Three Gallo-Roman bronze disks with astral inscriptions.

Accepted version, published in *Journal for the History of Astronomy* 52(4), 2021, 381–396.

https://doi.org/10.1177/00218286211052655

Three Gallo-Roman bronze disks with astral inscriptions.

Alexander Jones, Institute for the Study of the Ancient World, New York University
alexander.jones@nyu.edu

Abstract.
This article concerns three archaeologically recovered circular bronze objects found at Gallo-Roman (1st century BC – 4th century AD) sites in France. Through comparisons with other more or less contemporary objects of known function, it is argued that one of these disks definitely, and another likely, belonged to gearwork devices for keeping track of simple chronological cycles, while the third belonged to a clepsydra of a type recognized only recently.

Keywords.
Greco-Roman astronomy, Greco-Roman astrology, Greco-Roman time-reckoning, Egyptian time-reckoning astronomical mechanisms.

1. Introduction.

Among the material remains of the astral sciences (astronomy, astrology, and allied fields) from the time of the Roman Empire are various more or less circular objects of bronze plate inscribed with text or images related to astronomy or astrology. Their contents and purpose were diverse. The largest number (on the order of fifteen examples either extant or described in modern times) were components of portable sundials; in most instances these sundial plates have survived without the other components, though occasionally we have a partial or complete ensemble.[1] A second category, the revolving display dials of water-driven anaphoric clocks, is represented by two fragments of dials found at Salzburg and at Grand (Vosges), in both cases without any other parts of the clocks to which they belonged.[2] This note concerns three further disks that came to light over the past two centuries at Gallo-Roman archaeological sites and whose original functions have not been satisfactorily explained. I will argue, through comparisons with other more or less contemporary objects of known function, that one of these disks definitely, and another likely, belonged to gearwork devices for keeping track of simple chronological cycles, while the third belonged to a clepsydra of a type recognized only recently.

2. The "Dijon disk."

The so-called Dijon disk (Fig. 1) was discovered in 1843 at the sanctuary of the "Sources de la Seine" (Fontes Sequanae) cult site northwest of Dijon (Fig. 2); a description and drawing of the inscribed face were published by Henri Baudot two years later.[3] It is now in the collection of the Musée archéologique de Dijon, inv. Arb.873.[4] Precise dating within the broad Gallo-Roman period, say the first four centuries of our era, is not possible. The bronze disk, with diameter approximately 7.3 cm and plate thickness between 0.5 and 0.7 mm, has a sawtoothed or lobed outline. The fourteen lobes are roughly triangular but asymmetrical, such that, as one views the inscribed face of the disk, the left side of each lobe is nearly twice as long as the right side. The left sides also tend to have slightly convex outlines, whereas the right sides are straighter. A small drilled hole, diameter roughly 2 mm, perforates the disk close to the center, and is surrounded on the front face by a patch of rough surface, likely the remains of solder that formerly attached something here; there is also a smaller area of damaged surface around the hole on the uninscribed side.[5] Slightly closer to the center than the innermost points of the notches separating the lobes is a ring of fourteen inscriptions consisting of the abbreviated (first three letters) Latin names of the divinities associated with the consecutive days of the planetary week (*SAT*, *SOL*, *LVN*, *MAR*, *MER*, *IOV*, *VEN*), running clockwise around the disk through two complete weeks.[6] The tops of the letters are toward the center, so that when one looks at the inscribed face of the disk, it is the inscription at the bottom that is oriented the right way for reading. The hole is about 1 mm off-center, and, considered with respect to the hole and with respect to each other, the angular spacing of the lobes and of the inscriptions is not quite uniform; in general the execution of the object is somewhat coarse.

Figure 1. The Dijon disk, Musée archéologique de Dijon inv. Arb.873. (Musée archéologique de Dijon, photo M. Brunet, drawing Alexander Jones.)

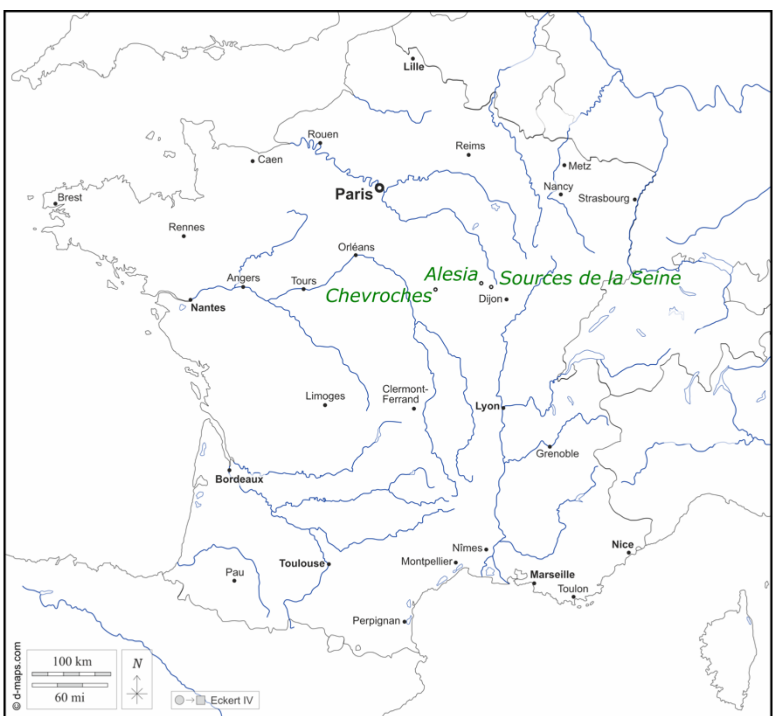

Figure 2. The findspots of the three disks. (Map derived from https://d-maps.com/m/europa/france/france/france30.svg)

Baudot called the disk a *semainier*, meaning an instrument for keeping track of the day of the week. He supposes that the disk was mounted so that it could be rotated, and that only one weekday name could be seen at a time. His description, brief as it is, seems to have been the only independent study of the object until, more than a century and a half later, Christian Vernou revived interest in it in connection with research on the Chevroches disk, to be discussed later in this note. It was put on public display as part of a temporary exhibition entitled "Dieux du ciel!" at the Musée Saint-Raymond, Musée des antiques de Toulouse, in 2010, and a photograph and brief description by Vernou were included in the exhibition guide.[7] Vernou speculates that the number fourteen was somehow connected with the lunar phase cycle (considering that cycle as comprising four stages of seven days, to the nearest whole number). This lunar connection seems unnecessary, however, since the astrological cycle of seven planetary weekdays, explicit in the disk's inscriptions, suffices to account for the number of inscriptions and teeth.

