

2 What Were Portable Astronomical Instruments Used for in Late-Medieval England, and How Much Were They Actually Carried Around?

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Telling the time in medieval England was not always straightforward. There were growing numbers of mechanical clocks, which had a significant impact on medieval society,¹ as well as a number of astronomical instruments that used the motion of the sun to tell the time: astrolabes, quadrants, and sundials. Writing in the late fourteenth century, Jean Froissart praised the clock in his poem *L'orloge amoureux*, describing it as beautiful and remarkable, pleasing and profitable, because it shows the hours night and day, even when there is no sun.² But is this really a statement of frustration at the challenges of telling the time on a cloudy day, or something more literary, more ambiguous, or more abstract? Looking specifically at the astronomical and timekeeping instruments that survive from the medieval period, many are portable and could have been carried around to tell the time. But were they? Or, were they made and used for other purposes? These questions run through much of the scholarship on such instruments. Examples of these instruments –

1 G. Dohrn-van Rossum, *History of the Hour: Clocks and Modern Temporal Orders*, trans. T. Dunlap (Chicago: Chicago University Press, 1996). See also L. R. Mooney, 'The Cock and the Clock: Telling the Time in Chaucer's Day', *Studies in the Age of Chaucer*, 15 (1993), pp. 91–109, on the methods and instruments used for telling the time in the late Middle Ages.

2 P. F. Dembowski (ed.), *Le paradis d'amour: L'orloge amoureux* (Geneva: Droz, 1986), p. 83 (lines 1–6):

... l'orloge est, au vrai considerer,
Un instrument tres bel et tres notable
Et s'est aussi plaisant et pourfitable,
Car nuit et jour les heures nous aprent
Par la soubtilleté qu'elle comprend,
En l'absence meisme dou soleil.
Dont on doit mieuls priser son appareil,
Ce que les aultres instrumens ne font pas,
Tant soient fait par art et par compass.

and mechanical clocks – survive in museum collections, but it is difficult to determine how they were used, and for what purpose.

Derek J. de Solla Price, the Whipple Museum's first serious instrument scholar, studied a range of different instrument types in his career.³ In 1980 Price published an influential article that outlines his view of the uses of medieval astronomical instruments, suggesting that their practical value may have been that they were 'ideas made brass' rather than instruments for observation. If someone understood the structure of the heavens and the motion of the heavenly bodies, then they could understand the construction of an astrolabe and how the various lines on the instrument related to the heavens, and the instrument could function as an embodiment of that knowledge:

These devices . . . were tangible models that served the same purpose as geometric diagrams or mathematical or other symbolism in later theories. They were embodied explanation of the way that things worked . . . I suggest that tangible modelling as a species of comprehension comes nearer to the 'purpose' of armillary spheres or star and earth globes than to imagine they had a prime utility as devices for teaching or for reference.⁴

Francis Maddison, who was Curator of the Museum of the History of Science in Oxford, took a similar view, and in an article based around a typology of the most important medieval instruments explained that 'none of the . . . instruments discussed above was of much use to any practical profession, except that of teaching astronomy', but that they were instead (with the exception of the magnetic compass and mechanical clock) an application of theoretical astronomical knowledge.⁵

Over a number of years, I used these two quotes as part of lectures and teaching sessions in the Department of History and Philosophy

3 Aspects of this work are described in detail in Chapter 9 by Boris Jardine. See also Seb Falk, 'The Scholar as Craftsman: Derek de Solla Price and the Reconstruction of a Medieval Instrument', *Notes and Records of the Royal Society*, 68 (2014), pp. 111–34.

4 D. J. de Solla Price, 'Philosophical Mechanism and Mechanical Philosophy: Some Notes towards a Philosophy of Scientific Instruments', *Annali dell'Istituto e Museo di Storia della Scienza di Firenze*, 5 (1980), p. 76.

5 F. R. Maddison, *Medieval Scientific Instruments and the Development of Navigational Instruments in the Fifteenth and Sixteenth Centuries* (Coimbra: Agrupamento de Estudos de Cartografia Antiga, 1969), p. 20. The instruments in the typology are the armillary sphere, the equatorium, the torquetum, the planispheric astrolabe, the quadrant, other types of sundial (under which heading he lists the navicula, horizontal dial, and universal equinoctial dial), the magnetic compass, and the mechanical clock.

of Science about medieval instruments. Some of those, thanks to the Whipple Museum collection and the support of museum staff, included hands-on engagement by the students with the instruments,⁶ and those sessions helped to engage undergraduate students in a subject that can be difficult and alien. However, the students also challenged me to explain what a medieval astrolabe like the one they were looking at (see Figure 1.1) was actually used for, and they looked at an astrolabe alongside a cylinder dial and asked about the difference between the two. Prompted by my students' questions, I here return to questions I considered earlier, now based on new evidence that has become available in the last two decades.

This chapter is the result of that reconsideration of fundamental questions about the uses and users of astronomical instruments in medieval England. I argue that we should look again at the practical uses of some types of instruments, and consider whether some were carried around to tell the time, to be used for practical purposes alongside the symbolic, teaching, and other functions that Price and Maddison articulate. Instruments could be 'ideas made brass' but they could also be of practical use, and I suggest that it was precisely this combination that may have made some instruments more important, or more common, in the period. Looking carefully at the provenance of objects, and at the reasons why they are or are not preserved in museum collections, and considering the full range of types of evidence available for the study of instruments paints a fuller picture.

