striking? The Early Development of Repeating and Rack Striking', *Antiquarian Horology*, 28.5 (2005), p. 585.

CHAPTER 5

Calendrical Insight

> The winds now are cold, and the Ayre chill, and the poore die through want of Charitie: Butter and Cheese beginne to rayse their prices, and Kitchen stuffe is a commoditie, that every man is not acquainted with.
> Nicholas Breton, *Fantasticks: Serving for a Perpetuall Prognostication*, 1626[1]

5.1 Introduction

When Nicholas Breton described the month of November in these terms, he not only prompted the reader to consider the approaching bitterly cold winter weather, but also provided a brief insight into the challenges faced by people in the early modern period which may have served as a reminder of issues of concern. The month of November is similarly indicated on the month index of the dial shown in Fig. 5.1. This watch was made in the same period in which Breton wrote his prognostication and gives an insight into its context of use. Calendrical indications on clock and watch dials enabled users to attain calendrical insight and apply it in their everyday lives. This was a form of insight in that it played a role in people's development and use of an accurate and deep understanding of the calendar, in terms of individual days or dates and in terms of calendrical sequences and combinations which the dial provided in diagrammatic, pictorial and numerical form. The way in which calendrical information was represented on dials changed over the course of the period 1550–1770 which was the result of changes in the

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_5

Fig. 5.1 Pocket watch by Nathaniel Barrow, London, c.1653–1660. Object no. WCC.60 (Photograph courtesy of the Worshipful Company of Clockmakers and Tony Gray)

wider context of ideas, evident in almanacs, mnemonic and astrological works. The representation of lunar and astronomical content on dials also changed in this period, but in a different way and it is only through a focus on use that these differences can be revealed.

From the mid-sixteenth up until the mid-late seventeenth century, the user of a multi-function dial such as that shown in Fig. 5.1 which was made by Nathaniel Barrow in London 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. While some dials continued to be made with this singular calendrical indication, the standard format which emerged by 1770 did not include any kind of calendrical information.

Combinations of calendrical information consisted of different levels of calendrical detail which were the various calendrical cycles within the larger cycle of a calendar year. Throughout the period, this included: periods of the day; the seven days of the week; day of the month; the twelve months (both civil January to December and zodiac Aquarius to Capricorn); the four seasons; the Golden Number[2]; Epact[3]; and the Dominical Letter.[4] The lunar calendar is considered in detail in Chapter 6. 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. Due to their focus on precision timekeeping, 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 in the period. Bruton[5] and others[6] have inadvertently marginalised the calendar function because different contexts of use were beyond their scope. A reinterpretation of the calendar function within the wider context of printed calendars from the period is vital for understanding changes in multi-function clock and watch dials during the period.

The work initiated by book historians who have concentrated on the calendar such as Richards[7] in combination with the work of historians of astrology such as Curry,[8] of memory such as Rossi[9] and the work of historians of early modern science such as Henry[10] provides a useful foundation on which a deeper discussion of the calendar function can be built. The calendar function on clock and watch dials was a temporal locating device, and this chapter utilises the dial shown in Fig. 5.1 as a point of reference, in comparison with other examples, for discussing the changing context in which it was used. The complexities of this journey are best explained by dividing the discussion into two parts, the first of which considers the different calendrical indications within the context of astrology and mnemonics. In the second part, the focus shifts to an exploration of the decline of astrology and mnemonics and the contexts of use for those calendrical indications that survived.

5.2 Astrological and Mnemonic Use

The calendar function is best understood with reference to the dial shown in Fig. 5.1, which will be returned to regularly throughout this section, the content of which was typical of multi-function dials from the late-sixteenth to the mid-late seventeenth centuries. Comparison with other dials will be made as the discussion progresses. As noted above, the calendar function served as a temporal locating device for users. Initially, there were five levels of calendrical detail on multi-function dials, referred to from here onwards 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 essential, and generally disappeared from dials. Some, however, remained important as locating 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 centuries was unique, in terms of astrological practice. Users could temporally locate themselves in terms of the day or month according to the astrological advice that they had 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 the advice read previously meaningful.

Curry,[11] Dear,[12] and Perkins[13] rightly agree 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 centuries. This would have included the wealthy owners of clocks and watches, identified in Chapter 1. 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.[14] This last point suggests that the two could be separated and is therefore not as convincing as that made by Dear[15] and Curry,[16] who emphasise that astronomy and astrology were not distinguished from each other in the early modern period as they are today. However, in terms of her first point about the connectedness of calendars and astrology, dials provide further evidence of this statement's validity. Representation of calendrical information on instruments and in printed paper sources in the early modern period, specifically before the

mid-late seventeenth century, must be interpreted as bearing relation to astrological concepts. In the period up to and including the early-seventeenth century, these calendrical indications should also be seen as potentially serving a mnemonic purpose for users and readers given the extent of works on the art of memory which drew on familiar ideas and practices for its imagery, including astrology.

As noted above, 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, which had been 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 source for the use of calendrical information for astrological purposes and they bear similarities with dials. Furthermore, it is also noteworthy that sixteenth-century and seventeenth-century almanacs were very similar in form and content across Europe as were clock and watch dials.[17]

Timepieces and almanacs shared combinations of calendrical information.[18] These combinations were an integral part of all almanacs and played a crucial role in the making of prognostications in those published before the mid-late seventeenth century. This suggests 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.[19] For many users, clock and watch dials with calendar function must also have been 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,[20] Henry,[21] and Tester[22] 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 appears to have been: the period of the day, day of the week, month of the year, and day of the month, all of which except period of the day can be seen in the dial shown in Fig. 5.1.

Rossi states that in the sixteenth century an effort was made by some writers to categorise the different 'arts',[23] as noted in Chapter 2. 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. While they cannot be separated as such, they deserve investigation, and in the manner of Rossi's categorisation, each one is examined in turn before returning to the whole.

5.2.1 Period of the Day

Some multi-function watch dials from the mid-sixteenth to the very early-seventeenth centuries indicated the period of the day along with several other calendrical cycles.[24] Temporal references in almanacs, diaries and literary narratives of the period demonstrate that the day was understood and routinely described in terms of six divisions: dawn, morning, midday, mid-afternoon, evening and night. This division was conceivably a remnant of the canonical hours, which appeared in Books of Hours[25] and divided the day into eight for the purposes of prayer: matins, lauds, prime, terce, sext, none, vespers and compline. On dials, the indication was usually achieved using an aperture which revealed either an image and a word, such as a figure holding a torch and the word 'nox',[26] or a symbol, such as the planetary symbol for Venus,[27] which was associated with a particular part of the day. Critics might argue that the indication of period of the day could not have served a practical function, given that the user must have been aware of what part of the day it was. However, in addition to a religious use 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 Thomas 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 imagine a user with a multi-function watch planning to leave the house 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 remember the weather change that was to be expected in the early morning.

While this calendrical indication clearly had its own purpose, or secondary use, its primary astrological use is best understood within the context of the wider combination of which it was always a part. It was invariably 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 some advice they had read in their almanac while away from the house or to say particular prayers. In the example of a watch[29] that represented 'night', it could be imagined that the period-of-the-day indication completed the combination as a mnemonic device. Thus, the autumn night of Saturday 3rd September, for example, may have been ascribed an additional meaning in the almanac for that year, for example a weather change or a particularly lucky day. Similarly, the example of watches[30] that represented the ruling planets of the periods of the day, such as Venus, 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, a consideration of mechanical timepieces helps to progress our understanding of the relevance of the calendar to early modern astrological practice. The example of the Venus indication, referred to 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 opportunity to perform any tasks that might have been negatively affected by Saturn or Mars during other periods 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. This may have been one of its secondary uses, but the primary use was more likely to have been astrological and mnemonic. The watch is a working, mechanical instrument and offers new symbols in the aperture throughout a given day, but times of sunrise and sunset are presented to the user of an almanac for reference at any point. They are provided in advance, and although they vary each day, they do so according to a pre-calculated cycle. Thus, rather than acting as a cue for the times of sunrise and sunset, the appearance of the indication on a dial suggests that it was conceivably a prompt for astrological advice. Furthermore, watches which represented images or planetary symbols for the period of the day were providing users with powerful images and

symbols to associate with other facts and concepts read in the almanac or elsewhere, as discussed in Chapter 2. In this role, they were part of the mnemonic tradition, supporting and expanding 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 a more common element of seventeenth-century calendrical dial combinations and was present on both clocks and watches. It was noted above 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 lends further support to this claim. The astrological week, similarly to the period of the day, was one of these concepts. Blackburn and Holford-Strevens, whose sole focus is 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 understanding can be expanded by considering the example of a watch that represents the day of the week using both its name in Latin and a stylised version of the planetary symbol for Mercury.[35] This dual representation makes the influence of Mercury on Wednesday clear for its user. Located at the top of the dial on this example, it is a strong reminder for the user to think about the effects of Mercury's influence on this day.[36] Given that Mercury was known to early modern users through their interest in Ancient Rome as the bearer of news and protector of travellers,[37] a user of this watch may have expected news or a safer journey than the previous day.

O'Neil informs us 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.[38] While O'Neil bases his claim on print, this view can be strengthened with reference to material evidence in the form of clocks and watches to demonstrate the ways in which this idea continued to be transmitted and experienced in the first half of the seventeenth century. Blackburn and Holford-Strevens go through each day of the week referencing examples of what made particular days lucky or unlucky.[39] 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 on some occasions and unlucky on others.[40] Clearly, there was a great deal to remember and the sixteenth-century 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 historians such as Landes,[41] representation of planetary symbols was merely a decorative feature with no significant meaning. They were indeed beautiful elements of the dial, but Landes' view is not convincing given the astrological context of which they were a part and cannot be divorced from. The decision taken by Barrow, the maker of the dial in Fig. 5.1, to symbolically represent Tuesday with a young man wearing a helmet, carrying a shield and holding an edged weapon, indicative of Mars the god of War,[42] and the planetary symbol for Mars in addition to the word 'Tuesday', which would have been sufficient for purely indicating the day of the week in civil calendar 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 Mars as the ruling planet of Tuesday, considered to be an unlucky day,[43] which astrologically speaking exerted a harmful influence.[44] The representation of an image of violence was also useful in terms of the art of memory. It may have prompted the user to be wary on that day and to delay important or risky tasks to another day. They may also have assigned additional meaning to it, a use of symbols within the art of memory as discussed in Chapter 2.

Where planetary symbols, without accompanying pictorial representations, indicated days of the week on dials,[45] it was invariably 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 temporal scope of Richards' notion that two calendars, in his example the liturgical and lunar, were often used simultaneously in the medieval period.[46] 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

fairs of Europe such as Frankfurt, as noted in Chapter 1. Similarly, they may have been useful for those who struggled to read without spectacles in this period.[47]

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 indicated on the dial. In sixteenth-century 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 shown in Fig. 2.4. 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.[48] Nevertheless, the presence of the planetary symbol on the dial adjacent to text[49] 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 was 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 explanation, 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 issue of 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 differs from the date Perkins suggests. Yet, there were a few rare exceptions of dials made in the mid-eighteenth century that represented the planetary symbol next to the name of the day of the week.[52] Nevertheless, this change is indicative of a fading awareness of astrological terminology among the population from the mid-late seventeenth century, which became outdated by the end of the eighteenth century. 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 into the eighteenth century.[53] 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 run the risk of enduring bad luck by ignoring them. In this sense, the dials enabled such users in the mid-late eighteenth century to mitigate against perceived risk. In one sense, this was similar to the experience of those late-seventeenth-century users who were reluctant to accept the new minute indication, as discussed in detail in Chapter 3, and reveals a further aspect of the influence of users' emotion on dial design.

5.2.3 Zodiac and Civil Months

It was noted above that whereas most people take the civil calendar for granted today as the only calendar worth referring to, people in the early modern period lived with different calendars. The distinction between zodiac and civil months did not complicate everyday life, but instead acted as separate calendrical locating co-ordinates.[54] Some calendrical combinations on multi-function dials included the indication of months of the year using zodiac symbols, which demonstrates their astrological application. In Samuel Foster's *Elliptical or Azimuth Horologiography* of 1654,[55] he described how to make a timepiece. On the subject of calendrical detail, he wrote 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 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 view is strengthened by the absence of eighteenth-century examples despite there being rare instances of day-of-the-week indication by planetary symbol, as noted above.

Some dials on sixteenth-century clocks represented the months of the year using only zodiac symbols on one of the concentric rings or on a subsidiary dial.[57] This clearly demonstrates 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 relatively rare. It was more common for the zodiac calendar to be represented alongside the civil calendar (see Fig. 1.1). The user of this dial, on the other hand, could cross-reference between the zodiac months and the civil months. In this example, the two sets of months are arranged in an offset manner

to indicate their relationship. This trend in representation is similar to that identified above with the planetary days of the week. In his extensive 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.[58] 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.

Returning to the watch shown in Fig. 5.1, the month of the year is represented on the second and third outermost concentric rings using a stylised zodiac image on one ring, followed by the name of the month in shorthand on the next ring. March, for example, is represented by an image of a ram and the word 'Mar'. On this dial, the signs of the zodiac have been assigned to each month, whereas they are traditionally offset to represent the relationship between the two calendars, as in Fig. 1.1. Examples such as Fig. 5.1 are convincing evidence of users thinking of the zodiac and civil months as interchangeable. On the other hand, examples such as Fig. 1.1 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 (quarters of the year 1–4, the seasons, and corresponding zodiac months) in tabular form in Robert Recorde's *Castle of Knowledge*[59] conceivably had a mnemonic use in situations 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 for the index on a dial was solely to aid legibility. Proponents of this view might also cite 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…."[60] This would be true of the examples where the zodiac months are represented on their own, but not in the example of Fig. 5.1 where the name of the month is represented alongside the stylised zodiac 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* in 1556, as

a part of a genre of books that were intended to be accessible to students and others, which makes his work valuable for understanding ideas in the mid-sixteenth and early-seventeenth centuries, 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…."[61] 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 offset indices on some dials. Nevertheless, they continued to be used as if they did line up 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 into groups according to the seasons of the year. Recorde's table, cited above, explained the relationship between the signs of the zodiac and the seasons. William Johnson's almanac shown in Fig. 5.2, which was typical of European almanacs of this period, 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 similar combinations of calendrical representation were equally useful within 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 into action or to referring to their almanac. George Hawkins' almanac of 1624, for example, was typical of late-sixteenth-century and seventeenth-century almanacs in its prediction and description of the seasons. He predicted that the summer of 1624 would begin on: "…the 11 of June, at two of the Clocke, 52 minutes, 4 seconds after noone…" and the weather would be hot and dry.[62] It is noteworthy that Hawkins' almanac was also produced in the same period as the watches which represented the seasons.[63] Some dials represented the season of the year by its Latin name, for example 'autumnus', beside a stylised picture representing that season.[64] These kinds of dials would have been useful as a prompt to refer to what the almanac

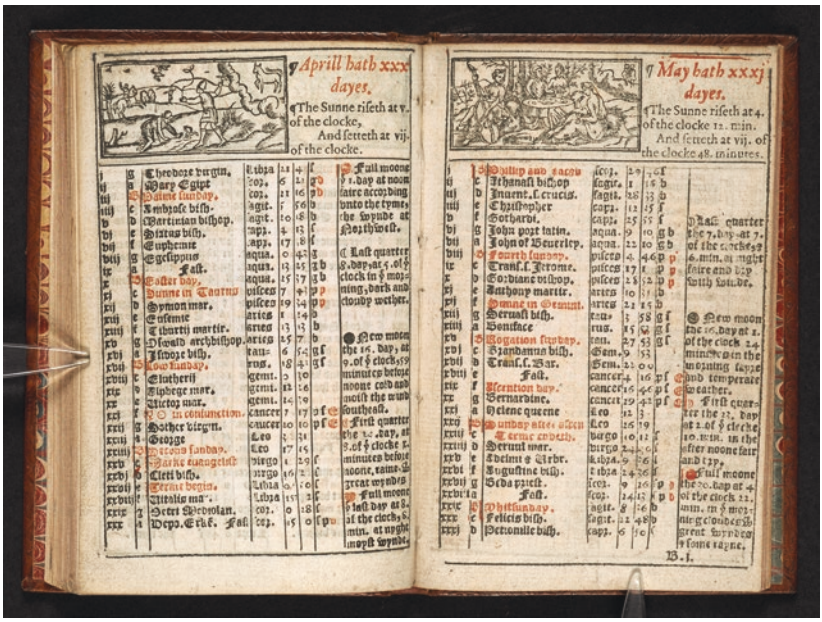


Fig. 5.2 *A New Almanacke and Prognostication* by William Johnson, 1569 (©The British Library Board (C_194_a_870_(2)_fbir))

advised concerning the season that year. It was noted in Chapter 2 that the symbols and images which characterised late-sixteenth-century mnemonic works were intended to veil secrets from the vulgar[65] and dials may have been a part of this, given their cost and possession by the wealthy. Almanacs and dials drew on a shared calendrical language and both played a role in cementing the convention. It was not the recognisable symbols that veiled secrets, it was combinations of them.

5.2.4 Calendrical Combinations

Calendrical indications were an important layer of the information hierarchy discussed in Chapter 2. The mechanical manifestation of combinations of calendrical information 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[66] by introducing clocks and watches to the discussion. The number of calendrical co-ordinates in Hawkin's almanac in Fig. 2.4 is very similar to dials such as Fig. 5.1. Both present the three co-ordinates of day of the week, month of the year and day of the month. Those dials which indicated seasons had a fourth co-ordinate in common with the almanac. 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 required to make plans for the day, week or month ahead.

Calculations based on the combinations of information were important for astrological predictions. 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.[67] 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-century and seventeenth-century examples, were reminiscent of the astrological horoscope. Calendrical information provided the location co-ordinates for both. In horoscopic diagrams of the period, the central box contained a summary, but with the dial, such as that shown in Fig. 5.1, the central summary took an invisible form and was constructed in the user's mind. The user 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 the next day or in a few months' time.

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 6, 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 three or 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. In Hawkins' almanac, there was a summary page of weather predictions in tabulated form, based on the astrological principle that the planetary aspects determined the weather.[68] 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…."[69] and then the reader was expected to cross-reference the conjunction with the data contained in the table in order to determine what the weather would be on 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 or estate manager 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 or estate manager to carry out tasks on the land. The almanac was a resource that needed to be renewed each year, whereas the timepiece was intended to be permanent, as long as it was serviced regularly. The calendar function on dials was undoubtedly a very aesthetically pleasing feature. Yet, 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 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.

5.3 Beyond the Decline of Astrology

> 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.[70]

This passage from John Smith's *Horological Dialogues* of 1675 epitomises 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 to include 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 of course have contained additional 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[71] until 1727.[72] 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 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.[73] 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 the indications they wanted and could make most use of.

Both dials and almanacs underwent change during the late-seventeenth and early-eighteenth centuries, 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….[74]

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' reveals 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 appeared 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. Criticism is very rarely offered if the object of that criticism no longer exists.

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.[75] There were indeed slight format changes, as demonstrated in Chapter 2, 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 in the early-eighteenth century.[76] 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.