Much more pertinent is the brief observation in a slightly earlier article by Vernou in collaboration with Frédéric Devevey and Aurélie Rousseau that the disk is reminiscent of the "arbor with ratchet from the Byzantine sundial-calendar conserved at the [London] Science Museum."[8] The object in question, Science Museum inv. 1983-1393, is a portable sundial from late antiquity (and of uncertain provenance though probably from the eastern Mediterranean) that, uniquely among the portable sundials currently known, was equipped with a gearwork apparatus that, as reconstructed by Michael T. Wright, could be set manually to display the current day of the planetary week, the current day of the lunar month, and the locations of Sun and Moon in the zodiac.[9] Among the surviving components is an arbor bearing a seven-lobed ratchet, diameter a little over 3 cm, and smaller gears of seven and ten teeth (Fig. 3).[10] According to Wright's reconstruction, the ratchet was effectively the "input" of the mechanism; every day, the operator turned the arbor one-seventh of a complete turn by hand, and a spring, possibly just a tongue of springy metal, pressing against the periphery would have ensured that the gearwork would be turned only one day's worth at a time, and only forward in time. Attached to the end of the arbor there would have been a pointer running along a dial that displays the seven weekdays, in the form of stylized profile busts of the corresponding weekday gods, engraved on the surviving face plate of the sundial (Fig. 4). The gears on the arbor would have driven other gears (one other arbor survives) leading to outputs in the form of dials on the other, lost, face plate.

Fig. 3. The arbor with seven-lobed ratchet of the Science Museum geared portable sundial, inv. 1983-1393. (Photos: Science Museum, CC BY-NC-SA 4.0,

https://collection.sciencemuseumgroup.org.uk/objects/co1082/byzantine-portable-universal-altitude-sundial-with-geared-calendrical-device-sundial-perpetual-calendar)

Fig. 4. The front face of the Science Museum geared portable sundial, inv. 1983-1393. The dial for displaying the astrological weekday is at the bottom, with Helios/Sol (the Sun, for Sunday, identifiable by rays, radiating from his cap, and whip) closest to the disk's central hole. (Photos: Science Museum, CC BY-NC-SA 4.0, https://collection.sciencemuseumgroup.org.uk/objects/co1082/byzantine-portable-universal-altitude-sundial-with-geared-calendrical-device-sundial-perpetual-calendar)

It can hardly be doubted that the reason that the Dijon disk resembles the Science Museum ratchet is because it was the corresponding component of a similar calendrical-astronomical gearwork mechanism, namely the "input" operating on a scale of single days. Its larger size implies that the mechanism was not provided as an auxiliary gadget to a small instrument such as a portable sundial. Whereas the ratchet-arbor of the Science Museum device would have needed a pointer to indicate the weekday, the Dijon disk was probably mounted in such a way that the relevant inscription was exposed, either by jutting below whatever plate lay in front of the gearwork or by showing through a window. Hence there would have been no need for a dial for the weekdays, while having the ratchet accommodate two weeks instead of one may have had some slight mechanical advantage for the smooth operation of the mechanism. Further conjectural reconstruction from a single surviving component—indeed, just part of a component since any gears that were on the same arbor are lost—is probably pointless, but there is some significance in the circumstance that the third verified example of computational gearwork surviving from antiquity conforms to an already recognized type, which might best be thought of as a mechanical counterpart of the inscriptional parapegmata that Daryn Lehoux classes as "astrological" and that were prevalent in the western Roman Empire.[11]

3. The "Alesia disk."

The Alesia disk (Fig. 5) was excavated by Émile Espérandieu at the site near Alise-Sainte-Reine (Côte-d'Or) that he identified as Alesia, the location of the famous engagement between Julius Caesar's Roman army and the Gallic confederation led by Vercingetorix in 52 BCE (Fig. 2).[12] It is now in the collection of the Musées d'Avignon, Palais du Roure, inv. PDR OM A12.[13] No precise dating within the broad Gallo-Roman period is possible. The disk is a circle of bronze plate, slightly convex (with conical profile, vertex a little less than 1 cm forward of the rim) towards the inscribed face, diameter approximately 11 cm, thickness not reported but apparently about 1 mm.[14] A hole of diameter approximately 5 mm is drilled through the center. The engravings on the convex face are entirely pictorial or decorative, with no text. Outward from the central hole, they consist of: (i) a circular ring formed from tightly spaced, short linear strokes bounded by concentric engraved circles of diameter approximately 2.5 and 3.5 cm, apparently decorative; (ii) a ring of frontal busts of the seven weekday gods (identifiable from their conventional attributes such as crescent for Moon and caduceus for Mercury), in clockwise order, oriented so that the top of the head is towards the rim of the disk while the busts are cut off at the bottom by an engraved circle of diameter approximately 4.5 cm; and (iii) along the rim, thirty-seven small hatched, more or less isosceles triangles with their bases along the rim, an engraved circle of diameter approximately 10 cm running through their vertices and with short radial strokes running toward the center from each vertex.[15] With respect to the central hole, neither the seven busts nor the thirty-seven triangles are angularly spaced with much precision. No information is available concerning the disk's other face.