Evidence from Texts

The challenges around answering questions about what instruments were used for relate in part to the available evidence. There are many hundreds of manuscripts that include technical works about astronomical and timekeeping instruments, describing how to make and use them.⁷ Many of these manuscript volumes are compilations of

6 These included Wh.1264, the medieval astrolabe analysed in Chapter 1 by Seb Falk.

7 On scientific and medical books in later-medieval England see, for example, P. M. Jones, 'Medicine and Science', in L. Hellings and J. B. Trapp (eds.), *The Cambridge History of the Book in Britain* (Cambridge: Cambridge University Press, 1999), pp. 433–48; and S. Livesey, 'Transitions 1: Scientific Writing in the Latin Middle Ages', in A. Hunter (ed.), *Thornton and Tully's Scientific Books, Libraries and Collectors: A Study of Bibliography and the Book Trade in Relation to the History of Science*, 4th edn (Aldershot: Ashgate, 2000), pp. 72–98. The US National Library of Medicine's *IndexCat* provides keyword search across the electronic versions of the classic catalogues compiled by Lynn Thorndike and

astronomical texts along with texts about instruments, mostly in Latin, but, from the later fourteenth century, with some in English. Some manuscripts are rubricated and some are illustrated with diagrams, but hardly any have pictorial images, indicating a scholarly or practical purpose more than a decorative one. One of the most well-known of these technical works was the *Treatise on the Astrolabe* written in English by Geoffrey Chaucer in the late fourteenth century. That text sets out the parts of an astrolabe, and then details more than forty observations and calculations that the instrument could perform.⁸ Other astrolabe treatises, as well as texts about other astronomical instruments, often also include detailed instructions for their construction, linking the lines on the instrument to the lines of the model of the heavens on which they were based. In many cases, although the instructions in these manuscripts are clear and can be followed, they are not straightforward practical manuals, but oriented towards an understanding of the theory of astronomy as much as to the use of an instrument to tell the time, or to survey a field.

One possibility for assessing what instruments were used for in the medieval period is to look at who owned them, and for this there are scattered and fragmentary references in wills and probate inventories. For example, the 1434 will of John de Manthorp, vicar of Hayton, East Yorkshire, in northern England, includes an astrolabe and a calendar, and the will of John Hurt in 1476 bequeathed to the Cambridge University Gotham Loan Chest a book about astronomical instruments that was already in the chest as security against a loan.⁹ Surviving probate inventories for Oxford University in the fifteenth century do not include any references to objects identifiable as astrolabes or sundials, nor do they list any books identifiable as

Pearl Kibre (for Latin scientific manuscripts) and by Linda Ehrensam Voigts and Patricia Deery Kurtz (for Middle English), but, although this is a useful starting point, it is still incomplete and must be supplemented by individual libraries' catalogues: www.nlm.nih.gov/hmd/indexcat/index.html (accessed 2 February 2018).

8 S. Eisner, *A Treatise on the Astrolabe, Volume VI: The Prose Treatises, Variorum Editions of the Works of Geoffrey Chaucer* (Norman: University of Oklahoma Press, 2002).

9 S. Cavanaugh, 'Books Privately Owned in England, 1300–1450', unpublished PhD dissertation, University of Pennsylvania, 1980, pp. 561–2; and P. D. Clarke, *The University and College Libraries of Cambridge* (London: British Library, 2002), p. 704, no. 14.

manuscripts about instruments.¹⁰ However, there is evidence from the fourteenth century that Oxford scholars did own instruments – Simon Bredon (d. 1372) and William Rede (d. 1385) both bequeathed astronomical books and instruments to individuals and to Oxford colleges.¹¹

None of these sources relating to the ownership of instruments gives clear information about what those people did with the instruments and manuscripts. Some non-technical works connect Oxford students and scholars to the use of astrolabes, and seem at first read to provide some evidence for what they did with them, including a story of the drunken behaviour of an Oxford student named Robert Dobbys, describing his use of an astrolabe to find his way home, sometime in the 1420s:

It is related of him that one night after a deep carouse, when on his way from Carfax to Merton, he found it advisable to take his bearings. Whipping out his astrolabe he observed the altitude of the stars, but, on getting the view of the firmament through the sights, he fancied that sky and stars were rushing down upon him. Stepping quickly aside he quietly fell into a large pond. 'Ah, ah', says he, 'now I'm in a nice soft bed I will rest in the Lord.' Recalled to his senses when the cold struck through, he rose from the watery couch and proceeded to his room where he retired to bed fully clothed. On the morrow, in answer

10 H. Anstey (ed.), *Epistolae Academicae Oxoniensis*, 2 vols. (Oxford: Her Majesty's Stationery Office, 1868), vol. 2: pp. 514–15, 525, 531–2, 543–6, 557–62, 565–67, 579–85, 592–7, 599–600, 604–15, 622–5, 627–31, 638–67, 671–3, 698, 704–8, 711–13. One entry is unclear: the 'bursa cum uno "diall" de ligno' owned by John Lashowe might have been a small wooden sundial kept in a purse (p. 663). Some of these records give evidence for mathematical interests, for example, Thomas Cooper owned a geometrical book (p. 516). Several of the inventories record the ownership of musical instruments, for example, Sir John Lydbery owned a lute, valued at 6d (p. 698), and John Hosear owned a harp valued at 4d (p. 705).

11 In Simon Bredon's will (dated 1368) he leaves his large astrolabe to Merton College and the small astrolabe to William Rede. See M. Powicke, *The Medieval Books of Merton College* (Oxford: Clarendon Press, 1931); and Cavanaugh, 'Books Privately Owned in England', p. 129. William Rede's will of 1 August 1382 includes a large number of astronomical and mathematical books, left to his relatives and to various Oxford Colleges. At the end is an indenture listing a number of instruments to be given to Merton College: 'Preterea dictus venerabilis pater dedit et assignavit eiusdem calicem deauratum, et decem alia instrumenta, videlicet albionem, equatorium planetarum, quadrantem, chilindrum, speram materialem, speram solidam, tabulam ymaginum celestium, cartam maris, lapidem calculatorium, et tabulas dealbatas pro tabulatione librorum.' See J. D. North, *Richard of Wallingford*, 3 vols. (Oxford: Oxford University Press, 1976), vol. 3, appendix 15, pp. 132–5.

to kind inquiries, he denied all knowledge of the pond. Thus were his feckless drunken ways amply proved.¹²

A clue that this may not be a straightforward account of the practical use of an astrolabe is in the last few words – which mirror the wording of academic argument in the medieval period. Indeed, this story about Dobbys was told as part of the disputations that qualified the medieval student to be granted a degree, by the ‘Father of the Act’, who introduced the inceptors by poking fun at them.¹³ It also harks back to the ancient story told about Thales of Miletus, who was so busy looking at the stars that he fell into a ditch.¹⁴ The story is clearly supposed to be funny, at least to the learned Oxford audience who heard it, so perhaps the joke is that this is precisely *not* how an astrolabe was used? Oxford scholars would know that it is only a short distance from Carfax to Merton, and so the only reason you might use an astrolabe is if you (like Dobbys, as painted by this story) were a fool.

