Humfrey Cole Revisited: Newly Found and Rediscovered Instruments Made by England's First Native Scientific Instrument Maker

Abstract

England's first native scientific instrument maker, Humfrey Cole (*c*. 1530–1591), is well-known to historians thanks to a collection of twenty-six instruments and a map of Palestine that survive today in public and private ownership. Two recently studied instruments have enhanced our knowledge of Cole's work: i) a horary quadrant, signed and dated 1573, now in the collections of the British Museum, and ii) an astronomical compendium, signed and dated 1590, held in a private collection. The unusual design of the horary quadrant demonstrates Cole's versatile approach in adapting his products for specific customers, while certain features on the astronomical compendium, possibly the last piece ever made by Cole, suggest that he was aware of his final days and passed on his work to a younger maker, James Kynvyn (*c*. 1550–1615), hinting at a possible collaborative working relationship between these two generations of instrument makers in Elizabethan London.

Keywords: horary quadrant; astronomical compendium; English scientific instrument makers.

1. Introduction

In 1998 the life and work of Humfrey Cole,[1] one of the most prolific instrument makers in Elizabethan England, was the subject of a small exhibition at the British Museum where nearly all known surviving examples of his work were brought together for the first time.[2] The assembly of twenty-three instruments included a range of both astronomical and surveying instruments such as sundials, astronomical compendia, quadrants, astrolabes, folding rules for gunnery, astrolabes and altazimuth theodolites. The detailed catalogue entries for these instruments, including the three extant items not displayed, reveal the wide-ranging scope of Cole's craftsmanship and mathematical skills in creating highly sophisticated instruments that heralded the start of the English scientific instrument trade. The growing demand for scientific instruments by Cole and his peers reflected the wider social, economic and military interests of the late Tudor period. Surveyors needed instruments to assess and reallocate former monastic lands to new owners, while merchants tried to extend their trade routes with better celestial navigation at sea. Similarly, England's military leaders sought to protect the country with fortifications and artillery that required a new suite of measuring instruments. Practitioners had previously relied on mathematical textbooks and instruments from the Low Countries, but this began to change in the 1530s with the arrival of a handful of Flemish printers, engravers and instrument makers who settled in London. Artisans such as Reyner Wolfe (*d*. in or before 1574) and Thomas Gemini (*fl*. 1540–1562) brought their skills to a burgeoning market and inspired a new generation of craftsmen.[3]

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[1] For full biographical details see Silke Ackermann, "Cole, Humfrey Cole (*d*. 1591)," in *Oxford Dictionary of National Biography*, http://www.oxforddnb.com/view/article/5853, accessed June 3, 2016. Although the form of his name varies on his signed works, "Humfrey Cole" is the most commonly used and thus also adopted in this article.

[2] Silke Ackermann, *Humphrey Cole: Mint, Measurement and Maps in Elizabethan England* (London: British Museum Press, 1998).

[3] Gerard L'E. Turner, *Elizabethan Instrument Makers: The Origins of the London Trade in Precision Instrument Making* (Oxford: Oxford University Press, 2000), chap. 1.

We know little of Cole's own origins, apart from a signature cartouche on a map of the Holy Land that he engraved for the second edition of Archbishop Matthew Parker's *Bishop's Bible* (1572): "Graven bi Humfray Cole goldsmith an English man born in ye north and pertayning to ye mint in the Tower 1572."[4] In tandem with this official work, Cole appears to have started his instrument business in 1568 with the production of a book-shaped astronomical compendium complete with compartments for drawing instruments.[5] Recent research by Boris Jardine has shown that Cole secured a patent around 1575 that gave him a monopoly on the production and sale of mathematical instruments, most likely as a reward from the Tudor state to encourage innovation and entrepreneurship.[6] Within a few years, Cole's reputation as a craftsman was firmly established and he was commissioned as one of the navigational instrument suppliers for the Frobisher voyages to discover the north-west passage to Asia.[7] The records of the Goldsmiths' Company reveal that Cole took on William Sysyswithe as an apprentice in September 1577 but no other records are known of Cole's staff and working practices.[8] A few years later, Cole is known to have traded from a house near the north door of St. Paul's where he continued to advertise his trade in "Scales, compasses, and sundry sorts of Geometricall instruments in metal."[9] Jardine has uncovered additional evidence to pinpoint Cole's address within Gutter Lane, just a few step from the cathedral.[10] Cole was finally buried nearby at St Gregory's by Paul's, London, on 5 July 1591 and his estate passed to his wife Elizabeth, of whom no further details are known.[11]

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[4] Peter Barber, "Humphrey Cole's Map of Palestine," in Ackermann, *Mint*, 97–100.
[5] History of Science Museum, Oxford, inventory number 36313.
[6] Boris Jardine, "Instruments of Statecraft: Humphrey Cole, Elizabethan Economic Policy and the Rise of Practical Mathematics," *Annals of Science* 75, no. 4 (2018): 304–29.
[7] James McDermott, "Humphrey Cole and the Frobisher Voyages," in Ackermann, *Mint*, 15–9.
[8] Ackermann, "Cole, Humfrey (*d.*1591)."
[9] Edward Worsop, *A Discoverie of Sundrie Errours and Faults Daily Committed by Landemeaters, Ignorant of Arithmetike and Geometrie, to the Damage and Prejudice of Many Her Majesties Subjects* (London: G. Seton, 1582), Aiiii(v).
[10] Boris Jardine "'Neere Unto the North Dore of Paules': New Light on the Life and Times of Humphrey Cole," *Bulletin of the Scientific Instrument Society* 14, no. 142 (2019): 20-4.
[11] Ackermann, "Cole, Humfrey (*d.*1591)."

In this article we describe the two recently studied Cole instruments in detail and discuss how these items compare against other examples of Cole's craftsmanship. Through the analysis of the quadrant, we explore how Cole produced custom-made items for clients who wished to use the instrument in certain locations, while analysis of the compendium reveals how Cole collaborated with other instrument makers during the final years of his life.