Furthermore, when the new white enamel dials began to replace metallic dials from the early-eighteenth century, calendrical information continued to be included. This is a good example of a type of dial that was modernised aesthetically, but its calendar function continued to follow the prevailing trend and its format echoed an older tradition.[77] In this sense, it underwent aesthetic change, leaving behind the useful content. The three-part combination differs from the dials discussed above in its representation of information. This form of calendrical indication occurred after the decline of the four- or five-layered calendrical tiers 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 for the names of the months.[78] This trend was not unique to dials; non-mechanised instruments also reflected this practice. In perpetual calendars, made up until the mid-late seventeenth century, the calendrical units remained the same, but planetary symbols were only represented up until to the early-seventeenth century.[79]

Many late-seventeenth-century almanacs experienced a similar period of change between displaying a mixture of numerals, symbols and images and displaying almost solely numerical information. It was this change that was described in Chapter 2 as effectively creating a formatting change due to the overall appearance it created. Similarly to dials, this too was characterised by an absence of astrological reference points. The *Weaver's Almanac*[80] 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.

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 keyword 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. As people began to distance themselves from astrology, the religious and financial use of the calendar function continued to be important for clock and watch users and the indication also became important for the newly emerging uses relating to the reform of the calendar and increased precision timekeeping, which will be considered in turn.

5.3.1 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. It was a constant feature in contemporary literature and stage plays with references to key dates in John Donne's *Anatomy of the World*[81] and Ben Johnson's *Bartholomew Fair*.[82] The religious context of use was one of the factors which led to the survival of the calendrical function on clock and watch dials into the eighteenth century. Considered within the context of Richards' reminder of the trouble taken to backdate the Creation,[83] the presence of calendrical information on dials indicates a desire to not only locate oneself in the year, but also according to God's chronology. Richards provides motivation to consider 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.[84] 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 informs us was important in terms of political hierarchy and natural magic.[85] 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 appropriately observe these days. In Thomas Trigge's almanac of 1684,[86] for example, Palm Sunday and various saints' days could be read in the third column from the left. 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 civil and religious duties.[87] In this sense, the calendar function on a timepiece acted as a mnemonic device for religious observance. As mentioned in Chapter 2, 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[88] and, for many people throughout the period, the passing of time from one day and one month to the next would have had a strong religious association. 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 occurs 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 partaking in private worship or perhaps by visiting a nearby Church.[89] 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.[90] This three-staged transition called for cross-referencing between calendars in a similar manner to that mentioned in Chapter 3 when users such as travelling merchants cross-referenced between alternative hour schemes in use in different countries. Some astronomical clock dials made in the mid-eighteenth century included an outer annual-calendar ring on which was inscribed the main religious dates and an indication of Easter both according to the Julian

and the Gregorian calendars.[91] Such dials demonstrate the continued importance of knowledge of the liturgical calendar in the period and the potential for timepieces to make such indications. Even though such clocks were essentially astronomical clocks made for teaching within the context of the rise of public science, as discussed in Chapter 7, it is vital evidence of the perceived capability of clockwork. Provision of both the Julian and Gregorian calendars, referred to as 'Old Stile' and 'New Stile', respectively, on dials and almanacs, demonstrates that this was an important issue of the day.

The works of the clock-makers John Naylor[92] and Henry Jenkins[93] (discussed in more detail in Chapter 7) 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…"[94] Naylor's publication of 1751, *An Explanation of an Astronomical Clock*, was written as an advertisement to sell his astronomical clock 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….[95]

Again, the space he dedicated to the subject of Easter demonstrates its importance and relevance to users in 1751. That Naylor included indications according to both the Julian and the Gregorian calendars also demonstrates the impact of calendar reform 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.

5.3.2 Financial Use

Calendrical locating co-ordinates were used for noting important financial dates. This was a second 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 1, who needed to keep track of key 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 into decline, calendrical information was still used to organise personal financial affairs because of state-imposed deadlines such as those for the payment of taxes. From the late-seventeenth century and early-eighteenth century, almanacs such as John Playford's of 1687[96] 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 were: Lady Day on the 25th March, Midsummer Day on the 24th June, Michaelmas Day on the 29th September, and Christmas Day on the 25th December.[97] A dial with month and date indication would be invaluable here.

Blackburn and Holford-Strevens support the notion that these dates would have been very important to people.[98] Indeed, as can be seen from the evidence provided by annotated almanacs, users made notes about the exchange of goods and accounts paid. The user of a copy of Thomas Gallen's almanac, for example, recorded that on the 24th January 1642 they had received a delivery at their house for the price of forty pounds.[99] Evelyn also recalled using his almanacs to make notes

and that his father had done so too.[100] In works of literature and stage plays such as Ben Johnson's *Bartholomew Fair*, characters described marking key dates in their almanacs.[101] For the same reason as was noted for important religious dates, dials from this period could not present this level of information. However, the initial survival of calendrical locating co-ordinates such as month of the year and day of the month, and then later the single co-ordinate day of the month, is evidence that dials were used by their owners to locate themselves within the financial calendar. By doing so, 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 landowner, 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 the day before. 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 context and scope of application were reduced.

The second part of an instruction pamphlet that was possibly written by Thomas Tompion[102] offers an insight into 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*[103] 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. The author begins the 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 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.[104]

He then supplied a calculation 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 the 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,[105] may have been intended to be used for this purpose. He did not mention such pieces, but perhaps that is because they would have been very expensive in 1709, whereas this pamphlet costs 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 the pamphlet, and then was able to spend a few extra hours finalising a separate piece of business or relaxing at a nearby town rather than waiting on the river bank.

5.4 Calendar Reform

Travel in the user's own country required knowledge of the day of the month and month of the year for attending county fairs, meeting coaches, making river crossings and sending post,[106] 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 reform of the calendar, and the confusion and complications for business and travel that it caused,[107] conceivably acted as one of the catalysts for the development of the calendar function on dials from the late-sixteenth to the mid-eighteenth centuries. 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 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. Different calendars 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, Richard 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…."[108] 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…"[109] in which he listed the subject of each of the columns in the calendar pages. The calendar pages of almanacs often contained unlabelled 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".[110] 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 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 the number of calendrical indications on dials in the eighteenth century. There was confusion at first with several almanacs dedicated to addressing the changes.[111] The author of the *Companion to the 1752 Almanack* acknowledged the uneasiness that some people felt (probably because of the effect it had on the shifting of payment dates for taxes and other bills), but advised the reader that the knowledge required to understand why this change had taken place was above their understanding and that they should submit to the experts.[112] As the years passed, people became accustomed to it and no longer needed to make conversions. This is one reason why single items of calendrical information prevailed from the early-eighteenth century, but it is not the only reason.

5.5 The Influence of Precision

Increased precision not only influenced the dial through the introduction of minutes, as discussed in Chapter 3, 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 centuries.

The equation of time, discussed in terms of trust between maker and user through instrument in Chapter 3, influenced dials from the late-seventeenth to the mid-late eighteenth centuries. Authors such as Bruton inform us 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.[113] As Clay, the 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….[114]

In consequence, equation-of-time data were 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 Disquisitions* of 1694, Smith recommended the specific almanacs of George Parker and William Salmon.[115] 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.[116]

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.[117] The calendar function was not his focus so he does not comment on the significance of knowing these dates for its development. These four dates made knowing the day of the month important. Mid-late eighteenth-century dials whose only calendrical representation was the day of the month, even if manually adjusted by their users to account for leap years, were used with equation-of-time tables to assess the performance 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 5.3 is an example of a dial made by Ferdinand Berthoud in Paris which provided an annual calendar with equation-of-time representation, made in the mid-eighteenth century.[118]

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 with calendar function.[119] 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 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

Fig. 5.3 Equation clock by Ferdinand Berthoud, Paris, c.1752. Object no. 2016.28a-e (Photograph courtesy of the Metropolitan Museum of Art. Purchase. c.1752, Acquisitions Fund, and Annette de la Renta, Mercedes T. Bass, Beatrice Stern, Susan Weber, William Lie Zeckendorf, Alexis Gregory, and John and Susan Gutfreund gifts in honour of Mrs. Charles Wrightsman, 2015)

the Eastern Horizon shews his rising, and at going down below the Western Horizon, shews his setting…."[120] In this passage, Naylor did not explain the equation of time or why it is important, which is a contrast to Clay's *An Explanation of the Nature of Equation of Time* published twenty years earlier in 1731. Presumably, by 1751 more people had knowledge of the equation of time and it did not need the same level of explanation.

This also strengthens the 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 increasingly becoming 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 no longer have been useful for many of the earlier tasks discussed in this chapter,

but the rise of accuracy had ensured the survival of the 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.

5.6 Conclusion

In this chapter, it was shown that the calendar function on clock and watch dials acted as a calendrical locating device. Rather than providing new knowledge for users, it provided the insight necessary for users to locate themselves temporally in relation to important astrological, religious and financial events. There was a reduction in the number of co-ordinates that dials provided over the period. The calendar function developed differently in the period 1550–1770 than the lunar and astronomical functions that complete the content set. Returning to the overarching journey of dial development from the multi-function dials of the mid-late sixteenth century to the standard format that emerged from 1770, this chapter has revealed three aspects that help us to understand this multifaceted journey. Firstly, the fluid boundary between dials and printed paper sources is evident in the changing representation of the calendar function. The calendrical information represented on dials reflected the calendrical content of almanacs and mnemonic diagrams. Both used the same calendrical locating co-ordinates. 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.

Secondly, it has been shown that the calendar function was used for astrology in the period. 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. 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 calendar reform, and for financial and religious use. A 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, is further evidence that the decline in combinations of calendrical information presented on dials reflected the decline in astrology from the mid-late seventeenth century. By considering the effect of precision timekeeping, it was shown that the equation-of-time tables used for judging whether a timepiece was supposed to be running either too fast or too slow compared with 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 this, 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.

Thirdly, it has been shown that the emotions of users influenced the development of the calendar function. 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. Some users of sixteenth-century 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. The change from the Julian to the Gregorian calendar on different dates in Europe acted as both a catalyst for the development of the calendar function on the dial in the period up until 1752 and afterwards acted to slow its continued presence. 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.

Notes

1. Nicholas Breton, *Fantasticks: Serving for a Perpetuall Prognostication* (London, 1626).
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 to G, an ancient system where the 1st January was set as A enabling any Sunday of the year to be worked out quickly by consulting a calendar in which each date has been assigned a letter accordingly.
5. Eric Bruton, *The Longcase Clock* (London: Hart-Davis MacGibbon, 1976), pp. 104–111.
6. David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (London: Viking, 2000); Brian Loomes, *Brass Dial Clocks* (Woodbridge: Antique Collectors' Club, 1998); Brian Loomes, *White Dial Clocks: The Complete Guide* (Newton Abbot: David & Charles, 1981); David Thompson, *Clocks* (London: British Museum Press, 2004); David Thompson, *Watches* (London: British Museum Press, 2007).
7. Edward Graham Richards, *Mapping Time: The Calendar and Its History* (Oxford: Oxford University Press, 1998). And others such as Bonnie J. Blackburn and Leofranc Holford-Strevens, *The Oxford Companion to the Year* (Oxford: Oxford University Press, 1999).
8. Patrick Curry, *Prophecy and Power: Astrology in Early Modern England* (Cambridge: Polity, 1989). And others such as Bernard Stuart Capp, *Astrology and the Popular Press: English Almanacs 1500–1800* (London: Faber, 1979); Maureen Perkins, *Visions of the Future: Almanacs, Time, and Cultural Change 1775–1870* (Oxford: Clarendon, 1996).
9. Paolo Rossi, *Logic and the Art of Memory: The Quest for a Universal Language* (London: Athlone Press, 2000). And others such as Frances Amelia Yates, *The Art of Memory* (London: Ark Paperbacks, 1966).
10. John Henry, *The Scientific Revolution and the Origins of Modern Science* (Basingstoke: Palgrave Macmillan, 2008). And others such as Peter Dear, *Revolutionising the Sciences: European Knowledge and Its Ambitions 1500–1700* (Basingstoke: Palgrave, 2001); William Eamon, 'Technology as Magic in the Late Middle Ages and the Renaissance',

Janus, 70 (1983), pp. 171–212; Stuart Clark, *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe* (Oxford: Clarendon Press, 1997); Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science* (Cambridge: Cambridge University Press, 1982).

11. Curry, p. 3.
12. Dear, p. 18.
13. Perkins, p. 17.
14. Ibid., p. 14.
15. Dear, p. 18.
16. Curry, pp. 31–32.
17. Examples have been examined from France and Germany such as Anonymous, *Almanac Ou Calendrier Pour L'Annee 1693* (Paris, 1693); Anonymous, *Almanac Ou Calendrier Pour L'Annee 1693* (Paris, 1693).
18. Chapter 2 discusses the significance of the way in which information was arranged on dials and printed paper sources.
19. Perkins, p. 15.
20. Curry, pp. 7; 45.
21. Henry, *The Scientific Revolution and the Origins of Modern Science*, pp. 60; 116.
22. Jim Tester, *A History of Western Astrology* (Woodbridge: Boydell, 1987), p. 223.
23. Rossi.
24. See British Museum object numbers 1874,0718.23, 1888,1201.229 and 1888,1201.213.
25. For example, British Library Books of Hours Add MS 35318 and Harley 2924.
26. For an example, see British Museum object number 1888,1201.229.
27. For an example, see British Museum object number 1874,0718.23.
28. Thomas Stephins, *A Newe Almanacke and Prognostication for the Yeare of Our Lorde God, M.D.LXIX* (London: Thomas Marshe, 1569).
29. For example, British Museum object number 1888,1201.229.
30. For example, British Museum object number 1874,0718.23.
31. Michael Hunter and Annabel Gregory, *An Astrological Diary of the Seventeenth Century: Samuel Jeake of Rye 1652–1699* (Oxford: Clarendon, 1988), p. 260.
32. Ibid.
33. Yates, p. 378.
34. Blackburn and Holford-Strevens, p. 567.
35. For example, British Museum object number 1874,0718.21.
36. See Chapter 2 for an in-depth discussion of arrangements of information on dials and the hierarchical significance.

37. Lucia Impelluso, *Gods and Heroes in Art* (Los Angeles: Getty, 2002), p. 162.
38. W. M. O'Neil, *Time and the Calendars* (Sydney: Sydney University Press, 1975), p. 37.
39. Blackburn and Holford-Strevens, pp. 570–582.
40. Ibid., pp. 570–582.
41. David S Landes, *Revolution in Time: Clocks and the Making of the Modern World* (London: Viking, 2000), p. 139.
42. Impelluso, p. 148.
43. Blackburn and Holford-Strevens, p. 571.
44. Hunter and Gregory, p. 260.
45. For example, British Museum object number 1874,0718.21.
46. Richards, p. 6.
47. Discussed in detail in Chapter 4.
48. 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 in which each date has been assigned a letter accordingly.
49. See British Museum object number 1874,0718.21.
50. Paul Glennie and Nigel J. Thrift, *Shaping the Day: A History of Timekeeping in England and Wales 1300–1800* (Oxford: Oxford University Press, 2009), p. 174.
51. Perkins, p. 199.
52. For example, British Museum object number 1977,0702.1.
53. Peter Dear, *Revolutionising the Sciences: European Knowledge and Its Ambitions 1500–1700* (Basingstoke: Palgrave, 2001), p. 28.
54. The signs of the zodiac within the context of the astronomical function are considered in detail in Chapter 7.
55. Samuel Foster, *Elliptical or Azimuthal Horologiography* (London: R. & W. Leybourn, 1654).
56. Ibid.
57. See British Museum object numbers 1958,1006.2097 and WB.222.
58. Levinus Hulsius, *Vierdter Tractat Der Mechanischen Instrumenten* (Franckfurt am Mayn, 1615), p. 29.
59. Robert Recorde, *The Castle of Knowledge* (London: R. Wolfe, 1556).
60. Ibid., p. 29.
61. Ibid., p. 46.
62. George Hawkins, *An Almanacke and Prognostication 1624* (London: Printed for the Company of Stationers, 1624).
63. See British Museum object number 1888,1201.229.
64. See British Museum object numbers 1888,1201.213 and 1888,1201.229.
65. Rossi, p. 62.

66. William Eamon, 'Technology as Magic in the Late Middle Ages and the Renaissance', *Janus*, 70 (1983), p. 172.
67. Stephins.
68. Ibid.
69. Ibid.
70. John Smith, *Horological Dialogues* (London, 1675).
71. This date is based on his birth in 1647 and assuming he undertook a seven-year apprenticeship at the age of fourteen.
72. This was the year in which he died.
73. Smith, *Horological Dialogues.*
74. John Evelyn, *Kalendarium Hortense or the Gard'ners Almanac* (London: Jo. Martyn & Ja. Allestry, 1666), p. 5.
75. Bernard Stuart Capp, *Astrology and the Popular Press: English Almanacs 1500–1800* (London: Faber, 1979), p. 238.
76. For example, British Museum object number CAI.873.
77. For example, British Museum object numbers 1977,0702.1, 1988,1104.1 and CAI.873.
78. For example, British Museum object number 1958,1006.2102.
79. For example, British Museum object numbers 1888,1201.332 and 1891,0217.8 and Musée du Louvre object numbers OA.10694 and OA.10693.
80. Thomas Strutt, *The Weaver's Almanack* (London: R. Holt, 1688).
81. John Donne, *An Anatomy of the World* (London, 1611).
82. Ben Johnson, *Bartholomew Fair*, printed from the play of 1614 (London, 1631).
83. Richards, p. 11.
84. Ibid.
85. John Henry, *Knowledge Is Power: Francis Bacon and the Method of Science* (Cambridge: Icon, 2002), p. 55.
86. Thomas Trigge, *Calendarium Astrologicum* (London: J. Playford, 1684).
87. David Cressy, *Bonfires and Bells: National Memory and the Protestant Calendar in Elizabethan and Stuart England* (London: Weidenfeld and Nicolson, 1989), p. 1.
88. Giordano Bruno, *De la Causa, Principio, et Uno* (Venice, 1584). In later chapters, 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.
89. For more information on the way in which both Protestant and Catholic travellers engaged with religion while away from home, see Antoni Maczak, *Travel in Early Modern Europe* (Cambridge: Polity Press, 1995), pp. 222–236.