Written a few decades earlier, Geoffrey Chaucer’s *Canterbury Tales* is a more well-known literary work that includes a number of references to pilgrims using astronomical and other instruments. Chaucer’s characters might use a cylinder dial to determine that it is time to eat, or be described as owning an astrolabe, but these

12 Oxford, Magdalen College, MS 38, ff. 41v–42r. This translation is from S. Gibson, ‘The Order of Disputations’, *Bodleian Quarterly Record*, 6, no. 65 (1930), pp. 107–12, on p. 108. See also C. Eagleton, J. Rampling, and D. Banham, ‘Masters of Incompetence: Learned Humour in 15th-Century Oxford’, in J. Rampling, D. Banham, and N. Jardine (eds.), *Recipes for Disaster* (Cambridge: Whipple Museum of the History of Science, 2010).

13 For biographical details of Robert Dobbys, see A. B. Emden, *Biographical Register of the University of Oxford*, 3 vols. (Oxford: Clarendon Press, 1957), vol. 1, pp. 579–80. Gibson ‘The Order of Disputations’, pp. 107–12; and S. Gibson, ‘Appendix C: The Order of Disputations’, in S. Gibson (ed.), *Statuta antiqua Universitatis Oxoniensis* (Oxford: Clarendon Press, 1931), pp. 643–7, describe the procedure of inception, the people involved, and the records in Magdalen MS 38.

14 R. H. Hicks, translation of Diogenes Laertius, *Lives of Eminent Philosophers*, 2 vols. (Cambridge: Harvard University Press, 1972), p. 35. The old woman who answered his cries said ‘How can you expect to know all about the heavens, Thales, when you cannot even see what is just before your feet?’ The stories told by Diogenes Laertius were widely available in fifteenth-century England, both directly, and in works based on them, such as Walter Burley’s fourteenth-century work *De vita et moribus philosophorum*: see Walter Burley (attr.), *Liber de vita et moribus philosophorum*, ed. H. Knust (Tübingen: Bibliothek des Litterarischen Vereins in Stuttgart, 1886). A similar story, of an astronomer who is so busy looking at the stars that he falls into a pit, is told in Chaucer’s ‘Miller’s Tale’: see L. D. Benson (ed.), *The Riverside Chaucer* (Oxford: Oxford University Press, 1987), p. 71, lines 3457–61.

references are not straightforward to interpret.¹⁵ Other medieval writers with courtly audiences included references to astronomy and its instruments in their works, too: for example, Gower included an astronomical section in the *Confessio Amantis*, and Robert Henryson's Middle Scots version of Aesop's Fables includes the astrolabe, quadrant, and almanac as things that can teach someone about the heavens.¹⁶ In all these cases, perhaps the clearest thing they indicate is that courtly audiences knew enough about astronomy and its instruments to understand their use in this literary context.

Some clues as to what instruments were seen as useful for can be found by considering other objects that they are described as, or seem to be, equivalent to. Henryson's poem lists an astrolabe, quadrant, or almanac together when talking about learning astronomy, and Chaucer's student Nicholas (in 'The Miller's Tale' in the *Canterbury Tales*) has not only an astrolabe, but also a manuscript of Ptolemy's *Almagest*, augrim (calculating) stones, among various other objects kept at the head of his bed.¹⁷ In a letter written to William Worcester (clerk to the Norfolk knight Sir John Fastolf) in May 1449, his correspondent John Crop asks about an augrim table, or a book of augrim, or an astrolabe, again indicating that there were connections made between these types of instruments in the period that we perhaps do not as strongly make in museums, where books and manuscripts may no longer be kept with astronomical instruments like astrolabes, or objects for calculation and accounting.¹⁸

15 A recent special issue of *The Chaucer Review*, 43.4 (2009), is dedicated to Chaucer's references to, and interest in, time and its measurement. The classic study is J. D. North, *Chaucer's Universe* (Oxford: Clarendon Press, 1988). In a more recent analysis, Sara Schechner concluded that none of Chaucer's pilgrims was likely to have both the means to own, and the skill to use, an instrument like an astrolabe: S. J. Schechner, 'Astrolabes and Medieval Travel', in R. Bork and A. Kann (eds.), *The Art, Science, and Technology of Medieval Travel* (Aldershot: Ashgate, 2008), pp. 181–210, on p. 204.

16 On Gower, see J. Simpson, *Sciences and the Self in Medieval Poetry: Alan of Lille's 'Anticlaudianus' and John Gower's 'Confessio Amantis'* (Cambridge: Cambridge University Press, 1995). On Henryson, see Robert Henryson, *The Morall Fabillis of Esope the Phrygian*, ed. G. G. Smith (Edinburgh and London: Scottish Text Society, 1906), p. 49; and A. Hanham and J. C. Eade, 'Foxy Astrology in Henryson', *Parergon*, 24 (1979), pp. 25–9.

17 Benson, *The Riverside Chaucer*, pp. 68–78, lines 3208–11.

18 See R. Beadle and C. Richmond (eds.), *Paston Letters and Papers of the Fifteenth Century*, part III (London: Early English Text Society, 2005). Worcester is known to have been interested in astronomical and calendrical subjects, and owned a number of manuscripts on these subjects, as well as on historical and antiquarian matters. See K. B. McFarlane, 'William Worcester: A Preliminary Survey', in K. B. McFarlane (ed.), *England in the Fifteenth Century* (London:

Finally, there is strong evidence from medieval England that manuscripts were kept together with the instruments they describe in libraries – astronomical instruments are the only objects other than books that appear in late-medieval English booklists. Library lists include details of the instruments held, which include astrolabes, quadrants, and in one case a navicula sundial. I have argued in a previous publication that this is the case because both are regarded as sources of information about astronomy and the achievements of great astronomers, with the instruments complementing the books. This was not only a connection made in abstract, but in practice, since for example Merton College library lent out astronomical instruments in the same way as it lent out astronomical books to fellows of the college. And, interestingly, in the few listings that give this detail, instruments and books were estimated as being of similar value to each other.¹⁹