Like all compact scientific instruments of this period, there are a number of abbreviations within the inscriptions used on both instruments. These inscriptions have been included in this article with the following conventions:

<> denotes a known abbreviation transliterated into full text

() denotes an unclear inscription with the most likely letters added

{} denotes the modern equivalent, where clarification is necessary

(?) denotes inscription is unclear with no suggested letters

2. A Newly-Studied Horary Quadrant

In September 2008, an auctioneer from Kent contacted the Department of Britain, Europe and Prehistory at the British Museum with regard to a scientific instrument that had been offered for sale at one of their forthcoming auctions. The auctioneer had seen the recent press coverage of a similar item discovered in Canterbury a few years earlier that had just been acquired by the British Museum.[12] A medieval astrolabic quadrant had been discovered beneath one of the city's historic timber-framed houses, known as the "House of Agnes," during renovation work in 2005. The device was excavated from a sealed silt deposit dated 1375-1425 and was later sold at auction in 2007. When the new owner later applied for an

[12] Stephen Adam, "Unique Medieval Astrolabe Saved by the British Museum," *The Daily Telegraph*, July 30, 2008, http://www.telegraph.co.uk/news/uknews/2474799/Unique-medieval-astrolabe-saved-by-the-British-Museum.html, accessed December 29, 2017; BBC News, "Medieval 'Calculator' Stays in UK," July 31, 2008, http://news.bbc.co.uk/1/hi/england/7534456.stm, accessed April 16, 2014.

export licence, a temporary export ban was placed on the object that provided the British Museum with sufficient time to raise the necessary funds to secure its acquisition in May 2008.[13] The media coverage of the export ban attracted the attention of a retired gentleman from Kent who realised that a curious item sitting on his mantle shelf was somewhat similar in appearance to the Canterbury quadrant. He contacted the local auctioneers who forwarded the enquiry to Silke Ackermann, then curator of scientific instruments at the British Museum, who identified the mystery object as a horary quadrant made by Humfrey Cole in 1574. The gentleman very generously decided to donate the quadrant to the British Museum for the benefit of present and future scholars and the quadrant was accessioned in 2009.[14]

Determining the provenance of a potential museum acquisition is often a challenge for curators but in this instance the donor was able to provide us with an insight into the object's biography over the past 130 years. He explained how the quadrant was purchased by his grandfather at an auction house in the Elephant and Castle district of London during the late nineteenth century. For most of the time, the grandfather lived in Sevenoaks, Kent, about 50km south-east of central London, where he rented a farm that specialised in growing feed for London's army of transport horses.[15] The Elephant and Castle area was particularly dependent on horse buses during the final decades of the nineteenth century since the London Underground's Northern Line did not extend into the area until 1890 and electric trams did not arrive until 1903.[16] Over 300,000 horses were in use across the entire reach of London's transport system by 1900,[17] thus providing a lucrative business for our yeoman farmer supplying horse feed. Making regular trips to the capital gave him the perfect opportunity to

[13] British Museum, London, Collections Online website, object number 2008,8017.1, https://www.britishmuseum.org/collection/object/H_2008-8017-1, accessed October 30, 2020.
[14] British Museum, London, Collections Online website, object number 2009, 8034.1 https://www.britishmuseum.org/collection/object/H_2009-8034-1, accessed October 30, 2020.
[15] British Museum, London, Department of Prehistory and Europe, object file 2009, 8034.1
[16] Elephant and Castle Partnership, "About Elephant and Castle: A brief history," https://www.elephantandcastle.org.uk/a-brief-history/, accessed February 2, 2021.
[17] London Transport Museum, "On the Surface 1900-1945," https://www.ltmuseum.co.uk/visit/museum-guide/surface-1900-1945, accessed February 2, 2021.

peruse any local sales and purchase curious items of interest, including this horary quadrant by Humfrey Cole. Unfortunately, we have no further details regarding the grandfather's interests, nor do we know if he purchased any similar items; we can only speculate that it was purchased for its novelty value. It is interesting to note that the purchase of the quadrant coincided with the main acquisition period of the British Museum's burgeoning collection of Medieval and Renaissance scientific instruments. A bequest by the antiquary Octavius Morgan (1803–1888)[18] led to the acquisition of 239 clocks, watches and scientific instruments in 1888,[19] while a decade later, the collection was enhanced by a bequest from the former Keeper of the Department of British and Medieval Antiquities, Sir Augustus Wollaston Franks (1826–1897)[20] who took a keen personal interest in collecting scientific instruments from this early modern period. Hence, the purchase of the horary quadrant by the donor's grandfather during the late nineteenth century was concurrent with a wider interest by other collectors of the day.

2.1 A Detailed Description of Cole's Horary Quadrant BM PE 2009,8034.1

The quadrant is made of copper alloy with a radius of 123 mm and a variable thickness between 1.4-1.9 mm. As shown in Figure 1, it is signed "Humfrey Cole 1573" in the tip of the planetary hours section but, as with many instruments of the period, the original string and plumb bob have since been lost and just a small attachment hole remains. The front of the instrument has unequal hour lines in the apex section labelled in abbreviated form "The houres of plēnet[9] <es>" with the numbers 6-12-6. A zodiacal scale marked with the symbols along the left edge is labelled for use at 51.30, 53, 54 and 55 degrees latitude. To the right of

[18] J. A. Jenkins, "Morgan, Charles Octavius Swinnerton (1803–1888)," rev. Brynley F. Roberts, in *Oxford Dictionary of National Biography*, http://www.oxforddnb.com/view/article/19218, accessed June 3, 2016.
[19] David Thompson, "Octavius Morgan, Horological Collector: Part Six," *Antiquarian Horology* 29, no. 2 (2005): 196.
[20] David M. Wilson, "Franks, Sir (Augustus) Wollaston (1826–1897)," in *Oxford Dictionary of National Biography*, http://www.oxforddnb.com/view/article/10093, accessed July 29, 2016.

the unequal hours scale there is a circular table showing the ruling planet for each hour of the day, labelled “THE GOVERNMENTE OF PLENNETES” with two rows of zodiac symbols. The remainder of this side of the quadrant is engraved with two equal hour quadrants, labelled “The houres of the daye” with “G<radus> 54” and “G<radus> 55” for the left and right set of lines respectively, each numbered 4-12-8 and with a corresponding zodiacal scale marked with the symbols along the edge. A small sighting vane remains on the right hand zodiac scale but the corresponding vane towards the apex has been lost or removed, leaving just a mark to denote its former location. A circular altitude scale from 0 to 90 degrees runs along the curved edge and is numbered by 10 and divided into 5 with subdivisions of single units shown by alternate shading and further subdivided into half degree units.