90. David Ewing Duncan, *The Calendar: The 5000-Year Struggle to Align the Clock and the Heavens* (London: Fourth Estate, 1998), pp. 289–317; Blackburn and Holford-Strevens, pp. 97; 862–867; Richards, pp. 352–353.
91. For example, British Museum object number 1985,1005.1.
92. John Naylor, *An Explanation of an Astronomical Clock* (London, 1751).
93. Henry Jenkins, *A Description of Several Astronomical and Geographical Clocks* (London, 1778).
94. Ibid.
95. Naylor.
96. John Playford, *Vade Mecum or the Necessary Pocket Companion* (London: Nath. Sackett, 1687).
97. Ibid.
98. Blackburn and Holford-Strevens, p. 588.
99. Thomas Gallen, *An Almanack and Prognostication for the Year of God 1642* (London: Rob Young, 1641).
100. David Loewenstein and Janel Mueller, eds., *The Cambridge History of Early Modern English Literature* (Cambridge: Cambridge University Press, 2002), p. 18.
101. Ben Johnson.
102. Thomas Tompion, *An Exact Measure of the Roads from Bath to London* (London: J. Good, 1709). The pamphlet consists of two pages. The first page is entitled *An Exact Measure of the Roads from Bath to London* and the second page is entitled *Directions for All Travellers & c. When to Pass Over at Aust and New-Passage, Between England and Wales.*
103. Ibid.
104. Ibid.
105. For example, British Museum object number 1958,1006.2078, which was made in the Tompion's workshop and Fitzwilliam Museum object numbers M.22–1947 and M.4–1965.
106. Playford.
107. 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, *A Companion to the Almanack for the Year 1752* (London: T. Jefferys, and W. Clarke, 1752); H. J., *The Pancronometer or Universal Georgian Calendar* (London, 1753).
108. Richard Saunders, *Apollo Anglicanus: The English Apollo* (London: A. Wilde, 1746).
109. Ibid.
110. Ibid.
111. H. J., *The Pancronometer.*

112. Anonymous, *A Companion to the 1752 Almanack*.
113. Eric Bruton, *The History of Clocks and Watches* (London: Little, Brown, 2000), p. 225.
114. F. Clay, *An Explanation of the Nature of Equation of Time* (London, 1731).
115. John Smith, *Horological Disquisitions* (London, 1694).
116. William Salmon, *The London Almanac* (London, 1694).
117. Thompson, p. 169.
118. Examples in other museum collections include British Museum Object number 1958,1006.2098 and Wallace Collection object number F271.
119. See British Museum object numbers 2010,8029.4, CAI.703 and OA.442.
120. Naylor.
121. The manner in which the equation of time was used to generate trust is discussed in detail in Chapter 3.

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]

6.1 Introduction

These words were written by the clock-maker John Smith in his *Horological Dialogues* of 1675. In this passage, in which he listed the various indications that clocks could make, the lunar function was listed as fourth in his hierarchy. It appeared after the 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 century 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 early watches and domestic clocks of the sixteenth century such as examples similar to that shown in Fig. 6.1, which was made by Jan Jansen Bockeltz who was originally from Aachen and later moved to Haarlem. It was also present some two hundred years later on longcase clocks such as the example shown in Fig. 6.2, which was made by Thomas Lister in Luddenden,

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_6

Fig. 6.1 Pocket watch by Jan Jansen Bockeltz, Haarlem, c.1605–1610. Object no. 17.190.1603 (Photograph courtesy of the Metropolitan Museum of Art. Gift of J. Pierpont Morgan, 1917)

Yorkshire. While to the untrained eye its representation may appear to have remained unchanged for over two hundred years, there were subtle differences which can only be explained with reference to the changing user context which was based on changing ideas and practices. The lunar function on dials developed differently in the period in comparison with the calendar and astronomical functions, and this was the result of the changing user context. Representation of the lunar phase was not part of the standard format which emerged by 1770, although the lunar phase did not disappear entirely and continues to be included on some dials as an aesthetically pleasing feature today.

Fig. 6.2 Longcase clock by Thomas Lister, Luddenden, 1718–1779 (Photograph courtesy of the Antiquarian Horological Society and Jeff Darken)

While an in-depth exploration of the lunar function has fallen beyond the scope of previous horological histories,[2] which have tended to prioritise precision timekeeping or aesthetic design, it is vital that the representation of the lunar phase on dials of this period is revisited. 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 several days each month, which was important throughout the period. Thus, knowing the phase of the Moon was immensely important. 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.[3] This was something people grew up with. The dial provided them with a prompt to recall the prior knowledge that was retained within the long-term memory.

This chapter will build upon the work of previous historians, for whom an in-depth analysis of the lunar function was beyond their scope. Historians such as Thompson comment on a particular clock using phrases such as 'clocks also have particular indications', but offer no further comment.[4] His use of the adverb 'also' places the lunar function further down the hierarchy of points that he perceived to be important, after the case and the mechanism. Bruton, writing specifically about longcase clocks in the period after 1657, is rare among authors of horological history in describing the provision of the lunar phase on longcase clocks as a service to users.[5] 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 without street lights, and as the provision of information on the best times to plant seeds or trees. The service it provided was as a technological aid for applying lunar wisdom, as will be demonstrated in this chapter.

Thompson's references to the lunar phase lack interpretive information on the significance of the lunar function and thereby unwittingly overlook its importance, which is the result of a lack of contextualisation of the function. By contextualising it in terms of related texts such as almanacs and craft books, it is possible to demonstrate the way in which lunar indications changed in the period under investigation and account for this change in terms of evolving 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.

There has been a lack of scholarly attention paid to perceptions of the Moon in the early modern period apart from works on astrology and fictional journeys to the Moon. The work of historians of early modern

science such as Henry[6] and others[7] provides a foundation for improving our understanding of the lunar function on clocks and watches within the context of early modern perceptions of the Moon. Similarly, the work of historians of astrology such as Curry[8] and others[9] provides a foundation on which our understanding of the astrological use of lunar wisdom can be better appreciated. This chapter also considers three additional ways in which knowledge of the Moon manifested itself in daily life during the period. The work of historians of the art of memory such as Rossi[10] and Yates[11] also provides a basis for discussing the connections between dials and mnemonic works in terms of lunar imagery.

The most effectual way to understand the changing application of lunar wisdom is through a consideration of the four main uses of lunar information represented on dials, each of which developed differently over the period 1550–1770, and will be considered in turn[12]: firstly, 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; secondly, 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; thirdly, 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; and fourthly, the renewed provision of times of high tide on dials. Not all of these uses were relevant to the entire period under discussion, some enjoyed a longer lifespan than others and some overlapped. It is for this reason that the lunar function developed differently from the calendar and astronomical functions.

6.2 Picturing the Changing Lunar Phase

People have represented the changing lunar phase pictorially for thousands of years. From ancient cave paintings, to Roman and Greek mythology, fascination with the Moon existed long before mechanical timepieces. It is unsurprising then that it was incorporated into many dials once visual displays of time were made possible. A striking feature of the changing face of time, the pictorial representation of the waxing and waning lunar face was present on many dials throughout the period, but not all, and crucially not on the standard format that emerged by 1770. Throughout the period, the lunar phase was often accompanied

by the numerical lunar calendar 1–29½ and, up until the early-seventeenth century, with the lunar aspect diagram, previously discussed in Chapter 2. Yet, 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-seventeenth century, the phase was almost exclusively represented with the face of the man-in-the-moon (see Fig. 1.1). Before this, it was sometimes represented as a plain disc or crescent[13] and most examples from the early-seventeenth century onwards featured the addition of stars to the background which had previously been blank.

It is clear from references to the Moon in works of literature, such as Shakespeare where the crescent is described as a silver bow that had been newly shaped in heaven,[14] pictorial representation in works of art, in printed paper sources and on clock and watch dials that the Moon had a spiritual significance. When artists, authors and clock- and watch-makers made decisions about how to represent the Moon pictorially, they were conveying both a religious feature of lunar wisdom and a lunar angle of their nascent scientific view to viewers, readers and users. For people in the early modern period, as had been the case since ancient times, the Moon was not just another part of the solar system as we might think of it today.

The lunar phase was used alongside calendrical information as a locating co-ordinate for determining the date of Easter, as discussed in Chapter 5, but the lunar phase had more of an association with religion than purely Easter. Indeed, the way in which the changing phase was represented on dials to replicate the perspective of the Moon as it is seen from Earth, as noted in Chapter 2, 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 correctly describes the late-seventeenth century as an age of questioning where many concepts, including traditional Christian ones, were being challenged.[15] However, 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. There was another discussion concerning the Moon which characterised the ways in which it was represented pictorially during the early-seventeenth to the late-eighteenth century, and it is partly with reference to this discussion that the lunar function on clock and watch dials should be reinterpreted.

This discussion concerned the possibility that the Moon was an inhabited place and was one that involved religion and nascent science and was represented in varying degrees on dials. Clock and watch dials specifically and mechanical devices more generally provide additional evidence in support of Henry's view that religion played a major part in the development of nascent science, despite the lingering view in the historiography that religion and science were opposed and incompatible.[16] 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.

The decision to represent the Moon on paper 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 drawings of the Moon featuring a human face appeared in medieval manuscripts.[17] Yet, their meaning in that period was allegorical rather than representing a statement about the God-created universe. This continued to be the case, and depictions of the man-in-the-moon were common in astronomical instruction works such as Petrus Apianus' *Cosmographia* in the sixteenth century where the phases of the Moon were explained using diagrams and images.[18] Clock- and watch-makers began to include a depiction of the man-in-the-moon on their presentations of the lunar phase during the late-sixteenth century (see Figs. 1.1 and 2.2). The representations of the plain Moon on dials, more prevalent earlier in the century, 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 late-eighteenth-century provincial longcase clocks (see Fig. 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 Fig. 5.2), whereas emblem books represented the face of the man-in-the-moon similarly to dials.[19] Yet, during the seventeenth century, there were abundant discussions about the possibility of inhabitants on the Moon and the man-in-the-moon began to represent these ideas.

Cressy correctly makes a link between early modern interest in the possibility of the inhabited Moon and the relatively recent geographical discoveries in America, Copernican ideas concerning the arrangement of the heavenly bodies and interest in the recent invention of the telescope.[20] The power of the telescope to reveal that which was previously unknown was demonstrated in 1610 by Galileo when he published his drawings of the lunar surface and its uneven terminator,[21]

which showed that it was not a flawless white orb, but a craggy, imperfect sphere.[22] Cressy says that people around this time became fascinated with the properties of the populated Moon, but while Cressy bases this on printed sources, his view can be used as a foundation for considering the influence on material culture. Clock- and watch-makers positioned themselves in this debate, either consciously by taking part in the debate or subconsciously by conforming to the prevailing trend, when they made dials with a lunar phase which included the man-in-the-moon. As Cressy informs us, despite some ridicule it was a subject that interested people at the highest levels of society, including senior clergymen,[23] and these were the kinds of people who could afford clocks and watches. To believe in the existence of an inhabited Moon was not thought to conflict with one's religious beliefs in the 1630s, whereas the rendering of the Moon as anything but a flawless orb had been met with some resistance in 1610. Indeed, it was thought by many 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.[24] Cressy identifies the active participants in the debate, such as John Wilkins[25] and Francis Godwin,[26] but does not consider the passive ways in which others may have contributed.

While the customers of clock- and watch-makers appeared to have little choice in terms of the way in which the Moon was represented, given the extant examples, they could choose whether or not to have a lunar phase represented as not all clocks and watches included the lunar function. The decision to own a clock or watch with the lunar phase, represented by the man-in-the-moon image, 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. Henry informs us that for seventeenth-century enquirers, nature was God's other book[27] and therefore to contemplate the Moon in this manner, using a clock or watch dial, was to come closer to God in the eyes of the user.

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-seventeenth century. This is further evidence that dial designs, similarly to printed

paper sources, transcended national boundaries in the period. There was no distinction to be made in terms of the lunar function 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 Académie des Sciences wondered whether sufficiently powerful telescopes could be constructed to see 'the reputed citizens of the Moon'.[30] Such was the continued interest, maintained through public concern with several eclipses, in this possibility that William Hogarth satirised the idea in 1724 when he created the print entitled *Some of the Principal Inhabitants of ye Moon*, which showed King George I, a bishop and other important individuals living on the Moon as if seen through a telescope.[31]

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 were the work of God, he said: "This induced me to make frequent digressions, and among others, the probability of an infinite number of habitable worlds".[32] Jenkins was very much part of the wider discussions taking place about the universe, as created by God, and it is significant that he chose to emphasise this in a work describing different clocks (discussed in more detail in Chapter 7). Although his is the only surviving record of a clock-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 (or have not survived). 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 Astrological and Mnemonic Use

The full title of William Johnson's 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".[33] Returning to the epigraph, it was noted earlier that had Smith been writing one hundred years earlier his reference to the Moon would have been further up the hierarchy of the list. Indeed, Johnson, in contrast, 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 demonstrated in Chapter 2, dials were a form of diagram or circular table similar to almanacs. Curry correctly says that the phases of the Moon were the basic component of astrology.[34] For Curry, it was important that the lunar phase was visible to the naked eye and did not require further calculation. This idea can be expanded by describing it as 'lunar wisdom', which is distinguishable from calendrical insight and astronomical knowledge. All three were used for astrology, but can be distinguished with reference to a comparison of clock and watch dials with printed paper sources.

The astrological and mnemonic use of information on dials is a recurring theme throughout this book, but the lunar function on clock and watch dials had a unique role with respect to astrology, which in terms of content must be interpreted separately from, but with reference to, the calendrical and astronomical functions. As mentioned earlier, the lunar function had a broader lifespan compared with the calendar and astronomical functions, which was due to its different context of use. Its use for astrology also had a different lifespan compared with the other functions, as its application to weather prediction was one of the elements that reformers of astrology in the late-seventeenth century concentrated on.[35] Whereas calendrical information on dials provided the calendrical insight users needed to temporally locate themselves according to astrological advice read in the almanac, as demonstrated in Chapter 5, lunar information on dials acted as a prompt for the pre-existing lunar wisdom that users possessed of the occult qualities of the Moon. This section thus contributes to the work of Henry who says that occult qualities were perceived as the influencing power of the heavenly bodies.[36] 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,[37] 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 into decline from the mid-late seventeenth century, which was due to continued use for other purposes. While the representation of the lunar phase itself changed very little in the period under investigation, there were subtle differences, which demonstrates the importance of contextualisation for understanding dials. Its inclusion on multi-function dials (see Fig. 6.1), which went into decline during the mid-late seventeenth century at a similar time to astrology, demonstrates the usefulness of the lunar function as part of a combination. It played a distinctive role within that combination.

There were three main astrological uses of lunar information derived from almanacs. These were weather prediction, health matters and farming. This approach expands the point made by Henry[38] and others,[39] who agree 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, clock and watch dials with the lunar function can be considered to be part of the natural magic tradition. This also expands the argument made by Eamon[40] and Dear[41] 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 components within the Great Chain of Being.[42] These three uses of lunar information on dials involved 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.[43] Whereas Eamon refers to nature generally, the specifics were the weather, health and farming for which the lunar function on dials was an aid.

6.3.1 Weather Prediction

Weather prediction in almanacs was based on the lunar phase and changed very little in the period from the mid-sixteenth century to the

mid-seventeenth century. Thomas Stephin's almanac of 1569 (see Fig. 6.3) advised its readers that: "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 weather, wynde southeast".[44] Henry 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…[45]

Sure enough Gregory 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

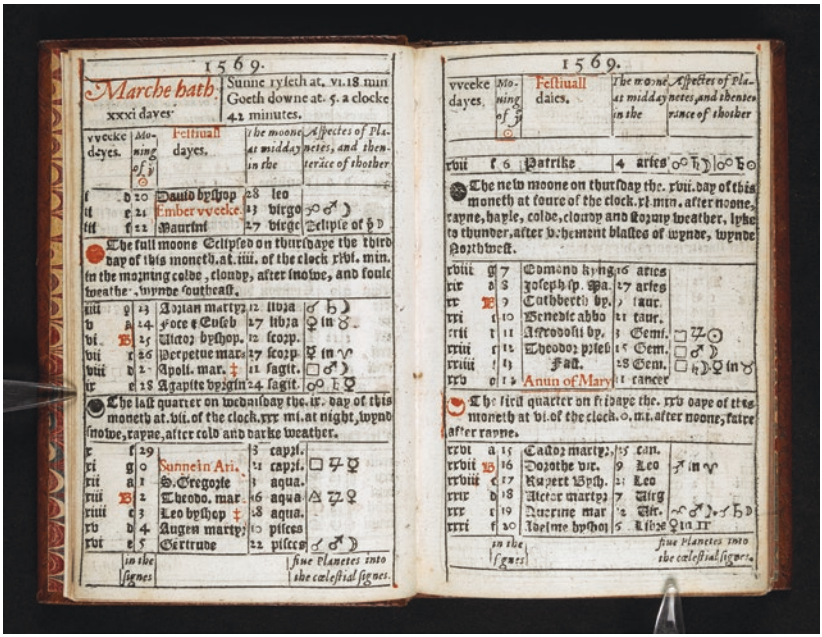


Fig. 6.3 *A Newe Almanacke and Prognostication* by Thomas Stephins, 1569 (©The British Library Board (C_194_a_870_(1)_March_1569_plate_xxxi))

> 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.[46]

Despite being written over fifty years apart, these three almanacs linked weather change to 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 the user was well disciplined, they 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 civil date and lunar date. Alternatively, a user could look at the Moon each night and anticipate the relevant quarter and the associated weather change. Yet, a user with a clock or watch dial such as that shown in Fig. 2.2, 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 described in the almanac, such as that shown in Fig. 6.3, with greater ease. The lunar phase on the dial was conceivably a prompt for thinking about the associated advice connected with the change of the Moon for those wealthy enough to own a clock or watch.

Lunar aspects were discussed in Chapter 2 in terms of the way in which the geometric shapes were part of the language of geometry and symbolism. Yet, they were also relevant for weather prediction in almanacs. Some multi-function dials from the mid-sixteenth century to the early-seventeenth century represented the lunar aspects in diagrammatic form on a central disc within the lunar calendar (see Figs. 1.1 and 2.2). While Rossi argues, as mentioned in Chapter 2, that symbols and hieroglyphs in late-sixteenth-century works were often intended to act as a veil to conceal secret knowledge from the vulgar,[47] 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 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…".[48]

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",[49] the anonymous author included rough notes on different clocks and watches that he was evidently working on. It would appear that these notes were related to timepieces that had been ordered by customers. The notes do not follow any particularly logical order 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 1 when discussing clock-makers, workshop notebooks are extremely rare for this period. As Evans informs us, virtually none have survived from the workshop of Thomas Tompion,[50] and he was England'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 connections between the change of the Moon and the weather, although the information was kept physically 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 happy both those who continued to believe in astrological weather advice and those who were by this time turning against it. Thomas Gallen's almanac of 1642,[51] an anonymous French almanac of 1693,[52] and Thomas Trigge's *Calendarium Astrologicum*[53] of 1747 all provided separate information about the age of the Moon and the weather, but did not connect the two.

Yet, weather prediction, as mentioned earlier, was one feature of astrology that reformers in the late-seventeenth century chose to emphasise in order to prevent its disappearance. John Goldsmith's almanac of 1733[54] continued to make weather predictions based on the phase of the Moon, similar to the early-seventeenth-century almanacs cited above, and people such as John Goad[55] attempted to rescue astrology by emphasising the importance of weather prediction over other facets such as the outdated judicial astrology. In this context, the lunar phase on dials continued to have an astrological use as a prompt for weather changes after the calendar and astronomical functions ceased to have an astrological use. 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…"[56] Smith's acknowledgement of the connection between the age of the Moon and changes in weather provides a direct link between makers, who were producing clocks and watches that presented lunar information, and the astrological use of that information, provided by almanacs and craft books of the period. Webster correctly claims that astrology was an adapting art,[57] and 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 component, as with all astrology, was more appropriately described in terms of decline rather than complete extinction.[58]

6.3.2 Health Matters

That which was referred to as 'physic' in early modern almanacs and craft books is called 'health matters' here, given that it related to physical bodily matters and not just medicines. While Tester correctly says that medicine and astrology were closely associated, his statement that this lasted as late as the seventeenth century[59] can be refined. This association in fact lasted up until the mid-seventeenth century.

