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GLOBES AND SUNDIALS: ON A STATUETTE OF ATLAS FOUND AT TOR PATERNO (SOANE M1254)

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Globes and armillary spheres have strong affinities with sundials—they can share the same symbolism and iconography, for example. In this paper we examine an unusual object of about the second century CE, found at Tor Paterno—a statuette of Atlas supporting a sundial. We find that the dial was modified around the year 1800 to tell time in modern, equinoctial hours.

Keywords: Atlas, sundials, Tor Paterno, Sir John Soane's Museum

Relations of Globes and Sundials

Ancient sundials were intimately linked with the theory of the celestial sphere and therefore also with the globe. To see the relationship most clearly it is helpful to consider the simplest kind of sundial - a spherical dial. Imagine a bock of stone in which a hemispherical cavity has been carved (fig. 1). If a shadow-casting gnomon is inserted (with the tip of the gnomon at the center of the sphere), the shadow-receiving surface of the sundial becomes an inverted image of the celestial sphere. Of course, such a design would have been impractical, as the cavity would have filled with rain water. Fortunately, a complete hemisphere is not needed, for the tip of the gnomon's shadow cannot be found just anywhere on the hemispherical surface. In particular, the shadow tip can never fall outside the belt between the tropic of Cancer and the tropic of Capricorn. Thus, the southern face of the sundial can be cut away. Figure 2 shows the classic form of an ancient spherical dial. The horizontal upper surface represents the horizon. Three engraved parallel circles correspond (from top to bottom) to the tropic of Capricorn, the celestial equator and the tropic of Cancer. The south face of the stone block is cut away and usually (though not always) the plane of the cut is parallel to the tropic of Cancer. Eleven hour lines are inscribed.

In ancient Greek and Roman culture, the hour in common use was different from the hour we use today. The hour of everyday life was a *seasonal hour*, which was, by definition, 1/12 of the time from sunrise to sunset. In the same way, there was a night seasonal hour, 1/12 of the time from sunset to sunrise. Thus, in summer, the day hour was long; in winter the day hour was short. The modern hour, which is 1/24 of a mean day and night taken together, is called an *equinoctial hour*: it is for practical purposes equal to a seasonal hour evaluated on the day of the equinox. In antiquity the technical astronomers made use of the equinoctial hour when they needed a time unit of constant length. But of the approximately 600 ancient sundials that are preserved, nearly all measure time in seasonal hours.[1] On a dial like that shown in

1 K. Schaldach has recently suggested that some (though not all) of the early equatorial plane dials may have been divided into equinoctial hours. See Schaldach 2006, p.116-127, 196-198, and Schaldach 2016, p. 65-68. (But note that in the first source the author argues that the winter side of the Oropos dial is divided into equinoctial hours and the summer side into seasonal hours, while in the latter source, the author accidentally inverts this remark—K. Schaldach, personal communication). For more on the equatorial dials see Herrmann, Sipsi, and Schaldach, 2015. A few dials, divided in the normal way into seasonal hours, do include an indication of change in the length of the day between winter and summer (sundials 1044, 1068, 3046 and 4001 in Gibbs1976).

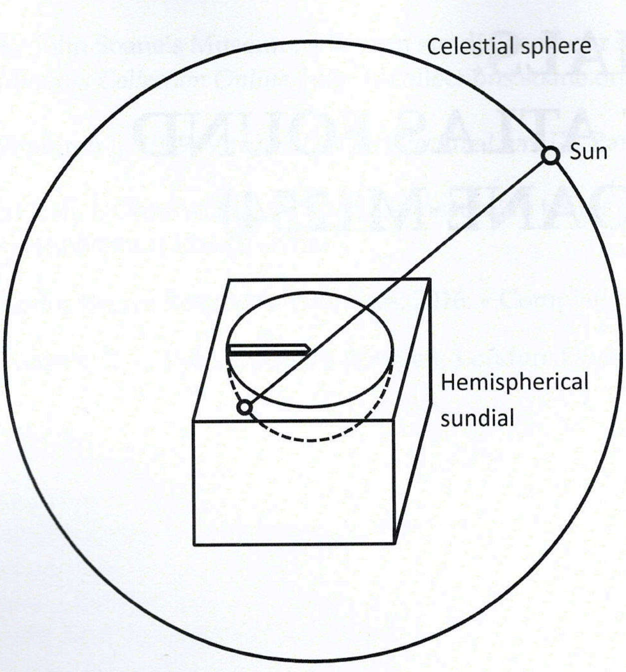

Figure 1. A spherical sundial as an inverted image of the cosmos.

