The Puzzle of a 'Reproduction' Astrolabe in the Style of Jean Fusoris

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The topic of 'imitation'[1] scientific instruments has been revisited recently[2], and it is becoming increasingly apparent that not all the dubious astrolabes, sundials, and associated instruments that were at one time labelled as 'Mensing fakes' are from the same source.[3] It is also known that copycat scientific instruments were made for many reasons, and not all with an intention to deceive or be mistaken as a valuable antique. As early as the late 17th century, we find copycats produced contemporaneously with the originals that were being mimicked.[4] In this paper, the authors will examine a European astrolabe of very high-quality workmanship, which has been in collections in the United States for a nearly a century and has puzzled many experts. In the style of Jean Fusoris (*c.* 1365–1436), the famed maker of astrolabes and astronomical clocks in Paris, the instrument is unsigned, undated, and has components in the fashion of a later period.[5] Replacement parts and improvements by later owners are commonly seen on instruments found in museum collections. That is not the issue here. But quirky, Renaissance-style features on what, at first glance, looks like a medieval astrolabe do raise questions. By comparing the puzzling instrument to similar astrolabes in other collections, we hope to shed light on the activities of makers, restorers, dealers, and collectors in Europe and North America between the late 16th and early 20th centuries.

Provenance

The astrolabe in question is in the Collection of Historical Scientific Instruments (CHSI), Harvard University, and can be seen in Fig. 1.[6] Its clear provenance begins in Paris at the Mercator shop of Gertrude Hamilton.[7] Hamilton sold the instrument for 1500 francs ($75) in 1929 to the American collector Harrold E. Gillingham (1864–1954), an insurance broker from Philadelphia.[8] Gillingham's romance with the instrument began at least a year earlier. In 1928, he pictured the front and back of the astrolabe in an essay on astrological instruments in *The Magazine Antiques*.[9] Perhaps he had it on approval, since he never said who owned it. He described it as an 'Astrolabe (1585) attributed to Erasmus Habermel. Diameter 5½ inches'. In a 1930 article on navigation, Gillingham again published photographs of the astrolabe, but now captioned them, 'Astrolabe, made by Erasmus Kabermehl [sic] c.1585. Writer's Collection.'[10] Whether this attribution to Habermel was his own or what he had been told by Mrs Hamilton is unknown. The misspelling was certainly due to the journal, which had also misspelled Gillingham's first name. By 1949, Gillingham was describing the instrument as possibly by James Kynvyn. In an inventory of his collection, he recorded:

'Astrolabe, 5¼ inches diam. Gilt brass with silver plates, silver pin and ring. Mercator, Paris, 1929 1500f. 75.00 (Gunther thinks by James Kynuyn, 1585–1593).'[11]

Gunther, of course, was Robert T. Gunther (1869–1940) of Oxford who had completed his magisterial catalogue of world astrolabes in 1932.[12] The possibility of the astrolabe being by the English mathematical instrument maker, James Kynvyn, *circa* 1590 was not an unreasonable guess at the time, given the style of the engraving and some components (as we will show below) and the fact that the group of astrolabes from the Fusoris *atelier* had yet to be identified.

In 1949 the astrolabe changed hands. In June, David P. Wheatland (1922–1993) of Topsfield, Massachusetts paid Gillingham a visit on the advice of R. Newton Mayall, the landscape architect and sundial authority.[13] He purchased Gillingham's collection of some 246 instruments *en bloc*. One of several astrolabes in the sale, the 'Kynvyn' astrolabe was valued at $350. Wheatland bought the astrolabe for his private collection, not for the Harvard Collection of Historical Scientific Instruments of which he was curator. At

Fig. 1 *Fusoris-style planispheric astrolabe at Harvard, inv. no. DW0594,* (left) *front and* (right) *back views. Courtesy of the Collection of Historical Scientific Instruments, Harvard University.*

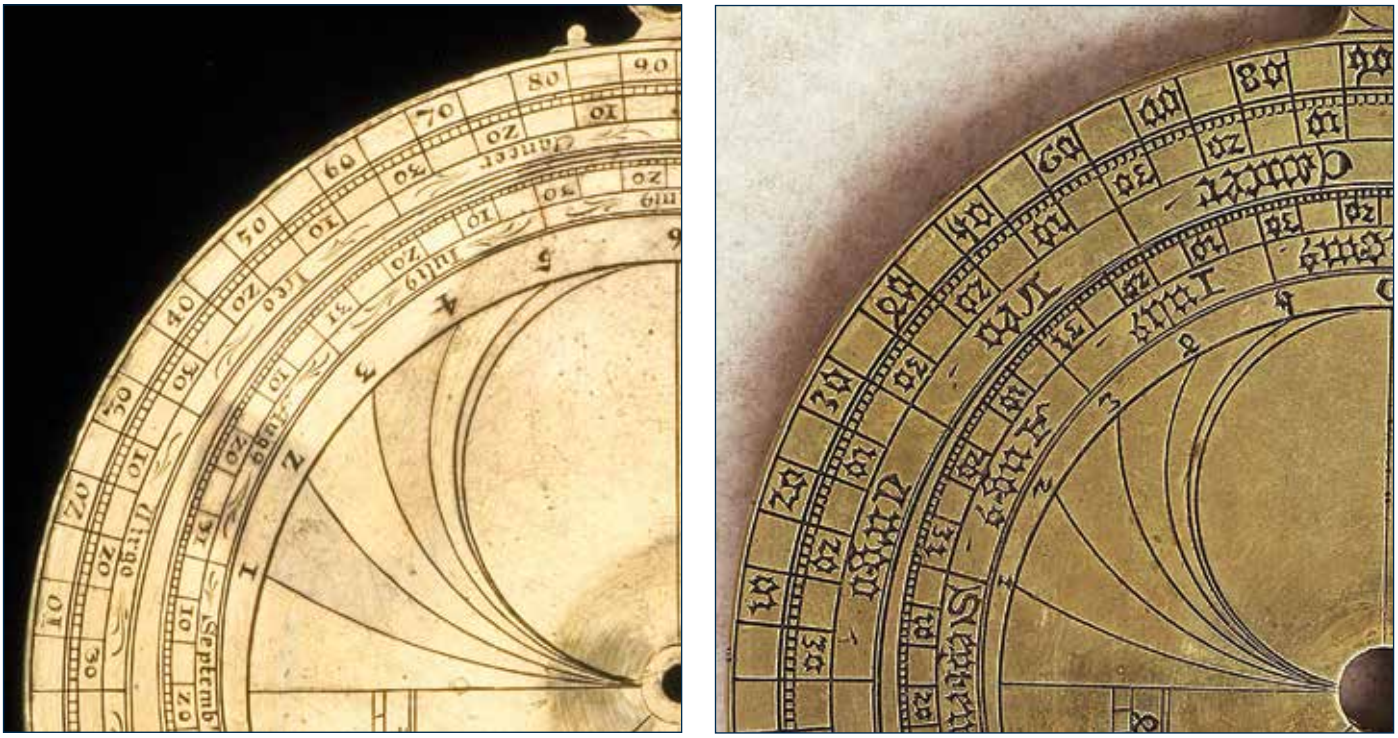

Fig. 2 *Detail of numerals on* (left) *Harvard's astrolabe DW0594 compared to* (right) *those on a genuine medieval Fusoris astrolabe in Oxford's Museum of the History of Science, inv. no. 49636. Courtesy of the Collection of Historical Scientific Instruments, Harvard University (photo Matthew Longchamps) and by the Museum of the History of Science, University of Oxford (photo John Davis).*