*****FIG. 1 HERE*****

As shown in Figure 2, the other side of the instrument has a rectangular table at the apex composed of four columns that show the dates of the Sun's entry into a particular zodiac sign, labelled “The table of the entraunce of y^{e} {the} sonne into y^{e} {the} 12 signes.”[21] A curved degree scale numbered 90 to 1 from left to right with alternate shading for the individual units separates the table from the hour lines below. The remainder of this side of the quadrant is engraved with two equal hour quadrants, labelled “The houres of the daye” for “G<radus> M<inutus> 51.30” and “G<radus> 53” degrees latitude, numbered 4-12-8, each with a corresponding zodiacal scale along the edge. Just inside the curved limb of the instrument lies an altitude scale across the range 0 to 90 degrees, numbered by divisions of 10 and divided to 1 by alternate shading and further subdivided into half degree units. In addition, beyond the altitude scale lies a double shadow scale to the base 60, labelled “LATVS VMBRAE

[21] The date values are identical to those featured on the instrument described in Ackermann, *Mint*, 41.

VERSAE" and "LATVS VMBRAE RECTAE" numbered by 10, divided to 5, subdivided to 1 by alternate shading and further subdivided into half degree units. Similar to the other side, there is a single sighting vane situated towards the apex with the remains of the corresponding sighting vane towards the curved edge on the right side.

*****FIG. 2 HERE*****

2.2 Discussion and Comparison with Cole's Other Quadrants

It is interesting to note that this recently studied instrument is the first standard wedge-shaped string and plumb-bob type of portable horary quadrant[22] to be associated with Humfrey Cole. Given Cole's wide-ranging expertise, it is surprising that multiple versions of quadrants have not materialised before, especially as their design is relatively straightforward in comparison to some of Cole's more complex and unique instruments. One could speculate that perhaps the relative simplicity of quadrants dissuaded ambitious makers such as Cole from investing their efforts in producing such instruments, or perhaps quadrants were favoured by those who made cheaper and less durable instruments from paper and wood.[23] Similarly, one could argue that surviving instruments distort our perspective, given that costly and more complex instruments are more likely to be valued and preserved, while cheaper, simpler items are more likely to be discarded or repurposed. As Turner comments in his overview of the Elizabethan instrument trade, quadrants only account for 5-7% of the known surviving instruments from the period 1540-1650, whereas astronomical compendia account for over

[22] For an overview of the history and different types of quadrant, see Mike Cowham, *A Study of the Quadrant: Horary Quadrants, Sundial Making Quadrants, Surveying Quadrants, Astronomical Quadrants* (Cambridge: M.J. Cowham, 2014), and James Morrison, *The Astrolabe* (Rehoboth Beach: Janus, 2007), chaps. 16-20.

[23] For more discussion on the production and use of paper instruments during this period, see David Bryden, "Evidence from Advertising for Mathematical Instrument Making in London, 1556–1714," *Annals of Science* 49, no. 4 (1992): 301-36; and Owen Gingerich, "Astronomical Paper Instruments with Moving Parts," in *Making Instruments Count: Essays on Historical Scientific Instruments Presented to Gerard L'Estrange Turner,* ed. Robert Anderson, Jim Bennett, and William Ryan (Aldershot: Ashgate, 1993), 63–74.

25%.[24] The survival and recent discovery of this new instrument is thus a valuable addition to our assessment of Cole's work.

For comparison, we are fortunate that there are two other known examples of horary quadrants made by Cole in the early 1570s, albeit both slightly different in design and layout. One such instrument is held within the collections of the Science Museum, London,[25] signed but undated, whereas the other is held within the collections of the Kunstgewerbe Museum, Berlin[26] and is signed and dated 1574.

Both instruments have a horizontal square plate on which the quadrant is engraved accompanied by a triangular gnomon that is secured into an upright position and aligned with the assistance of a plumb bob positioned within a decorative cut-out. The precise alignment required to set up the dial[27] suggests that it was designed for use on a table or similar level surface, whereas the new quadrant follows the traditional format of a portable instrument with a string and plumb-bob to determine the hours. All three instruments can be used to determine the time by the Sun while the Science Museum instrument can be used to determine the time by the stars with "A table of fixed sterres" providing the necessary latitude, longitude and declination data for 12 bright stars. In addition, all three instruments feature a circular table of two rows of planetary symbols denoting the influence of the planetary hours.

There are a number of specific features on the two table-top quadrants that suggest that these were bespoke items produced for customers who wished to use the instrument for specific purposes. For example, the Science Museum quadrant has inscriptions in English and

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[24] Ackermann, *Mint*, 9, and Turner, *Elizabethan*, 45.

[25] Science Museum, London, Collections Online website, object number 1985-100, https://collection.sciencemuseumgroup.org.uk/objects/co11/silver-sundial-by-humfrey-cole-sundial-case-container, accessed October 30, 2020. See Ackermann, *Mint*, catalogue entry no. 7, 42–43 and 49. See also Turner, *Elizabethan*, 130–2.

[26] Kunstgewerbemuseum Berlin, object number K4670. See Ackermann, *Mint*, catalogue entry no. 6, 41. See also Turner, *Elizabethan*, 132–3.

[27] See Ackermann, *Mint*, 40, for a diagram of this alignment.

can only be used at latitude 51°30' i.e., the latitude of London, hence it would be reasonable to assume that it was produced for a local customer. The instrument also features a table containing data such as the names of the four main winds, the seasons, the ages of man and the Galenic four humours, an indication that this instrument may have been modified for a customer interested in medical astrology.[28] In contrast, the Kunstgewerbe Museum example has inscriptions written in Latin, suggesting that it was produced either for a learned English customer or a wider European market. The inclusion of "Anglus" within his signature on this instrument suggests that Cole was keen to emphasise his Englishness, implying that the instrument was indeed made for an international audience. Cole does not appear to have used this suffix when signing his other work, apart from the astrolabe made in 1575 which is signed "Humfridus Côle Londiniensis."[29] Again, Cole may have included this suffix to demonstrate his Englishness and perhaps additional sophistication by his association with the capital city.