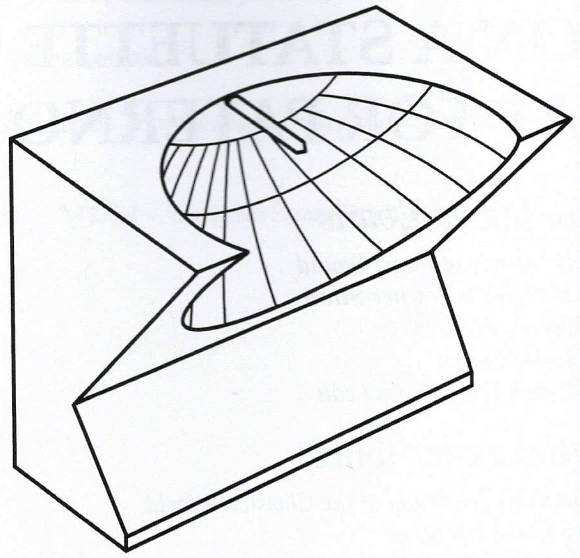

Figure 2. The common form of an ancient spherical sundial.

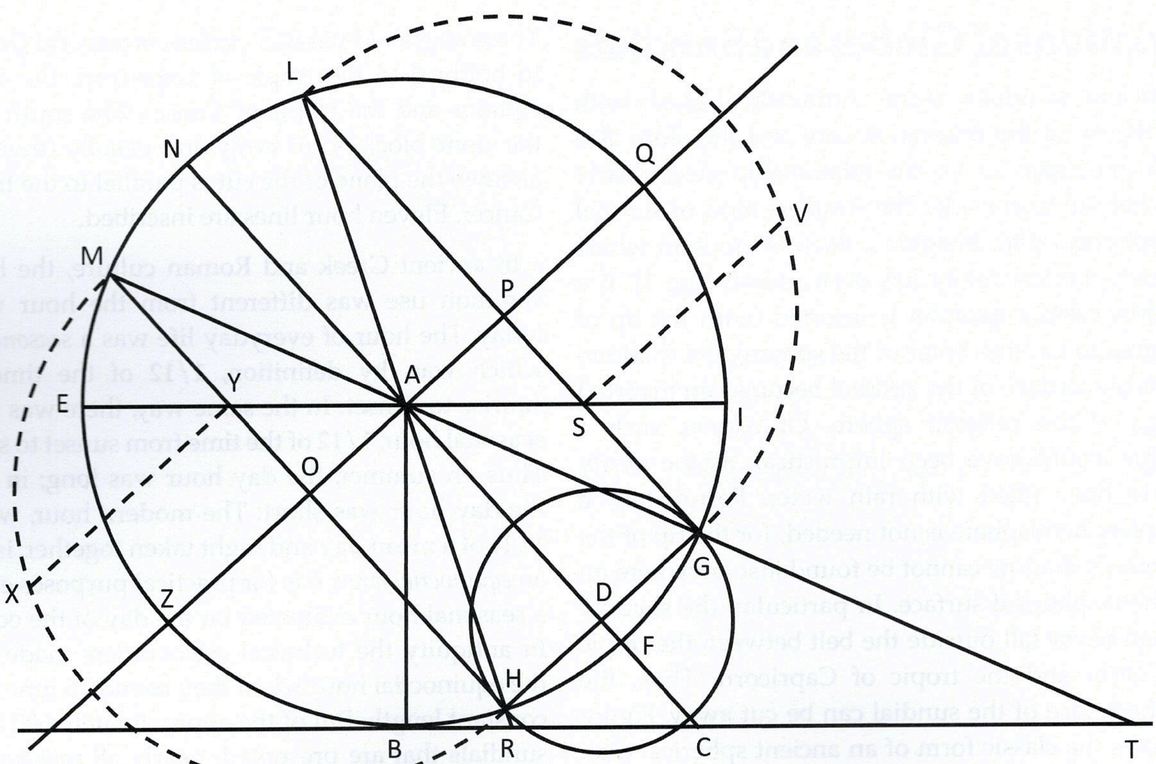

Figure 3. The analemma of Vitruvius, showing a side view of an armillary sphere as an aid to sundial construction.

figure 2, the hour lines are determined in the following way. One half of the equator circle lies below the horizon. This semicircle is divided into 12 equal parts. More than half of the tropic of Cancer lies below the horizon (corresponding to the greater length of the day in summer); and this arc is also divided into 12 equal parts. Finally, less than half a semicircle of the tropic of Capricorn lies below the horizontal (corresponding to the shorter day in winter); and this, too, is divided into 12 equal parts. Each hour line is then inscribed by connecting the three dividing dots.