Francis Bacon wrote in *Sylva 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 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.[60]

It is evident from his use of 'it is like' and 'it is like also' that Bacon knew he was not introducing new knowledge by saying that the Moon had this effect. 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 was considered highly in the medical faculties of the early modern universities.[61] This was by no means a preoccupation of the poor. It was something that many of the wealthy owners of clocks and watches also strongly 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 many 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.[62]

The user who could afford a multi-function clock or watch such as that in Fig. 1.1 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 Fig. 1.1 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 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 on the dial's zodiac index ring. 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 Fig. 1.1 would be useful in this context.

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 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 served purely an aesthetic purpose. In addition to almanacs, there were health-related pamphlets such as *A Treatise of 113 Diseases of the Eye*[63] and *Two Treatises Concerning the Preservation of the Eyesight*[64] 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 Fig. 6.1 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.[65] 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.[66] While Tester does not comment further on this scenario, this information on the lunar phase was surely supplied to the doctor as he would not 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 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[67] and Goldsmith's,[68] 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 phase of the Moon. By relegating the information to a column instead of a page, but not withdrawing it altogether, it is probable that he or his printers retained it to keep a portion of their readership happy. In the 1640s, there were still some people who believed in the traditional astrological principles, but they 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,[69] 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.

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 in Taurus 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.[70]

This was typical of the astrological advice provided by almanacs up until the mid-late seventeenth century.[71] Richard Allestree's almanac advised readers: "Gather Apples and other fruits, herbes, and flowers to have them in most beauty and greatest virtue, the moone at the full".[72] 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 mentioned in Chapter 1, the wealthy users of clocks and watches would have included the landed gentry and estate managers. 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 shown in Fig. 2.5 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,[73] though 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.

Almanacs were not alone. Craft books such as *the Husbandman's Practice* of 1664,[74] based on Thomas Tusser's handbook of 1557,[75] 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 gather, when Mighel is past".[76] 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.[77] Clock and watch dials both 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.[78] 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[79] and very likely bought these texts there and then used them for estate management at home. These were the same people who could buy multi-function clocks and watches with lunar indications.

By the late-seventeenth century, some almanacs, such as William 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.[80] Unlike the almanacs mentioned above, there was no mention of the Moon. The multi-function dial, such as that shown in Fig. 2.5, in use between the mid-sixteenth century and the mid-late seventeenth century, had also gone into decline. The lunar function remained on some dials (see Fig. 6.5) which were 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. Yet, all of the different types of astrological advice discussed here 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 assume it into the realm of nascent science. Goad, writing just three years after Dade, not only continued to make the connection 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…".[81]

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.[82] However, the lunar phase continued to be represented on clock and watch dials as it was useful throughout the period for other purposes.

6.4 Illuminating the Night

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 earlier, 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 the introduction of artificial street lighting. This meant that it continued to be used in the

countryside for a little longer than it did in the city. The way in which some dial formats enabled users during the dark inside the house was discussed in Chapter 4, but in this chapter, we focus on how dial content enabled users to plan journeys. Although historians such as Bruton[83] and Uglow[84] have casually referred to the potential of the lunar function to be used to plan travel at night, none have based this on referenced evidence. For them, it was a common-sense argument, which, while logical, is insufficient for understanding the lunar function on dials. A more in-depth focus on this context of use can be provided by comparing dials with printed paper sources in order to improve our understanding of the user experience.

Henry 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.[85]

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 of almanacs was acknowledged by Perkins,[86] but she too skimmed past it quickly. 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 that 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 Fig. 6.2).

In the absence of street lighting, moonlight, particularly on the night of the full Moon, was extremely helpful 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".[87] This statement demonstrates that Pepys and many others in this period were able to extend their visits on nights that were moon-lit. It was also important for conducting certain activities such as harvesting crops hence the term 'harvest Moon' the full Moon nearest the autumn equinox, which increases in brightness by up to 30% from the preceding day.[88] Undertaking agricultural activities under the light of the full Moon so that people could see what they were doing was different from undertaking them due to a belief that the activity would be more successful because of the influence of the Moon on that activity, as discussed earlier.

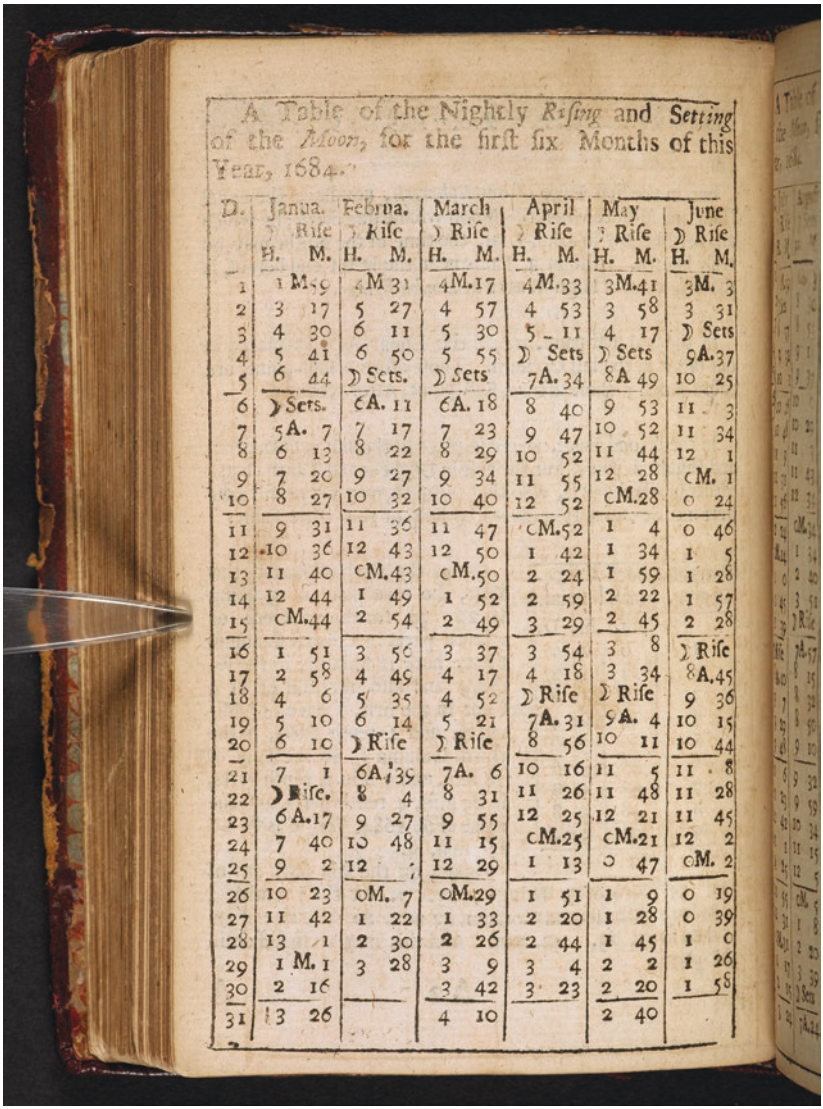
Information on the duration of moonlight on a particular lunar date was extremely widespread. Craft pamphlets, in addition to almanacs, often included a diagram of the duration of moonlight such as Levinus Hulsii's *Vierdter Tractat* of 1615.[89] In this context, it is easy to understand why dials with 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[90] represented the hours of moonlight using a similar diagrammatic form of representation to that which featured in craft books of the period such as Leonhard Zubler's *Beschreybing dess Astronomischen Instruments* of 1614–1615. It consisted of three concentric rings with the lunar date on the outside, followed by an hour ring and a minute ring on the inside, across which a user could read that on the sixteenth day of the lunar calendar, the night of the full Moon, the duration of moonlight will be twelve hours and zero minutes, for example.[91] 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. Such dials served 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 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, sharing news about 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".[92] 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 significant also that by 1606, a 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 suggestive of a mechanical timepiece.

Although multi-function dials were important, those which solely 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 dials of the first domestic bracket clocks[93] and some late-eighteenth-century examples.[94] 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, was so named because they met on the night of the full Moon so that members could easily travel home afterwards.[95] 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 Fig. 6.2 was made in Luddenden, Yorkshire, a rural area similar to that in which members of the Lunar Society lived. It could easily be imagined that their members owned clocks such as this one and that people in Luddenden used it to plan their evening travel.

Dials were not alone. Almanacs throughout the period often included a data table of the times of the Moon's rising and setting (see Fig. 6.4). Indeed, the subject even took the interest of the natural philosopher, James Ferguson, who provided: "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".[96] Ferguson's provision of such extensive temporal parameters was intended to demonstrate the versatility of his method, but also demonstrates that people wanted



A Table of the Nightly *Rising* and *Setting* of the *Moon*, for the first six Months of this Year, 1684.

D.	Janua. ☽ Rise H. M.	Februa. ☽ Rise H. M.	March ☽ Rise H. M.	April ☽ Rise H. M.	May ☽ Rise H. M.	June ☽ Rise H. M.
1	1 M. 9	4 M. 31	4 M. 17	4 M. 33	3 M. 41	3 M. 3
2	3 17	5 27	4 57	4 53	3 58	3 31
3	4 30	6 11	5 30	5 11	4 17	☽ Sets
4	5 41	6 50	5 55	☽ Sets	☽ Sets	9 A. 37
5	6 44	☽ Sets.	☽ Sets	7 A. 34	8 A. 49	10 25
6	☽ Sets.	6 A. 11	6 A. 18	8 40	9 53	11 3
7	5 A. 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	☌ M. 1
10	8 27	10 32	10 40	12 52	☌ M. 28	0 24
11	9 31	11 36	11 47	☌ M. 52	1 4	0 46
12	10 36	12 43	12 50	1 42	1 34	1 5
13	11 40	☌ M. 43	☌ M. 50	2 24	1 59	1 28
14	12 44	1 49	1 52	2 59	2 22	1 57
15	☌ M. 44	2 54	2 49	3 29	2 45	2 28
16	1 51	3 56	3 37	3 54	3 8	☽ Rise
17	2 58	4 49	4 17	4 18	3 34	8 A. 45
18	4 6	5 35	4 52	☽ Rise	☽ Rise	9 36
19	5 10	6 14	5 21	7 A. 31	9 A. 4	10 15
20	6 10	☽ Rise	☽ Rise	8 56	10 11	10 44
21	7 1	6 A. 39	7 A. 6	10 16	11 5	11 8
22	☽ Rise.	8 4	8 31	11 26	11 48	11 28
23	6 A. 17	9 27	9 55	12 25	12 21	11 45
24	7 40	10 48	11 15	☌ M. 25	☌ M. 21	12 2
25	9 2	12	12 29	1 13	○ 47	☌ M. 2
26	10 23	○ M. 7	○ M. 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 26
30	2 16		3 42	3 23	2 20	1 58
31	3 26		4 10		2 40	

Fig. 6.4 *A Compleat Ephemeris* by Thomas Streete, 1684 (©The British Library Board (P_p_2465(1)_fa1v))

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, removing dependency on the almanac. Yet, 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 civil calendar date to work out the date of the next full Moon and so on.

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 nine o'clock in the evening during winter.[97] 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 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.[98] This is further evidence to support the view that the lunar function survived on provincial longcase clocks into 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 eighteenth-century dials on which it did not feature 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.[99] The lunar phase was not part of the standard format dial that emerged by 1770, but its continued presence on provincial longcase clocks demonstrates that the standard format was a standard but not an absolute. As

has been demonstrated, there was much more to the use of the lunar phase for planning night-time travel than a common-sense statement could provide.

6.5 Tidal Reckoning

On the 22 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…".[100] Given Pepys' navy work, this comment may not seem significant at first glance. However, context is critical. Pepys wrote these words at a time in which tidal theory was experiencing renewed interest within the wider context of nascent science. The first table of high water for London Bridge appeared in a thirteenth-century manuscript and subsequent tables continued to be created from that time,[101] but the cause of tidal change was not theorised about until the writings of William Gilbert, Francis Bacon, Galileo Galilei and Johannes Kepler in the early-seventeenth century. In the mid-late seventeenth century, renewed interest, which by that point included systematic measurements and is evident in published pamphlets, the *Philosophical Transactions* of the Royal Society, almanacs and dials of the period, was specifically a British phenomenon.[102] This was probably due to the combination of increasing interest in natural philosophy led by Fellows of the early Royal Society, such as John Wallis and Robert Moray, and the growth of trade and travel taking place on the Thames, Severn and at sea, which must have been a catalyst for John Flamsteed who collected his own tidal data. It was within this context that clock- and watch-makers began to include tidal indications on dials. Again, they mirrored almanacs and a variety of pamphlets on tidal reckoning.

Returning to the epigraph, Smith included the times of high tide as the sixth in his list of possible indications that could be made by a timepiece: "…They may shew the time of the tide or full sea in any Port or Harbour whatsoever".[103] His reference to 'any Port or Harbour whatsoever' was significant in the sense that the most referenced location in tables of high tides and on dials was London Bridge. Yet, 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 other locations—mostly out of curiosity for new knowledge. 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 William Salmon's almanac of 1694, which provided the information that he stated a clock could also represent.[104] 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 11 h 33 which is 1 h. 39 m. too late; a very gross error which may make a passenger lose his Tide".[105] The risk of a passenger losing their tide, and therefore having to wait for the next one, was something Henry Philips had warned of in 1668.[106] Similarly, to Tompion's *Instructions* considered in Chapter 5, there were consequences for not knowing the time of high tide. A dial such as that shown in Fig. 6.5, which was made by Thomas Alcock in London, provided a solution to a very practical challenge. The index on which the hour of high tide was indicated is located on the inner-most concentric ring.

Tidal indication on clock and watch dials re-emerged in the 1640s and coincided with the first almanacs with tidal data in around 1642.[107] Almanacs of the period and publications such as John Gadbury's diary[108] of 1673 and Flamsteed's tables[109] of 1685 all provided the hour of high tide at London Bridge for each day of the year. Phillippes' almanac described the information provided as:

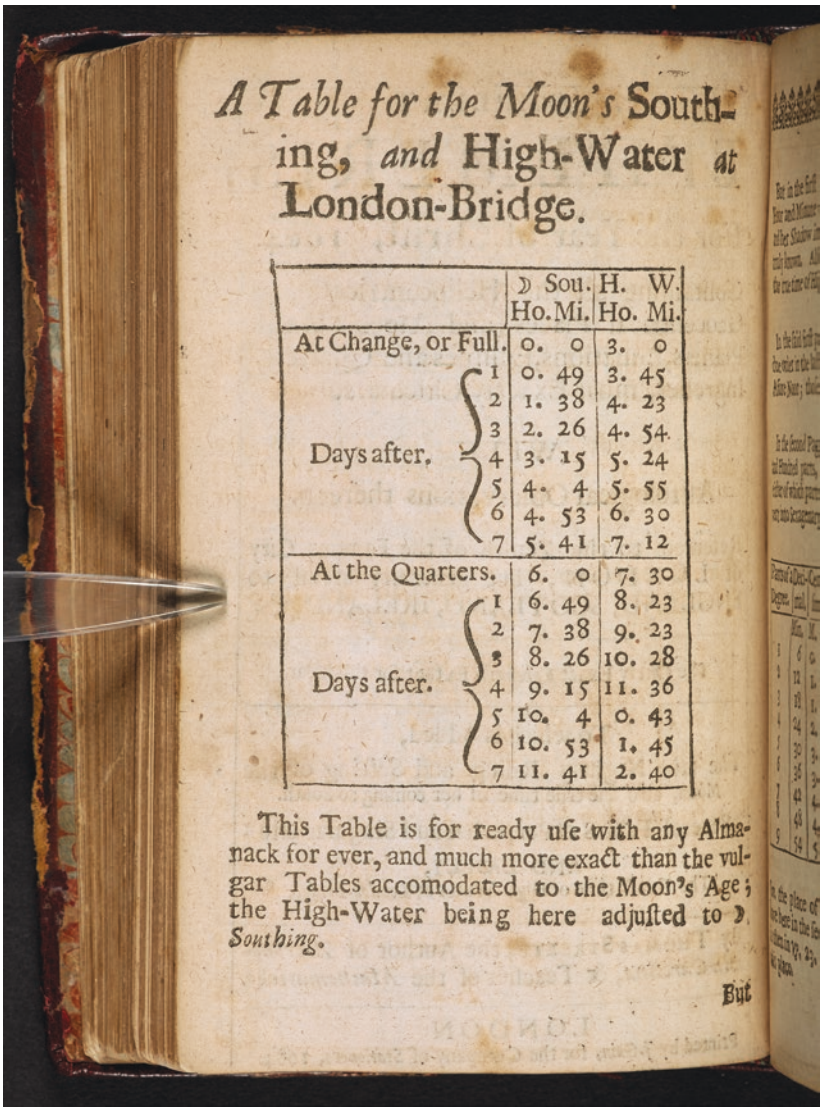
> The eighth column shewes the true time of high water at London Bridge…only note that whereas there is a Tide every 12 hours, this shews the Tide that falls out in the day time, between six in the morning and six at night…the other tide falls in the night, about half an hour later…[110]

Phillippes' comment about the provision of the time of the daytime high tide offers an explanation as to why most 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, those involved in shipping and natural philosophers who either travelled, had a commercial interest in the waterways or an intellectual interest in natural phenomena. It could easily be imagined that people made use of both an almanac such as Thomas Streete's (see Fig. 6.6) and a dial with tidal indication (see

Fig. 6.5 Pocket watch by Thomas Alcock, London, 1630–1655. Object no. 17.190.1470 (Photograph courtesy of the Metropolitan Museum of Art. Gift of J. Pierpont Morgan, 1917)

Fig. 6.5), which were both made during the mid-late seventeenth century. They both indicate that the time of high tide at London Bridge at the time of the full Moon would be three o'clock.

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,[111] but the indication was not common in the period and regained popularity in the mid-seventeenth century. Its re-emergence in the 1630s 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 demonstrates that the tidal indication on dials was not used for astrological purposes and astrology was not used to explain tidal change.



A Table for the Moon's South-ing, *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*.

But

Fig. 6.6 *A Compleat Ephemeris* by Thomas Streete, 1684 (©The British Library Board (P_p_2465(1)_fa2v))

Critics might claim that it was a difference in the quality of maker which separated multi-function dials with tidal indication from accurate timepieces such as observatory clocks. Landes referred to the words of a master clock-maker of the eighteenth century to dismiss multi-function dials as 'lively layouts'.[112] Yet, 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 multi-function watches with tidal indication.[113] The tidal indication index on dials made by Quare is represented with Arabic numerals 1–12 twice to account for the day and evening, suggesting that his were rare examples of watches that indicated both tides in the twenty-four hour period. He made an example in 1675, just before the invention of the balance spring, which also represents the hours and quarters rather than minutes. 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. They were very much a part of the wider interest in natural philosophy.