Similarly, the Kunstgewerbe Museum instrument can be used for a range of latitudes from 52° to 55° which would be useful for customers in northern Europe. Unlike the Science Museum instrument, this quadrant does not include the Galenic humours or the positions of bright stars; instead, the remaining space is filled with a perpetual calendar and epact table for calculating the date of Easter, suggesting that the owner might have requested this information for administrative or ecclesiastical purposes.

If we now reconsider the British Museum instrument, we can see how this quadrant has all the ingredients for a portable device that is purely used for determining time by the Sun. Unlike the square plate quadrants, this instrument can be used for four different

[28] For an overview of medical astrology during Cole's instrument-making period, see Carroll Camden, "Elizabethan Astrological Medicine," *Annals of Medical History* 2 (1930): 217-26; Lauren Kassell, *Medicine and Magic in Elizabethan London. Simon Forman: Astrologer, Alchemist and Physician* (Oxford: Clarendon Press, 2005).

[29] Derek J. de Solla Price, *An International Checklist of Astrolabes* (Paris: Peyronnet, 1955), item no. 307, held within the collections of the University of St. Andrews, Scotland. See Ackermann, *Mint*, 33–5, and Turner, *Elizabethan*, 149–55.

latitudes: 51°30', 53°, 54° and 55°. Given that these latitudes encompass the length of mainland Britain, it would appear that Cole intended this product to be used by a travelling Englishman, particularly as the inscriptions are in English rather than Latin. Similarly, the lack of perpetual calendar and epact table suggest that the device was constructed for a travelling merchant rather than an ecclesiastical user. The lack of heraldic symbols, such as a badge or coat of arms, or even the owner's name, suggests that this item was not produced for a nobleman, unlike some of the other instruments produced by Cole and his contemporaries.[30] Interestingly, the most northerly latitude of 55° corresponds with the latitude value for the city of Newcastle-upon-Tyne used by Cole on some of his other instruments. Given that Cole once described himself as "an English man born in ye north"[31] it is tempting to surmise that perhaps Cole produced this item for a friend or relative, particularly as previous research by Turner suggested that the name Cole was common in the north-east of England.[32] Indeed, Jardine's research has strengthened this association by uncovering evidence to show that Cole once owned property in County Durham.[33] In the absence of any definitive evidence, this suggestion of a bespoke design for a local contact in the north-east of England is purely circumstantial and speculative at this stage.

In summary, this horary quadrant was produced during the same period as Cole's other surviving quadrants around 1573-1574 and is unusual with its provision of hour lines suitable for four different latitudes. It is a simple and utilitarian design based on telling the time by the Sun with reference to the astrological significance of planetary hours. It does not appear to have any particular features that are indicative of Cole's fondness for including

[30] For example, see Turner, *Elizabethan*, catalogue entries 5, 27, 41, and 71.
[31] Ackermann, *Mint*, 8.
[32] Turner, *Elizabethan*, 20.
[33] Jardine has discovered that Cole once owned Twizel Manor in Chester-le-Street, County Durham, which strengthens this inferred association between the London instrument maker and north-east England. See Jardine, *Neere*, 23.

unusual and ingenious design elements,[34] suggesting that it was made for the specific purpose of travel or perhaps was a prototype for a later, more complex instrument. The generous private donation of this object following the very public acquisition of another Cole instrument has thus increased our awareness of the scope of Cole's work and offers us some interesting and useful comparisons with other surviving examples of his work.

3. A Rediscovered Astronomical Compendium

In addition to the recently studied horary quadrant, we have been fortunate enough to have been made aware of a relatively unknown Cole instrument that was once exhibited during the 1960s but has since remained obscure. Thanks to her entry on "Humfrey Cole" in the Oxford Dictionary of National Biography,[35] Ackermann was contacted in 2013 (at that time teaching in Germany) by a gentleman living in Kent who owned an astronomical compendium signed by Humfrey Cole. According to the owner, the compendium was purchased in 1941 by his mother's first husband, Francis C. Harper, a pre-war collector, connoisseur and member of the Society for Nautical Research (SNR). In a letter written at Brown's Hotel, London, on 28 November 1941, Harper explained to his wife in Barbados that he had purchased several items, including the compendium, at a sale of items from the Duke of Cumberland's family, recently held in Cirencester.[36] He described the instrument as "some wonderful nautical compasses etc. Signed and dated Humfrey Cole 1590 ~ 1588, the great[est] Elizabethan maker we ever had." According to Harper's letter, he had "bid and bought them all for less

[34] For example, two of Cole's astrolabes feature hidden mechanisms for securing and releasing the various components, while another mechanism in a compendium releases a miniature theodolite. See Turner, *Elizabethan*, 24-5, for more details. Jardine has also discussed Cole's design approach in "Gestural Knowledge? Humfrey Cole's Ingenuity Revisited," *Bulletin of the Scientific Instrument Society* 134 (2017): 44-5.

[35] Ackermann, "Cole, Humfrey (d.1591)."

[36] On 30 September 1941 Laura Cumberland-Jones, widow of Richard Denison Cumberland-Jones, passed away (*The Times*, October 2, 1941, p.1). The contents of her home at Fosse Lodge, Cirencester, were subsequently sold by local auctioneer Jackson Stops over the course of 5-7 November 1941. In the auction catalogue under the section "Brass, Copper and Bronze Items" we find "Lot 651. Rare circular brass astronomical folding Compass and Clock." In the letter to his wife dated 28 November 1941, Harper refers to purchasing other items in an auction in Cirencester whose descriptions match those listed in the sale catalogue, hence we can be reasonably confident that this is the relevant sale and lot 651 is most likely the Cole compendium of study.

than a fiver!!"[37] Earlier in the month, Harper had already written to Sir Geoffrey Callender (1875–1946),[38] Director of the National Maritime Museum and fellow member of the SNR, explaining that he had bought two "nautical instruments," one of which he described as "like a watch, signed inside Humphrey Cole 1590," about which he would be desirous to learn more. The return correspondence from Callender has not survived but another letter by Harper dated 5 December 1941 indicates that Callender appeared to take an interest in the item and provided much background information.[39] This response appears to have galvanised Harper into arranging for the two men to meet and discuss his purchases on 12 December 1941 at Callender's home in Oxford. It is likely that Callender tried to persuade Harper to either donate or sell the Cole compendium to the Museum, but Harper obviously decided to keep it at this stage, explaining gleefully in a letter dated 20 December 1941 that "for the present I like to gloat over them [the nautical instruments], & weave romances! But let me assure you they shall not part company with me before I let you know first!" Harper continues to write to Callender for another two months and, while there is no further mention of the Cole compendium, Harper offers several other nautical items which he has purchased at similar country house sales.[40]