first, he took Gillingham's inventory number, 142, and prefaced it with a 'W' to identify it as W142 in the Wheatland collection. He later changed the number to DW594, perhaps due to his falling out with Gillingham. On small, white index cards Wheatland catalogued the astrolabe. He copied the information from Gillingham's 1949 inventory, including the possible association with James Kynvyn, whom he seemed to believe was French. On the reverse of one card, Wheatland added, 'French 15th cent (1450) lost original plates (some re[en]graving. Emanuel Poulle is writing paper on this kind of instrument (1960).' On another card, 'James Kynvyn – France" was amended in a different hand to "Jean Fusoris – France.'[14]

When Mr Wheatland prepared to offer his personal collection to Harvard in 1984, the astrolabe was examined by Alain Brieux, the instrument dealer and scholar. A founding member of the Societé Internationale de l'Astrolabe based in Paris, Brieux was a connoisseur of fine astrolabes. He thought it authentic and appraised it as 'Astrolabe – not marked – 136 mm dia. Round brass with single SILVER tablet plate and pin with 'continental type' pin. [$]45,000.'[15] The only item out of 455 that he valued more highly was the 'bowl of Ahaz' refracting scaphe sundial by Georg Hartmann (1489–1564), which had also come from Gillingham's collection. Wheatland donated the astrolabe to the Collection of Historical Scientific Instruments in 1985, where today it has the inventory number DW0594.

Although Gunther had clearly seen the instrument in person or by photographs, it did not appear in his 1932 catalogue, suggesting that he had examined it after publication and before Gillingham's inventory in 1949. The astrolabe was not listed in Derek de Solla Price's 'International Checklist of Astrolabes' (1955)[16], but Price apparently was aware of the instrument by 1957. He advised Emmanuel Poulle that the astrolabe was worthy of inclusion in his research on Jean Fusoris. Correspondence between Poulle and Wheatland in 1957 and 1958 makes it clear that Poulle had spoken to Price and knew the provenance from Hamilton to Gillingham to Wheatland, along with Gillingham's inventory number, 142. Poulle asked Wheatland for photographs and further information.[17] Poulle included the astrolabe as among works from the Fusoris workshop in his 1963 book, listing it as 'un astrolabe provenant de la collection H. E. Gillingham' (an astrolabe from the collection of H. E. Gillingham).[18] He also listed 'un astrolabe serait conservé à Harvard University, Collection of Historical Scientific Instruments, mais nou n'avons pu avoir de details à son sujet' (an astrolabe that would be kept at Harvard University, Collection of Historical Scientific Instruments, but we could not get any details about it).[19] It is not clear whether Poulle accidentally double listed the Gillingham-Wheatland astrolabe or had heard of a second instrument that would be preserved at CHSI. At the time he wrote, Harvard did not own the astrolabe nor would another by Fusoris ever come into its possession. A key point here is that Poulle thought the astrolabe(s) were not problematic and distinguished them from some fake instruments ('astrolabes faux') he went on to describe. One of the fakes was a Fusoris-style astrolabe in the Utrecht University Museum (which we will discuss further below).[20]

The astrolabe also appeared twice in the *Computerized Checklist of Astrolabes* (CCA) prepared by Derek Price with Sharon Gibbs and Janice Henderson in 1973 as number 3081 belonging to Gillingham and 3083 belonging to the Collection of Historical Scientific Instruments.[21] The latter was false, since the astrolabe belonged to David P. Wheatland in 1973. Both CCA 3081 and 3083 were ascribed to Jean Fusoris, *circa* 1430. It was also twice listed in David King's unpublished *Catalogue of Medieval Astronomical Instruments* in the category of 'fifteenth-century French astrolabes in the tradition of Jean Fusoris.'[22] The 2002 provisional table of contents refers to CCA 3083 as a 'Fusoris-type' astrolabe and CCA 3081 as an unsigned 'imitation' Fusoris-type, which in this context meant a 16th-century instrument in the older style. King had inspected the astrolabe at Harvard in 1993, and his notes in the CHSI file show that he had come to suspect that CCA 3081 and 3083 were the same object.[23] The double entry,

Fig. 3 *Detail of engraving style on* (left) *tympan and* (right) *mater of Harvard's DW0594 showing the unusual infill of some of the broad strokes. Courtesy of the Collection of Historical Scientific Instruments, Harvard University.*