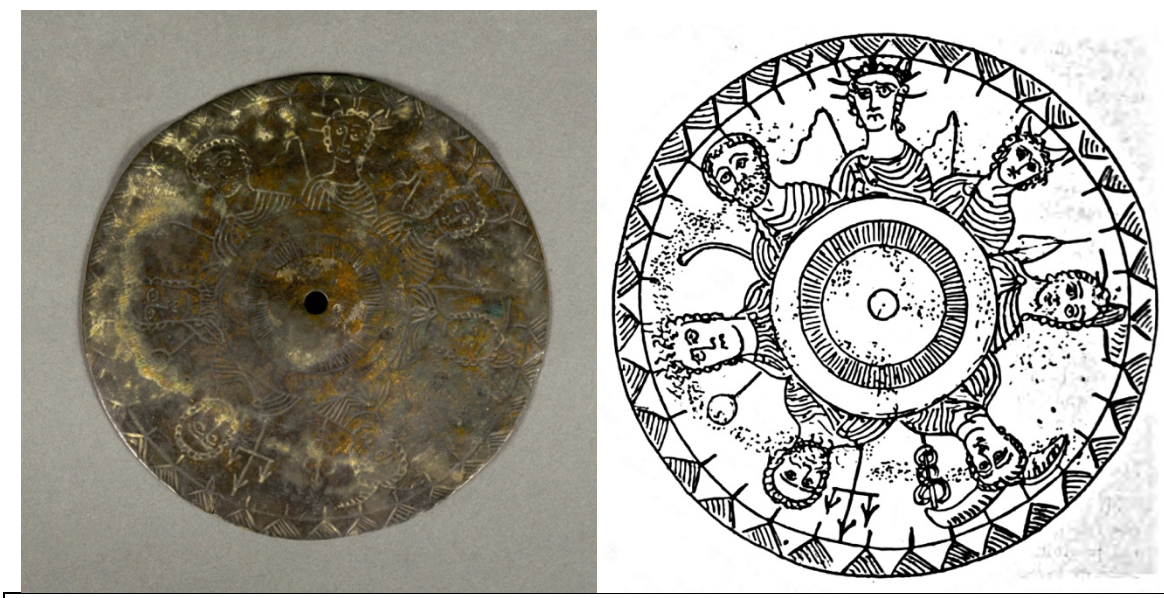

Fig. 5. The Alesia disk, Palais du Roure inv. PDR OM A12, with Espérandieu's drawing. Helios/Sol is at the top. The drawing has only 36 triangles around the rim instead of the correct 37. (Photo: Caroline Martens, CC BY-SA 4.0, https://commons.wikimedia.org/wiki/File:Semainierdalesia-75.jpg)

Espérandieu correctly identified the busts as representing the weekday gods, and noted (but downplayed) that this provided a point of resemblance to the Dijon disk.[16] While conceding that the purpose of the Alesia disk was uncertain, he proposed that it was originally mounted so as to be turnable over a circle with a mark so that it could be set with the current weekday god against the mark. In common with the Dijon disk, Devevey, Vernou, and Rousseau adduced it as a comparand to the Chevroches disk, as possible indications (though they do not explain how in each instance) of having been parts of complex astronomical mechanisms, "to calculate and predict the movements of planets, for instance."[17] A key, but undeveloped, observation is that the representation on the Alesia disk "is like" the surviving dial plate of the Science Museum portable sundial, the reference clearly being to the smaller circular dial inset on that plate with the profile busts of the weekday gods (Fig. 4).

In the "Dieux du ciel!" guide, however, Vernou maintains that the thirty-seven triangles are more relevant to the disk's purpose than the divine busts; interpreting them as a representation of the Egyptian decans (the "standard" thirty-six decans plus one corresponding to the five epagomenal days that complete the Egyptian calendar year following the twelve thirty-day months), he rejects the designation "semainier" in favor of "calendrier décanal." This seems to me doubtful for several reasons. First, there is nothing at all on the disk to suggest that the triangles mean decans, to associate any particular triangle with any particular decan, or indeed to distinguish one triangle from the rest. To all appearances they are simply a decorative element, like the inner ring of radial strokes. Secondly, by the time of the Roman Empire and in the context of astrology in which familiarity with the decans was diffused outside Egypt, the decans were no longer tied to the Egyptian calendar but had become astrologically significant 10° subdivisions of the twelve zodiacal signs, so that their number was fixed as thirty-six. Vernou's objection to treating the weekday gods as the defining feature of the disk seems to reside in the inequalities of their angular spacing, but these are not so great as to preclude a display in which each could in turn indicate the current weekday, either through the disk's revolving or through some indicator revolving with respect to it.

The central perforation establishes this much, that something in the original setup revolved, and the point of the revolution was surely so that at any time one or another of the weekday gods was being indicated. In principle, as Espérandieu supposed, this could have been no more than a manually set dial showing the weekday, free to rotate on a pivot passing through the hole, with no additional mechanical elements. However, since the identification of the Dijon disk as a ratchet from a gearwork device with multiple calendrical or astronomical outputs establishes that this kind of mechanical parapegma existed in precisely this region, it seems a reasonable alternative supposition that the Alesia disk was the hedomedal display element of such a device.

4. The "Chevroches disk."

The Chevroches disk (Figs. 6–7) was found, in the context of a deposit of numerous metal objects probably destined for recycling of their material, in preventive archaeological excavations led by Frédéric Devevey in 2001–2002 at Chevroches (Nièvre), roughly a hundred kilometers west of the findspots of the Dijon and Alesia disks (Fig. 2).[18] It is now in the Musée d'Art et d'Histoire Romain Rolland de Clamecy, inv. D 2011.5.1.[19] Together with the other metal artifacts was found a coin hoard that dates the deposit to around or after the 340s CE, while a paleographical dating to the end of the third century has been offered for the Greek letter forms inscribed on the disk.[20] The disk is circular in outline, diameter approximately 6.45 cm and thickness 0.5 mm, not flat but effectively a circular segment of a sphere of diameter about 9 to 10 cm so that, lying flat, its center is approximately 1.3 cm higher than its periphery.[21] (Hence publications on it have preferred to use the term *calotte*, "cap.") The center is perforated by a circular hole, diameter approximately 5 mm. The concave face has remains, over a wide area, of tin solder, indicating that this face was once fixed flush against a metal object with a similar spherical contour.

Fig. 6. The Chevroches disk: left, the inscribed convex face (photo Denis Gliksman, INRAP); right, the concave face with remains of tin solder (photo Gilbert Renaud).