Instruments and Archaeology

Medieval astronomical and timekeeping instruments are today not only rarely found in libraries, but are more often found in museums and collections around the world.²⁰ Hundreds of astrolabes, quadrants, sundials, and related instruments survive from the Middle East and from Europe, and detailed research on them has revealed much about how they were made, and where. Most instruments from medieval Europe are neither signed nor dated, and their identification relies upon close study of the objects themselves, looking at the letter and number forms marked on them, as well as construction marks, lines, and clues that sometimes help to identify the maker or workshop.²¹

Comparing the astronomical instruments preserved in museums with those described in the manuscript texts indicates that, as might be expected, metal instruments are much more likely to have

Hambledon Press, 1981), pp. 199–224, on p. 199; and J. Harvey, *William Worcester: Itineraries* (Oxford: Clarendon Press, 1969), p. 240.

19 C. Eagleton, 'John Whethamstede, Abbot of St Albans, on the Discovery of the Liberal Arts and Their Tools. Or, Why Were Astronomical Instruments in Late-Medieval Libraries?', *Mediaevalia*, 29.1 (2009), pp. 109–36.

20 D. A. King, 'Medieval Astronomical Instruments: A Catalogue in Preparation', *Bulletin of the Scientific Instrument Society*, 31 (1991), pp. 3–7.

21 For example, the close study of three English quadrants that enabled them to be dated, and linked to the court of Richard II: S. Ackermann and J. Cherry, 'Richard II, John Holland and Three Medieval Quadrants', *Annals of Science*, 56 (1999), pp. 3–23.

survived than those made from other materials. It is likely, for example, that paper and wooden instruments were more widely made and used in the medieval period, and a commonly copied text on the cylinder dial specifies that it should be made from a piece of boxwood.²² Other, often larger or more complex, instruments may only rarely have been made;²³ on the other hand, there are instruments that were used but not widely written about, like sandglasses and simple compass dials.²⁴

This bias in the survival of instruments comes in part from the fact that it is more likely that wooden or paper instruments were disposed of, or became damaged, since they were less durable than instruments made of brass. Occasionally, it is possible to identify medieval instruments that were altered in the sixteenth century, indicating perhaps that they were still then being used.²⁵ By the seventeenth century, scholars and antiquaries had begun to collect astronomical manuscripts, and sometimes instruments too. For example, there were three scholars and collectors in the eighteenth century who were interested in the navicula sundial, one of whom made his own instrument following the designs preserved in medieval manuscript texts (Figure 2.1). In the eighteenth and nineteenth centuries an increasing interest in the medieval period also had an impact both on the collecting and on the study of astronomical instruments from the period.²⁶ Across all periods, however, collectors of astronomical instruments seem to have preferred more

- 22 C. Kren, 'The Traveller's Dial in the Late Middle Ages', *Technology and Culture*, 18 (1977), pp. 419–35, discusses the construction of the cylinder dial, questioning whether they were made in large numbers but do not survive, or whether the cylinder existed primarily as a written text.
- 23 For example, the equatorium, on which see S. Falk, 'A Merton College Equatorium: Text, Translation, Commentary', *SCIAMVS*, 17 (2016), pp. 121–59; S. Falk, 'Learning Medieval Astronomy through Tables: The Case of the Equatorie of the Planetis', *Centaurus*, 58 (2016), pp. 6–25; and Falk, 'The Scholar as Craftsman'.
- 24 On the iconography of sandglasses, see D. G. Boullin, 'An Iconographic Study of Sandglasses', *Nuncius*, 4 (1989), pp. 67–85. On references to them in accounts of navies and merchants, see P. F. Naish, 'The Dyoll and the Bearing Dial', *Journal of the Institute of Navigation*, 7 (1954), pp. 205–8. On compass dials, which may have been imported from German-speaking areas of Europe, see E. G. R. Taylor, *The Haven-Finding Art* (London: Hollis and Carter, 1956), p. 173.
- 25 G. L'Estrange Turner, 'Charles Whitwell's Addition, c. 1595, to a Fourteenth Century Quadrant', *Antiquaries Journal*, 85 (1995), pp. 454–5.
- 26 J. H. Leopold, 'Collecting Instruments in Protestant Europe before 1800', *Journal of the History of Collections*, 7 (1995), pp. 151–7, describes the collecting of astronomical instruments in *Kunstammer* and outlines the early English collections of the seventeenth and eighteenth centuries.

Figure 2.1
A *navicula sundial* in the Whipple Museum's collection, made in the eighteenth or nineteenth century, closely following the diagrams in medieval manuscript texts. Image © Whipple Museum (Wh.5902).



complex and decorative instruments over those that were more functional, which almost certainly skewed what survives.

However, while traces of ownership of manuscripts can sometimes be found in annotations made in them by later owners, few instruments have detailed provenance recorded on them or about them. Few medieval astrolabes, quadrants, or sundials in museum collections are associated with specific places or people beyond the eighteenth or nineteenth centuries, hampering efforts to consider what these instruments in particular might (or might not) have been used for and how they might have come to be preserved in museum collections. Complementing museum collections, however, there is some archaeological evidence relating to medieval astronomical instruments, which has so far not been analysed in order to consider the uses of medieval instruments.