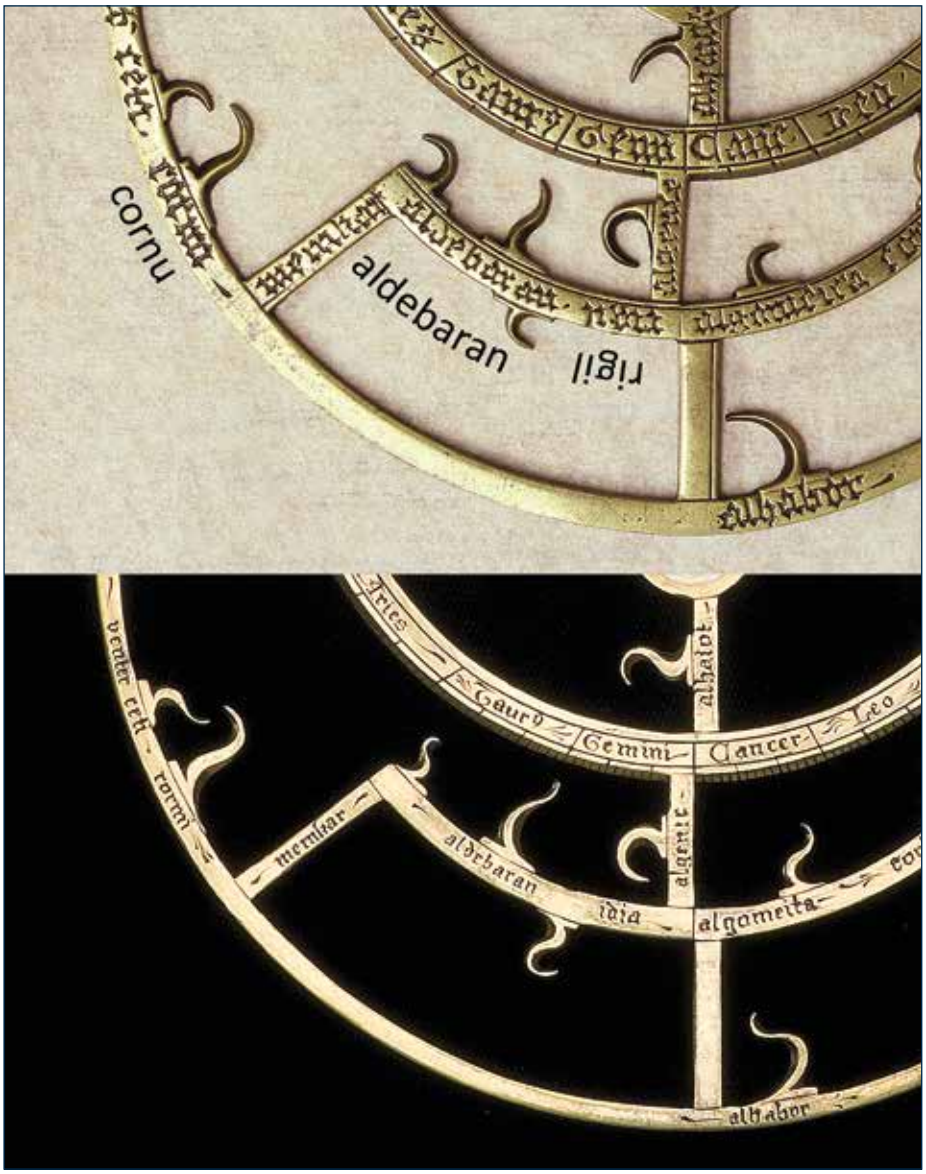

Fig. 4 *Star names 'rormi' and 'idia' (Harvard DW0594* (below) *compared to 'cornu' and 'rigil' on a genuine Fusoris rete (Oxford 49636* (above)*). Courtesy of the Collection of Historical Scientific Instruments, Harvard University (photo Matthew Longchamps), and the Museum of the History of Science, University of Oxford (photo John Davis).*

however, was reproduced again in the most recent listing of Fusoris astrolabes by Fausto Casi.[24]

With Poulle, King, and others listing Harvard's DW0594 as from the Fusoris *atelier*, the instrument has continued to be identified with this French maker until very recently.[25] The instrument is very well constructed, and its general arrangement very closely matches known Fusoris astrolabes, which were always unsigned. In particular, the rete design has the characteristic 'error star' of *cornu arietis* (β *Arietis*). In his manuscript star tables, Fusoris gave the star a southern declination rather than its correct northern one. He then proceeded to show the star in totally the wrong position on all his astrolabes.[26] Nevertheless, there are numerous features which show that Fusoris could not possibly have made the instrument. In the remainder of this article, the authors will examine the possibility that a 16th-century maker could have produced an imitation of a Fusoris instrument, although the likelihood of this is rather small.

Description

The astrolabe, 136 mm in diameter, is an unusual combination of gilt brass and silver. The mater, rete, alidade and rule are brass. The single tympan, bolt, washer, cotter pin (perhaps a replacement for the usual horse or wedge), suspension ring, and shackle are silver. These materials on their own beg questions as no other Fusoris astrolabe is recorded with this combination. The alidade is of a 16th-century style, being counter-changed and having hinged sights with slits. It also has a scale of morning and afternoon common hours, labelled 'horae ortus' (hours of sunrise) and 'horae occasus' (hours of sunset), which is not usable on the mater.[27] (More will be said about this below.) The silver tympan is prevented from rotating by a pair of pins (one now missing) projecting from the mater back rather than by the nearly-universal method of a tab in a slot under the throne. Its single stereographic projection is for a latitude of 34° N, suitable for Fez and Rabat (Morocco), Sultanabad (Iran), Herat (Afghanistan), and

Fig. 5 *Fusoris-style astrolabe in the University Museum of Utrecht, inv. um.342* (left)*, front view and* (right) *details of front and back of rete showing workmanship. Courtesy of the Universiteitsmuseum Utrecht (photos Kenneth Launie).*

within half a degree of Damascus and Baghdad. By contrast, astrolabes from the workshop of Jean Fusoris typically have four or five double-sided brass tympans for European latitudes in the range of 40° to 56°. That the silver tympan is original to the instrument rather than a later customisation for a North African or Middle Eastern client is shown by the fixing pins and the fact that the lettering style matches the rest of the instrument exactly. The depth of the womb also shows that the mater was designed for a single plate.

Some of these oddities could be written off as replacements, but the most obvious sign that the astrolabe is not medieval is the calligraphy of the lettering and numerals. In particular, the shapes of the 4, 5 and 7 have their modern forms rather than the medieval ones, which persisted until at least 1500 (see Fig. 2). The other numerals have a distinctly Renaissance feel about them, as do the letters: although the capitals have their medieval Gothic forms, the lowercase letters are in a rounded italic style without the 'spikey' shapes of a series of minims that would be expected for Fusoris's normal Gothic style.[28] Looking in more detail (Fig. 3), it can be seen that where a large character requires a broad stroke, it is sometimes formed of two parallel narrow lines with a series of short perpendicular connecting lines looking like a ladder—an engraving style we have never seen on any medieval instrument.

By closer examination of the twenty-two stars on the rete, we can see (Fig. 4) that the text marking the "error star" (β *Arietis*) reads more like 'rormi' than 'cornu'. The star name Rormi is unknown in any of the star tables[29] of the period but it does appear on an astrolabe of the same overall design signed 'I.B. 1547' in the Utrecht University Museum.[30] The Utrecht astrolabe (Fig. 5), which was identified as 'doubtful' but not as a reproduction when catalogued in 1954 by Van Cittert[31], has since been determined to be a 20th-century fake on two grounds. The first is that it is among a group of spurious astrolabes signed 'Johannes Bos' or 'I. B'. These include astrolabes in the National Maritime Museum (Greenwich), the Whipple Museum (Cambridge), the Museum Boerhaave (Leiden), the Collection of Historical Scientific Instruments, and the Josten Collection (Oxford).[32] It must be noted, however, that all but the Utrecht and Greenwich astrolabes have the exact same signature and are modelled on an authentic Bos instrument at the Adler Planetarium in Chicago that is not in the Fusoris style.[33] The Greenwich instrument, which carries a different 'Bos' signature, is a hybrid of the Bos and Fusoris styles; it was called a fake in 1963 by Poulle.[34] These 'Bos' copies, therefore, lead us astray from the issue at hand—namely the authenticity and date of the Fusoris-style Harvard astrolabe, DW0594. It is nothing like the 'Bos' or 'I.B'. instruments, does not carry those signatures, and is of far superior workmanship.