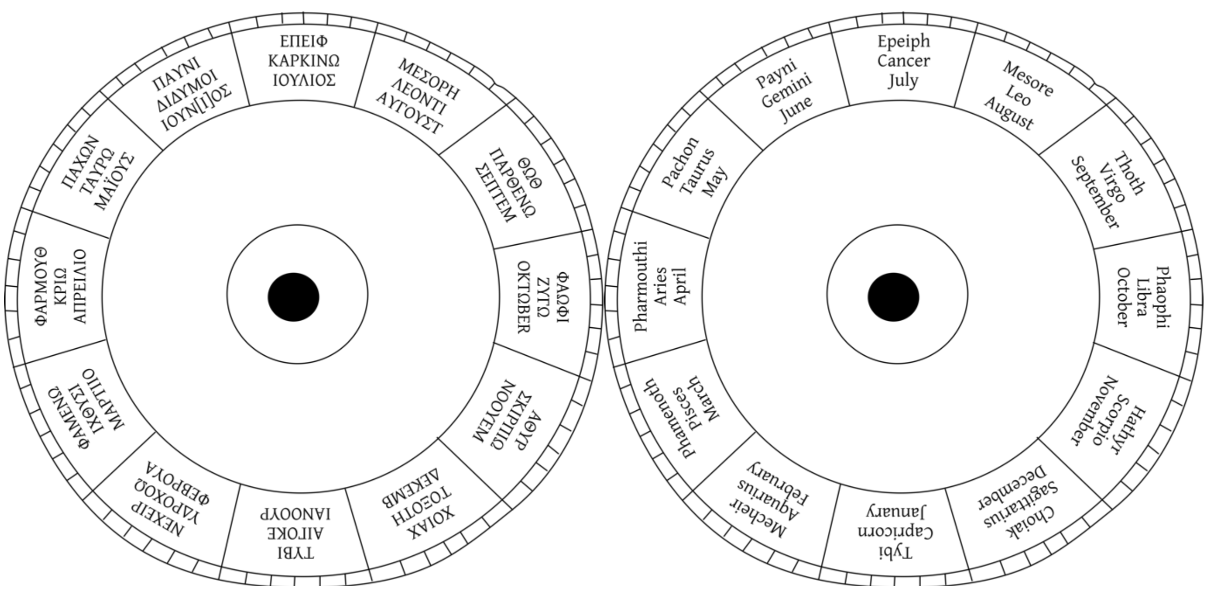

Fig. 7. Schematic drawing and translation of the Chevroches disk (Alexander Jones).

The convex face is inscribed, outward from the center, with (i) a circle of diameter approximately 1.5 cm; (ii) a circle of diameter approximately 4.3 cm; (iii) the space between this circle and the periphery is divided by radial lines into twelve equal 30° sectors; (iv) along the periphery, each sector is divided by short (approx. 1 mm) radial strokes into six 5° divisions, with a circle of diameter approximately 6.2 cm running through the inner ends of the strokes; (v) in each sector are inscribed three lines of text in Greek, oriented with the tops of the letters toward the periphery and bending along its curvature. The three lines contain, from outermost to innermost, the Greek names of the twelve months of the Egyptian calendar year, in two instances abbreviated, running in order clockwise; the name, in the dative case and in two instances abbreviated, of the twelve zodiacal signs running in order clockwise; and the Greek names, in the nominative case and in seven instances abbreviated, of the twelve months of the Roman calendar year, running in order clockwise.[22] If we consider the Egyptian month names as referring to the civil Egyptian calendar as reformed (by the introduction of leap-years) after Egypt became a Roman province in 30 BCE, and the zodiacal signs as referring to the intervals of the year during which the Sun occupies each sign, then the intervals named in each cell are those from the three distinct ways of dividing a solar year that have the most overlap; for example in one cell we have Thoth (the first Egyptian month), Virgo, and September, and it is the case that the Sun is in Virgo through most of September and through most of Thoth. (In no case would the intervals exactly coincide.)

Successive publications by Devevey and colleagues since 2006 concerning the Chevroches disk have offered only tentative suggestions about its purpose and the kind of larger object or instrument of which it was a part. These have included that it might have been part of a complex mechanism such as one for calculating planetary motions, or of an armillary, a globe, or an anaphoric clock; these suggestions have not been developed, however, beyond citing other extant objects that fall, or might fall, in these categories.[23] Additionally, Patrice Cauderlier has proposed that the disk could have been an aid in composing a horoscope, though I have to confess I do not understand his instructions for using it in this way.[24]

To arrive at an understanding of what the Chevroches disk was, I will begin with another Gallo-Roman object that has no obvious connection with it. In 1997 the Archäologisches Museum Frankfurt acquired from a private collection a remarkable bronze outflow clepsydra, now inv. 2000,07.[25] Its provenance is not documented, though it is reported to have been recovered from the bed of the Rhine. Its date of manufacture is estimated as between the middle of the second and the middle of the third century CE. In form it is an approximately hemispherical bowl of bronze plate of approximately 1 mm thickness (Fig. 8). The diameter of the rim is 39–40 cm (it is very slightly oval), and inside the rim runs a horizontal lip approximately 2 cm broad. At the center of the bowl's base is a circular hole of diameter approximately 1.7 cm, and offset from this, a second, smaller hole of diameter approximately 0.4 mm.

Fig. 8. The Frankfurt clepsydra, Archäologisches Museum Frankfurt inv. 2000,07. (Photos: Archäologisches Museum Frankfurt/U. Dettmar. Further use forbidden.)