Within the family records there is an additional letter from Harper to Charles Relly Beard, a well-known specialist in armour who regularly contributed to the art magazine *The Connoisseur* and who is known to have written articles elsewhere about Harper's acquisitions.[41] In an undated letter now held by Harper's family, Beard complained that *The Connoisseur* would only pay £2 12s for a thousand-word article and he calls upon Harper's

[37] Letter owned by the family. Details provided in email correspondence between the owner and authors, 2015-2017.
[38] Michael Lewis, "Callender, Sir Geoffrey Arthur Romaine (1875–1946)," rev. by H. C. G. Matthew, in *Oxford Dictionary of National Biography*, http://www.oxforddnb.com/view/article/32249, accessed June 3, 2016.
[39] Letter owned by the family. Details provided in email correspondence between the owner and authors, 2015-2017.
[40] National Maritime Museum Archives, London, ref. NMM5, Callender General H Correspondence, 1941, Harper, F.
[41] For example, see Charles Relly Beard, "An Unrecorded Map by Diogo Homen," *The Mariner's Mirror* 31 (1945): 51-5.

previous offer to "see me right" by requesting an additional fee for each article written about the collector's purchases. Beard explained that he intended to publish several articles in the autumn, including "Humphrey Cole nocturnal – *Connoisseur* – 1000 words - £3.3" but unfortunately this article does not appear to have materialised.[42]

Despite the lack of publication, the compendium must have been known within the museum community because it subsequently appeared as a loan item for the exhibition "William Shakespeare 1564–1964" that was originally displayed in Stratford-upon-Avon and Edinburgh.[43] The organisers intended to repeat the exhibition in London but were unable to find a suitable location to host the complete collection of items. As a compromise, the National Portrait Gallery agreed to host part of the exhibition in a suite of three rooms over the winter of 1964.[44] The compendium was included within the selection and was displayed as an example of Elizabethan craftsmanship in the section of jewellery, medal and silver plate. The catalogue entry for the compendium, written by British Museum curator Hugh Tait,[45] describes the item as follows:

> O. **Equatorial dial**/*Mrs Nicolette Bragge*/By Humphrey Cole/Dated 1590/2 x ¾ in./Cole was the most celebrated of Elizabethan instrument makers. The sun-dial was used for telling the time anywhere; and the dial-case contains a lunar index, tide indicator together with a perpetual calendar.[46]

[42] Letter from Charles Relly Beard to Francis C. Harper, undated, held by the family. Details provided in email correspondence between the owner and authors, 2015-2017.
[43] Jack Lyons, Earl of Harewood, and Richard Buckle, *The Shakespeare Exhibition: 1564-1964: Stratford upon Avon, Edinburgh, London* (London: Arts Council of Great Britain, 1964).
[44] Displayed within "Treasures from the Shakespeare Exhibition," National Portrait Gallery, London, 17 November 1964 to 30 January 1965. Correspondence between various museum staff members and the owner of the compendium, private collection.
[45] For a brief biography of Hugh Tait, see https://www.britishmuseum.org/collection/term/BIOG79756, accessed October 30, 2020.
[46] Lyons, Earl of Harewood, Buckle, *The Shakespeare Exhibition*, 80, object O.

Following this public outing the instrument was returned to the family and, to the best of the authors' knowledge, was not included in any subsequent publication or display until it was brought to our attention in 2013.[47]

3.1 A Detailed Description of the Compendium

At first glance, the compendium appears to be made from copper alloy and is similar in size to other compendia of the period. The two leaves are fastened with a clasp, complete with suspension ring. The outer surface of the upper leaf is engraved with calendar and hour scales indicative of a nocturnal. The calendrical scale is labelled with the names of the months in English: Ianuarie, Februarie, March, Aprill, Maie, Iune, Iulie, August, September, October, Nouember, December. Each month is labelled with the corresponding number of days, numbered by 10 and subdivided into single units. There is no zodiacal scale so one cannot determine the dates of the equinoxes and solstices. The saw-tooth edge of the hour volvelle has an extended tooth at 12 and the style of the numerals is reminiscent of those found on similar Cole instruments. The most noticeable difference, however, is the rough shape and distressed condition of the current index arm that suggests that it is a later addition. Possibly made using an original piece of brass, the index arm appears to have once featured a hinged, foldable arm that has since broken off with a new section braised on, although the lack of a straight edge makes it very difficult to read the calendar scale accurately. Similarly, the original central hole, an essential component of the nocturnal for viewing Polaris, has been plugged and a new hole has been drilled in an offset position, similar to a lunar volvelle, thus rendering the nocturnal function of this compendium to be unusable (Fig. 3).

*****FIG. 3 HERE*****

[47] Conversation between the authors and the current owner, British Museum, September 24, 2013.

Unfortunately, some well-intentioned cleaning at some point during the instrument's history has created a white deposit around the teeth. Thankfully none of the scales appear to be have been obscured, rather the white deposits have helped clarify the central scrollwork decoration more easily. Around the edge of the compendium an inscription is engraved as two lines of text:

From the hinge on the side of the nocturnal:

▼ NON ▼ REVOCARE ▼ POTES ▼ QVI ▼ PERIERE ▼ DIES ▼

From the hinge towards the suspension ring:

▼ SED ▼ FVGIT ▼ INTEREA ▼ FVGIT▼ IRREPARABILE ▼ TEMPVS ▼

The upper section quote can be translated into English as "One cannot recall the days that are gone" and is taken from the *Epigrammata* of the Roman poet Ausonius (*c*. 310–*c*. 395).[48] The lower section quote can be translated as "But meanwhile it is flying, irretrievable time is flying" and is taken from the works of the Roman poet Virgil (70–19 BCE).[49] The sentiment of these quotes perhaps reflects Cole's own sense of time passing in his advancing years.