Another master clock-maker who was renowned for his precision timepieces was Tompion, who made regulator clocks for Flamsteed at the Royal Observatory at Greenwich. Flamsteed collected data on the times and heights of water at high and low tide and surely talked to Tompion about this work, even if only in passing. Tompion also made several longcase clocks which indicated the lunar phase and the times of high tide.[114] On an initial inspection, such a dial might be dismissed as a product for a gentlemen's study 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,[115] which contained advice for calculating the best times to cross the River Severn rather than waiting for hours on the riverbank as discussed in Chapter 5, its value is clear. The River Severn was a major commercial waterway in this period, which was why this information was so significant. Although in the pamphlet, the author referred to printed tables for making the calculation, those lucky enough to own one of Tompion's clocks[116] would have been able to make plans for the crossing without the need for long-hand calculations.

By around 1720, tidal indication once more 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 were no street lights. Interest in understanding tidal motion continued, evident from pamphlets of the mid-late eighteenth century. 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*[117] and Oliver Goldsmith's *An History of the Earth and Animated Nature*[118] provided the explanations and calculations necessary for working out the tide times. Gentlemen were also able to purchase models,[119] which demonstrated the Moon's gravitational pull on the Earth's waters, and attend lectures, which explained this natural phenomenon. One reason for the disappearance of tidal indication on dials was the decline of new theories of tidal motion after Newton's publication of his laws of universal gravitation in *Principia* in 1687, until at least the next century. In Britain at least, it was assumed that the answers had been provided and new theorising was not necessary. In France, where natural philosophers clung to Cartesian theory for a little longer, interest in new tidal theory gained new momentum from 1701,[120] but was not accompanied by tidal indications on dials.

6.6 Conclusion

In the epigraph, we saw that the clock-maker John Smith listed the lunar function as fourth in a list of indications that could be made on clocks. 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. This chapter has shown that the lunar indication developed differently from both calendrical and astronomical indications on dials in this period 1550–1770. 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. 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 also did this 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. Returning to the overarching journey of dial development from the multi-function dials of the mid-late sixteenth century to the standard format dial that emerged by 1770, this chapter has revealed two facets that help us to understand this complex journey.

Firstly, this chapter has shown 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 should not 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 make plans 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 the attainment of complete knowledge, was important in this context given these layers of information and hierarchies of knowledge. Of all of the different methods of representing the lunar calendar, the lunar phase was the last to decline from use. 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 without street lighting, this function was invaluable, which was why it survived the decline of astrology in the mid-late seventeenth century and survived longer on country clocks.

Secondly, this chapter has shown that the lunar function mirrored perceptions of knowledge creation and transmission in the period. It was significant that the lunar phase was represented using the man-in-the-moon from the early-mid-seventeenth century. It represented discussions

concerning the inhabited Moon from the mid-seventeenth century and throughout the eighteenth century. These were discussions involving natural philosophers, the clergy and clock-makers. The tidal indication, related to the lunar phase, was revived on dials in the same period as pamphlets on tidal reckoning. Tidal indication had existed on late-sixteenth-century dials, but enjoyed increased popularity from the mid-late seventeenth century. Both the 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.

The lunar phase did not feature on the standard format that emerged 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 1550–1770. This aesthetic legacy was paralleled in almanacs, which as Perkins reminds us did not stop presenting it until the nineteenth century.[121] Its lack of presence was an indication of both its point of decline and its past prominence.

Notes

1. John Smith, *Horological Dialogues* (London, 1675).
2. David Thompson, *Clocks* (London: British Museum Press, 2004), p. 22.
3. Patrick Curry, *Prophecy and Power: Astrology in Early Modern England* (Cambridge: Polity, 1989), p. 98.
4. Thompson, p. 22.
5. Eric Bruton, *The Longcase Clock* (London: Hart-Davis MacGibbon, 1976), p. 111.
6. John Henry, *The Scientific Revolution and the Origins of Modern Science* (Basingstoke: Palgrave Macmillan, 2008).
7. David Cressy, 'Early Modern Space Travel and the English Man in the Moon', *The American Historical Review*, 111.4 (2016), pp. 961–982; Richard Samuel Westfall, *Science and Religion in Seventeenth-Century England* (New Haven: Yale University Press, 1958), pp. 961–682.
8. Curry.
9. Jim Tester, *A History of Western Astrology* (Woodbridge: Boydell, 1987); Bernard Stuart Capp, *Astrology and the Popular Press: English Almanacs 1500–1800* (London: Faber, 1979); Maureen Perkins, *Visions of the Future: Almanacs, Time, and Cultural Change 1775–1870* (Oxford: Clarendon, 1996).

10. Paolo Rossi, *Logic and the Art of Memory: The Quest for a Universal Language* (London: Athlone Press, 2000).
11. Frances Amelia Yates, *The Art of Memory* (London: Ark Paperbacks, 1966).
12. This does not include use of the Moon for navigation, which is beyond the scope of this book.
13. For example British Museum object number 1958,1006.2138.
14. David Whitehouse, *The Moon: A Biography* (London: Headline Book Publishing, 2001), p. 9.
15. Westfall, p. 9.
16. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 85.
17. Ewen A. Whitaker, *Mapping and Naming the Moon: A History of Lunar Cartography and Nomenclature* (Cambridge: Cambridge University Press, 1999), p. 8.
18. Petrus Apianus, *Cosmographia* (Vaeneunt G. Bontio: Antuerpiæ, 1550).
19. George Wither, *A Collection of Emblemes* (London, 1635).
20. Cressy, p. 961.
21. The lunar terminator divided the illuminated hemisphere of the Moon from the dark hemisphere.
22. Galileo Galilei published his lunar drawings in *Sidereus Nuncius* (known as Sidereal Messenger) in 1610. The concept of the maculate Moon, which was initially considered as ungodly by some people, was supported by the artist Lodovico Cigoli, who painted a mural, entitled *The Virgin of the Immaculate Conception* in Santa Maria Maggiore in Rome in which the Moon is represented with an uneven surface of white, cream and grey colour.
23. Cressy, pp. 961–962.
24. Ibid., p. 963.
25. John Wilkins, *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, 1638).
26. Francis Godwin, *The Man in the Moone or A Discourse of a Voyage Thither Domingo Gonsales* (London, 1638).
27. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 98.
28. Ibid., p. 963.
29. Ibid., p. 964.
30. Ibid., p. 976.
31. Royal Museums Greenwich object number ZBA4565.
32. Henry Jenkins, *A Description of Several Astronomical and Geographical Clocks* (London, 1778).
33. William Johnson, *A New Almanacke and Prognostication* (London, 1569).
34. Curry, p. 11.

35. Capp, pp. 238–239; Perkins, p. 33; Curry, p. 59.
36. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 60.
37. Ibid., p. 57.
38. Ibid., p. 60.
39. Stuart Clark, *Thinking with Demons: The Idea of Witchcraft in Early Modern Europe* (Oxford: Clarendon Press, 1997), p. 218; Peter Dear, *Revolutionising the Sciences: European Knowledge and Its Ambitions 1500–1700* (Basingstoke: Palgrave, 2001), p. 18.
40. William Eamon, 'Technology as Magic in the Late Middle Ages and the Renaissance', *Janus*, 70 (1983), p. 172.
41. Dear, p. 25.
42. John Henry, *Knowledge Is Power: Francis Bacon and the Method of Science* (Cambridge: Icon, 2002), p. 55.
43. Eamon, p. 198.
44. Thomas Stephins, *A Newe Almanacke and Prognostication for the Yeare of Our Lorde God, M.D.LXIX* (London: Thomas Marshe, 1569).
45. Henry Alleyn, *An Almanack and Prognostication* (London, 1606).
46. Gregory Burton, *A New Almanacke and Prognostication* (London, 1621).
47. Rossi, p. 62.
48. Burton.
49. MS6619. 1696–1708. *Anonymous Workshop Notebook*. Worshipful Company of Clockmakers.
50. Jeremy Evans, *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, 2006), p. 40.
51. Thomas Gallen, *An Almanack and Prognostication for the Yeare of God 1642* (London: Rob Young, 1641).
52. Anonymous, *Almanac Ou Calendrier Pour L'Annee 1693* (Paris, 1693).
53. Thomas Trigge, *Calendarium Astrologicum* (London: J. Playford, 1684).
54. John Goldsmith, *An Almanack for the Year of Our Lord God, MDCCXXXIII* (London: E. Palmer, 1733).
55. John Goad, *Astro-Meteorologica* (London: Obadiah Blagrave, 1686).
56. John Smith, *Horological Disquisitions* (London, 1694).
57. Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science* (Cambridge: Cambridge University Press, 1982), p. 18.
58. Curry, p. 121.
59. Tester, p. 223.
60. Francis Bacon, *Sylva Sylvarum: Or a Naturall Historie in Ten Centuries* (London: John Haviland for William Lee, 1627).
61. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 60.
62. Alleyn.

63. Richard Banister, *A Treatise of One Hundred and Thirteene Diseases of the Eyes and Eye-Liddes* (London: F. Kyngston for T. Mann, 1622).
64. Walter Bailey, *Two Treatises Concerning the Preseruation of Eie-Sight* (London, 1633).
65. Tester, p. 223.
66. Ibid.
67. Gallen.
68. John Goldsmith.
69. Goldsmith had been publishing almanacs with this format and content since 1660.
70. Alleyn.
71. Richard Allestree, *A New Almanacke & Prognostication* (London, 1617); Joseph Chamberlaine, *A New Almanacke and Prognostication* (London, 1631) were both other almanac examples.
72. Allestree.
73. Tester, p. 226.
74. Godfridus, *The Knowledge of Things Unknown Shewing the Effects of the Planets and Other Astronomical Constellations; Together with the Husbandman's Practice* (London, 1676).
75. Thomas Tusser, *A Hundreth Good Pointes of Husbandrie* (London, 1557).
76. Ibid.
77. Curry, p. 97.
78. Ibid.
79. Peter Earle, *The Making of the English Middle Class: Business, Society and Family Life in London 1660–1730* (London: Methuen, 1991), pp. 18; 92.
80. William Dade, *A New Almanack with a Prognostication, Deduced from the Motions, Distances, and Aspects of the Planets, and Their Conjunctions with the Moon* (London, 1683).
81. Goad.
82. Rossi, p. 38.
83. Bruton, pp. 111–114.
84. Jennifer Uglow, *The Lunar Men: The Friends Who Made the Future 1730–1810* (London: Faber, 2002), pp. xxii; 453.
85. Henry Phillippes, *An Almanac for the Year of Our Lord 1655* (London, 1655).
86. Perkins, p. 210.
87. Diary of Samuel Pepys, Wednesday *24th July 1667*, http://www.pepysdiary.com/.
88. 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. For more information, see Whitehouse, p. 36.

89. Levinus Hulsius, *Vierdter Tractat Der Mechanischen Instrumenten* (Franckfurt am Mayn, 1615).
90. For example British Museum object number 1958,1006.2102.
91. 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.
92. Edward Gresham, *Strange, Fearful and True Newes* (London, 1606).
93. For example British Museum object number 1958,1006.2138.
94. For example British Museum object number 2010,8029.42.
95. Uglow, p. xxii.
96. James Ferguson, *Select Mechanical Exercises*, 1790.
97. Earle, p. 78.
98. Ibid.
99. Craig Koslofsky, *Evening's Empire: A History of the Night in Early Modern Europe* (Cambridge: Cambridge University Press, 2011), p. 131.
100. Diary of Samuel Pepys, *22nd May 1663*, http://www.pepysdiary.com/.
101. David Edgar Cartwright, *Tides: A Scientific History* (Cambridge: Cambridge University Press, 1999), p. 17.
102. French intellectuals began to take a renewed interest in tides from around 1701. For more information, see Cartwright, p. 59.
103. Smith, *Horological Dialogues.*
104. John Smith, *Horological Disquisitions* (London, 1694).
105. William Salmon, *Salmon's Almanack* (London: T. Dawks, 1684).
106. Cartwright, p. 54.
107. Gallen is just one example.
108. John Gadbury, *Ephemeris or a Diary Astronomical, Astrological, Meteorological for the Year of Our Lord 1673* (London: printed by J.C for the Company of Stationers, 1673).
109. John Flamsteed, *A Correct Tide-Table Shewing the True Times of the High-Waters at London-Bridge* (London: J. Stafford, 1687).
110. Phillippes.
111. Figure 1.1 is one example of a table clock made by Nicholas Vallin around 1600.
112. David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (London: Viking, 2000), p. 139.
113. For example British Museum object number 1958,1201.535.
114. Fitzwilliam Museum object number M.21-1947.
115. Thomas Tompion, *An Exact Measure of the Roads from Bath to London* (London: J. Good, 1709).
116. For example Metropolitan Museum of Art object number 1999.48.2 and Fitzwilliam Museum object number M.21-1947.

117. Benjamin Donn, *The Description and Use of Four New Instruments* (London, 1772).
118. Oliver Goldsmith, *An History of the Earth and Animated Nature* (London: J. Nourse, 1774).
119. For example Science Museum object number 1927–1852.
120. Cartwright, p. 59.
121. Perkins, p. 17.

CHAPTER 7

Astronomical Knowledge

7.1 Introduction

Astronomical information on clock and watch dials such as the indication of the position of the Sun in the zodiac, the 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 enabled astronomical knowledge to be derived from them. Compared with the calendar and lunar functions, the astronomical function developed differently on dials during the period 1550–1770 and these differences can only be revealed through a focus on contexts of use. The dials shown in Figs. 1.1 and 7.1 illustrate two distinct contexts in which astronomical knowledge was derived from clocks and watches in the period. Separated by around one hundred and fifty years, one was for astrological and mnemonic use and the other was for pedagogic purposes.

To the untrained eye, these dials might appear similar—they both indicate astronomical information in addition to the indication of the time of day. Indeed, astronomical indications have mainly been discussed by historians of horology such as Thompson[1] and others[2] in terms of their decorative function or have been interpreted on the basis of an eighteenth-century understanding of astronomy, which emphasised discovery. The aesthetic approach defines astronomical indications as a pleasing space-filler on dials. The discovery approach defines astronomical indications as the communication of discoveries of new planets or stars, using instruments. Yet, neither of these

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_7

Fig. 7.1 Astronomical clock by Samuel Watson, London, c.1695. Object no. 1970-25 (Photograph courtesy of Science Museum/Science & Society Picture Library)

approaches is as effective as a user-based approach for improving our understanding of the use of the astronomical knowledge that could be derived from dials. It is necessary to understand the nature of the astronomical knowledge held by different types of people in the period in which the dials were made and used and, more importantly, to understand their perceptions of the value and application of that knowledge.

While with the exception of format differences Figs. 1.1 and 7.1 may appear very similar in terms of astronomical representation, despite one having been made between 1530 and 1540 and the other one hundred and fifty years later in around 1690, they were used for different purposes. Traditionally, 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'.[3] From a craft or collecting perspective, this is logical, but by doing so this approach separates the non-hour indications from the hours, thereby defining them as relatively unimportant and isolating them from their history of use. Approaching astronomical indications in this way from the outset leads to these authors overlooking crucial changes over an extended timeframe. Similarly, when authors such as Christianson divide their accounts of horological change into a pre-pendulum era of beautiful objects for the few and a post-pendulum era of accurate timepieces for the many, they inadvertently disregard the usefulness of the non-hour indications for wealthy owners before 1657.[4]

While historians of early modern astronomy such as North[5] and others[6] have concentrated on changes in astronomical knowledge and teaching of astronomy in the universities, they have not considered the ways in which these ideas manifested themselves in material culture outside of the observatory and university. Mention may have been made to telescopes and observatory regulator clocks, but not to the representation of astronomical information on dials. The work of historians of early modern science, such as Henry,[7] Stewart[8] and others,[9] provides a useful foundation on which an explanation of the different contexts of use of clocks and watches with astronomical indications can be built. In a similar manner as Chapters 5 and 6, this chapter will expand the work of historians of astrology, such as Curry[10] and others,[11] by introducing the astronomical function on clocks and watches to the discussion. By considering the connections in terms of astronomical imagery between dials and mnemonic works, this chapter will contribute to the work of historians of the art of memory, such as Rossi[12] and Yates.[13] These different bodies of literature can be brought together with the evidence gathered from dials to demonstrate the existence of two different contexts of use that were separated by one hundred and fifty years—one that flourished from the mid-sixteenth to the early-seventeenth centuries and one that thrived in popularity from the late-seventeenth to the mid-eighteenth centuries.

7.2 Astrological and Mnemonic Use

Clock and watch dials that were made in the period from the mid-sixteenth to the early-seventeenth centuries and represented the signs of the zodiac (see Fig. 1.1) and the lunar aspects in combination clearly demonstrate that the use of astronomical information as part of a compendium of knowledge transcended national boundaries. Examples were made in Denmark, England, France and Germany in this period.[14] The purpose of this astronomical representation was to indicate the positions of the Sun and the Moon, which is not inherently meaningful beyond a point of reference since the zodiac is merely a convenient way of dividing the ecliptic (the Sun's apparent path over the course of one year). Yet, for many people from the mid-sixteenth to the early-seventeenth centuries, it was significant in terms of astrology and the art of memory, which makes it meaningful in the context of exploring dial change on the basis of use. As Henry correctly points out, there was an assumption in this period that many bodies, including the planets, had occult powers to influence life on Earth.[15] A user reading from a dial such as this would learn that on a given day the Sun is in the tenth degree of Aries, for example. This knowledge gave the user a locating co-ordinate within the zodiac calendar. Yet, as discussed in Chapter 5, this zodiac calendar indication was rarely provided on dials as the sole calendrical locating co-ordinate; it was usually represented alongside the civil calendar.[16] On the one hand, this demonstrates that the zodiac calendar was provided as an alternative to the civil calendar, given that some users preferred it and may account for those late examples of the indication such as Fig. 5.1 which were made in the mid-seventeenth century after the indication had more-or-less disappeared. On the other hand, it is equally valid that the zodiac calendar and aspect diagram combination, which were only present together until the early-seventeenth century (see Fig. 1.1), had an additional astrological and mnemonic purpose that represented a user's efforts to reach a higher plane of knowledge. While Rossi rightly asserts that the *pansophia* ideal dominated early modern thought,[17] he confines his discussion of the methods by which people hoped to achieve it to books. Yet, people also surely used three-dimensional objects to achieve this goal. Multi-function dials with astronomical indications were conceivably intended as a tool similar to books such as Giordano Bruno's *Clavis Magna*[18] for accessing that universal key to total knowledge, which many people believed was necessary for getting closer to God. By representing astronomical information, clock- and watch-makers

represented[19] the motions of the superlunary sphere and it was through contemplation of the relationships between the heavenly bodies and the effect of these relationships on life on Earth that some people believed higher, divine knowledge could be attained.

Historians of astronomy and early scientific thought, such as North,[20] Dear[21] and Donahue,[22] agree that astronomical knowledge in this period was a complex mixture of astrological prediction, star mapping and mathematics for computation. Clock and watch dials of the period reflect this mixture to some degree. Yet, it is possible to gain a better understanding of their use by comparing them with printed paper sources and other instruments bearing similar astronomical information from the period. This process reveals three significant parts of the story, which will be considered in turn: signs of the zodiac and conceptions of astronomy in the period; the decline of the astrolabe; and the decline of the astrological context of use before the mnemonic context of use as part of the first phase of astrological reform.