Aside from the added signature on the Utrecht astrolabe, a second reason to question its date was discovered by Poulle.[35] The Utrecht as-

Fig. 6 *Astrolabe by Jean Fusoris, early-15th century,* (left) *view of front and* (right) *back, CNAM inv. 19544. © Musée des arts et métiers-Cnam, Paris / photo S. Pelly.*

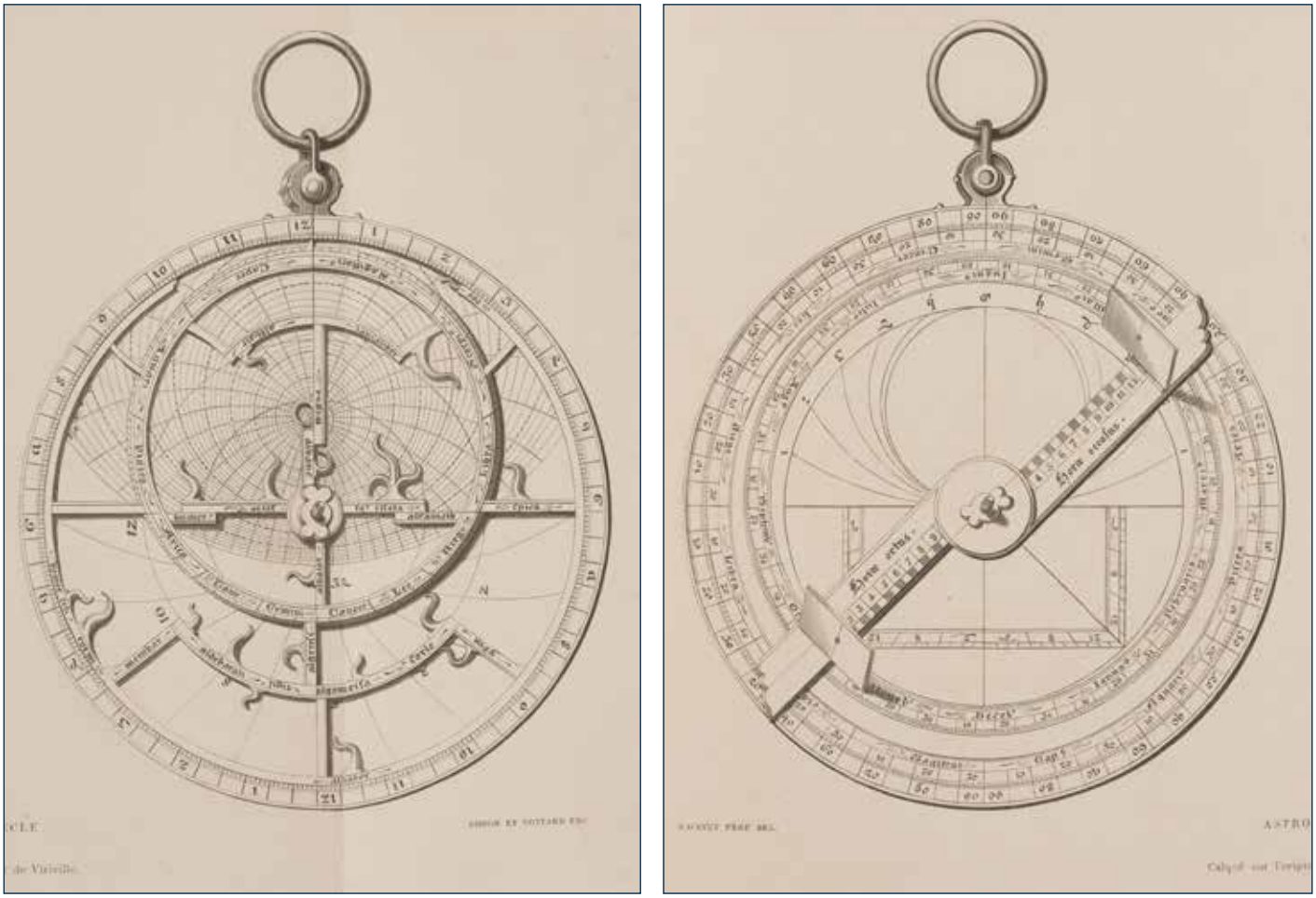

Fig. 7 *Engraving of an astrolabe in Pierre Dubois,* Histoire de l'horlogerie *(Paris, 1849). Courtesy of the Harvard University Library.*

trolabe is similar to a Fusoris-type astrolabe now at the Musée des arts et métiers, Paris[36], as it was illustrated in an 1849 engraving.[37] Curiously, the Harvard astrolabe is also extremely similar.

Three 'Fusoris' Astrolabes

Let's begin with the genuine Fusoris-type astrolabe now in the Musée des arts et métiers, Paris, which we will refer to as the CNAM astrolabe in recognition that the museum is part of the Conservatoire national des arts et métiers (Fig. 6). The CNAM instrument was first depicted in an engraving in an 1849 book by Pierre Dubois on the history of clockmaking.[38] The engraving (Fig. 7) is captioned 'Astrolabe du XVI^{e} Siècle. (Face et Revers) Calqué sur l'original appartenant à M Vallet de Viriville' (astrolabe of the 16th century (front and back) modelled on the original belonging to Mr Vallet de Viriville). Viriville was an archivist and medieval historian (1815–1868). After his death, the astrolabe was acquired by the Collection Vaudenberg, which sometime before 1914 presented it to the École d'Horlogerie de Paris. It ultimately came to reside with the CNAM's Musée des arts et métiers before 1950, perhaps at the time that the school closed.[39] The alidade which is depicted in the book is not on the astrolabe now in CNAM.

As is typical of Fusoris astrolabes, the 'error star' on the CNAM instrument is labelled 'cornu'. The illustrator or engraver of the 1849 book plate, however, transcribed the Gothic script with its confusing minims and similar letters 'c' and 'r' into text reading more like 'rormi'. The makers of the Utrecht and Harvard astrolabes also engraved their retes with text that can be read as 'rormi'. The first person to notice this was Poulle, who suggested that the Utrecht astrolabe was copied from the 1849 engravings of the Paris instrument.[40]

The similarities of the retes of the Utrecht, CNAM, and Harvard astrolabes do not stop there. Each instrument has a star pointer springing from the right-hand strut of the equatorial arc inside the ecliptic that is labelled 'lancalibre' (for Lanx Borealis, the northern pan of Libra, β *Librae*). This star is relatively rare on Fusoris astrolabes and is usually written as 'lanſalibre', with a long 's', which can be mistakenly read as a taller 'c'. Poulle himself reads the star name as both 'lanca libre' and 'lansa libre'.[41] The artist or engraver of the Dubois print has gone with the taller 'c'. The engravers of the Utrecht and Harvard astrolabes also went with 'c'. Curators discern the swapping of 'c' and 's' often enough on instruments, so this spelling variation raises few eyebrows.[42] A more unusual spelling change is detected for Rigil. The engraved image of the CNAM astrolabe correctly labels Rigil (β *Orionis*) as 'rigil' and rotates the text by 180° in relation to the names 'aldebaran' and 'algomeiſa' on its left and right sides in accordance with Fusoris workshop practice. This was to indicate that Rigil's pointer was on the opposite side of the equatorial arc from those of Aldebaran (α *Tauri*) and Algomeiza (now better known as Procyon, α *Canis Minoris*). The makers of the Harvard and Utrecht astrolabes, however, seem not to have realized that the star name was upside-down. Thus, the Harvard astrolabe has Rigil's pointer marked 'idia', whereas the Utrecht one looks like 'libia'. (see Fig. 4). The Utrecht astrolabe also follows the Dubois print's hybrid calligraphy with Gothic numerals but an alphabet style befitting the 16th-century (the date mistakenly ascribed to the CNAM astrolabe in 1849). The Harvard instrument, however, uses a 16th-century style for both numerals and letters.