Opening the two leaves using the clasp reveals additional scales and instruments inside. The inner surface of the upper leaf is marked with a list of 32 European cities and their latitudes arranged in four concentric circles which can be read clockwise from the hinge in segments (Fig. 4):

*****FIG. 4 HERE*****

[48] Decimus Magnus Ausonius and Hugh Gerard Evelyn White, *Ausonius, with an English Translation by H.G. Evelyn-White* (London and New York: William Heinemann and G. P. Putnam's Sons, 1919), 176.
[49] Virgil and H. Rushton Fairclough, *Virgil. With an English Translation by H. Rushton Fairclough* (London and New York: William Heinemann and G. P. Putnam's Sons, 1916), *Georgics*, bk. III, 174, v. 284.

At the centre of the compendium (Fig. 5) there is a universal equinoctial sundial, mounted on a semicircular support. A skeletonised latitude quadrant, with a degree scale 0-90 with numbered divisions every 10 degrees, subdivided into units of 2 degrees, folds neatly underneath the hour ring. The degree scale is repeated on the other side of the latitude arc. The innermost straight edge of the quadrant has been extended to create a pin gnomon with an aperture at the apex which once accommodated a plumb bob and string, now lost.

*****FIG. 5 HERE*****

The upper side of the hour circle is numbered I-XII twice, labelled every 10 minutes, subdivided into 2-minute intervals, designed for use during the summer months. The lower side of the hour circle is numbered along the lower semicircle with the hours VI-XII-VI with no smaller divisions, designed for use in the winter months. The remainder of the lower side of the hour circle is blank apart from the signature, “Humfrey ▼ Cole ▼ 1590.”

The compass well is devoid of a needle and glass cover but is lined with a loose paper compass card marked with the classic 32 directions with abbreviated labels, transcribed as follows (Fig. 6), starting at the hinge reading clockwise:

*****FIG. 6 HERE*****

The cardinal points are labelled by the single letters N, E S and W while north is further indicated by a fleur-de-lys. The direction of west is also labelled with the letters “T P” whose significance is unknown. This paper compass rose is most likely to be a later addition as it bears no resemblance Cole’s other compendia whose roses include distinctive details such as

a cross to denote the direction of east and a spade to denote the direction of west.[50] Similarly, this compass rose does not correlate with Turner's classification of compass roses produced during the period 1570-1610.[51] A metal rim numbered from 0-360 degrees with smaller divisions of 10 and 2 degrees lies above the card and completes the compass well.

The outer surface of the lower leaf features seven concentric circles of calendrical and epact data that are significantly worn and difficult to read (Fig. 7). On general inspection, it appears to be engraved with a similar sequence of scales to those seen on other Cole compendia where each segment contains three months and the relevant symbols are used for the zodiac signs.

*****FIG. 7 HERE*****

Combining the data in the transcription (Fig. 8) with additional calendrical information from other Cole instruments[52] provides us with the following calendar of saints' days (Fig. 9):

*****FIG. 8 HERE*****

*****FIG. 9 HERE*****

The parallel bands of the fourth and fifth circles contain the golden numbers (*Aure nū*) and their corresponding epact numbers which would enable the user to determine the date of Easter (Fig. 10):

[50] British Museum, London, PE 1888, 1201.293, https://www.britishmuseum.org/collection/object/H_1888-1201-293, accessed October 30, 2020; National Museums Scotland, Edinburgh, H.NL 18, https://www.nms.ac.uk/explore-our-collections/collection-search-results/compendium-dial/29263, accessed October 30, 2020.
[51] Turner, *Elizabethan*, plate 14.
[52] Ackermann, *Mint*, Appendix I, 91.

*****FIG. 10 HERE*****

At the centre of the perpetual calendar lies a cartouche with the inscription: “This Tabell begineth at 1588 and ſo for euer.”

3.2 Discussion and Comparison with Other Cole Compendia

Thus, having described the instrument in detail, we can now compare this rediscovered instrument with similar examples of Cole’s work for greater insight into his choice of features for this compendium. In this respect, we are spoilt for choice: of the twenty-eight surviving instruments made by Cole, eight of them are compendia.[53] The compendia were produced in three main bursts of activity: 1) two were made during the early period 1568-1569; 2) another four were made in the period 1575-1579; 3) the remaining two (including the rediscovered compendium) were produced at the end of Cole’s career in 1590.[54] The two compendia produced during the early period are highly complex and ornate pieces that are markedly different to the compendium under review so we will focus our comparison across the remaining range of compendia, particularly those which contain the same range of instruments (nocturnal, magnetic compass, universal equinoctial sundial, table of latitudes and perpetual calendar). Similarly, we will also compare this compendium to two known examples made by James Kynvyn (*c*.1550-1615), a wealthy gentleman from Llantilio in Monmouthshire, South Wales, who, unlike Cole and his peers, did not begin his career as a goldsmith or engraver, but seemingly started this new artisan venture in his forties.[55] Kynvyn is believed to have produced at least 12 instruments during the 1590s, of which four signed examples can be found at the Museo Galileo as part of the collection of instruments taken by

[53] Turner, *Elizabethan*, 21.
[54] Ibid., table 2.2, 21.
[55] For Kynvyn’s career and instruments see Turner, *Elizabethan* 25–7, catalogue entries 65–76.

Sir Robert Dudley (1574–1649) when he moved to Florence in 1606.[56] As we shall discuss, examining distinctive features on Kynvyn's known instruments could help us explain the disparities between the rediscovered compendium and the other surviving examples of Cole's craftsmanship.

3.2.1. Nocturnal

Although extremely worn and difficult to read, the outside calendar scales appear to have the names of the months in English, as demonstrated by Cole on two other compendia.[57] The poorly-crafted replacement index pointer appears to have been made from a lunar volvelle, possibly from another instrument, and the lack of central hole for viewing Polaris renders the instrument useless. While this feature is a disappointment, it is curious to note that a similar compendium in the collections of the British Museum, signed "Kynvyn 1593," also features an index arm riveted at the centre with no aperture for viewing Polaris, thus depriving the instrument of a functional nocturnal.[58] While it is not uncommon for the moveable parts of such instruments to become damaged and later replaced or modified, especially as they are situated on the outside leaf, it is interesting that this example of Kynvyn's work has been modified in a similar fashion to the instrument here discussed.