7.2.1 Signs of the Zodiac

Historians of early modern European astronomy have highlighted the work of Nicolaus Copernicus, Tycho Brahe, Johannes Kepler and Galileo Galilei as the names associated with the most significant development in astronomical thought in the years before Isaac Newton.[23] Yet, their impact on almanacs and clock and watch dials in the period in which they were writing was negligible. This was not because dials were disconnected from intellectual ideas, the reason was that scholarly ideas took time to become accepted and astronomical ideas in particular were themselves intertwined with traditional astrology and mnemonics in this period. As Donahue,[24] Dear[25] and Henry[26] correctly point out, astronomy and astrology were not often distinguished from each other in the sixteenth century. Indeed, the Latin term *astrologia* translates as both astronomy and astrology.[27] Astronomical data such as the relationships between the heavenly bodies were essential for the practical task of creating calendars and horoscopes. Dials reflected this by providing the positions of the Sun and the Moon in the zodiac and the relationship between them from the perspective of the Earth through the indication of the lunar aspects. Certainly, Brahe and Kepler are known to have practiced astrology, Copernicus and Galileo must have learned about it at university, and thus their ideas could not simply be separated from the wider conceptual landscape.

According to the Aristotelian view of Man's place in God's hierarchy, the Earth was positioned at the centre of a pre-ordered system of seven planets, which at this time included the Sun and the 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 components of the Great Chain of Being,[28] which included the effect of the planets on life on Earth. 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 changes in the weather, the spread of disease and the effective cultivation of crops and livestock. 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,[29] Capp[30] and Perkins.[31] 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. Almanacs were practical and suited to the needs of the period. As demonstrated in Chapter 2, the almanac reader could access information and predictions for the present day, but could also look ahead to plan future activities, according to the advice provided. Historians such as Morrison[32] have discussed the astrolabe in this context also, but the multi-function clock and watch dial (see Fig. 1.1) was similarly very much an astrological tool and, as such, a tool of natural magic in the period.

Almanacs, astrolabes and multi-function clock and watch dials with astronomical indices indicated the apparent place of the Sun in the ecliptic over the course of the year, which was very important for astrology. Similar information was provided in almanacs in the period such as Henry Alleyn's *Almanacke* of 1606, which concluded that for January 1606: "Taurus, into which the sunne entereth the eleventh day of this month, is of ye south, feminine, earthlie, and melancholique, and governeth the necke, throte, and voice, and of sicknesses, squinances, scrophules, catharres, and hoarseness".[33] It was believed that the Sun influenced different aspects of health and the weather, exerting varying levels of strength according to its position in the zodiac. The dial indication shown in Fig. 1.1 shows the Sun moving through the sign of Taurus, which is represented using a symbol of the bull that is similar

to that seen in the upper right of the vignette on the page for April in the almanac shown in Fig. 5.2. The dial was made around 1600 and the almanac in 1617, which makes for a useful comparison. The clock would still have been used in 1617 and the advice given in the almanac would not have changed significantly in the seventeen years that separated their dates of production. It could easily be imagined that a user would read the dial indication and then consult the almanac as to the meaning, thereby deriving general astronomical knowledge from the dial that was then given specific meaning by the almanac. In the example of the dial shown in Fig. 1.1, the user could try to make the best of the melancholic and earthly influence, presumably referring to the unsettled weather of spring, and try to look after their respiratory health, probably referring to the colds and flu that are associated with cold and rainy weather, according to the advice provided by Alleyn. Indeed, there were numerous references in contemporary literature to characters using astronomical information to predict their futures, such as Christopher Marlowe's Dr. Faustus who wished to possess a book that would show him all of the movements of the heavenly bodies so that he might know their dispositions and, one assumes, their influences.[34]

Similarly, the apparent angles of separation between the planets, known as the planetary aspects, were thought to considerably influence life on Earth. The aspects were conjunction, opposition, quartile, sextile and trine and were indicated using geometric shapes such as a square and triangle.[35] 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. Yet, the inclusion of the aspect diagram and the representation of the aspect symbols that would have been well known to users, as discussed in Chapter 6, would surely have prompted the user to consult an almanac to determine whether or not the planets were going to be 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.[36] 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, was certainly a representation of astronomy as mathematical, and specifically geometrical, knowledge.

In this context, the astronomical indication on the dial played a similar role to the lunar and calendar functions in terms of prompting a user to

consult their almanac or to recall advice previously read in it, as discussed in Chapters 5 and 6, but this use was only shared between the three functions until the early-seventeenth century. During the first wave of astrological reform,[37] proponents of astrology began to discard and distance themselves from certain aspects of the tradition (such as judicial astrology),[38] which at this point appears to have manifested itself in the disappearance of the signs of the zodiac, lunar aspects (noted in Chapter 6) and the planetary periods of the day (noted in Chapter 5) from dials and almanacs. While, as we have seen in earlier chapters, the calendar and lunar functions featured other indices that continued to be used for reformed astrology, and indeed went through a second wave of reform several decades later during the mid-late seventeenth century, the astronomical function did not. This marked the end of the astrological use of the astronomical function before the end of the astrological use of the other two functions.

While this combination of astronomical representation can be said to have declined during the first phase of astrological reform, there were some mid-late sixteenth-century dials that only represented the signs of the zodiac[39] and these also declined during the early-seventeenth century. Their existence and subsequent decline at the same time as the combination discussed above may suggest that the decline of the representation of the signs of the zodiac was 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 ecliptic, on a ring concentric to the centre of the dial, was in one sense a representation of the path on which the Sun travelled. We now call this the 'apparent motion' of the Sun, but for adherents to the Ptolemaic geocentric concept, it was the true path. North informs us that some people at the end of the sixteenth century when Brahe was writing, and some even as late as the 1650s, still doubted Copernican theory.[40] Pannekoek informs us that there were others who received Copernican data with pleasure and used it for almanac production, while rejecting its central message.[41] It was not a clear-cut case of full acceptance or dismissal after 1543, which might point to users who wished to keep the signs of the zodiac on their dials. The late example shown in Fig. 5.1 referred to earlier, which was made between 1653 and 1660, may have been made for such a customer.

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 and early-seventeenth-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 majority of the book-buying European public in the early-seventeenth century, many of whom were the wealthy owners of clocks and watches, 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 and unsustainable. It was in this context that 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 5 and 6.

Furthermore, the zodiac ring whose index progressed in an anticlockwise direction declined in the early-seventeenth century. On this type of index, the pointer used as a representation of the Sun moved in an anticlockwise direction, which is the opposite of the apparent motion of the Sun as seen from Earth. Alternating clockwise and anticlockwise motion over several rings was a feature of mid-late sixteenth-century and early-seventeenth-century multi-function dials (see Fig. 1.1) and as demonstrated in Chapter 2 was a means of aiding legibility for the user. In this scenario, the index of each ring progressed in a different direction. Yet, in the context of changing astronomical knowledge, and given that it did not feature on dials after the early-seventeenth century, apart from in a few rare examples, its inclusion can also be interpreted as an expression of support for the theory of the geocentric universe. Thus, the deliberate decision taken by makers not to 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 plausible given Remmert's argument that seventeenth-century frontispieces were used to express which side of the Copernican debate the author, and the target reader to some extent, stood.[43] Remmert informs us that some Jesuit writers expressed their opposition to Copernican theory by depicting the geocentric universe through biblical miracle images such as the Sun reversing (travelling anticlockwise). Although this was a feature of seventeenth-century works, given the dials mentioned above, it is likely

that the Jesuits and some clock- and watch-makers were drawing on traditional imagery when they designed their frontispieces and dial indices. Indeed, in Petrus Apianus' *Cosmographia* he made use of a schematic diagram of the geocentric universe and a zodiac calendar diagram which progressed in an anticlockwise fashion in the same manner as dials from the sixteenth century (see Fig. 7.2).

7.2.2 The Decline of the Astrolabe

Bennett[44] and Mosley[45] disagree about whether or not the astrolabe provided a representation of the heavens, as perceived from the observer's point of view on Earth. For Bennett, the instrument's prime function was for measuring celestial altitudes and making calculations for time-telling and navigation. For Mosley, while it might have served a practical purpose, its star map necessarily also represented the celestial sphere, which in the sixteenth century played an important role when people were thinking about the God-created hierarchy. Mosley correctly identifies the representational role of the astrolabe, but this role was also achieved physically as well as visually. By providing users with a device which they had to manipulate, makers were also enabling users to think about their own place within the hierarchy of the heavens and thus the influence of the heavenly bodies on their lives. The astrolabe enabled the user to contemplate the positions of the stars in the past, present and future. Astrologically, this was significant. Users could read almanac predictions and advance the astrolabe's indications to show the positions of the stars for the date in question or indeed reverse the positions to ascertain what they were on the date a specific event[46] took place. This capacity helped people to make sense of events, similarly to the act of looking back over past almanac pages to identify causes of events or occurrences. This was much like the indications on a clock or watch dial, as discussed in Chapter 2. Similarly, multi-function clock and watch dials with astronomical indications, made before the mid-seventeenth century, provide support for the representative role of astrolabes. Whereas almanacs provided a tabulated visualisation of the coming year in astrological terms, the astrolabe and the clock and watch dial provided a representation of the user's present day in astronomical terms, which before the mid-seventeenth century was surely intended to be interpreted astrologically.

In one area at least, multi-function clock and watch dials with an astronomical function superseded astrolabes by providing self-moving

Fig. 7.2 *Cosmographia* by Petrus Apianus, 1550 (©The British Library Board (C_114_e_2_(2)_plate_instrumentum))

information through the mechanism. Whereas astrolabes had to be manually set by taking celestial altitude measurements each day and could only be accurately used in clear weather, clocks and watches, once set with reference to an almanac or similar, would have automatically presented some of the same information that was appropriate to each day. Clocks and watches may have been easier to use, but most provided less information than astrolabes. This significant difference demonstrates that clock- and watch-makers responded to changing user needs. The astronomical function on multi-function dials from the mid-sixteenth to the early-seventeenth centuries mostly 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 showed the positions of the principal stars visible on any given night, which many multi-function dials did not. Yet, some mid-late sixteenth-century clock dials consisted of a mechanically-driven astrolabe rete with many of the same constellations as astrolabes from the same period, such as *Canis Minor* and *Orionis*, rotating on an engraved plate with horizon lines, which indicated the positions of those constellations and when they would be visible (see Figs. 7.3 and 7.4). While the astrolabe had a longer history of use than the domestic clock, some early dials reflected some of the same user needs which continued to be fulfilled by the astrolabe for a little longer. However, the astrolabe began to decline during the late-sixteenth century and clock- and watch-makers responded by no longer making astrolabic dials.

Historians of the astrolabe such as Morrison[47] argue that it would never have achieved the popularity it did if its uses had only been astronomical in the modern sense that excludes astrology. He claims that there were simply not enough people interested in astronomy as a science, whereas astrology was deeply embedded in contemporary culture. Morrison correctly points out that many astrolabes had astrological features that allowed the user to determine the astronomical elements of horoscopes such as the positions of the planets. While Morrison's claim that the astrolabe must have been useful for astrology is accurate, a position that is echoed by Gibbs,[48] his assertion that this is evident due to a lack of interest in astronomy proper and the associated distinction on which this is based are both inaccurate. As mentioned earlier, there was little distinction made in the sixteenth century between astronomy and astrology,[49] which means that instruments bearing astronomical information were suited to this combined purpose. Whereas historians such as

Fig. 7.3 Astrolabe by Georg Hartmann, Nuremberg, 1548. Object no. 1880-25 (Photograph courtesy of Science Museum/Science & Society Picture Library)

Bennett and Mosley have disagreed about whether the astrolabe represented the heavens or was solely practical, 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 astrolabic clocks and concludes that astrolabic discs were added to dials because astrolabes were popular

Fig. 7.4 Masterpiece clock, Augsburg, 1550–1600. Object no. 1952-312 (Photograph courtesy of Science Museum/Science & Society Picture Library)

in the period and that both served an astrological purpose.[50] Gibbs does not comment on the astrological potential of other mechanical clocks and watches and thus inadvertently implies that only those with astrolabic dials were used for this purpose. Yet, in a sense the emphasis should not be placed on why astrolabic plates were incorporated onto dials, but

on when and why they both disappeared. Astrolabic clocks and astrolabes began to decline in the same period as the indication of the Sun's apparent position in the zodiac on multi-function dials, in the first few decades of the seventeenth century. Historians of horology such as White have helpfully drawn attention to the masterpiece clocks that were part of the Augsburg clock-making guild's examinations and hinted that the disappearance of astrolabic dials was the result of them no longer being a requirement of those examinations.[51] From this foundation and by comparing astrolabic dials with astrolabes more widely, it is possible to make the connection that both declined at a similar time. Contextualisation enables us to see astrolabic dials such as that shown in Fig. 7.4 as more than elaborate clockwork toys. 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. Yet, 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 astrolabe and began to decline a decade or two later. That the multi-function dial with astronomical indications survived the decline of the astrolabe indicates that the self-moving form of representation was more desirable to users than the one that had to be set manually using measurements and was dependent upon clear skies.

7.2.3 A Mnemonic Role Beyond Astrology

The astronomical function on clock and watch dials served a similar mnemonic purpose to the calendar and lunar functions that were discussed in Chapters 5 and 6. This was to prompt the user to recall astrological advice and any significant information that could help the user to move closer to God. Yet, as noted earlier, the astronomical function developed differently from the other functions in the period. One distinguishing component of its development was the disappearance of representations of the apparent positions of the Sun and the Moon in the

zodiac and the lunar aspect diagram during the first wave of astrological reform in the early-seventeenth century and before the general decline of astrology during the mid-late seventeenth century. The traditional art of memory also began to decline in the early-seventeenth century, which may suggest that the astronomical function's mnemonic role for achieving higher knowledge was stronger than its prompting role for astrology. This suggestion requires further explanation. Whereas the calendrical and lunar indications survived the first wave of astrological reform, the astronomical indications did not which suggests that its use for astrology was not as strong as it was in the other two functions. Similarly, the use of the calendar and lunar functions for the art of memory may not have been as strong as their astrological use, given that they survived the decline of the art of memory (with the exception of the indication of the period of the day and the lunar aspects), only to decline during the second wave of astrological reform during the mid-late seventeenth century. Clock and watch dials, in comparison with printed material, provide further evidence that astrology was very much in transition in this period.

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,[52] it is clear that the astronomical function on dials was an extremely useful tool for mnemonic practice. Indications such as the positions of the Sun and the Moon in the zodiac and the planetary aspects were pictorial devices that could be made use of while following advice on image and *loci* construction in mnemonic works. Rossi's point that the frontispiece was perceived as a mnemonic aid for getting to know the contents of a book before reading it[53] 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, Bruno provided the reader with a list of useful and significant images for use in his mnemonic wheels.[54] 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. 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 shown in Fig. 7.5, for example, he suggested Aries: "In the second [face of Aries],

Fig. 7.5 *De Monade Numero et Figura* by Giordano Bruno, 1591 (©The British Library Board (532_b_29_p130))

a beautiful woman dressed in a tunic dyed in true tyrian purple, her loose hair crowned with laurel".[55] 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….".[56] 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 zodiac information used them as a mnemonic tool. When the Sun pointer on the dial in Fig. 1.1 moved into the zodiac sign of Gemini for example, the user could associate this indication with a servant according to Bruno's suggested images,[57] which might prompt them to attend to certain household affairs or contemplate ways in which they themselves could become better servants of God.

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.[58] 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.[59] Webster informs us that the Elect were to face the future wary of the stars' powers to corrupt but determined to overcome the forces of evil.[60] However, he does not reveal how people were to do so. Emblem books were one obvious source since most contained images and messages relating to God and the celestial realm. George Wither's depiction of a human figure looking up at a night sky, filled with stars with one larger star held by the divine hand, was typical of the emblem book genre.[61] He accompanied his image with the epigram: "God by their Names, the Stars doth cast; And hee is Ruler of them all".[62] In his accompanying verse, he explains that while many people attribute good and bad to the stars themselves, it must be remembered that they were created by God as signs or warnings to help people: "Hee make the stares to bee an ayd unto us…."[63] In this context, multi-function dials bearing astronomical symbols were plausibly one of many devices, including printed 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,[64] clock and watch dials reflected this ordering of information. As discussed in Chapter 2, whether dials used multiple concentric rings or subsidiary dials as a method of organising information, there was invariably 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 was indicative of the order of importance for each piece of information on the dial. In the case of subsidiary dials, as mentioned in Chapter 2, the resemblance was to Lullian trees[65] in which the user was intended to move from one branch, or subsidiary dial, to the next in order to attain greater knowledge. It is noteworthy that one of the sixteen branches on the Lullian tree was the celestial tree which concentrated 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.

On the whole, multi-function dials survived the decline of publications on the art of memory, which took place in the early-seventeenth century according to Rossi.[66] However, the astronomical indications on these dials declined at approximately the same time during the early-seventeenth century. This demonstrates that while the use of the multi-function dial was not solely mnemonic, the astronomical indication on those dials from the mid-sixteenth to the early-seventeenth centuries was an important part of that tradition for wealthy users. Dials such as that shown in Fig. 1.1 would have been useful for recalling astrological advice before the first wave of its reform and key 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 history of science. Approximately fifty years after the decline of astronomical indications in the early-seventeenth century, the function enjoyed a resurgence, but for a very different purpose.

7.3 Pedagogical Use

Those clocks made between the late-seventeenth and mid-eighteenth centuries which represented the movements of the heavens were a distinct group designed for teaching astronomy, not in a school or university, but to groups of fee-paying attendees in public venues or to wealthy individuals in private settings.[67] Preferring to cluster all astronomical indications together rather than distinguishing between different types

on the basis of the context in which they were used, most historians of horology have not fully considered this angle before. As a type of clock, the astronomical teaching clock was relatively short-lived—being made for approximately sixty years. A case-study approach based on four examples of astronomical clocks from different museum collections enables us to fully explain their use. These four examples have been chosen because they are representative of this particular type of clock, span the timeframe 1690–1778 to give as widespread coverage of the period as possible and were each accompanied by pamphlets written by the clock-makers themselves which explained their use.

Teaching with instruments was certainly not new in the 1690s. Samuel Pepys referred to teaching his wife geography and astronomy with globes in the 1660s.[68] The multi-function clocks and watches described above could have been used for informal teaching of astrology and the mnemonic method within 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] If an astrolabe could be used for teaching, a dial could also. The difference between the teaching contexts of the late-seventeenth and eighteenth centuries was that there was a new fashion for public lectures, which included demonstration using instruments. The first public mathematics lectures in London were conducted by James Harris in 1698 and the first public natural philosophy lectures were conducted by James Hodgson in 1705, which was the pedagogical backdrop in which astronomical clocks were made and used in this period.

The content of astronomical teaching clocks invariably 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, as can be seen in accompanying pamphlets such as John Keill's *An Introduction to the True Astronomy* of 1760, for example.[70] In the first half of the eighteenth century, a wide range of pamphlets were published which offered tuition on subjects such as astronomy and mechanics, for example Joseph Moxon's *Use of the Astronomical Playing Cards* of 1717,[71] Benjamin Martin's *A Course of Lectures in Natural and Experimental Philosophy, Geography and Astronomy* of 1743[72] and James Ferguson's *The Use of a New Orrery* of 1746,[73] and it is clear from such pamphlets that astronomy was an important component of these courses

of natural philosophy. Orreries and celestial globes were often used for teaching, but astronomical clocks were also made for a pedagogical purpose and must be considered as being a part of this wider context.