Now, it is by no means necessary that the shadow-receiving surface be spherical in shape. For example, large numbers of conical dials are also preserved. In this case the shadow-receiving surface is the surface of a cone. The angle of opening of the cone is arbitrary, but the axis of the cone must be oriented to match inclination of the real axis of the universe in the latitude for which the dial is designed. A small number of cylindrical dials are also known. These varieties represent abstractions or developments of the basic theory, in which easier stone-working has been achieved at the price of a modest increase in mathematical complexity. And even in the case of the spherical dial, it is not necessary that the gnomon tip be located at the center of the sphere. But a non-central projection complicates the pattern of the engraved lines and ancient non-central spherical dials with metal gnomons are much less common.[2]

Practical manuals on the making of sundials were written and circulated. The most common tool was a drawing called the *analemma*, in which celestial circles were folded down into a plane and projections could easily be made for establishing the divisions on a sundial. One of the ordinary meanings of the Greek word *analemma* is "supporting structure". Thus the analemma is a drawing that supports the construction of the dial. Our best source for this technique is the drawing and accompanying explanation in the *De architectura* of Vitruvius, although the technique was certainly not original with him.[3] Figure 3 is a modern representation of Vitruvius's drawing. *LNM* represents the celestial sphere and, more specifically, the meridian. The horizon plane is *EI* and thus *A* represents the Earth. *ZQ* is the axis of the universe and thus angle *QAI* is the altitude of the celestial pole, which is equal to the latitude of the place for which a sundial is to be constructed. At right angles to the axis is *NF*, the celestial equator seen from the side. *LG* is the tropic of Cancer. A semicircle of this tropic therefore stands up perpendicular to the plane of the diagram. If this semicircle of the tropic is folded down into the plane of the diagram it becomes the dashed semicircle *LVG*. It should now be clear that *the analemma of Vitruvius is a side view of an armillary sphere*. A designer of an ancient sundial would find considerable help in making the necessary projections by constantly thinking about the features of the celestial sphere embedded in the analemma.

One final connection between the sphere and the craft of dialing is related to a remark made by Ptolemy.[4] Ptolemy wants to prove that the Earth is a mere point in relation to the celestial sphere. One of the arguments he gives is this: a gnomon placed at any part of the Earth can play the role of the Earth's true center. We can see this reflected in the analemma of Vitruvius. Point *A* is the tip of the gnomon. In Vitruvius's diagram, the ground, onto which we project the shadow, is *BT*. For the sake of convenience, Vitruvius makes the height *AB* of the gnomon equal to the radius of the celestial sphere. But all that is really required is that the tip *A* of the gnomon be placed at the center of the universe. If one wished, one could use a shorter gnomon in the drawing by placing the ground line higher. This aspect of dialing perhaps inspired the makers of several ancient globes. For example, in the Mainz globe (one of the three preserved ancient celestial globes), there is a small square hole at the north pole and a larger round hole at the south pole (Künzl, 2000; Dekker 2013, p. 69-80). This has led scholars to conjecture that the globe was fitted to the tip of a gnomon of a garden sundial. Using a globe as the tip of a gnomon does serve a practical purpose—it is much easier to spot the center of the shadow of a sphere than to spot the tip of the shadow of a spike-like pole. But the tip of the gnomon does really play the role of the center of the Earth and of the celestial sphere in the art of dialing. The rather common ancient practice of putting a celestial globe at the end of the gnomon is justified by this fact.

A Mysterious Object: Soane M1254

Sir John Soane's Museum in London has in its collection a small statue of Atlas, supporting an approximate quarter of a convex sphere that was likely intended to be a sundial. We shall refer to

2 But a rather common variety of spherical dial with non-central projection is the "roofed spherical dial," in which the hour is indicated by a spot of sunlight let into the dial through a small hole in the upper part of the dial. The hole functions as the gnomon tip (which is therefore located in the surface of the spherical dial itself). On these dials see Jones 2017.