Along the inner rim of the lip are 368 (*sic*) tiny holes that evidently represent the days of the solar year, and along these holes are inscribed, at appropriate intervals, abbreviated Latin indications of the cardinal days of the Roman calendar year (kalends, nones, and ides of the twelve months) as well as solstices and equinoxes. On the inside of the bowl, aligned with the solstices, equinoxes, and intermediate dates at intervals of approximately one-twelfth of a year, are rows of small dots of solder spaced apart along radial arcs; though some are now missing, there would have been twelve of these marks along each arc, with progressively wider spacing as the marks approach the bottom, and overall wider spacing for the marks aligned with the summer part of the calendar year than for those aligned with the winter. The corresponding marks in the consecutive columns are joined by inscribed lines. On the exterior of the bowl is an inscription stating that the bowl, in its present form, was a votive offering of one Mapilius Mapilianus, subprefect of the waters of the god Borvo; on the basis of the inscription it seems probable that the bowl originated at a cult site with healing springs somewhere in present-day France.[26]

As was recognized in the original publication on the Frankfurt clepsydra, it is, except for the spherical shape, a close analogue of ancient Egyptian "flowerpot" outflow clepsydras, in which the varying length of diurnal or nocturnal seasonal hours through the course of the year was represented by means of twelve vertical rows of interior marks distributed around the circle.[27] The small hole would have been for the outflow, while the large one was probably to enable rapid emptying. At the time of the publication, this was the unique known example of a "western" outflow clepsydra on the Egyptian model but calibrated according to the Roman calendar. More recently fragments from what are almost certainly the calendrical lips of similar bronze clepsydras have come to light from sites (Vindolanda [Inv./SF 12,233] and Hambledon [PAS unique ID SUSS-BA3CBE]) in Great Britain.[28]

The holes on the lip and their inscriptions are a kind of parapegma: probably some marker was inserted in the appropriate hole to indicate the present date as well as which row of hour-markers on the bowl's interior was the right one for reading off the seasonal hour. On the Frankfurt and Hambledon clepsydras the holes represent single days (with some small discrepancies from a strict daily count), while the spacing of the holes on the Vindolanda fragment would correspond to intervals of two days. Most of the extant Egyptian clepsydras do not have calendrical indications more refined than entire months, though a fragment of Hellenistic or Roman date found near the site of the temple of Isis and Serapis in Rome has lip holes, at five-day intervals, with calendrical inscriptions (Egyptian month names and zodiacal signs occupied by the Sun) in Greek.[29] Like the Frankfurt clepsydra, this Roman-Egyptian specimen joins up the corresponding hour marks in the columns for consecutive months with inscribed lines, a device that would enable the user to "interpolate" time readings for dates between the ones lined up with the hour marks.

In 2018 Sophie Descamps, curator in charge of bronzes in the Department of Greek, Etruscan, and Roman Antiquities of the Louvre, drew my attention to an object of unknown nature, inv. Br 5129, that had entered the museum in 1863 as part of the collection of Giampietro Campana (1808–1880), which was the subject of an exhibition then in preparation. The only publication describing the object in depth was an 1817 study of it by Giuseppe Settele (published in 1823).[30] According to Settele, who called it an *astrolabio* and attempted to reconstruct it as an elaborate instrument of astronomical observation, it was owned at that time by the archaeologist Carlo Fea (1753–1836), who had purchased it in Siena from someone who had been using it, grotesquely, as a base for an ancient bronze bust. From the photographs provided by Mme Descamps it was immediately obvious that the mysterious object was another hemispherical outflow clepsydra, though of a new type.[31]

Fig. 9. The Campana clepsydra. (Photos: © Musée du Louvre, distr. RMN-GP / Hervé Lewandowski.)

The Campana clepsydra (Fig. 9) consists of a hemispherical bowl of bronze plate, diameter approximately 14 cm, outside the rim of which is soldered (but now detached in part) a horizontal lip approximately 1.5 cm broad.[32] The bottom of the bowl is somewhat flattened, apparently by impact or pressure (I would guess from the bronze bust that was once mounted there). The bowl has several holes with irregular outlines, some of which at least, I suspect, are simply the result of damage though it is possible that one or more original and intentional perforations have been enlarged irregularly through subsequent damage around their edges. Two circular holes are clearly original: (a) a hole of approximately 4 mm diameter right at the center of the bottom, (b) another slightly smaller one about halfway up one side. (The larger hole between holes a and b is clearly not original, since it has obliterated part of an inscribed word on the exterior.) The lip is also perforated in various places by six small holes that look as if they were made by nails; these are likely to have been made at the time of the object's abuse as a plinth, when it would have been mounted upside-down.

No radial rows of hour marks are visible on the interior, and the lip does not bear calendrical inscriptions; instead, it is divided into sixteen equal 22.5° sectors, inscribed with Roman numerals from I through XVI running clockwise. Hole b is aligned with the division line between sectors XVI and I. There are also traces of inscribed letters along the divisions between sectors at intervals of 90°, namely between XVI and I (illegible and partly obliterated by a nail hole), IIII and V (Settele read *ORIIS*, correctly so far as I can judge from photographs), and VIII and VIIII (*B* ||| ||| *AS* according to Settele, of which I can only verify the *A* from photographs—again one of the nail holes has obliterated part of the word). There is no inscription between XII and XIII. If *ORIIS* (*oriens*?) signifies "east" as Settele supposed, then the inscriptions of the lip would appear to refer to directions along the horizon, not chronological intervals; but that would put in doubt Settele's proposal to read *BOREAS* ("north") at the VIII/VIIII division since this should correspond to south.[33]

On the exterior of the bowl, centered on hole b, is a circular complex of inscriptions, which we can characterize as a kind of dial (Fig. 10). There are two concentric rings of writing, running clockwise and with the tops of the letters outwards from the center. The outer ring consists of three-letter abbreviations of the twelve months of the Roman calendar year spaced at neat 30° intervals, with *DEC* (December) and *IAN* (January) at the top; the inner ring has three-letter abbreviations of the twelve zodiacal signs, with *SAG* (Sagittarius) and *CAP* (Capricorn) at the top, so that the signs are aligned with the months during most of which the Sun occupies them. (*ISC* is an odd error for *SCO*, Scorpio.) Outside the ring of month abbreviations and concentric with it, *K* (clearly standing for *kalends*, i.e. marking the beginning of each month) is inscribed at the gap between each month and its successor, and between each *K* and the next, slightly closer to the center, are five equally spaced short radial strokes, so that each twelfth of the ring is effectively divided into subintervals of 5° or five nominal days. Inscribed radially between the central hole and the gaps preceding the abbreviations for Capricorn, Aries, Cancer, and Libra are abbreviated names of the equinoxes and solstices that take place when the Sun as at the beginning of those signs. The diameter of the entire inscriptional dial is about half that of the bowl.