Moxon's *Astronomical Playing* Cards, accompanied by his instruction booklet mentioned above, were an example of astronomical teaching material. Each playing card depicted a constellation with its associated image and name. There were several makers who made and sold these sets in the late-seventeenth and early-eighteenth centuries, but Moxon was the most high-profile (being a rare example in this period of an instrument maker that was elected to be a Fellow of the Royal Society). These were a legacy of the mnemonic method. Though not part of the traditional art of memory (whose main purpose was higher knowledge) discussed earlier, 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 shown in Fig. 7.1 and the playing cards are two devices that offer the user with at-a-glance knowledge of astronomy and a tool which operates by visual stimulus to prompt previously acquired information to aid learning. Again, this acted in a similar way to the traditional emblem books, discussed in Chapter 2. Both the cards and the clock dial effectively provide an assurance that the user will learn about astronomy by repeated viewing. The only difference in the user experience is that the cards must be manually moved by the viewer, whereas the clock dial is self-moving.

Connected with the arrival of this type 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 considered 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*[74] and Caleb Smith's *The Description of a new Sea Quadrant.*[75] The appearance of the instrument-treatise genre was significant. Writing about an earlier period, Eamon informs us that in the sixteenth and early-seventeenth centuries artisan craftsmen were perceived as magicians, given their closely guarded secret knowledge of the machines they made.[76] This view is useful here for contrasting with the late-seventeenth and eighteenth

centuries when clock-makers shared secrets. Sharing of information that had previously been guarded was a deliberate attempt by clock- and watch-makers to distance themselves and their work from the natural magic tradition and its associated secrets. Clocks and watches were not made in horological isolation and one of the contexts of which they were an important part was natural magic, particularly the elements that were subsumed into early science. Indeed, Henry informs us that natural philosophers sought to separate naturalistic elements from the remainder of the magic tradition, thereby discarding what they no longer wanted.[77] The astronomical symbols used on the indices of astronomical teaching clocks of the late-seventeenth and early-eighteenth centuries were very similar to those used on earlier multi-function timepieces that had been used for astrology in the late-sixteenth and early-seventeenth centuries. This meant that the only way clock-makers could distance their products from these earlier examples was by publishing accounts to accompany them.

In the first of two such pamphlets, Smith described the different indications that clocks could make. He did not describe any 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".[78] His choice of the term 'conclusion' suggests 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 here, which will be considered in turn, 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, with which astronomical functions on multi-function dials were associated. Makers emphasised 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 the wealthy and inquisitive gentlemen (and possibly ladies) that made up London's consumer base. The target audiences for both the astronomical clocks and public lectures on natural philosophy were wealthy gentlemen (and ladies according to some advertisements), and it is clear that these clocks were a part of this demonstration and learning context.

7.3.1 Samuel Watson

Samuel Watson, a clock-maker originally from Coventry who later moved to London, published *The Chronological Automaton or Self-Moving Ephemeris of the Celestial Motions*[79] in 1690 as a method of marketing the sale of a similar clock to that shown in Fig. 7.1, which was initially intended for the late King Charles II.[80] The dial shown in Fig. 7.1 which was made around 1695 features fourteen concentric rings and in addition to the time of the day and calendar, represents the Copernican solar system, the position of the Sun in the zodiac, the times of the rising and setting of the Sun and the Moon, the lunar phase and aspects, and the times of high tide at London Bridge. Watson's comments concerning the clock for King Charles II are useful for understanding the clock shown in Fig. 7.1. By styling his astronomical clocks a 'self-moving ephemeris', Watson made the same connection between almanacs, also known as ephemerides, and clocks that is emphasised throughout this book. 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. As discussed in earlier chapters, 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 Thomas Streete's almanac of 1683 (see Fig. 6.4). Most late-seventeenth-century and early-eighteenth-century multi-function dials provided singular calendrical indications such as the date of the month or the lunar phase. Yet, the dial in Fig. 7.1 presented the full range of information that was found in almanacs of the late-seventeenth century.

Watson inferred that eighteenth-century astronomical clocks were designed as teaching aids when he said that the clock 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".[81] He said it could be set for any location, which meant that the user could learn the planetary positions observable for any date at any location. This made for

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.[82] In terms of the uses of these indications, he said they were too diverse to cover in such a short pamphlet.[83] By emphasising use and not mentioning planetary aspects (though they were represented on his clock), Watson was distancing himself from the previous era of astrology, with which earlier dials with astronomical indications were associated. This clearly demonstrates that there was a difference between astronomical clocks of this period and the multi-function dials of the earlier period because they were not intended for astrological use, they were designed for teaching.

7.3.2 Henry Bridges and Edward Davies

The clock made by Henry Bridges in 1733[84] toured around the UK, which is evident from numerous newspaper adverts from the period.[85] It was called the 'Microcosm', but the word had by this time lost the meaning it had possessed 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 earlier.

For some historians of horology, the advertisements associated with this clock demonstrate that it was conceived as an entertainment.[86] Indeed, the notice 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…".[87] Taken in isolation, away from the context of public lecturing on natural philosophy mentioned above, this advertisement may appear to be indicating that the clock in 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 with the

home or workplace where timepieces are referred to only by members of the household and guests. Yet, if the advert is considered within the wider context of the page and publication in which it featured, its original meaning becomes apparent. An adjacent notice advertised 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 in attending the demonstration of an astronomical clock to learn about astronomy.

Later advertisements demonstrate that the clock was also displayed in coffee houses, many of which in the eighteenth century became known as venues for discussion of natural philosophy and for public lectures. 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…".[88] In this advertisement, a direct connection is made between lecturing and the clock. The reference to associated lectures further demonstrates that the clock was very much a part of the mid-eighteenth-century fashion for learning through demonstrations, rather than something people filed past to entertain themselves without much attention.

While Thompson did comment on the use of the clock when he said that it went on tour around the world,[89] by not commenting further he leaves the reader to interpret the word 'entertainment' as possibly meaning something akin to a travelling 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*,[90] used the term 'entertainment' to mean learning in an informal, or non-university, environment. The advertisements for the clock used similar language compared with those for lectures and demonstration pamphlets of natural philosophy in the period. The notice for the clock used terms such as 'elaborate' and of interest to the 'curious'.[91] Adverts for lectures such as that by John Clarke used terms such as 'peculiar method'.[92] Both of the advertisements featured in the same newspaper, the *Daily Journal*. The notice for the lectures was also placed beside a notice for the sale of a mathematical instrument maker's stock, which gives a sense of the practical aspect of these advertisements rather

than the music-hall-style entertainment that Thompson alludes to in his reference to the clock being 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 when viewing the clock,[93] evident in a notice in the *Dublin Mercury* in 1769 in which it was stated: "Of the proprietor may be had…. A Succinct account of the Microcosm".[94] 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 had taken Bridges twenty years to make and required close study and application.[95] He also claimed that the Royal Society admired it greatly,[96] 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.[97]

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".[98] 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 and ladies in this period. All of the clocks and watches discussed throughout this book are beautiful objects in their own right, and this is one reason why previous historians have chosen to neglect the dial's knowledge-conveying attributes. Their beauty reflects their need to fit into the owner's opulent surroundings, but this does not detract from their utility. Indeed, Davies continued 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".[99]

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. This was similar to the clock that Watson

described in his pamphlet.[100] 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 listed the duration of each planet's revolution around the Sun, such as Mercury revolving around the Sun in 87 days and 23 hours. 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. Furthermore, the size of the solar system and the distances of the planets from the Sun was a very popular topic in the mid-late eighteenth century.[101]

Further evidence of the teaching capacity of this clock lies with Davies' description of the additional compartments that were housed in the case of the clock beneath the lower dial.[102] Each compartment housed a detail of the astronomical system in model form. There were: 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".[103] 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 century to demonstrate astronomical principles such as Benjamin Martin's miniature orrery.[104]

7.3.3 John Naylor

Sixty years after Watson sold the chronological automaton by lot, John Naylor, who moved to London from Nantwich, also published a pamphlet proposing to sell an astronomical clock by lot in 1751.[105] The dial of this clock, which was originally made in around 1725, features seven

concentric rings and five subsidiary dials and in addition to the time of day represents the movement of the planets using a celestial map, the positions of the Sun and the Moon in the zodiac and their times of rising and setting, the lunar apogee and perigee which was used for eclipse prediction, the times of high tide at London Bridge and a calendar which indicates important religious dates including Easter according to both the Julian and Gregorian calendars. When the clock was made in 1725, both Catholic and Protestant Europe were by then using the Gregorian calendar and Britain was still using the Julian calendar, which made cross-referencing between the two calendars essential. The sale of the clock in 1751, when the accompanying pamphlet was published, took place the year before Britain began to use the Gregorian calendar and the subject was of great interest, which meant that this was an opportune moment to emphasise the usefulness of this device for teaching.[106]

The pamphlet was entitled *Explanation* of *An Astronomical Clock*. In his discussion of this clock, Thompson describes 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.[107] Yet, while Thompson claims the fashion for astronomical clocks revolved around demonstrating knowledge to associates, these clocks were in reality 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 with the pamphlets. As noted above, most of the clocks could be manually progressed 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*[108] for microscopes. Thompson compares the eighteenth-century fashion for astronomical clocks with astronomical clocks of the sixteenth century that were present in royal and aristocratic cabinets of curiosity.[109] While there were some similarities in terms of content, such as the apparent position of the Sun in the zodiac, the use was very different due to the intellectual context of which they were an important part.

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. Yet, he made absolutely no mention

of astrology or planetary aspects. His statement that the clock shows "…many more astronomical questions…"[110] 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".[111] 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 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, the clock needed to answer these needs. 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.

7.3.4 Henry Jenkins

In 1778, Henry Jenkins published a pamphlet entitled *A Description of Several Astronomical and Geographical Clocks*,[112] which described the astronomical clocks he made between 1757 and 1759. Some of those clocks are thought to have survived, but the publication also coincided with his making of one example that is held at the British Museum.[113] This clock features upper and lower dials. The upper consists of three concentric rings representing the movement of the Moon and the Earth around the Sun and their positions in the zodiac. The lower dial consists of four subsidiary dials which, in addition to the time of day, represent calendrical information, the times of high tide at several ports and the constellations visible at different times of the year. It is highly probable that the pamphlet was Jenkins' second publication and that he had previously published a similar version 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".[114] 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".[115] 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".[116] 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 more perfect manner, and to better advantage, than at a less mature age".[117] Clearly marketing the clock as an educational device was an effective strategy for attracting older customers.

Yet, 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.[118]

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. The user of an astronomical clock such as this has already been identified as a wealthy gentleman with an interest in early 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 craftsmen who were successful at marketing their wares such as Ferguson's *The Use of a New Orrery* of 1746.[119] However, Jenkins claimed that the astronomical clock was a more effective learning device than these other 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".[120] 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.[121] The year of construction was only two years before the first transit of Venus of the eighteenth century, which took place in 1761.[122] There was great interest in this astronomical event, which only occurs once in every century and takes 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 those in the know would have continued to be interested in the clock in 1769 amid the great interest (among the informed) surrounding Captain James 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.

7.3.5 Clock-Maker Authors

Taken together, the writings of these clock-makers and 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 began to distance themselves from the natural magic tradition when describing their experiments.[123]

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.[124] Very much in keeping with the genre of pamphlets written by clock-makers, Hatton offered a technical explanation of clock-making.[125] 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…".[126] 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'.[127] It was surely for the latter given that any practicing craftsmen would already know everything he discussed within its pages, having served a seven-year 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 was to position the craft of clock-making 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.[128] The second method he used was to associate clocks and watches with known men of early science. He listed 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.[129] Hatton mentioned some other names, but he focussed on these ten. As

a combination, they represent a significant group of natural philosophers, eminent clock-makers at the top of their respective fields and individuals whose work continues to be celebrated by historians of science.

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".[130] 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 on the basis established by this pamphlet that many historians of horology have set up their work in terms of a pre- and post-pendulum dichotomy. As mentioned in Chapter 1, this angle of approach and interpretation has remained relatively unchanged. 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 alone.

The connections between lectures on astronomy and eighteenth-century astronomical clocks demonstrate the use of such timepieces as learning aids, which is supported by the words of the makers themselves. Indeed, the way in 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…"[131] which: "…wonderfully please and recreate the mind".[132] 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". [133]

Astronomical clocks were fashionable as learning aids from the late-seventeenth to the mid-eighteenth centuries 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 that emerged by 1770. Instead, they serve as an example of the revival of astronomical representation on clock and watch dials beyond the decline of astrology and to serve a new purpose. In one sense, the original mnemonic use of the astronomical function, which declined during the early-seventeenth

century as noted earlier, 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

This chapter has shown that there was a distinction 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 mid-eighteenth centuries. These were both different contexts of use where the dial provided the user with astronomical knowledge. Returning to the overarching journey of dial development from the multi-function dials of the mid-late sixteenth century to the standard format dial that emerged by 1770, this chapter has revealed two facets that help us to understand this complicated journey.

Firstly, this chapter has shown that the astronomical indication on early dials was clearly useful in terms of the mnemonic method as their similarities in terms of information indicated and style of representation with 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 Romberch 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. Its presence 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 order to come closer to God. The astronomical function on dials declined just before the general decline in astrology. It was more useful as part of the mnemonic art and it declined in the same period as pamphlets on the art of memory. 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.

Secondly, this chapter has shown that the astronomical function mirrored perceptions of knowledge creation and transmission in the period. 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, 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. The new genre of pamphlets written by clock-makers constitutes a distancing from astrology which was part of a wider trend from the late-seventeenth century. 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 centuries when teaching of natural philosophy, of which astronomy was a major part, was popular. These points position clock and watch dials within the history of natural philosophy demonstration, such as the work of Stewart,[134] Morton and Wess,[135] thereby expanding both the history of horology and the history of science teaching.

There were no signs of astronomical indication, for any context of use, on the standard format dial that 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.

Notes

1. David Thompson, *Watches* (London: British Museum Press, 2007), pp. 24; 34.
2. Clutton, C., ed., *Britten's Old Clocks and Watches and Their Makers*, 9th ed. (London: Bloomsbury Books, 1990), p. 49.

3. Eric Bruton, *The Longcase Clock* (London: Hart-Davis MacGibbon, 1976), p. 5.
4. David Christianson, *Timepieces: Masterpieces of Chronometry* (Newton Abbot: David & Charles, 2002).
5. John David North, *Cosmos: An Illustrated History of Astronomy and Cosmology* (Chicago: University of Chicago Press, 2008).
6. William Donahue, 'Astronomy', in *Cambridge History of Science Volume 3*, ed. by Katharine Park and Lorraine Daston (Cambridge: Cambridge University Press, 2006), pp. 562–595.
7. John Henry, *The Scientific Revolution and the Origins of Modern Science* (Basingstoke: Palgrave Macmillan, 2008).
8. Larry R. Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain 1660–1750* (Cambridge: Cambridge University Press, 1992).
9. Peter Dear, *Revolutionising the Sciences: European Knowledge and Its Ambitions 1500–1700* (Basingstoke: Palgrave, 2001); Alan Q. Morton and Jane A. Wess, *Public & Private Science: The King George III Collection* (Oxford: Oxford University Press in association with the Science Museum, 1993).
10. Patrick Curry, *Prophecy and Power: Astrology in Early Modern England* (Cambridge: Polity, 1989).
11. Bernard Stuart Capp, *Astrology and the Popular Press: English Almanacs 1500–1800* (London: Faber, 1979); Maureen Perkins, *Visions of the Future: Almanacs, Time, and Cultural Change 1775–1870* (Oxford: Clarendon, 1996).
12. Paolo Rossi, *Logic and the Art of Memory: The Quest for a Universal Language* (London: Athlone Press, 2000).
13. Frances Amelia Yates, *The Art of Memory* (London: Ark Paperbacks, 1966).
14. For example, British Museum object numbers 1958,1006.2113, 1856,0429.1 and 1874,0718.21 and Deutsches Historisches Museum object number 1989.2188. These examples, along with the dial shown in Fig. 1.1, were made between 1550 and 1625. As with most of the aspects of dial change considered in this book, there were slightly later examples made after the general disappearance of zodiac representation, such as Fig. 5.1 which was made between 1653 and 1660, but it must be seen as a rare survival of the indication rather than bookmarking the end of the era of the indication's popularity.
15. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 56.
16. See Chapter 5 for the distinction made between the civil calendar of the twelve months January to December and the zodiac calendar of the twelve months Aquarius to Capricorn.

17. Rossi, p. 38.
18. Giordano Bruno referred to his work entitled *Clavis Magna*, the key to understanding the art of memory, but it has not survived.
19. Indications of the changing positions of the Sun and Moon in the zodiac and the aspect diagram which showed the apparent relationship between them was a representation of their motions, rather than a replication of them in the way that was achieved later with orreries and other planetary models.
20. North, pp. 321–322.
21. Peter Dear, *Revolutionising the Sciences: European Knowledge and Its Ambitions 1500–1700* (Basingstoke: Palgrave, 2001), pp. 17–18.
22. Donahue, p. 562.
23. North, pp. 321–377; Henry, *The Scientific Revolution and the Origins of Modern Science*, pp. 19–29; Donahue, pp. 562–589.
24. Donahue, p. 563.
25. Dear, p. 18.
26. Henry, *The Scientific Revolution and the Origins of Modern Science*, pp. 23; 59–60.
27. James Morwood, *The Oxford Latin Desk Dictionary*, Rev (Oxford: Oxford University Press, 2005), p. 19.
28. John Henry, *Knowledge Is Power: Francis Bacon and the Method of Science* (Cambridge: Icon, 2002), p. 55.
29. Curry.
30. Capp.
31. Perkins.
32. James E. Morrison, *The Astrolabe* (Delaware: Janus, 2007), p. 28.
33. Henry Alleyn, *An Almanack and Prognostication* (London, 1606).
34. Christopher Marlowe, *Doctor Faustus* (London, 1592).
35. Discussed in detail in Chapter 2.
36. Dear, p. 17.
37. The first wave of astrological reform to be evidenced in almanacs. Writers had criticised astrology earlier than this, but their ideas had little impact on astrological practice as evidenced in almanacs and other astrological pamphlets.
38. Judicial astrology was used to forecast great events and was distinguished from astrology that was used to predict weather and change and influences on an individual's health. People began to reject judicial astrology in the late medieval period, but some people continued to believe in it and the full decline did not take place until the early-seventeenth century.
39. For example, British Museum object number 1958,1006.2113.
40. North, pp. 330–332.