3 Vitruvius, De arch. IX.7. Soubiran 1969, p. 26-29, 220.

4 Ptolemy, Almagest I.6. Toomer 1984, p. 43.

this piece, shown in figure 4, as Soane M1254.[5] It immediately calls to mind the well-known Farnese Atlas, a statue from the early Roman Empire of Atlas supporting marble celestial globe. But in Soane M1254 the artist has seemingly played with the ancient iconography by fancifully turning the cosmos inside out. Or we may also regard the hollow globe more literally - it represents what we, who live in the interior of the cosmic sphere, do actually see. From the drill work this piece has been characterized as garden sculpture of the Antonine period (138-192 CE) or later. This dating was made by Cornelius Vermeule in the 1950s in his *Catalogue of the Classical Antiquities at Sir John Soane's Museum*, in which this object was assigned number 183. The catalogue was never officially published, but in the 1970s a small number of copies of a revised form of the catalogue were sent to libraries in Europe and North America. The online catalog description of Sir John Soane's Museum is a slightly adapted version of the description written by Vermeule. Although this object has been discussed, and images of it published, on several occasions, it has received no close astronomical study. The sundial presents a riddle. Although the object is probably of the second century CE, the sundial, astonishingly, tells time in modern (equinoctial) hours, rather than the seasonal hours almost always used in ancient Greek and Roman culture. This fact about the dial has never been pointed out before.

To begin, one might doubt that the object was really intended to be a sundial. Perhaps it was meant only as a whimsical image of a dial. Or perhaps the engraved meridians and parallels were only meant to suggest the celestial sphere, which would make it rather similar to the generalized globe depicted on a mural found at Boscoreale.[6] But why then would the artist not have used a convex sphere? That an actual sundial was intended is suggested by that fact we do have some ancient examples of sundials supported by Atlas. A conical dial found at Pergamon and now in the Archaeological Museum of Bergama, Turkey, has a kneeling Atlas, down on his right knee.[7] A broken dial in the National Archaeological Museum of Naples is supported by an Atlas down on both knees.[8]

On Soane M1254, the extension of the hour lines beyond the tropic of Capricorn to a small circle near the celestial pole is unusual. However, we do have a number of ancient spherical and conical sundials in which the hour lines are extended beyond the tropic of Capricorn and meet at a point, as in figure 5.[9] On such dials, the portions of the hour lines beyond the tropic zone have no meaning or use, since the tip of the shadow can never fall on these extensions. So these extensions may be regarded as simply aesthetic, or as efforts to emphasize the spherical shape; or perhaps they are merely mistakes. Soane M1254 possibly was influenced by this tradition. But there is an important difference: In the common variant form shown in figure 5, the hour lines meet at the north point of the horizon. But in Soane M1254, they converge on a small circle centered (apparently) on the celestial pole.

On balance, then, it seems that we are dealing with a sundial, but one with some unusual features. As we shall see below, it is a reasonably well-made dial for telling time in equinoctial hours and the parallels were placed using a non-central projection. Three solutions suggest themselves: (1) the dial is an almost unique example of the use of equinoctial hours on an ancient sundial, or (2) the object is a forgery, or (3) the ancient dial was modified in the late 18th or early 19th century to tell time in modern hours. As we shall see, option 3 is best supported by the evidence.

Some Background

John Soane (1753-1837), knighted in 1831, was an English architect noted for his neoclassical style. As a young man, in 1778-1780, he made a grand tour that included a long sojourn of sketching and collecting in Italy and he continued to collect over the course of his life. From the 1790s to the 1810s Soane acquired buildings in Lincoln's Inn Fields, London, which he gradually developed to provide space for his collections. In 1833 an Act of Parliament established support for the museum in

5 H 525mm; W 360mm; D 220mm.

6 For details and references see https://www.metmuseum.org/art/collection/search/247006

7 Sundial 3054 and Plate 40 in Gibbs 1976.

8 Museo Archeologico Nationale de Napoli, Inventory number 120464. This dial was found at Pompeii in a garden in Area IX.vii 12. Photographs may be seen on the website of the Berlin Sundial Collaboration, where it is Dialface ID 631. In Pagliano 2019, p. 227-233, this dial is identified as conical. In the catalogue of the Naples museum it was not classified as a sundial but as decorative sculpture, and the figure was identified with Telamon rather than Atlas. Some additional examples of ancient sundials supported by human figures may be located in the SYRTE database, La mesure du temps dans l'ántiquité, Témoignages archéologiques, e.g., by searching for "Atlas"or "Hercule".