The genuine Fusoris astrolabe in Paris has a

diameter of 136 mm, the same as the Harvard one. It has a set of three double-sided tympans (32°/33°; 34°/46° 45′; 48°/48° 50′ Parisi), although Poulle reported a fourth for 47° 30′ Monqoqier with a blank reverse.[43] In the Dubois illustration, the visible plate behind the rete is for 34°; this, rather tellingly, is the value for the only tympan on the Harvard instrument. The Utrecht astrolabe also holds a single tympan, but it is for 42°/52°.

When we turn the astrolabes over, we find anachronistic alidades on the purportedly medieval Harvard and Utrecht astrolabes and in the 1849 engraving of the CNAM instrument. The alidades have folding sights—a Renaissance innovation not seen on medieval instruments. They are graduated with equal hours divided into half-hour intervals. One side is marked 1–9 and '*horae ortus*' (hours of sunrise). The scale continues on the other side of the bolt with 4–12 and '*horae occasus*' (hours of sunset). This type of alidade is often seen on astrolabes from 16th-century Louvain makers.[44] Today, the genuine medieval Fusoris astrolabe in Paris no longer has the Renaissance alidade that was depicted in 1849. Perhaps a later owner recognized it as a replacement part and removed it or, alternatively, it is conceivable that the astrolabe had already lost its alidade by 1849 so the engraver substituted one from a different instrument of the 16th century. The interesting thing about the Harvard astrolabe is that the alidade and other late-style parts were engraved by the same hand as the Fusoris-style components.

Another noticeable difference between the CNAM astrolabe and the Harvard and Utrecht examples is the spelling of April on the calendar scales. The Harvard astrolabe has 'Aprili9' where '9' is the traditional medieval abbreviation of 'us'. The Utrecht instrument has 'April'. The CNAM astrolabe is inscribed with the standard Latin 'Aprilis', but this is hidden by the alidade in the 1849 print. Spelling and orthography frequently differ from one instrument to another issued from the same maker's workshop, so one should not make too much of this.[45] Nevertheless, the orthographic differences may reflect guesswork made by an instrument maker who could not see what he was copying.

Metallurgy

The composition of the copper alloys and silver of some Fusoris-type astrolabes (both genuine and reproduction) has been measured by X-ray fluorescence (XRF) by various investigators. The results are shown in the Table, alongside some comparative instruments. The instruments can be divided into several groups. First, three genuine Fusoris astrolabes now in Oxford (4, 5 & 6 in the table) show what might be regarded as a fairly typical Continental 'latten' of the 14th to 15th century: The zinc (Zn) concentration is about 20%, and tin (Sn) levels are quite low but variable at about 1%. Lead (Pb) levels are variable, and the metal contains significant trace impurities, particularly of silver (Ag) and iron (Fe). The British Museum instrument (no. 7 in the table) is a Fusoris-style astrolabe thought to be late 15th century and made after Fusoris's lifetime (since it lacks the erroneous placement of the star Cornu Arietis).[46] Its composition is similar to the foregoing but with a slightly higher zinc level around 25%. In marked contrast, an acknowledged 'Bos' copy and forgery (nos. 2 and 3 in the table, including the Utrecht Fusoris-type) are clearly made of electrolytically-refined copper, which has been gilded. The differences between modern and pre-1600 metalwork are striking.

The Harvard astrolabe, which is the subject of this paper (no. 1 in the table), is not only of better workmanship than the Utrecht astrolabe, but also does not have the physical and mechanical characteristics of typical 19th and 20th century imitations handled by the authors. It not only 'feels' right but also does not have their modern metallurgical composition. The composition of the Harvard astrolabe's mater, rete, and alidade conforms to late medieval and 16th century brass, having high zinc levels and trace impurities. The silver tympan is very 'clean' with only a small copper addition but is not 92.5% pure sterling silver. The copper alloys are quite close to those found in the British Museum astrolabe. Thus, the composition is not inconsistent with the hypothesis that the Harvard astrolabe is a 16th-century imitation of a Fusoris design. It is not, though, possible to prove that it is from this period since old metal stock could have been used into the 19th century in small local foundries and workshops. Evidence for this is given by the composition of the Gabriel Davis sundial plate (no. 8 in the table) which is known to have been made in England, *circa* 1820.[47] This has a very similar composition to the Harvard astrolabe.

Discussion and Conclusions

Over the course of a century, instrument scholars and specialists have interpreted the Harvard astrolabe as first a Renaissance object and then a medieval one, possibly from the Fusoris workshop. The authors do not find this latter association tenable. The Harvard astrolabe, with its Renaissance-style engraving, could not have been made by Jean Fusoris or in his workshop. We think that there are two viable hypotheses for when it was made.

The first is that it was produced in a 16th–century workshop—possibly in the Louvain area–by a maker who had seen a genuine Fusoris instrument similar to the CNAM example now in Paris. It was not intended to be an exact copy but an imitation in the Fusoris style. Hence, the calligraphy was updated to be more easily read, and the contemporary (though non-functional) alidade added. The silver components might have been incorporated to impress and please an aristocratic customer. Many examples of gilt brass and silver instruments survive from this period in courtly collections. They were show pieces then and remain so now. The very high quality of craftsmanship fits this bill. Mid-20th-century opinions on its authenticity as a 15th- or 16th-century astrolabe—by such formidable connoisseurs as Gunther, Price, Poulle, Brieux, and King—lend support for this hypothesis.

But there is the needling concern about the striking similarities between the Harvard astrolabe and the 1849 Dubois engraving of the CNAM instrument. Could it be that the Paris instrument passed through the same workshop as the Harvard astrolabe in the early modern period, acquiring a similar alidade? Could the Gothic calligraphy that tripped up an artist in the early 19th century also have caused trouble for a 16th-century artisan? Although many examples of replacement parts, transcription errors, and orthographic changes are to be found on historical instruments, we do not feel much confidence in answering these questions 'yes'. The alternative hypothesis is that the Harvard astrolabe might have been made in the late-19th or early 20th centuries by someone copying from the 1849 Dubois engraving. If this were the case, then the maker was more highly skilled than the fabricators of the Utrecht astrolabe and the copycats made by forgers for the art market. He also worked with old metal stock and used old metallurgical techniques.