3.2.2. Latitude Table

At first glance, the eclectic list of northern hemisphere cities and latitudes in Figure 4 might suggest that Cole made this bespoke compendium for a wealthy merchant or cleric who planned to travel between important Christian sites across Europe and the Middle East. This list of cities and their latitudes is highly unusual in several respects. Firstly, there are several

[56] See https://catalogue.museogalileo.it/biography/JamesKynvyn.html, accessed January 13, 2021.
[57] See Ackermann, *Mint*, cat. 14 (64–6) and cat. 15 (66–8).
[58] Turner, *Elizabethan*, cat. 66 (225–9).

spellings of European cities that differ to those used on Cole's other surviving instruments.[59] For example, the Italian city of Naples is spelt here as "Napels" whereas on other instruments Cole uses "Neapolis." Similarly, the Scottish city of Edinburgh is spelt here as "Edenburg" whereas on other instruments Cole uses "Edenboro," "Edenbo," "Edenbor," and even a wonderfully complex version, "Edenborongh." The most unusual aspect of this latitude table, however, is the choice and geographical range of the cities which extend from "Edenburg" at 58° to "Ierusalem" at 30°40'. On the other seven surviving compendia,[60] Cole's latitude lists feature a number of key European cities such as Paris, Rome and Lisbon, and a selection of regional British cities such as Nottingham, Bristol and Oxford. In this latitude list we only find two British cities, "London" and "Edenburg" and the choice of European cities is highly skewed towards places with significant cathedrals such as "Burgis" [Burgos] in Spain and "Br^{a}ga" [Braga] in Portugal. The remaining selection of cities extends eastwards to "Malta," "Dāaſcus" [Damascus], "Babelon," [Babylon] and southwards to "Alexandria" in Egypt.

Yet a comparison with similar compendia of the period reveals that this latitude list is almost identical to the one present in both known compendia made by Kynvyn. The first instrument,[61] believed to have been made around 1590, features a list of 31 cities that is essentially the same as the latitude list on the rediscovered instrument, apart from the omission of Braga and some minor spelling variations. The second example[62] has a more extensive list of 39 cities that includes far-flung places such as Cuba and Hangzhou in China. The choice of these specific locations suggests that Kynvyn either influenced Cole's design, or else perhaps Kynvyn completed the list once Cole was no longer able to complete the instrument himself. It is feasible that Cole may have chosen these locations as a bespoke

[59] Ackermann, *Mint*, Appendix 2: Latitude list on Humphrey Cole instruments, 92.
[60] Ackermann, *Mint*, 54–69; Turner, *Elizabethan*, catalogue entries 8, 9, 24, 25, 26, 27, 33.
[61] Historisches Museum, Basel, object number 1982.538. See Turner, *Elizabethan*, cat. 65, 223–5.
[62] British Museum, London, object number PE 1866,0221.1, https://www.britishmuseum.org/collection/object/H_1866-0221-1, accessed October 30, 2020. See Turner, *Elizabethan*, cat. 66, 225–9.

order for a particular customer, hence the deviation from his usual choice of cities, but the existence of very similar locations on Kynvyn's instruments suggests that the younger maker played a role in creating this list which he continued to use after Cole's death.

Another feature which points towards Kynvyn's involvement is the presence of mistakes in the numerical values of the cities' latitudes when compared against the same two compendia described above. For example, Constantinople has the incorrect value of 33° instead of 43° while both Jerusalem and Nuremberg have 30°40' and 40°24' instead of 36°40' and 46°24' respectively. This confusion between specific numerals is typical of other errors seen across Kynvyn's work[63] and once again strongly suggests that he was involved in the construction of this instrument.

3.2.3 Perpetual Calendar

The choice of specific saints' days is in general agreement with those used by Cole on his other compendia, a choice thought to have been based upon those listed by Leonard Digges in his *A Prognostication* (1555).[64] There are, however, some interesting variations, such as the inclusion of the entrance dates of the Sun into the signs of the zodiac, a feature which Cole has only included twice before on two compendia made at the beginning of his instrument-making career in the late 1560s, over 20 years earlier.[65] Similarly, this calendar includes "Spring" on 12 March and "17 [August] Dog days end," neither of which Cole used on his compendia since the construction of his first example during the late 1560s.[66] There is also a variation in the spelling of Saint James as both "Iacob" and "James" for the feasts on 1 May and 25 July respectively. As Turner comments in his review of Cole's work, such inconsistencies between instruments are not untypical of the maker, but it is interesting that

[63] Turner, *Elizabethan*, 63.
[64] For a complete list of saints' days, see Ackermann, *Mint*, Appendix I, 91.
[65] See Turner, *Elizabethan*, cat. 8 (115) and cat. 9 (118).
[66] Ackermann, *Mint*, cat. 11 (55–9).

the saints' calendar on this compendium is identical to the one seen on the Kynvyn compendium at the British Museum, described in the previous section with regard to the latitude list. Such a coincidence is not inconceivable if Kynvyn wanted to refer to Cole's previous instruments, but the most distinctive feature is the English spelling of "James." Cole appears to prefer the abbreviations of "Iac" or "Iā"; there is no known example of the full spelling of James on his work. In contrast, Kynvyn uses "James" on his own compendium, raising the possibility that he was involved in the decision to include "James" on the rediscovered compendium.

Finally, if we review the table of golden numbers and epact values (Fig. 10), we can see that the numbers have been shifted by one place i.e. golden number 17 should correspond with epact 26, not 7 as shown. This shift is typical of Cole's work[67] but the value of epact 20 for golden number 16 is unusual. One would expect to see a value of 26, perhaps indicating that Kynvyn's lack of experience may have been responsible for this error, but the inscription is ambiguous, and this supposition cannot be verified.

3.2.4 Engraving

While various features of the instrument's design appear to indicate that Kynvyn played a role in the choice of some of its features, the engraving itself offers further evidence that Kynvyn may have contributed to the actual production of the compendium. For example, Turner describes how Kynvyn includes a small dot above the number 1, similar to the lowercase letter i. This is evident within the latitude value for "Cesaria" which has the value 31·40 with the characteristic dot over the number 1. Similarly, Turner comments on how one can often see the guidelines for the text in Kynvyn's work.[68] This is certainly visible within

[67] Ackermann, *Mint*, 94.
[68] Turner, *Elizabethan*, 27.

the latitude table for this compendium, although similar lines can also be seen on Cole's earliest known instrument (Fig. 11).