The archaeological evidence for England and Wales is particularly useful thanks to the Portable Antiquities Scheme (PAS). This voluntary scheme records hundreds of thousands of small finds, including many objects that are not required to be processed as Treasure, often made by metal detectorists, but which can nonetheless create a valuable picture of the material culture of a place or period. The PAS is supported by a network of Finds Liaison Officers who work with finders and local communities to ensure the quality of the data and images in the database, as well as to promote good practice among metal-detector communities, including the need to gain

permission from the landowner, and the importance of recording context and precise locations for finds.²⁷

Some common types of objects dominate those recorded by the PAS: on 14 July 2017, there were more than 380,000 coins in the database, along with more than 41,000 buckles and 34,000 brooches. These are the kinds of things that people probably lost while moving around their local area, or travelling further afield (often known as 'stray finds'), rather than objects that were deliberately concealed or hoarded. They are also dominated by base-metal objects that are relatively easily located with a metal detector. Finds in the PAS database are categorised by time period, with more than 298,000 Roman-period objects, more than 171,000 medieval objects, and more than 141,000 post-medieval objects recorded at the time of writing. Looking to some less common types of objects, and thinking back to Chaucer's pilgrims travelling to or from Canterbury, there are 461 pilgrim badges recorded,²⁸ and sixty-one book-related objects (including book clasps), which suggests that some people carried books around with them.²⁹

Turning to astronomical and timekeeping instruments, the numbers are smaller: 110 sundials are recorded from medieval and post-medieval periods, the majority of which are ring dials from the seventeenth and eighteenth centuries. In many cases, the PAS database cross-references major museum collections, including the British Museum and the Museum of the History of Science, Oxford, giving some (albeit limited) consistency of dating and identification.³⁰ Crucially, finds in the PAS database have locations associated with them, which enables an assessment of where these types of objects were used, or where they were lost (Figure 2.2). Taking these data, and removing those objects that are dated, or are likely to date, from after c. 1500, gives a small dataset of finds that can be combined

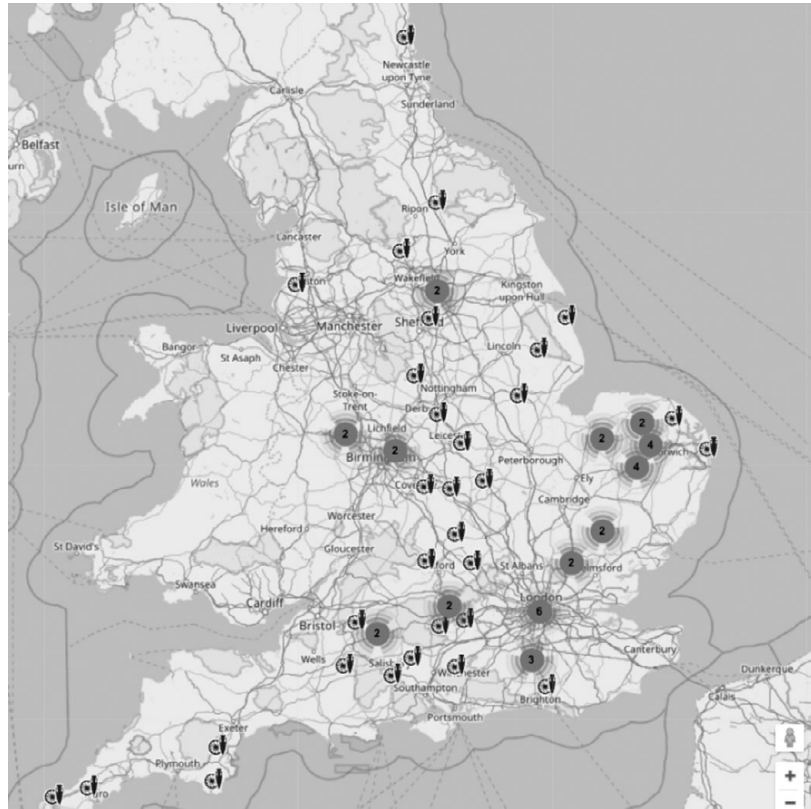
27 www.finds.org.uk and R. Bland, M. Lewis, D. Pett, I. Richardson, K. Robbins, and R. Webley, 'The Treasure Act and Portable Antiquities Scheme in England and Wales', in Gabriel Moshenska (ed.), *Key Concepts in Public Archaeology* (London: UCL Press, 2017), pp. 107–21.

28 <https://finds.org.uk/database/search/results/q/pilgrim+badge/show/100> (accessed 14 July 2017).

29 <https://finds.org.uk/database/search/results/q/book+clasp/show/100> (accessed 14 July 2017).

30 John Davis has been active in helping to identify things that are or might be sundials or other mathematical and astronomical instruments, which means those records are often better than average. He has also published a number of articles about particular instruments recorded by the Portable Antiquities Scheme: see the publication list at www.flowton-dials.co.uk/publications/ (accessed 12 May 2018).

Figure 2.2 Map of all finds whose database record includes the keyword 'sundial' in the Portable Antiquities Scheme database, on 14 July 2017. Some finds have their find spot protected and are not mapped, but they have less precise information on the location at which they were found in the database record text. Map of search results from Portable Antiquities Scheme database www.finds.org.uk (CC-BY 4.0) using Google Maps, with data from Open Street Map www.openstreetmap.org (CC-BY-SA).



with evidence from museum collections, and information from texts, to begin to assess whether portable astronomical instruments were carried around, or whether they more often stayed inside the libraries, studies, and other places in which they were kept.

Astrolabes and Compass Dials

The astrolabe, in some ways the quintessential medieval astronomical instrument, has been the focus of much substantial research. In a recently published listing drawing on many years of detailed work, David King lists the European astrolabes from before c. 1500 that are known to survive, grouping them by type.³¹ Some English instruments can be grouped together, and it has been argued that some

31 D. A. King, 'European Astrolabes to ca. 1500: An Ordered List', *Medieval Encounters*, 23 (2017), pp. 355–64.

should be associated with the royal court,³² whereas others have long connections to Oxford or Cambridge colleges that suggest learned contexts for their ownership.³³

Reviewing a range of evidence, including the latitudes for which astrolabe plates were made, unusual markings or parts on surviving instruments, and literary and other references to the instrument, Sara Schechner concluded that there is little evidence of medieval travellers taking an astrolabe on the road, or to sea, until the late fifteenth century.³⁴ Astrolabes and texts about them did move around Europe, she explains, but once they were owned by someone it seems that they were not taken outside their study for more practical purposes like timekeeping, despite the instrument being well-adapted for that purpose as well as for astrological medicine or for surveying. The evidence from the PAS backs this up, with no astrolabes or fragments of astrolabes recorded in the database. (One item was listed in the database with the keyword ‘astrolabe’ (the object top left in Figure 2.3, found at a site where more than 226 medieval objects have been recorded), but John Davis has more recently reidentified it as part of a nocturnal.³⁵)

If astrolabes were complex, expensive, and often too large to be carried around easily, the same was not true for simple compass dials for telling the time from the sun at a particular (fixed latitude). These instruments, or parts of them, are the majority of medieval astronomical and timekeeping instruments recorded by the PAS. Some of these examples, when complete, were probably compass dials with nocturnals on their lids, which could be used at night as well as during the day.³⁶ These instruments (those in the all but the top row

32 J. Davis, ‘A Royal English Medieval Astrolabe Made for Use in Northern Italy’, *Journal for the History of Astronomy*, 48.1 (2017), pp. 3–32; and J. Davis, ‘Fit for a King: Decoding the Great Sloane Astrolabe and Other English Astrolabes with “Quatrefoil” Retes’, *Medieval Encounters*, 23 (2017), pp. 311–54.