9 Examples include spherical dials 1012, 1014, 1027, 1046, 1057, 1058, and 1059 in Gibbs 1976, as well as dial 27 in Schaldach 2006. Conical dials with hour lines extended to the gnomon hole include dials 3024, 3041, 3066, 3075, 3091, and 3103 in Gibbs 1976, as well as dials 15 and 24 in Schaldach 2006. Schaldach also has a cylindrical dial (dial 41) with hour lines extended to the gnomon hole.

Figure 4. Statuette of Atlas supporting a quarter of a concave sphere, Sir John Soanes's Museum M1254. ©Sir John Soane's Museum, London. Photography by A. C. Cooper.

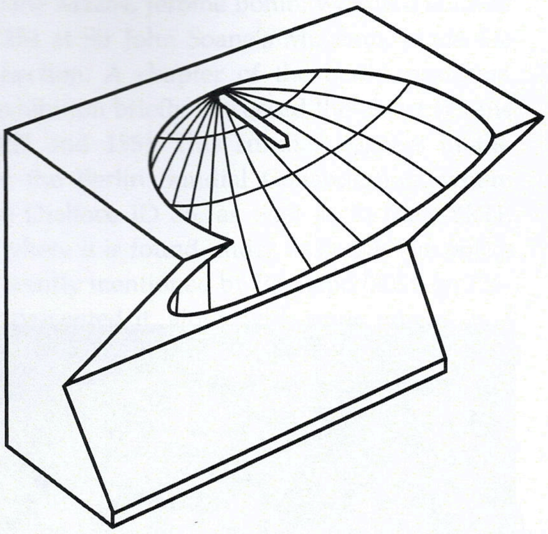

Figure 5. A variant of the common spherical dial form shown in fig. 3. The hour lines are extended beyond the tropic of Capricorn and come together at the gnomon hole (north point of the horizon).

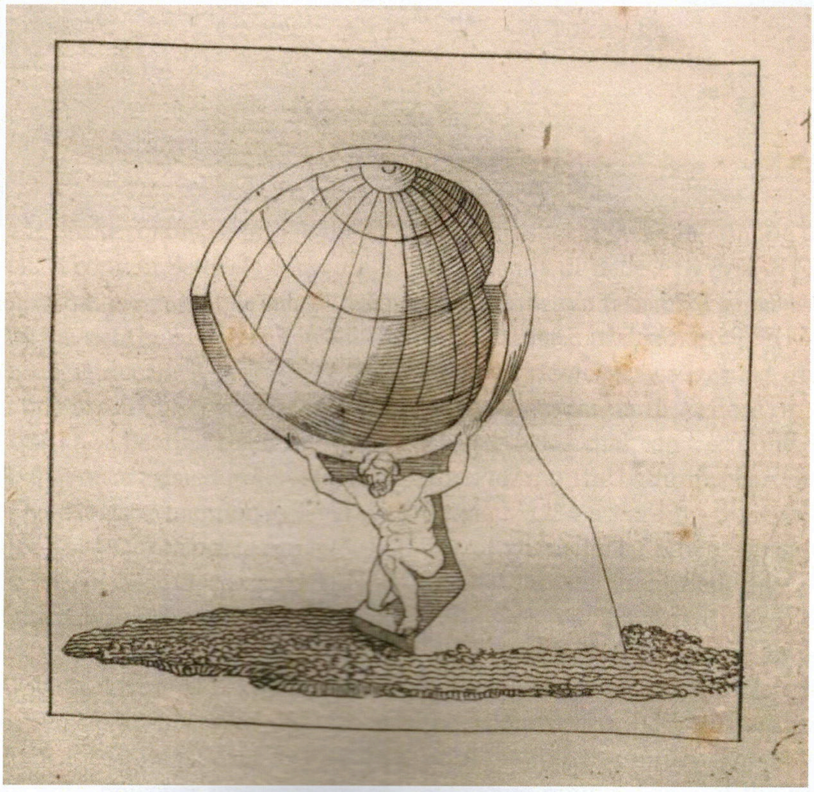

Figure 6. Settele's sketch (1816), of the plaster cast that was then in the Vatican Museum.