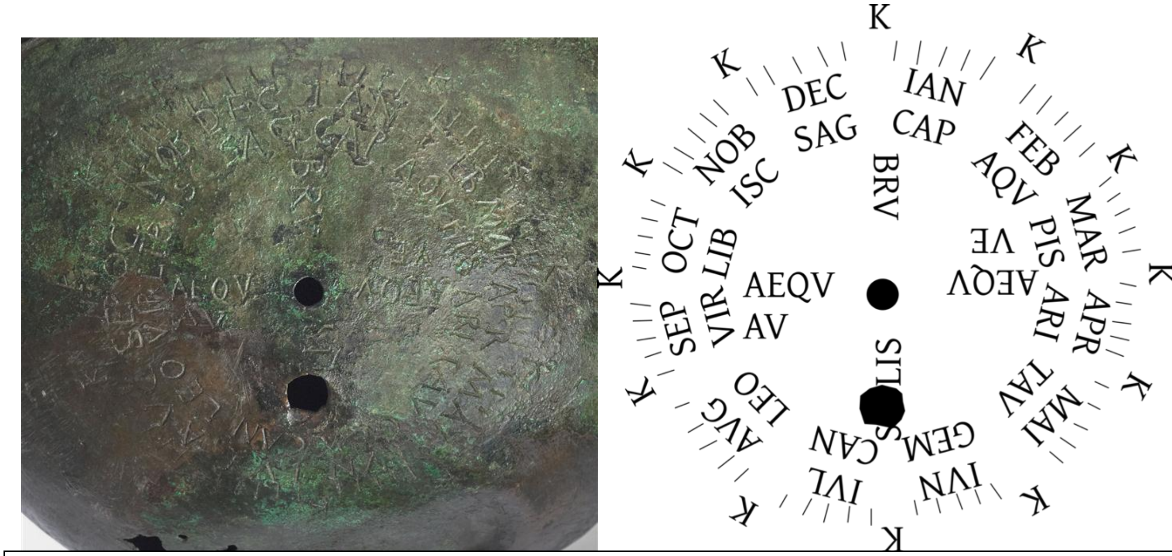

Fig. 10. The calendrical dial inscriptions on the exterior of the Campana clepsydra, with a schematic drawing. The inscriptions closest to the central hole mean, from top in clockwise order, "winter solstice" (*bruma*), "vernal equinox" (*aequinoctium vernum*), "solstice" (*solistitium*), and "autumnal equinox" (*aequinoctium autumnale*). (Photo: © Musée du Louvre, distr. RMN-GP / Hervé Lewandowski, drawing Alexander Jones.)

It is immediately obvious that the Chevroches disk is practically the same thing as this dial on the Campana clepsydra, but in Greek instead of Latin, and including the Egyptian months while omitting the solstices and equinoxes; in other words, it was part of a similar hemispherical clepsydra. The resemblance even extends to the subdivision of each zodiacal sign or calendar month into six intervals of five degrees or nominal days (cf. also the Capitoline clepsydra fragment); while this may be just an arbitrary choice among the factors of thirty, the possibility cannot be excluded that these divisions had some astrological significance.[34] In the case of the Campana clepsydra the inscriptions have been made directly on the hemispherical bowl, while the Chevroches disk was fashioned as a separate component that was shaped to match and soldered flush against the bowl. The Chevroches disk is nearly the same size as the Campana dial, and so was slightly larger relative to its bowl.

Much remains unclear about the functioning of the kind of clepsydra represented by the Campana bowl and the Chevroches disk, but one can at least reasonably assume that these calendrical-zodiacal dials served an analogous purpose to the calendrically inscribed lips of clepsydras of the Frankfurt type, namely to allow the clock's operator to take account of the variation in length of the seasonal hour through the year. We are dealing here with vessels of much smaller capacity than the Frankfurt bowl: the Campana would have held less than a twentieth as much water as the Frankfurt, while the Chevroches would have had only about a third the capacity of the Campana.[35] Perhaps, therefore, they were designed to measure out single seasonal hours rather than indicate the passage of time through an entire day or night. There must have been a pointer-like component that could be revolved around the axis represented by the hole at the center of the dial, turning something on the inside. Was this simply an indicator of how high to fill the bowl? Or was there some arrangement by which the rate of flow was regulated by the setting of the date? Closer study of the Campana clepsydra may offer some clues, though still better would be the discovery of an example of the missing component.

Notes on Contributor.

Alexander Jones is Leon Levy Director and Professor of the History of the Exact Sciences in Antiquity at the Institute for the Study of the Ancient World, New York University. He is author of *A Portable Cosmos: Revealing the Antikythera Mechanism, Scientific Wonder of the Ancient World* (Oxford University Press, 2017) and editor of *Time and Cosmos in Greco-Roman Antiquity* (Princeton University Press, 2016).

---

[1] Richard Talbert, *Roman portable sundials: the Empire in your hand* (New York: Oxford University Press, 2017) provides descriptions and (where available) photographs of fifteen portable sundials incorporating disks, or disks that belonged to otherwise lost sundials; the material is usually bronze, occasionally brass.

[2] Marcel Nordon, "Sur un objet en bronze découvert à Grand, en Lorraine, en 1886," *Bulletin de l'association nationale des collectionneurs et amateurs d'horlogerie ancienne* 57 (Spring 1990), 27–42 gives the most in depth analysis of the Grand fragment; Otto Benndorf, Edmund Weiss, and Albert Rehm, "Zur Salzburger Bronzescheibe mit Sternbilder," *Jahreshefte des Österreichischen archäologischen Institutes in Wien* 6 (1903), 32–49 is the fundamental publication on the Salzburg fragment. See also Anthony Turner, "The anaphoric clock in the light of recent research," in Menso Folkerts and Richard Lorch (eds), *Sic Itur ad Astra: Studien zur Geschichte der Mathematik und Naturwissenschaften, Festschrift für den Arabisten Paul Kunitzsch zum 70. Geburtstag* (Wiesbaden: Harrassowitz, 2000), pp. 536–547.