33 For example, Merton College, Oxford, which still has instruments in its old library: A. Chapman, ‘Merton College and Its Astrolabes’, *Postmaster and The Merton Record* (October 1992), pp. 88–100. A fourteenth-century English astrolabe at Gonville & Caius College, Cambridge, has been associated with Walter Elveden, who wrote a *Kalendarium* in 1327 and was associated with the founders of the College: see J. Davis and M. Lowne, ‘An Early English astrolabe at Gonville & Caius College, Cambridge, and Walter of Elveden’s *Kalendarium*’, *Journal for the History of Astronomy*, 46.3 (2015), pp. 257–90.

34 Schechner, ‘Astrolabes and Medieval Travel’, p. 204.

35 J. Davis, comment at <https://finds.org.uk/database/artefacts/record/id/192080> (accessed 2 February 2018).

36 An early-sixteenth-century drawing by Urs Graaf shows a man holding a compass dial which, in common with several of the surviving instruments, has a nocturnal on the lid so that the owner could tell the time by day or by night:

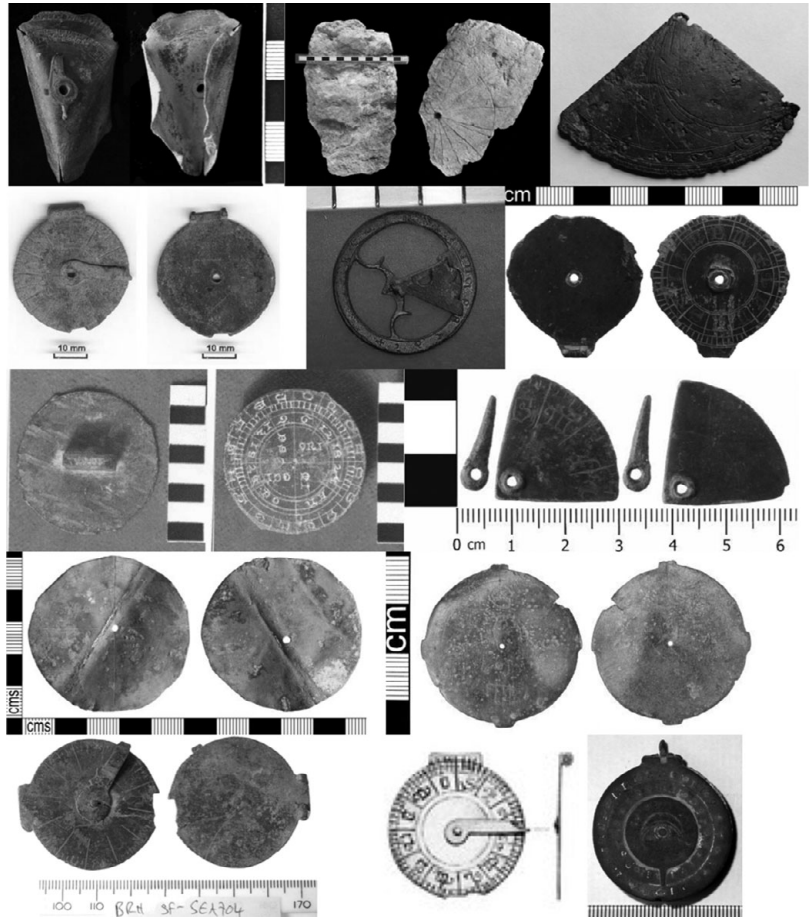


Figure 2.3 Thirteen astronomical or time-telling instruments (or parts of them) that are likely to be late-medieval in date, recorded by the Portable Antiquities Scheme. Composite image from www.finds.org.uk (CC-BY 4.0).

of Figure 2.3) are similar in their size, form, and decorative details to the few examples of medieval English compass dials that are preserved in museum collections. Indeed, some of the examples in museum collections display clear evidence of corrosion consistent with being buried in the ground, so perhaps they, too, are objects that were found, even though their archaeological context is no longer known or was at the time of finding and/or acquisition not recorded. There are finds of similar simple compass dials in other parts of Europe, dating to the fifteenth century, indicating that this pattern is also repeated outside England.³⁷

F. A. B. Ward, 'An Early Pocket Sundial Illustrated in Art', *Antiquarian Horology*, 11 (1979), pp. 484–7.

³⁷ For example, R. Salzer, 'Mobility Ahead of Its Time: A Fifteenth-Century Austrian Pocket Sundial as a Trailblazing Instrument for Time Measurement

For these two very different instruments, the archaeological evidence suggests two very different kinds of usage: astrolabes probably were not carried around much, but compass dials were. Astrolabes may have been more associated with studying the heavens, or for timing religious observances,³⁸ than with more practical needs, while compass dials, although they still worked by observation of the motion of the sun through the heavens, were more practical in their function. Compass dials were probably more common, and carried around (and lost) more frequently.

Quadrants and Naviculae

I turn now to the first of two types of English astronomical instrument that, in the medieval period, seem to have existed between the extremes of the astrolabe and the compass dial. Medieval-period quadrants of various kinds are preserved in museum collections, and there are also archaeological finds. An exceptional find was made in 2005, when, during an excavation of a sealed soil deposit at the back of a medieval inn building in Canterbury, a quadrant was found and dated to 1388 by close examination of the tables engraved on it.³⁹ This instrument was made for latitude 52°, appropriate for Southern England; it has no stars marked on it, simplifying the instrument but meaning that it could not have been used for finding the time at night.