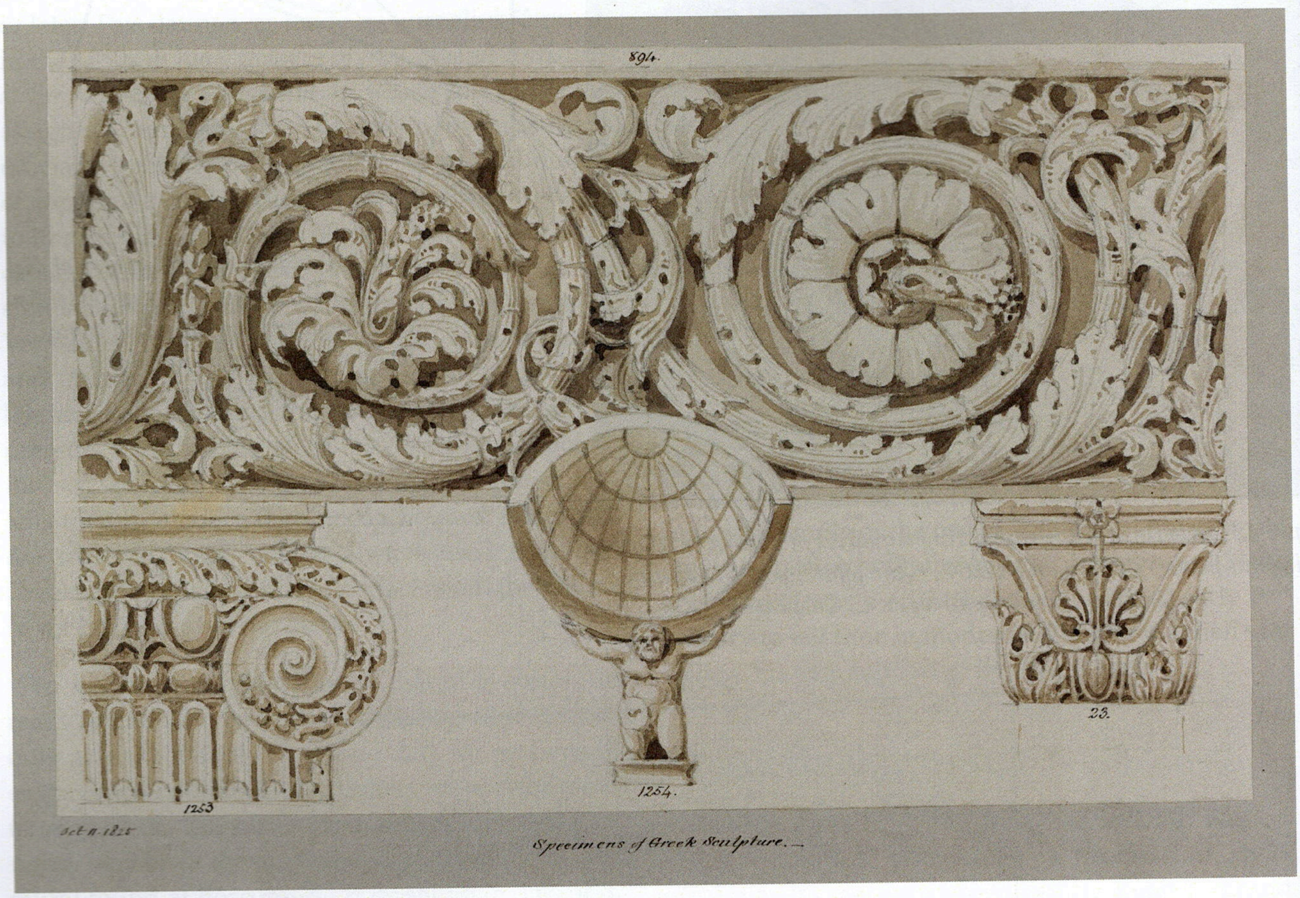

Figure 7. The Atlas sundial in 1825, as it was drawn, for practice, by one of Soane's pupils. Sir John Soane's Museum SM Vol 82/95. © Sir John Soane's Museum, London. Photograph: Ardon Bar Hama.

perpetuity on condition that it remain open to the public free of charge, which is still the case today. The records of the museum do not indicate whether Soane brought back the Atlas sundial from his grand tour or acquired it later; but, as we shall see, it was a later acquisition, made sometime between 1791 and 1822.