[3] Henri Baudot, *Rapport sur les découvertes archéologiques faites aux Sources de la Seine* (Paris, 1845), p. 36 (item 15) with plate 14. Jean de Witte, "Les divinités des sept jours de la semaine," *Gazette archéologique* 3 (1877), 50–57 and 77–85 with plates 8–9, at p. 84, and "Les divinités des sept jours de la semaine," *Gazette archéologique* 5 (1879), 1–6 with plates 1–2, at p. 5 has nothing original to say about the disk, and Witte's drawing in the latter article is a reproduction of Baudot's. The disk is also briefly described in Paul Lejay, *Inscriptions antiques de la Côte-d'Or*, Bibliothèque de l'école des hautes études, Sciences philologiques et historiques 80 (Paris, 1889), p. 207 (no. 263), and in *Catalogue du musée de la commission des antiquités du département de la Côte-d'Or* (Dijon, 1894), p. 147 (no. 873).

[4] I am grateful to the Musées et Patrimoine de Dijon and particularly to Christine Peres for information concerning the Dijon disk (including its dimensions) as well as for the photograph and permission to publish it here.

[5] Observed on a low resolution photograph of the reverse side provided by the Musées et Patrimoine de Dijon; see also Claudine Magister-Vernou's drawings of both faces in Frédéric Devevey, Christian Vernou, and Aurélie Rousseau, "The Chevroches Zodiacal Cap and its Burgundy Relations," *Proceedings of the International Astronomical Union* 5 (S260), E3 (2009), p. 8, fig. 9.

[6] See Ilaria Bultrighini and Sacha Stern, "The Seven Day Week in the Roman Empire: Origins, Standardization, and Diffusion," in Sacha Stern (ed), *Calendars in the Making: The Origins of Calendars from the Roman Empire to the Later Middle Ages* (Leiden: Brill, 2021), 10–79 on the astrological week, which they persuasively argue was originally a development from the western Roman Empire.

[7] Christian Vernou, "Les objets savants de l'est de la Gaule," in *Dieux du ciel! L'irruption de l'espace* (Toulouse: Musée Saint-Raymond, Musée des Antiques de Toulouse, 2010), pp. 36–39, at p. 37.

[8] Devevey, Vernou, and Rousseau, *op. cit.* (Note 4), p. 6.

[9] Judith V. Field and Michael T. Wright, "Gears from the Byzantines: A Portable Sundial with Calendrical Gearing," *Annals of Science* 42 (1985), 87–138; Michael T. Wright, "Rational and Irrational Reconstruction: The London Sundial-Calendar and the Early History of Geared Mechanisms," *History of Technology* 12 (1990), 65–102. The sundial was reportedly acquired by a previous owner in Lebanon (Field and Wright, *op. cit.*, p. 99), while the list of localities with latitudes inscribed on the surviving dial plate in Greek comprises mostly places in and around the eastern Mediterranean, with none further west than Sicily, Rome, and Africa (the Roman province).

[10] See Wright, *op. cit.* (Note 8), p. 68 fig. 3 for good photographs of this component.

[11] Daryn Lehoux, *Astronomy, Weather, and Calendars in the Ancient World: Parapegmata and Related Texts in Classical and Near Eastern Societies* (Cambridge: Cambridge University Press, 2007), pp. 168–179. Proclus, *On Providence* 65 refers to a gearwork astronomical device made by his addressee Theodorus as a "parapegma"; this was probably something like the mechanical part of the Science Museum portable sundial, as suggested by

Alexander Jones, *A Portable Cosmos: Revealing the Antikythera Mechanism, Scientific Wonder of the Ancient World* (New York: Oxford University Press, 2017), p. 241. I also suspect that it is such mechanisms, not textual parapegmata, that Proclus is alluding to at *In Platonis Rem Publicam* ed. Kroll 2.234. The other example of ancient computational gearwork, of course, is the Antikythera Mechanism. Concerning the so-called Olbia gear, claimed to be ancient and indeed a remnant of Archimedes's planetarium, see Jones, *op. cit.* and Michael G. Edmunds, "The Antikythera Mechanism and the Mechanical Universe," *Contemporary Physics* 55.4 (2014), 263–285, at p. 285.

[12] Émile Espérandieu, [no title], *Académie des inscriptions et belles-lettres, Comptes-rendus* 1933, 383–385. This short report provides no information on the context in which it was discovered; Vernou, *op. cit.* (Note 6), p. 38 situates it in a "cave de l'agglomération antique," as part of an ensemble of metal objects.

[13] Vernou, *op. cit.* (Note 6), p. 38; Pascale Picard (ed.), *Mirabilis: Collections d'Avignon* (Cinisello Balsamo: Silvana, 2018), at p. 148.

[14] I owe to James Evans the information that the disk is not quite flat; see also Claudine Magister-Vernou's cross-section diagram in Devevey, Vernou, and Rousseau, *op. cit.* (Note 4), p. 7, fig. 8. The thickness of the plate is estimated from the disk's reported weight of 75 g.

[15] As James Evans points out to me, Espérandieu's drawing erroneously shows thirty-six triangles—hence the mistaken number reported in Lehoux, *op. cit.* (Note 10), p. 211.

[16] Espérandieu seems to have known about the Dijon disk only from the article "Dies" (i.e. "day") in the Daremberg-Saglio *Dictionnaire des antiquités grecques et romaines*. He was misled by the drawing given there to suppose that the Dijon disk was not perforated. In addition, by confusing two other objects portrayed on the same page of Daremberg-Saglio—namely the British Museum Gallo-Roman statuette of Tutela GR 1824,0424.1 found at Mâcon and a clay lamp published by Giovan Battista Passeri, *Lucernae fictiles musei Passerii* vol. 1, 1739, plate 15, which according to Heinrich Dressel, "Le lucerne della collezione Passeri nel Museo di Pesaro," *Mitteilungen des Deutschen Archäologischen Instituts, Römische Abteilung* 7 (1892), 144–151, at p. 146, is a fake like much of the Passeri collection—Espérandieu created a spurious, nay doubly spurious, planetary metal disk in the British Museum.