*****FIG. 11 HERE*****

3.3 Cole's Other Work from about 1590

Our final comparison must lie with the compendium signed and dated "Humfrey Cole 1590," now held within the collections of the Horniman Museum.[69] Produced during the same year as the rediscovered compendium, this instrument provides us with a valuable insight into Cole's final years. At first glance, the object is smaller than his previous work and there is a distinct lack of information on this instrument. For example, the base features a decorative vignette rather than a perpetual calendar and the latitude list has been reduced from 40 Europe-wide cities to just 15 British cities and Antwerp. Curiously, Cole spells Edinburgh here in the form of "Edenborongh" which is markedly different to the "Edenburg" spelling seen on the new instrument—a remarkable difference in spelling over the course of a year. The universal equinoctial dial has also been replaced with a horizontal dial, although the gnomon is now missing. Cole's choice of motto around the rim of the instrument is particularly morbid: "VIGILATE QVIA NESCITIS QVA HORA DOMINVS VESTER VENTVRVS SIT" ("Be vigilant since you knoweth not the hour when the Lord cometh'" [Matthew 24:42]). It is interesting to note how Cole appears to switch from English to Latin mottos over the course of his career, and he increasingly chooses Biblical verses during the last decade of his life, perhaps in response to a growing awareness of his own mortality.

The most interesting difference between these two compendia, however, is the lack of Cole's renowned ingenuity in the design and construction of the rediscovered compendium.

[69] Horniman Museum, London, inv. No. 31.183 A, https://www.horniman.ac.uk/object/31.183A/, accessed October 30, 2020. See Ackermann, *Mint*, 68–9, and Turner, *Elizabethan*,172–3.

Even though it was produced at the end of his career, the Horniman compendium still has innovative features, such as the nocturnal with its slit to observe the pole star, rather than the customary central hole. In addition, Cole included a horizontal dial with multiple hour lines for different latitudes: a feature completely atypical of compendia design. For the rediscovered compendium, Cole reverted to his standard design from the early 1570s with the curious addition of a latitude table featuring far-flung destinations that bears no resemblance to his previous work. It would seem sensible to surmise that towards the end of his career Cole wanted to reuse an existing design at this late stage, rather than create something innovative, or even use an earlier, unusual compendium, but the existence of the Horniman device clearly indicates that Cole was still reworking his designs right up until 1590. However, the theory that James Kynvyn may have been involved in the choice of latitude table raises several possible scenarios. For example, one might assume that Cole deliberately chose the simple format of his early career compendium design to create an apprentice piece for Kynvyn, whose presence can be inferred by his characteristic engraving habit of including a dot above the number one in the latitude table. Alternatively, Kynvyn may have acquired the unfinished device after Cole's death in 1591 and decided to complete the latitude list to suit the needs of his own customers, rather than Cole's customers who mainly travelled in Britain. Kynvyn seemingly repeated this latitude list on several other instruments, although curiously, he seems to have dropped Cole's custom of including a motto around the rim, either in English or Latin.

4. Conclusions

This review of two highly unusual additions to the known corpus of Humfrey Cole's craftsmanship has yielded interesting insights into the work of Elizabethan England's most prolific scientific instrument maker. The quadrant is a new design within the diverse

repertoire of instruments produced by Cole and, in typical Cole style, it is no ordinary horary quadrant but a sophisticated version that can be used across a range of latitudes. Produced at the peak of Cole's instrument making career, it is a utilitarian, portable device that is significantly different in design to his other table-top quadrants. The English inscriptions suggest that it was made for the domestic market, or even perhaps for a friend or family member.

The astronomical compendium is more difficult to assess as it has obviously been modified over the centuries with the replacement lunar phase volvelle and indicator arm on the nocturnal, and the paper compass rose that is inconsistent with the period. On first impressions, the simple design and general lesser-quality feel of the instrument are disappointing, but closer examination of the instrument has revealed the possibility that this device may provide the material evidence for a sharing of expertise between Humfrey Cole and James Kynvyn at the start of Kynvyn's career in 1590. Other scholars have mentioned Cole and Kynvyn in the same context of the Elizabethan instrument-making community but there was no evidence of a direct link between these two makers.[70] With this compendium, however, we have material evidence for some kind of collaborative effort between the two makers, although whether it occurred during Cole's final years as an informal apprenticeship, or continued after his death through Kynvyn's completion of partially-made instruments, will have to be the subject of future research.

5. Acknowledgements

The authors would like to acknowledge the generosity of the private owner who kindly donated the horary quadrant to the British Museum in 2009. They would also like to thank the private owner who kindly permitted them to study this rediscovered astronomical

[70] Bryden, *Evidence*, 305.

compendium in detail and provided information about the provenance and former display of this object. The authors would also like to acknowledge the invaluable support of their colleagues Oliver Cooke (British Museum), Richard Dunn (Science Museum) and Geraldine Charles (Royal Museums Greenwich) who provided assistance in viewing the objects, arranging new photography, sourcing publications and uncovering essential archive material. Finally, the authors would like to thank Boris Jardine (Cambridge University) for his insightful comments on an earlier version of this paper. The authors also acknowledge the valuable comments and suggestions on the manuscript by the anonymous reviewers.

Captions

FIGURE 1

The horary quadrant, showing the hour scales for latitudes 54 and 55 degrees (BM PE 2009, 8034.1).

FIGURE 2

The horary quadrant, showing the hour scales for latitudes 51.5 and 53 degrees (BM PE 2009, 8034.1). © Trustees of the British Museum, London.

FIGURE 3

The nocturnal of the rediscovered Cole compendium. Photo by Louise Devoy, courtesy of the owner.

FIGURE 4

City names featured on the latitude list with their modern equivalents.

FIGURE 5

The interior of the compendium showing the latitude table, universal equinoctial dial and compass well. Photo by Louise Devoy, courtesy of the owner.

FIGURE 6

List of thirty-two compass directions marked on the compass card.

FIGURE 7

The perpetual calendar on the outer leaf of the compendium. Photo by Louise Devoy, courtesy of the owner.

FIGURE 8

Transcription of the saints' calendar scales and associated astrological symbols. See Figure 9 for a full transcription.

FIGURE 9

The complete saints' calendar based on the transcribed scales.

FIGURE 10

The table of golden numbers and epact numbers.

FIGURE 11

Guidelines for the text can be clearly seen on Cole's first known instrument, a book-shaped compendium (HSM 36313). © History of Science Museum, Oxford.