Using the nomenclature of Gerard Turner, it appears that the Harvard astrolabe is an imitation or reproduction object made in the fashion of an astrolabe of an earlier period. The question is when. Although the imitation has many characteristics to suggest it might be an authentic 16th-century astrolabe in the medieval style of Fusoris, the similarities to the published 1849 print favour a 19th-century date. In either case, we can only speculate on whether the maker or any later seller intended to deceive the buyer into thinking the instrument was made earlier than it actually was. When Gertrude Hamilton sold the instrument to Harrold Gillingham, she probably thought it to be a real 16th-century antique, as did Robert Gunther and Alain Brieux years later. It was Derek Price and Emmanuel Poulle, the Fusoris expert, who recognized the Fusoris style and thought that the astrolabe could be as early as 1430. David King was more circumspect, describing the instrument as in the Fusoris tradition and dating it to the 15th or 16th century. Now we add the possibility that the Harvard astrolabe could be a remarkable

Table: X-ray fluorescence (XRF) Determinations

Astrolabe	Signature/maker	Part	Cu	Zn	Sn	Pb	Ag	Ni	Fe	As	Sb	Au	Comment
1. Harvard DW0594	Unsigned	mater	76.8	21.4	0.5	0.6	0.1	0.1	0.5	0.0	0.0	0.0	non-gilded area
		rete	79.4	17.9	0.6	1.3	0.2	0.1	0.4	0.1	0.0	0.0	non-gilded area
		alidade	74.8	23.3	0.3	1.0	0.2	0.0	0.3	0.1	0.0	0.0	non-gilded area
		plate	5.0	0.0		0.0	94.6					0.0	
		washer	5.7	0.1		0.1	94.0					0.1	rubbed on gilded rete?
2. Utrecht um.342	"I.B. 1547"	mater	99.17	0.19	0.02	0.14	0.09	0.14	n.a.		0.01	0.19	gilded
		rete	98.97	0.25	0.03		0.08	0.15	n.a.	0.002		0.32	gilded
		plate	95.62	0.32			0.09	0.15	n.a.			3.82	gilded
3. Whipple Wh.0305	"I. Bos"	mater	89.09	0.033				0.017	0.12		0.004	10.57	Hg 0.11% Au 0.06 µm
		rete	99.12	0.014	0.007	0.12		0.028	0.065	0.026	0.048	0.39	Au 0.08 µm
		plate 44°										tr,	Au 0.04 µm
4. Oxford 49359	Unsigned [Fusoris]	mater	78.98	13.68	3.57	2.19	0.152	0.049	0.788	0.118	0.366		
		limb	78.76	13.62	3.75	2.26	0.161	0.049	0.78		0.399		
		rete	81.26	17.65	0.025	0.42	0.15	0.018	0.398		0.007		
		plate 1	78.89	19.89	0.03	0.45	0.119	0.02	0.504		0.01		
		plate 2	78.82	19.81	0.034	0.40	0.121	0.025	0.649		0.007		
		plate 3	79.04	19.64	0.027	0.52	0.131	0.023	0.504		0.007		
		alidade	74.01	25.19	0.076	0.31	0.085	0.028	0.206	0.049	0.007		
		rule	81.6	11.37	5.76	0.40	0.157	0.041	0.28	0.287	0.014		
		pin	77.10	21.76	0.17	0.48	0.134	<LOD	0.211		0.02		
5. Oxford 49636	Unsigned [Fusoris]	mater	76.83	19.81	1.06	1.47	0.174	0.023	0.487		0.015		
		limb	77.84	17.81	1.53	1.80	0.193	0.048	0.621		0.041		
		rete	79.09	17.77	0.91	1.12	0.155	0.16	0.315	0.403	0.021		
		plate 1	80.70	16.98	1.13	0.81	0.108	0.018	0.162		0.007		
		plate 2	80.31	17.07	1.18	0.87	0.111	0.016	0.323		0.007		
		plate 3	80.19	15.33	1.09	0.19	0.208	0.84	0.202	1.838	0.023		blank spacer
		plate 4	76.92	21.18	0.72	0.84	0.128	0.016	0.105		0.012		
		plate 5	77.92	19.96	0.75	0.94	0.099	0.02	0.196		0.008		
		plate	77.17	20.77	0.95	0.56	0.091	0.02	0.301		0.01		
		alidade	77.38	19.04	0.79	0.69	0.13	0.43	0.149	1.318	0.029		
6. Oxford 53801	Unsigned [Fusoris]	mater	78.28	19.10	0.49	0.46	0.1	0.383	0.159	0.959	0.024		
		limb front	76.91	17.45	2.41	1.43	0.155	0.092	1.318	0.116	0.039		
		rete	77.28	19.30	0.68	0.58	0.124	0.403	0.345	1.193	0.023		
		rete front	77.05	19.47	0.77	0.57	0.133	0.415	0.225	1.312	0.028		
		plate 42	77.03	20.72	1.01	0.57	0.097	0.028	0.391	0.069	0.009		
		plate 45 c	80.52	17.20	1.18	0.76	0.109	0.023	0.153		0.007		
		plate 3	76.04	21.78	1.20	0.54	0.091	0.016	0.272		0.012		
		plate 52	77.05	20.82	0.99	0.56	0.092	0.024	0.314		0.008		
		alidade	77.51	19.55	1.07	1.26	0.19	0.067	0.261		0.018		
7. Brit Mus 1857, 57-23.1	Unsigned [Fusoris workshop?]	mater(back)	74.02	24.89	0.38	0.26	0.06	0.024	0.251	0.069	0.006		
		limb (cast)	72.59	21.22	4.44	0.68	0.08	0.06	0.312	0.283	0.163		
		rete	74.98	24.00	0.34	0.23	0.06	0.027	0.247	0.043	0.008		
		plate 45 & 47	71.88	26.87	0.21	0.34	0.107	0.104	0.257	0.307	0.026		
		plate 51 & 49	72.42	26.26	0.27	0.25	0.096	0.095	0.298	0.248	0.026		
		alidade	77.18	19.52	1.22	1.34	0.194	0.036	0.378		0.022		
		rule	78.56	18.40	1.17	1.06	0.194	0.043	0.452	0.027	0.016		
8. Sundial plate, c.1820	Gabriel Davis	dialplate, back, cleaned	78.25	17.78	1.01	1.93	0.09	0.105	0.388	0.26	0.035		Bi 0.12%. Bristol brassworks, England.

Table explanation

Alloy compositions measured by X-ray fluorescence (in wt.%) of the various components of Harvard DW0594 (measured by Katherine Eremin, 2007, unpublished) compared with the Utrecht imitation um.342 (measured by Peter Hallebeek of the Instituut Collectie Nederland, cited in Jan C. Deiman's paper, 'Imitations among the Mensing Instruments', in Peter de Clercq, *Scientific Instruments*, see note 1, p. 101. The XRF figures are copied from the Deiman paper). Also shown are three Fusoris-type astrolabes from the Oxford MHS with firm attributions, a slightly later Fusoris-style astrolabe in the British Museum and a 'Mensing, J. Bos' fake astrolabe of the Fusoris style in the Whipple Museum (measured by J. Davis using a Niton XL3t calibrated using the CHARM set of certified reference materials[48]). Additionally, the plate of an early 19th-century sundial is included for further comparison.

19th-century fabrication. No matter where one lands in time, the astrolabe bears witness to the pleasure and profit makers have taken in reproducing elegant instruments in older styles for discerning customers.

Acknowledgements

The authors wish to thank Anthony Turner, Peter de Clercq, Jan C. Deiman, Paul Lambers, and Rob van Gent (Universiteitsmuseum Utrecht), Josh Nall (Whipple Museum, Cambridge), Tiemen Cocquyt (Museum Boerhaave, Leiden), Silke Ackemann, Lucy Blaxland, and Tom Hopkins (Museum of the History of Science, Oxford), and Katherine Eremin (Straus Center for Conservation and Technical Studies, Harvard Art Museums), and Oliver Cooke (British Museum).