[17] Devevey, Vernou, and Rousseau *op. cit.* (Note 4), p. 6.

[18] Frédéric Devevey, "L'agglomération antique inédite de Chevroches (Nièvre), Ier siècle-début Ve siècle apr. J.-C.," *Les nouvelles de l'archéologie* 107 (2007), 1–38, esp. p. 27; Frédéric Devevey, Patrice Cauderlier, Claudine Magister-Vernou, and Christian Vernou, "Découverte d'un «disque» astrologique antique à Chevroches (Nièvre): note de présentation," *Revue archéologique de l'Est* 55 (2006), 299–306; and for a more popular presentation, "Dossier: Les Gaulois et la divination," *Sciences et Avenir* Août 2008, 44–53.

[19] I am grateful to the Musée Romain Rolland (specifically its director, Pierre-Antoine Jacquin) for information and photographs and the permission to publish them.

[20] Frédéric Devevey, Patrice Cauderlier, Aurélie Magister-Vernou, and Christian Vernou, "La calotte astrologique de Chevroches," *Les nouvelles de l'archéologie* 107 (2007), 1–6, at p. 3, revising a previous estimate of the second half of the fourth century in Devevey, Cauderlier, Magister-Vernou, and Vernou *op. cit.* (Note 17), p. 302.

[21] Devevey, Cauderlier, Magister-Vernou, & Vernou *op. cit.* (Note 18), p. 1 estimate the diameter of the sphere as approximately 100 mm.

[22] There are a couple of rather gross orthographic errors (ΣΚΙΡΠΙΩ for ΣΚΟΡΠΙΩ, ΝΕΧΕΙΡ for ΜΕΧΕΙΡ). In my drawing in Fig. 6 I have transcribed the text as best I am able, consulting photographs and Claudine Magister-Vernou's drawing and the table of readings and interpretations in Devevey, Cauderlier, Magister-Vernou, & Vernou *op. cit.* (Note 18), pp. 300 and 304, but there are some (unimportant) uncertainties.

[23] Devevey, Vernou, and Rousseau, *op. cit.* (Note 4), pp. 6–7.

[24] Devevey, Cauderlier, Magister-Vernou, and Vernou *op. cit.* (Note 17), p. 305.

[25] Dagmar Stutzinger, *Museum für Vor- und Frühgeschichte – Archäologisches Museum – Frankfurt am Main: Ein römische Wasserauslaufuhr* (Frankfurt: Kulturstiftung der Länder, 2001), pp. 4 (preface by Walter Meier-Arendt) and 30. New research on the Frankfurt clepsydra by Richard Talbert and Derek Miller is underway, and a digital 3D model and reflectance transformation imaging have been made available at https://www.archaeologisches-museum-frankfurt.de/de/ein-blick-hinter-die-kulissen/. I thank the Archäologisches Museum Frankfurt (and particularly Andreas Sattler) for photographs and the permission to publish them here.

[26] Stutzinger, *op. cit.* (Note 23), pp. 30–35.

[27] On the Egyptian clepsydrae see Anette Schomberg, "The Karnak Clepsydra and its Successors: Egypt's Contribution to the Invention of Time Measurement," in Jonas Berking (ed), *Water Management in Ancient Civilizations* (Berlin: Edition Topoi, 2018), 321–346. The *Ancient Egyptian Astronomy Database* (https://aea.physics.mcmaster.ca/index.php/en/) includes a database of the extant examples. With the notable

exception of the intact New Kingdom (Amenhotep III) clepsydra in the Egyptian Museum, Cairo, inv. JE 37525, all are fragmentary and date from between about 600 BCE and the second century CE.

[28] Alexander Meyer, "The Vindolanda Calendrical Clepsydra: Time-Keeping and Healing Waters," *Britannia* 50 (2019), 185–202. Independently of my own identification of these fragments as calendrical rims of clepsydras in 2016, as credited by Meyer at p. 191, Schomberg, *op. cit.* (Note 26) at p. 339 so identified the Vindolanda fragment.

[29] Ludwig Borchardt, *Die altägyptische Zeitmessung* (Berlin: de Gruyter, 1920), p. 8 and plate 6.3; Schomberg, *op. cit.* (Note 26) at p. 339; Eva Winter, *Zeitzeichen: Zur Entwicklung und Verwendung antiker Zeitmesser* (2 vols., Berlin: de Gruyter, 2013) at vol. 2 p. 532.

[30] Giuseppe Settele, "Illustrazione di un antico astrolabio letta nell' Accademia romana di archeologia nell' adunanza del 22 maggio 1817," *Dissertazioni della Pontifica Accademia romana di archeologia* 1.2 (1823) 201–246 with one plate after p. 246. The object is mentioned (as *orologio solare*) in *Cataloghi del Museo Campana Classe II. Bronzi etruschi e romani* ([Rome], n.d. [*c.* 1858]) at pp. v and 11.

[31] This identification is reflected in the description of the Campana clepsydra by Sophie Descamps in the exhibition catalogue, Françoise Gaultier, Laurent Haumesser, and Anna Trofimova (eds), *Un rêve d'Italie: La collection du marquis Campana* (Paris: Louvre éditions, 2018) at p. 187.

[32] Victor Gysemberg and I are carrying out further research on the Campana clepsydra; some details reported here have been confirmed from photogrammetric digital 3D models we have prepared.

[33] One has to remember that Settele assumed that the object should be set up with the bowl facing down, though in that situation the lip inscriptions are facing down. His drawing in the plate following p. 246 confusingly conflates a schematic view of the bowl's exterior, i.e. bottom, face with a view as if of the lip's top face but with the sectors running *counterclockwise*.

[34] The 2nd century Greek astrological papyrus *P.Oxy.* 3.465 (now P.Lond. inv. 1526) is a calendar of prognostications associated with five-day intervals in the Egyptian calendar.

[35] The Vindolanda and Hambledon bowls are estimated from the spacing of the calendrical holes on the surviving fragments of their lips to have had diameters respectively about 35 and 27 cm, so they were nearer the scale of the Frankfurt; see Meyer, *op. cit.* (Note 27), p. 189.