41. Anton Pannekoek, *A History of Astronomy* (New York: Dover, 1989), pp. 224–234.
42. Ibid., p. 224.
43. Volker Remmert, '"Docet Parva Pictura, Quod Multae Scripturae Non Dicunt." Frontispieces, Their Functions, and Their Audiences in Seventeenth-Century Mathematical Sciences', in *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe*, ed. by Sachiko Kusukawa and Ian Maclean (Oxford: Oxford University Press, 2006), pp. 249–256.
44. Jim Bennett, 'Knowing and Doing in the Sixteenth Century: What Were Instruments For?' *The British Journal for the History of Science*, 36.2 (2003), pp. 135.
45. Adam Mosley, 'Objects of Knowledge: Mathematics and Models in Sixteenth Century Cosmology and Astronomy', in *Transmitting Knowledge: Words, Images, and Instruments in Early Modern Europe*, ed. by Sachiko Kusukawa and Ian Maclean (Oxford: Oxford University Press, 2006), pp. 193–201.
46. These were small events at the individual level, rather than great world events.
47. Morrison, p. 40.
48. Sharon Gibbs, 'Astrolabe Clock Faces', in *The Clockwork Universe: German Clocks and Automata 1550–1650*, ed. by Klaus Maurice and Otto Mayr (New York: Neale Watson Academic Publications, 1980), pp. 49–56.
49. Dear, p. 18.
50. Gibbs, pp. 49; 54.
51. George White, *The Clockmakers of London* (Hampshire: The Midas Press, 1998), p. 12.
52. Rossi, p. 2.
53. Ibid., pp. 27–28.
54. Scot Gosnell and trans., *Giordano Bruno: De Umbris Idearum on the Shadow of Ideas 1582* (Huginn Muninn & Co., 2013), pp. 167–189.
55. Gosnell, p. 152.
56. Ibid., p. 154.
57. Gosnell, p. 154.
58. Rossi, p. 3.
59. Charles Webster, *From Paracelsus to Newton: Magic and the Making of Modern Science* (Cambridge: Cambridge University Press, 1982), p. 49.
60. Ibid., p. 23.
61. George Wither, *A Collection of Emblemes* (London, 1635).
62. Ibid.
63. Ibid.

64. Rossi, p. 31.
65. The works of Ramon Lull enjoyed a revival in the Renaissance.
66. Rossi, p. 129.
67. Astronomical teaching clocks were not only made in England. For an example made and used in France, see Wallace Collection object number F98.
68. Diary of Samuel Pepys Tuesday 8 September 1663, http://www.pepysdiary.com/.
69. Mosley, p. 195.
70. John Keill, *An Introduction to the True Astronomy or Astronomical Lectures* (London, 1760).
71. Joseph Moxon, *The Use of the Astronomical Playing-Cards* (London: John Lenthall, Stationer at the Talbot, 1717).
72. Benjamin Martin, *A Course of Lectures in Natural and Experimental Philosophy, Geography and Astronomy* (London, 1743).
73. James Ferguson, *The Use of a New Orrery* (London, 1746).
74. George Adams, *The Description and Use of the Universal Trigonometrical Octant, Invented and Applied to Hadley's Quadrant* (London, 1753).
75. Caleb Smith, *The Description of a New Sea Quadrant* (London, 1740).
76. William Eamon, 'Technology as Magic in the Late Middle Ages and the Renaissance', *Janus*, 70 (1983), p. 178.
77. Henry, *The Scientific Revolution and the Origins of Modern Science*, p. 57.
78. John Smith, *Horological Dialogues* (London, 1675).
79. Samuel Watson, *A Chronological Automaton or, Self-Moving Ephemeris of the Celestial Motions* (London, 1690).
80. Charles II died before the clock could be completed. The clock was due to be sold by lottery. It is now part of the Royal Collection object number RCIN.30260.
81. Watson.
82. Ibid.
83. Ibid.
84. British Museum object number CAI.2101.
85. Anonymous, 17 July 1734. To be Seen: the Microcosm Clock. *Daily Journal*; Anonymous, 16–19 December 1769, Microcosm, *Dublin Mercury*; Henry Bridges, 2 January 1750, Wanted: a Convenient Light Chamber or Room, *General Advertiser*.
86. David Thompson, *Clocks* (London: British Museum Press, 2004).
87. Anonymous, 17 July 1734, To be Seen: the Microcosm Clock, *Daily Journal*.
88. Henry Bridges, 2 January 1750, Wanted: a Convenient Light Chamber or Room, *General Advertiser*.
89. Thompson, p. 104.

90. George Adams, *Micrographia Illustrata* (London, 1747).
91. Anonymous, 17 July 1734, To be Seen: the Microcosm Clock, *Daily Journal*.
92. John Clarke, 'A Demonstration of Some of the Principal Section of Sir Isaac Newton's Principles of Natural Philosophy', *Daily Journal* (London).
93. Edward Davies, *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, 1765).
94. Anonymous, 16–19 December 1769, Microcosm, *Dublin Mercury*.
95. It is known that Bridges was active between 1697 and 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.
96. 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.
97. Paul Nurse, *Philosophical Transactions: 350 Years of the Royal Society 1665–2015* (London: The Royal Society, 2015).
98. Davies.
99. Ibid.
100. Royal Collection object number RCIN.30260.
101. Fellows of the Royal Society aimed to use observations of the transit of Venus in 1769 to calculate the size of the solar system.
102. The case and thus the additional compartments and demonstration models have not survived.
103. Davies.
104. Science Museum object number 1912–222.
105. This clock was very likely British Museum object number: 1985,1005.1.
106. The reform of the calendar is discussed in detail in Chapter 5.
107. Thompson, pp. 106–108.
108. George Adams, *Micrographia Illustrata* (London, 1747).
109. Thompson, pp. 106–108.
110. John Naylor, *An Explanation of an Astronomical Clock* (London, 1751).
111. Ibid.
112. Henry Jenkins, *A Description of Several Astronomical and Geographical Clocks* (London, 1778).
113. British Museum object number: 1992,1001.1.
114. Jenkins.
115. Ibid.
116. Ibid.
117. Ibid.
118. Ibid.

119. Ferguson.
120. Jenkins.
121. Ibid.
122. The second transit took place in 1769.
123. Haileigh E. Robertson, '"Imitable Thunder": The Role of Gunpowder in Seventeenth-Century Experimental Science' (University of York, 2015), p. 71.
124. Thomas Hatton, *An Introduction to the Mechanical Part of Clock and Watch Work* (London, 1773).
125. Ibid.
126. Ibid., p. vii.
127. Ibid., p. i.
128. Ibid., p. viii.
129. Ibid., pp. viii; ix; xi; xiii; 11; 15.
130. Watson.
131. Keill.
132. Ibid.
133. Jenkins.
134. Stewart.
135. Morton and Wess.

CHAPTER 8

Conclusion

The preceding chapters have shown that while dials that were made in the period 1550–1770 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 the changes in their format and content reflected changing uses. The standard format of 1770 was not a random, minimalist design; it was the culmination of vast changes in thinking and practises. Until now, this has generally been overlooked by historians due to alternative priorities and the challenges posed by the existing archival evidence. The approach employed here has demonstrated 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 standard format that 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 reveal different aspects of the narrative and help us to understand how this came to be. As a set, the chapters demonstrate that the standard format, in terms of both format and content, came into being as a consequence of the conventions established in early dials and the decline of other aspects 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 feature disappeared once it was no longer useful, with the exception of rare

J. Desborough, *The Changing Face of Early Modern Time, 1550–1770*,
https://doi.org/10.1007/978-3-030-15353-3_8

examples that survived for nostalgic or aesthetic reasons. 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 the most use of.

Throughout the preceding chapters, dials have been referred to as examples of a mechanised knowledge tool. From the way in which they enabled users who were otherwise disabled by traditional dials, discussed in Chapter 4, to their capability of providing users with a prompt for recalling astrological advice, discussed in Chapters 5, 6 and 7, dials not only made users' lives easier, but demonstrated the capability of clockwork for providing combinations of knowledge.

8.1 Fluid Boundary Between Media

This book has shown that the true meaning of clock and watch dials can only be revealed through a comparison with printed paper sources and this was due to the fluid boundary that existed between text, diagram and instrument. Historians of horology[1] have generally concentrated on the development of precision timekeeping, which necessarily prioritises the mechanism over the dial. Yet, as a set, the preceding chapters 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.

Comparison of dials with printed paper sources has not involved a random comparison with any printed paper source; to be meaningful a careful selection was made, as outlined in Chapter 1. As was shown in Chapter 2 on Communication Methods, Chapter 5 on Calendrical Insight, Chapter 6 on Lunar Wisdom and Chapter 7 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. It was demonstrated that the use of symbols and pictures as notation indicated a form of symbol literacy among readers and users. Symbols were prevalent on both media from the mid-sixteenth century to the early-mid-seventeenth century, when they began to decline, with the exception of representation on astronomical clocks that were made for teaching. Furthermore, Chapter 5 identified 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 to one. 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.

In Chapter 2, it was shown that analysing the dial as a form of diagram is the most effective method for understanding the significance of differences in dial format and associated changes. Dials and diagrams with the same symbols and numerals presented similar visual hierarchies to users and readers. A similarity was identified between the two media in terms of the 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, the use of subsidiary dials from the early-seventeenth century was identified as an arrangement comparable to tree diagrams and tables in print. The number of subsidiary dials declined during the mid-late seventeenth century, which was comparable with the tabulated information in almanacs becoming plainer in appearance and inclusive of less information. Again, 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[2] do not mention, despite their focus on this medium. They compare different diagrams, but do not push the boundaries of diagram definition. The preceding chapters expand these boundaries and position the dial within the historical account of diagrammatic representations of knowledge.

We have seen throughout the book 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. Chapter 2 demonstrated that both in terms of the arrangement of information and the notation used, dials were not created in horological isolation; they reflected established methods of communication. By providing the first in-depth deconstruction of dial formats this book reveals that clock and watch dials also influenced printed paper sources by playing an active role in validating existing communication methods and establishing new ones. Until now, the different components of the dial have not been identified in the level of detail necessary to expose

these points. Historians of horology[3] have previously tended to use a catalogue-like approach and list dial indices, but their lack of contextualisation means that they have overlooked these highly significant connections.

In Chapter 4 on enablement devices, it was demonstrated that the illuminated night clock was a religious or devotional aid for users during the night. The function was likened to religious texts such as the earlier Books of Hours. In Chapters 5, 6 and 7 which focus on dial content, it was shown 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. Yet, it was also shown that dials influenced these texts and diagrams. In Chapter 6, for example it was shown that one of the three forms of representation of the lunar calendar on dials was replicated in almanacs. In Chapter 3 on trust, it was demonstrated 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 referred to the quarters of the hour prior to the introduction of minutes to clocks and from 1657 referred to the minutes. Elsewhere in the chapter, it was shown that, from the late-seventeenth century, equation-of-time tables were provided in almanacs to give users of clocks and watches 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[4] and Landes.[5] 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 are made in this book. 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 those of whom overlook the dial as unimportant beyond the context of aesthetic appeal.

In Chapter 7, it was shown 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 considering the subtle changes such as the direction in which the indices progressed from the perspective of prevailing perceptions of the universe, this book repositions the clock and watch within the existing work on early modern astronomy, such as that by North.[6] Considering the ways in which the fluid boundary between dials and printed paper sources manifested itself in the period has contributed to improving our understanding of why the standard format appeared the way that it did by 1770.

8.2 Astrology and Memory

This book has demonstrated that clock and watch dials were used for astrological purposes from the late-sixteenth to the mid-late seventeenth century and the decline in astrology, which took place in two waves at the beginning and towards the end of the seventeenth century, led to the decline of certain aspects of dial representation, but notably the survival of others.

A consideration of dial format yielded significant results. In Chapter 2 on communication methods it was shown 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 was of a similar range, which formed the basis of astrological advice, and were represented using the same symbols and images. It was shown that from the mid-late seventeenth century both dials and almanacs became plainer in appearance due to the reduction of information presented on them. 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 4 on enablement devices, it was shown 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 its relatively short life and its decline in the early-eighteenth century.

An exploration of dial content in Chapters 5, 6 and 7 revealed that dials were useful as a memory prompt for astrological advice, previously read in the almanac, up until the mid-late seventeenth century (although this was a little earlier in the case of the astronomical function). 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 5, provided the calendrical location co-ordinates necessary for users to locate themselves temporally. The lunar function, discussed in Chapter 6, provided users with a device which prompted their existing lunar wisdom. The astronomical function, discussed in Chapter 7, 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 symbol combination of zodiac signs and lunar aspect symbols. Its use for astrology declined during the first wave of astrological reform in the early-seventeenth century, which was several decades earlier than the main wave of the mid-late seventeenth century that led to the decline of the astrological use of the calendar and lunar functions.

These connections offer an update, through a complete reinterpretation of dials, to the work of historians of horology[7] and historians of time,[8] who have overlooked the significance of early modern dials. By deconstructing the dial and closely comparing its components with texts from the period, dials are positioned within the history of astrology and mnemonics for the first time. This has expanded the parameters of existing scholarship on the history of astrology and memory, most notably Curry[9] and Rossi[10] who focus solely on textual sources. The preceding chapters contribute a redefinition of what an astrological and mnemonic text is by introducing the dial as a self-moving astrological diagram.

The 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, the first wave of which took place during the early-seventeenth century and the main wave took place from the mid-late seventeenth century. The calendar and lunar functions survived while they continued to serve a purpose. Chapters 5, 6 and 7 reveal that the calendar, lunar and astronomical functions developed differently. Chapter 5 shows 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[11] by positioning the clock and watch into the debate for the first time and consider the use of instruments alongside paper calendars.

In Chapter 6, it was shown that the lunar function received renewed use as a tidal indicator in the late-seventeenth century. The indication of high-tide 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. The establishment of this connection demonstrated that clock- and watch-makers responded to their users' desire for knowledge. 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 continued 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,[12] writing about the experience of the early modern night, and Maczak,[13] writing about early modern travel, did not mention the role of the Moon. This book expands those histories by positioning the lunar function on dials at the centre of those experiences.

In Chapter 7, it was shown that astronomical indication declined during the early-seventeenth century and was survived by the calendar and lunar functions. A link was made 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.[14] Like many other instrument historians, Morrison concentrated on one type of instrument, rather than comparing different types. Elsewhere in the chapter, it was revealed that the astronomical clocks of the late-seventeenth century and early-eighteenth century were used for teaching. A link is made between these clocks and texts, such as Moxon's *Astronomical Playing Cards*, and it is shown that this is an indication of the astronomical function retaining its mnemonic role in a pedagogic context.

As a set Chapters 5, 6 and 7 have shown that the memory function survived, although not as part of the traditional art of memory, which serves to expand discussion by historians such as Yates[15] and Rossi[16] by introducing clocks and watches as part of the continued legacy of the

art. In Chapter 2 on communication methods, it was shown 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, a contribution is made to histories of nascent science.[17] Clocks and watches provide some 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. Understanding the broad influence of astrology and indeed its decline has made a substantial contribution to our understanding of the standard format that emerged by 1770 and the decline of its predecessors.

8.3 Knowledge Transmission

Dials were a device for both transmitting and creating knowledge. It has been shown throughout the preceding chapters that they were designed to be effective communication devices, based on perceptions of knowledge acquisition in the period. Each chapter demonstrates that the dials and the printed paper sources with which they have been compared 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 that focus on dial format provided a different perspective for understanding dials as aids for knowledge transfer. Chapter 2 on communication methods has shown that the various arrangements of information on dials were conducive to 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 since the human eye consists 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 it is shown that concentric rings and subsidiary dials were conducive to this. Chapter 3 on trust has shown that alternative hour schemes and the representation of minutes and quarters together were different methods by which layers of information were represented to enable cross-referencing in the late-sixteenth century to early-seventeenth century and late seventeenth century, respectively. The plainer dials and printed paper sources from the mid-seventeenth century onwards were outward expressions of the decline of this perception of knowledge communication, which was linked to the decline of the art of memory.

Chapter 4 on devices of enablement has shown that clock- and watch-makers used touch as an alternative sense to sight, in order to follow the same conventions of communication that were used to transmit information to sighted readers. Dials and text were similar, even 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. It has been shown 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[18] and Franklin[19] who do not mention people who might be excluded from reading texts. In terms of the cultural view of disability history, these points expand the discussions initiated by Hobgood and Wood[20] 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.

Chapter 6 on lunar wisdom has shown that the indication of high tide, 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 indications had existed on late-sixteenth-century dials, but enjoyed renewed

and increased popularity from the mid-late seventeenth century. Both the indication of high tide 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.

It has been demonstrated throughout the book that dials were an effective aid for assisting religious practices. Chapter 5 on calendrical insight shows 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. Similarly, night clocks, discussed in Chapter 4, were shown to have served as an aid for religious devotion.

Chapter 7 on astronomical knowledge also demonstrated that dials were used for pedagogical purposes in the late-seventeenth century 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 overlooked 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. Understanding how dials conveyed knowledge has contributed to our understanding of the reasons why the standard format appeared the way that it did by 1770.

8.4 Emotional Influences

An important finding of this book is that users' emotions influenced dial design throughout the period. Dial change rarely took place immediately. 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. It was demonstrated over the course of three chapters that some users preferred older formats and older types of numeration or points of reference. Chapter 3 on trust identified several examples where clock- and watch-makers provided users with reassurance through dials.

The provision of alternative hour schemes, until 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, it was revealed that the coexistence of minutes and quarters on different dials was not random. They were not isolated examples designed as novelties, as historians of time[21] have suggested, but in effect a representation of a period of transition between the old and new systems. In this situation, the clock-maker 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 use. It serves as a contribution to Gooday's work on trust[22] by introducing clock and watch dials to the discussion and expanding the temporal boundaries of trust debates. Furthermore, whereas historians such as Wyatt[23] have begun the discussion of reluctance to change as a stimulus to the continued use of technology in the twentieth century, it has been demonstrated here 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, Chapter 5 on calendrical insight has shown 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*. 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[24] and Lindsay,[25] 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.

It has been demonstrated throughout the book that the clock- and watch-makers' voice emerges only at moments when users required reassurance concerning 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. While a lack of archival evidence left by makers has been a continual challenge throughout this book, some clock- and watch-makers' publications survive from the late-seventeenth century onwards. Chapter 3 has shown that some of these reveal information about the relationship between the maker and the user.

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 for clocks in 1657 and the 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.

Chapter 7 on astronomical knowledge revealed that clock-makers also wrote lengthy descriptions about astronomical teaching clocks in the late-seventeenth and early-eighteenth centuries in which they strongly emphasised the practical value of their clocks. This was to distance themselves from the by-then outdated multi-function dials used for astrological purposes before the mid-late seventeenth century and thereby maintain trust in their work. Understanding the influence of users' emotions and makers' responses to them has completed our understanding of the factors that led to the emergence of the standard format by 1770.

8.5 Epilogue

It cannot be emphasised enough that none of these findings would have been possible without comparing dials with 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 has been shown here, to unlock those meanings. Subtle differences to otherwise unchanging representations on dials appear insignificant if the objects are considered in isolation. The interrogation of dials as a source for understanding different aspects of knowledge and its transmission in the period has not only enabled a reinterpretation of dials within the field of horology and material culture, but has made several contributions to the history of early modern knowledge transmission and epistemology. The preceding chapters have shown that an inter-disciplinary approach to instrument research is a valuable one that can reveal new information about historic objects. It is hoped that this book will mark the beginning of new research into clock and watch dials and their users and that its reinterpretation of dials based on a new approach will inspire further research into both timepieces and scientific instruments more generally.

It has been shown that despite challenges posed by a lack of immediately obvious archival sources, it remains possible to ask and answer new questions of objects.

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