Following widespread news reporting of this quadrant (and its subsequent sale price), another quadrant was found by a metal detectorist in 2014, near Chetwode, Buckinghamshire (Figure 2.4). This quadrant was found in a field through which there is a footpath running to a medieval priory, indicating perhaps that the person who lost it was travelling to or from the priory.⁴⁰ John Davis has

on Travels', in M. C. Beaudry and T. G. Parno (eds.), *Archaeologies of Mobility and Movement* (New York: Springer, 2013), pp. 65–79.

38 On religious uses for astrolabes in this period, see Chapter 1 by Seb Falk.

39 The quadrant found at the 'House of Agnes' in Canterbury, in 2005, is British Museum 2008,8017.1, and images of it can be seen in their online collections database at www.britishmuseum.org/research/collection_online/search.aspx. On this quadrant, including its dating, see E. Dekker, 'With His Sharp Look Perseth the Sonne: A New Quadrant from Canterbury', *Annals of Science*, 65.2 (2008), pp. 201–20. For more detailed archaeological and site details see A. Linklater and E. Dekker, 'The Discovery of a Quadrant Novus at the House of Agnes, St Dunstan's Street, Canterbury', *Archaeologia Cantiana*, 130 (2010), pp. 65–82.

40 www.christies.com/features/The-Thrill-of-Discovery-Finding-the-Chetwode-Quadrant-6620-1.aspx (accessed 2 February 2018).

Figure 2.4 The Chetwode quadrant, BERK-C673DD, image from www.finds.org.uk database (CC-BY 4.0).



argued that it is similar to another metal-detectorist find of part of a medieval quadrant in Norfolk, and suggests that the two instruments may have been produced to the same design, or even in the same workshop.⁴¹

Looking at an instrument with similar size and functionality to the quadrants, the *navicula* sundial, there is a similar pattern. Four medieval *naviculae* are preserved in museum collections,⁴² and these instruments share – both with each other and with the manuscript texts on each *navicula* – a remarkably consistent design.⁴³ Some recorded provenance information, even if only partial, exists for all of them. The Oxford *navicula* was given to Lewis Evans in 1898 by the Curator of the Norwich Museum, and then given by Evans to the Museum of the History of Science.⁴⁴ The Greenwich *navicula*, in the collections of the National Maritime Museum, was found by metal detectorists near Sibton Abbey, Suffolk. The Geneva *navicula* was owned in the eighteenth century by John Wilson (1719–83), an antiquarian and collector who lived in the North of England, near Sheffield. This instrument remained in his family until it was sold at auction to the Musée d’Histoire des Sciences in Geneva. Its excellent

41 J. Davis, ‘The Chetwode Quadrant: A Medieval Unequal-Hour Instrument’, *Bulletin of the British Sundial Society*, 27.2 (2015), pp. 2–6.

42 In Oxford (History of Science Museum) www.mhs.ox.ac.uk/object/inv/54358; Greenwich (National Maritime Museum) <http://collections.rmg.co.uk/collections/objects/211073.html>; Geneva (Museum of the History of Science) http://institutions.ville-geneve.ch/fileadmin/user_upload/mhn/images/votre_visite/site_mhs/aide_cadrans_e.pdf; and Florence (Galileo Museum) <https://catalogue.museo.galileo.it/object/NaviculaDeVenetiis.html> (all links accessed 12 May 2018).

43 C. Eagleton, *Monks, Manuscripts, and Sundials: The Navicula in Medieval England* (Leiden: Brill, 2010), especially Chapter 5 on the design of the instrument and the relationship between instrument, text, and image.

44 Provenance notes in the record of a meeting at the National Maritime Museum, Greenwich, 1992, which are in the instrument’s accession file at the History of Science Museum, Oxford. The meeting was called to assess the Geneva *navicula*, then being researched before it was sold, since its larger size had created some doubts about whether it should be dated to the fifteenth or the eighteenth century.

condition makes it most likely that it passed from owner to owner until it came into the possession of John Wilson in the eighteenth century, although there are no records of where or how Wilson might have acquired such an instrument, other than a reference to his having collected ‘some things which were scarcely worth preservation’ by a near-contemporary commentator.⁴⁵

Another navicula, of a similar size to the Geneva navicula, and with very similar decorative features to Greenwich’s example, was found in 2017.⁴⁶ It is about the same size as the larger Geneva instrument, and has similar letter and number shapes, as well as similar positioning of those markings in relation to the hour lines on the front of the instrument. Despite their different sizes, this newly found instrument also has much in common with the Greenwich navicula, details that are mostly not specified in the manuscript texts about the navicula. This privately owned navicula was most probably found by a metal detectorist in Yorkshire, although details are somewhat uncertain; nevertheless, its archaeological context is clear from the corrosion on the instrument.⁴⁷ Indeed, only the Florence and Geneva naviculae, those that have provenance linking them to collections in the eighteenth century and earlier, do not seem to have surface corrosion consistent with having been buried in the ground.

Despite the information being incomplete and to some degree uncertain, the places where the naviculae have been found can be compared with lists of towns and their latitudes that appear on some of the instruments, as well as in manuscripts describing how to make and use them. The same places appear in manuscripts and on the instruments, albeit with fewer places listed on the instruments than in the written sources.⁴⁸ And the places where naviculae were found, or have provenance linking them to, are within the same range of latitudes as these lists of places (Figure 2.5). The places themselves are also striking, with Sibton Abbey (the find spot for the Greenwich navicula) adding to the evidence from manuscripts and library booklists that points to the study and use of astronomical and

45 J. Hunter, *Hunter’s Hallamshire* (London: privately printed, 1819), p. 276.

46 This instrument is described and illustrated in J. Davis, ‘The Navicula: Made in Medieval East Anglia?’, *Bulletin of the British Sundial Society*, 29.2 (2017), pp. 15–23.

47 Information on provenance and likely find spot provided by the instrument’s owner, personal correspondence with the author.