Notes and References

1. In this paper, we will follow the usage of terms such as 'imitation', 'reproduction', 'copy', 'restoration', 'forgery', and so forth as defined by Gerard L'E. Turner, 'An Enquiry into the Imitation of Scientific Instruments', pp. 49-60 in Peter de Clercq, ed., *Scientific Instruments: Originals and Imitations. The Mensing Connection*, Proceedings of a symposium, held at the Museum Boerhaave, Leiden, 15-16 Oct 1999 (Leiden: Museum Boerhaave, 2000), although we recognize that the meanings are still open to some interpretation. Since it is very difficult to determine if a 'copycat' or 'fake' item was created solely with the intention of deceiving for monetary or social gain, we will refrain from using terms like 'forgery' except in special cases. For a broader consideration of counterfeits, see Marco Beretta and Maria Conforti, eds., *Fakes!? Hoaxes, Counterfeits and Deceptions in Early Modern Science* (Sagamore Beach, MA: Watson Publishing International, 2014).

2. Boris Jardine, Joshua Nall, and James Hyslop, 'More than Mensing? Revisiting the Question of Fake Scientific Instruments', *Bulletin of the Scientific Instrument Society,* No. 132 (March 2017), pp. 22-29.

3. De Clercq, *Scientific Instruments* (note 1).

4. On sundials, telescopes, watches, and microscopes, see Sara J. Schechner, 'Counterfeits, Copycats, and Knockoffs in the Branding and Selling of Scientific Instruments', paper presented at the XXIII International Congress of History of Science and Technology, Budapest, July 2009. On sundials, see Sara J. Schechner, 'The Material Culture of Astronomy in Daily Life: Sundials, Science, and Social Change', *Journal for the History of Astronomy*, **32** (2001), pp. 189-222; and Sara J. Schechner, 'These Are Not Your Mother's Sundials: Or, Time and Astronomy's Authority', pp. 49-73 in *The Science of Time 2016: Time in Astronomy & Society, Past, Present and Future*, eds. Elisa Felicitas Arias et al. (Cham, Switzerland: Springer International Publishing, 2017).

5. Emmanuel Poulle, *Un constructeur d'instruments astronomiques au XVe siècle, Jean Fusoris* (Paris: Librairie Honoré Champion, 1963).

6. Collection of Historical Scientific Instruments, Harvard University [hereafter cited as CHSI], inv. no. DW0594. Online in *Waywiser*: http://waywiser.rc.fas.harvard.edu/objects/11865/fusoristype-planispheric-astrolabe?ctx=d915d229-77d8-4880-9aff-461977e71b37&idx=0. (accessed 4 June 2018).

7. On Mrs. Gertrude Hamilton, see Willem F. J. Mörzer Bruyns and Anthony Turner, 'Gertrude Hamilton, an American Instrument-Dealer in Paris', *Bulletin of the Scientific Instrument Society*, No. 73 (June 2002), pp. 23-26.

8. Harrold E. Gillingham, 'Sundials & Instruments', typescript inventory of his collection, 5 April 1949, p. 5, Harrold Edgar Gillingham Collection Records, David P. Wheatland Papers, Collection of Historical Scientific Instruments, Harvard University [hereafter cited as Gillingham Collection Records and the Wheatland Papers].

9. Harrold E. Gillingham, 'Astrological Instruments', *The Magazine Antiques*, **14**, no. 1 (July 1928), pp. 32-34, see p. 32.

10. Harrold E. Gillingham, 'Notes on Early Navigating Instruments', *The Mariner: The Quarterly Journal of the Ship Model Societies of Rhode Island and New York*, **4**, no. 1 (January 1930), pp. 3–8, see p. 4. There is no description in the text. Poulle, *Un constructeur* (note 5), p. 21, n.1 observed that this astrolabe was wrongly identified and shown in illustration of a stupid article ('Reproduit…sous une légende, d'ailleurs, et en illustration d'un article stupides').

11. Gillingham, 'Sundials & Instruments' (note 8), Gillingham Collection Records.

12. R. T. Gunther, *Astrolabes of the World,* 2 vols. (Oxford: Oxford University Press, 1932; reprint edition as a single volume, London: Holland Press, 1976).

13. An account of the visit and transaction is found in the Gillingham Collection Records. R. Newton Mayall was the co-author (with his wife, Margaret W. Mayall) of *Sundials: How to Know, Use, and Make Them* (Boston: Hale, Cushman & Flint, 1938). The Mayalls had close connections to the Harvard College Observatory and the American Association of Variable Star Observers, of which Margaret Mayall was director.

14. Wheatland Small Cards, W142 and DW594, in the Wheatland Papers. Today the CHSI inventory number for the astrolabe is DW0594.

15. Alain Brieux, 'Inventory of the apparatus and sundials offered to Harvard 1984 by Mr. David P. Wheatland', 44-page typescript, see p. 30, in folder: [Brieux] 1984 Sundial Appraisals and Wheatland's Donation List, Wheatland Papers.

16. Derek de Solla Price, 'An International Checklist of Astrolabes', *Archives Internationales d'Histoire des Sciences*, **8**, nos. 32-33 (1955), pp. 243-263, 363-381.

17. Emmanuel Poulle to David P. Wheatland, Paris, 15 November 1957, and David P. Wheatland to Emmanuel Poulle, Topsfield, MA, 4 February 1958, on transmitting photographs and information. DW0594 (astrolabe, planispheric) file, CHSI.

18. Poulle, *Un constructeur* (note 5), p. 21.

19. Poulle, *Un constructeur* (note 5), p. 21.

20. Poulle, *Un constructeur* (note 5), p. 21, discusses Universiteitsmuseum Utrecht, um.342 (CCA 539). See also P. H. van Cittert, *Astrolabes. A Critical Description of the Astrolabes, Noctilabes and Quadrants in the Care of the Utrecht University Museum* (Leiden: E. J. Brill, 1954), pp. 5–9 and plates 2-3, for astrolabe um.342.

21. Sharon Gibbs, Janice Henderson, and Derek de Solla Price, *A Computerized Checklist of Astrolabes* (New Haven: Department of History of Science and Medicine, Yale University, 1973), p. 26 [hereafter abbreviated as CCA].

22. David A. King, *A Catalogue of Medieval Astronomical Instruments to ca. 1500* (Frankfurt am Main: Institute for the History of Science, Johann Wolfgang Goethe University, unpublished), preliminary notes and table of contents (May 2002) online at http://www.davidaking.org/instrument-catalogue.htm (accessed 15 January 2018). See Part 6: Early European Astrolabes (to ca. 1500), Section 8: Fifteenth-century French astrolabes in the tradition of Jean Fusoris, nos. 18 (CCA 3083) and 24 (CCA 3081).

23. David A. King, draft catalogue entry for section 6.8, item 24 ('An unsigned 'Fusoris-type' astrolabe with a single plate for latitude 34°'), typescript with annotations by David King, faxed 21 February 1994 to CHSI, and then further annotated by William Andrewes and dated March 1994. DW0594 file, CHSI.

24. Fausto Casi, 'A Medieval Astrolabe in the Tradition of Jean Fusoris', *Nuncius*, **19**, no. 1 (2004), pp. 3-29, see pp. 14-15.

25. For example, Sara J. Schechner, 'Astrolabes and Medieval Travel," pp. 181-210 in *The Art, Science, and Technology of Medieval Travel,* eds. R. Bork and A. Kann (Aldershot, UK: Ashgate, 2008).

26. The sign error for the declination of β *Arietis* persisted into the 17th century in some books. See, for example, Adriaan Metius, *Fundamentale onderwysinghe, aengaende de fabrica, ende het veelvoudigh ghebruyck van het astrolabium, soo catholicum, als particulier* (Franeker: Ulderick Balck, 1627), p. 17.

27. This type of alidade is graduated with equal hours (one side for morning, the other for afternoon) and is often seen on astrolabes from 16th-century Louvain makers where the alidade travels over a conversion table for equal-unequal hours. See, for example, the 1573 Arsenius astrolabe (CCA 485 now in Florence) in Koenraad Van Cleempoel, *A Catalogue Raisonné of Scientific Instruments from the Louvain School*, *1530 to 1600* (Turnhout, Belgium: Brepols, 2002), pp. 156-159.

28. As there were several engravers in the Fusoris workshop over its lifetime, more than one style of engraving is found, varying from the extremely spikey, linear Gothic to a more rounded – but still medieval – uncial form.

29. Paul Kunitzsch, *Typen von Sternverseichnissen in astronomischen Handshriften des zehnten bis vierzehnten Jahrhunderts*, (Wiesbaden: Otto Harrassowitz, 1966).

30. Universiteitsmuseum Utrecht, inv. no. um.342 (CCA 539).

31. Van Cittert, *Astrolabes* (note 20), 5-9, quotation on 5.

32. European copies of an astrolabe by Johannes Bos, 1597, late 19th or early 20th century, all signed on the rete, 'IOANNES BOS / 1597 / DIE 24 MARTII': Museum Boerhaave, Leiden (CCA 534); Whipple Museum of the History of Science, Cambridge, Wh.0305 (CCA 406); C. H. Josten Collection, Oxford (CCA 405); and CHSI, DW0595 (not listed in CCA). See also the astrolabe signed 'JOANNES BOS. FECIT 1591', The Netherlands?, *c*. 1920, National Maritime Museum, Greenwich, AST0572 (CCA 430), in Koenraad van Cleempoel, *Astrolabes at Greenwich: A Catalogue of the Astrolabes in the National Maritime Museum, Greenwich* (Oxford and London: Oxford University Press and the National Maritime Museum, 2005), pp. 206-209 (this astrolabe copies the Bos instruments, except for its Fusoris-style rete).

33. The authentic Bos: Astrolabe, Johannes Bos, Italy, 1597, signed on rete, 'IOANNES · BOS · I · / 1597 / DIE · 24 · MARTII ·', Adler Planetarium, Chicago, M-33a (CCA 185); Roderick S. Webster and Marjorie K. Webster, *Western Astrolabes*, Historic Scientific Instruments of the Adler Planetarium and Astronomy Museum, 1 (Chicago: Adler Planetarium, 1998), no. 14, pp. 80-81. See G. Brian Stephenson, Bruce Stephenson, and Dean R. Haeffner. 'Investigations of Astrolabe Metallurgy Using Synchrotron Radiation'. *MRS [Material Research Society] Bulletin*, **26**, no. 1 (2001): 19–23; and C.B. Stephenson, G.B. Stephenson, and D. Haeffner, 'The Mystery of Ioannes Bos: The Metal Speaks: X-ray Studies of Astrolabes', *Advanced Photon Source Research*, **3**, ANL/APS/TB-37, pp. 35-40 (Argonne, IL: Argonne National Laboratory, 2000).

34. Poulle, *Un constructeur* (note 5), p. 21.

35. Poulle, *Un constructeur* (note 5), p. 21, n. 4; and more recently, Jan C. Dieman, 'Imitations among the Mensing Instruments', in de Clercq, *Scientific Instruments* (note 1), pp. 99-112, see no 16, p. 110.

36. Astrolabe attributed to Jean Fusoris, Paris, Musée des arts et métiers, le CNAM (Conservatoire des arts et métiers), inv. no. 1954-0000; online at http://cugnot.cnam.fr:8000/BASIS/COLLEC/INTERNET/imagette/SDF?CLE_COL=O000000424 (accessed 4 June 2018) It is classified as 'Fusoris-type', 15th century in King, *Catalogue* (note 22), section 6.8, no. 10 (CCA 3080).

37. Pierre Dubois, *Histoire de l'horlogerie depuis son origine jusqu'à nos jours: précédée de recherches sur la mesure du temps dans l'antiquité et suivie de la biographie des horlogers les plus célèbres de l'Europe* (Paris: Administration du Moyen Âge et la Renaissance, 1849), foldout plate opposite p. 24.

38. Dubois, *Histoire de l'horologerie* (note 37).

39. Personal communication, Anthony Turner, 17 April 2017; the CNAM record provides the same data. However, Casi, 'Medieval Astrolabe' (note 24) states that this is incorrect and reports that Gaston Bière donated the astrolabe to the CNAM.

40. Poulle, *Un constructeur* (note 5), p. 21, n. 4.

41. Poulle *Un constructeur* (note 5), pp. 16, 23 notes 'lansa libre' and 'lanca libre' respectively. When remarking on the star's rarity–identifying only two astrolabes with the pointer (CCA 337, CCA 3080)– Poulle defaults to 'lanca libre'. A third Fusoris astrolabe with the star pointer was sold by Sotherby's London, *The Studiolo: Old Master Paintings and Works of Art from the London Residence of Luigi Koelliker* (3 December 2008), lot 75. Note that Sotheby's expert read the star name as 'lansalibri', but a photo shows 'lansalibre'.

42. Take for instance Pierre Sevin's alternative signature as Cevin on 17th century instruments.

43. A.J. Turner, personal communication, 23 April 2017.

44. Van Cleempoel, *Catalogue Raisonné* (note 27).

45. See variations in spelling within the same workshop on sundial gazetteers and other inscriptions in Sara J. Schechner, *Sundials and Time Finding Instruments: Hour Angle Dials* (Chicago: Adler Planetarium, forthcoming 2018).

46. F.A.B. Ward, *A Catalogue of European Scientific Instruments in the Department of Medieval and Later Antiquities of the British Museum* (London: British Museum Publications, 1981), pp. 114–115, inv. no. 1857, 57-23.1 (CCA 195).

47. J. Davis, 'Sundials by the Davis Dynasty', *British Sundial Society Bulletin*, **28**, no. 3 (2016), pp. 2–6.

48. A. Heginbotham et al., 'The Copper CHARM Set: a New Set of Certified Reference Materials for the Standardization of Quantitative X-ray Fluorescence Analysis of Heritage Copper Alloys', *Archaeometry*, **57** (2015): 856–868. doi: 10.1111/arcm.12117.

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