48 Egleton, *Monks, Manuscripts, and Sundials*, Chapter 4 on latitude lists.

Figure 2.5 Places marked on the back of surviving *naviculae* (York, Northampton, Oxford, London, Winchester, and Exeter) and places where *naviculae* were found or have provenance linking them to (Vale of York, Norfolk, and Sibton Abbey in Suffolk). Map of search results from Portable Antiquities Scheme database (www.finds.org.uk) using Google Maps, with map data from Open Street Map (www.openstreetmap.org, CC-BY-SA), and GeoBasis-DE/BKG ((c) 2009).



timekeeping instruments by people in monasteries and other religious institutions.⁴⁹ The picture is far from complete, although the manuscript sources and surviving instruments together suggest that the *navicula* was a fairly common type of portable sundial in medieval England. The fact that two of them have been found by metal detectorists suggests that they were not only made and studied for their connection to astronomical theory, but also carried around.

Considering texts and instruments together – and, for the latter, including archaeological finds along with objects in museum collections – points to a more complex pattern of uses and usage for astronomical instruments in medieval England than any of those sources alone can give. There is little evidence that astrolabes, that quintessential astronomical instrument of the period, were carried around, and this is perhaps unsurprising given the size and weight,

⁴⁹ John Davis's argument that the *navicula* was a specifically East Anglian instrument seems rather thin, however, when looking at all the available evidence.

and likely value, of the brass astrolabes that are preserved in museums. It is possible that paper or wooden astrolabes were more affordable and more portable, but these are unlikely to have survived. These instruments, then, perhaps stayed in libraries, monasteries, colleges, and people's houses, and were just the kind of 'tangible model' that Price described.⁵⁰ On the other hand, there are finds indicating that simple compass dials may have been fairly commonly used, and carried around, but not written about in manuscript texts. Between these two extremes – of astrolabes and compass dials – archaeological context combines with other evidence to suggest that quadrants and naviculae might have been two types of instruments that were portable, and actually were carried around. At the same time, they still embodied the kind of astronomical learning that astrolabes do, albeit with less complexity. So, they were written about and studied in learned contexts like monasteries and universities, and kept in libraries along with astronomical books, but they were also carried around (and occasionally lost).

Conclusion

If we know that an instrument is carried around, this does not necessarily mean that we can determine what practical purpose it had for its owner. If someone carried his quadrant, perhaps in a leather case, or his navicula, was it decorative, acting as a symbol or representation of his astronomical learning? Or, were there practical reasons why people travelling around medieval England might have needed to use timekeeping instruments of these kinds? It is tempting to imagine, as in Chaucer's *Canterbury Tales*, pilgrims determining the time using instruments, and there is some evidence for astronomical instruments being used in religious contexts,⁵¹ but it is important to consider astrological medicine as perhaps the primary context within which small and portable instruments like quadrants and naviculae found practical use. Time, whether calculated or observed using an instrument, or derived using tables, was important for the efficacy of herbal remedies, and medical treatises were often

50 This is not to say that, in those locations, there couldn't also have been practical use made of astrolabes. They were useful for calculations, among other things, as noted by one Middle English writer of a *compotus* text: L. Braswell-Means, 'Ffor As Moche As Yche Man May Not Hauē the Astrolabe: Popular Middle English Variations on the Compotus', *Speculum*, 67.3 (1992), pp. 595–623.

51 The Chetwode quadrant was found near a priory, but it is not clear whether this links it to religious uses or contexts. See also Chapter 1 by Seb Falk.

combined with astronomical works in manuscript volumes, attesting to the importance of this connection. Hilary Carey has argued that in medieval England astrology was the preserve of three groups: people at court, those in academic institutions, and medical men.⁵² It is striking, then, that these are three groups for whom there is good evidence of interest in astronomical instruments at the time.⁵³ Indeed, one of the manuscripts containing a text on how to make and use the *navicula sundial* includes this work on an instrument along with astrological and medical texts. A bifolium from this manuscript seems to have been carried around folded, indicating that these parts in particular (including text on whether a patient will die, and whether an expected baby is a boy or a girl) were needed for reference separately from the rest of the volume.⁵⁴ Folded almanacs of various kinds survive from late-medieval England, containing calendrical and astrological information aimed at medical practitioners.⁵⁵ Alongside these portable manuscript texts, it is easy to imagine a small instrument like a quadrant or a *navicula* being useful, either to tell the time or to simplify calculations relating to the hours of the day.

It is hard to assess how widespread the use of astronomical instruments was in medieval astrological medicine, and how many practitioners might have carried around timekeeping instruments. This example is an outline of a group of people who could – and perhaps did – use instruments, more than a definitive study of the many functions and purposes of these objects. However, it is clear from the limited archaeological evidence available that some kinds of instruments were carried around, and piecing together the provenance recorded for medieval instruments held in museum collections, along with the locations of finds of instruments (and parts of instruments) in the last twenty years, suggests that Price and Maddison may have been too categorical in their assessment of the practical utility of instruments. Indeed, the possibility that some types of astronomical instrument could both demonstrate and symbolise

52 H. M. Carey, *Courting Disaster: Astrology at the English Court and University in the Later Middle Ages* (London: Macmillan, 1992), p. 56.

53 Courtly and academic interest in astronomical instruments is clear in the literary and other references to them, outlined above. For examples of physicians interested in astronomical instruments, see also L. White, 'Medical Astrologers and Late-Medieval Technology', *Viator*, 6 (1975), pp. 295–308.

54 Trinity College, Cambridge, MS O.5.26, ff. 92–3.

55 H. M. Carey, 'What Is the Folded Almanac? The Form and Function of a Key Manuscript Source for Astro-medical Practice in Later Medieval England', *Social History of Medicine*, 16.3 (2003), pp. 481–509.

learning about the heavens, and also be of practical use, might explain why quadrants and naviculae seem to have been made in larger numbers, and to similar or standardised designs, than has in the past been recognised. These instruments were, I would argue, both ‘ideas made brass’ and portable, practical, objects for the people who owned them. As more finds are made, and as provenance research and detailed cataloguing of museum collections continues, it seems likely that this contextual information – relating to the history of the object from when it was made to when it was collected by a museum – will further enrich the understanding that can be gained from close study of the surviving instruments and texts.