In 1816 the canon Giuseppe Settele, professor of applied mathematics at the Archigennasio della Sapienza, read a paper on the mathematical form of the seasonal hour lines on ancient sundials, before the recently revived Accademia de' Lincei. A version of the paper was published as a book of 44 pages in the same year. In several notes in this book, Settele gave information about some ancient sundials that he had personally examined. The frontispiece of his book also carried an engraving of an Atlas statuette and sundial, which he included because, as he said, this dial had not previously been published. Settele's engraving is reproduced in figure 6 and we can see that it closely resembles Soane M1254. However, Settele reported that the object he worked from was not the original statuette, but a plaster cast, which was in the Galleria de' Candelabri of the Vatican Museum, and that the original had been found at Tor Paterno, about 25 years before his publication (Settele 1816, Note III on p. 19-20). This would put the date of discovery around 1791. And, according to Settele, the object had since passed over to England. In comparing figure. 6 with figure 4, it will be seen that there is a mirror reversal. On the original, Atlas's left knee is down; but in Settele's engraving the right knee is down. We presume that the reversal occurred when Settele's drawing was engraved on a plate for printing.

The Atlas sundial has been described on several occasions since 1900. One group of discussions were all based on Settele's book. A copy of Settele's engraving, with a short description based on Settele's text, was published in Gatty 1900 (p. 36). The discussion in Gibbs 1976 (p. 150) is similarly dependent on Settele's note. The same is true of the mention of our object as a parallel to a statue of Hercules on one knee, bearing a sundial in the form of a scallop shell, that once existed in Ravenna, in Arnaldi 1996 (p. 109). There is also a mention in Severino 2003, in the section titled *Meridiane sferiche e varianti non descritte da altri autori*, p. 26. All these discussions pertain to the plaster cast, which was seen only by Settele.

Recently, the original object, Soane M1254, has received attention. As we have seen, an art-historical discussion of Soane M1254 was made for Sir John Soane's Museum by Cornelius Vermeule, who, however, was unaware of Settele's description of the cast. One of the authors of the present article (AJ), who was searching for objects that might be suitable for an exhibition, "Time and Cosmos in Greco-Roman Antiquity," at the Institute for Study of the Ancient World, realized that Settele's cast was a copy of Soane M1254. Jérôme Bonin, who had studied Soane M1254 at Sir John Soane's Museum, made the same connection. A chapter of the book connected with the exhibition briefly discussed the object (Evans 2016, p. 153 and 155). This sundial appears in the registry of the Berlin Sundial Collaboration, where it is called Dialface ID 36, as well as in the SYRTE database, where it is found under Fiche 29. The object was also recently mentioned by Pagliano (2019, p. 226-233), who presented it, along with some others, as a parallel to the Atlas dial in Naples (MANN 120464).

As we have seen, Settele indicated in his book that the original had been discovered at Tor Paterno around 1791 and that when his book was published, in 1816, the object had already gone over to England. Just when it entered into John Soane's collection is not known. But it was certainly there in 1822, for it is shown in its current position in the museum in a large watercolor painted by Joseph Michael Gandy (Sir John Soane's Museum, SM P113). The sundial was recorded in more detail on October 11, 1825 when it appeared in an assemblage of works of art drawn by some of Soane's pupils (fig. 7).

Meanwhile, the cast described by Settele soon dropped out of sight. As mentioned above, when Settele examined it, around 1816, the cast was in the collection of the Vatican Museum. We were informed by Alessandra Uncini, Registrar of Collections at the Vatican Museums, that the object is not any longer in their collection and that large numbers of casts were disposed of in the nineteenth century. According to Uncini, a substantial number of casts from the Vatican Museums were given to (among other institutions) the Accademia di Belle Arti (Via di Ripetta, Rome). When the Accademia became a separate institution from the Liceo Artistico the works of art were divided between the two. However, we learned from Costanza Barbier, of the Accademia di Belle Arti, that no trace of the plaster Atlas dial can be found in either institution. Tor Paterno (in Latium, near Ostia), the findspot of Soane M1254 according to Settele's account, was the site of an ancient Roman sea-side villa. At one time, some scholars identified this villa with Pliny the Younger's villa, Laurentinum; but the widely held view now is that it was an imperial residence. The construction dates from the late first to second half of the second century CE, with additions and restorations until the fourth century. There was an aqueduct and extensive piping. Some of the pipes carry stamps of Ti. Claudius Pompeianus, the son-in-law of Marcus Aurelius (Marzano 2007, 313-323). Excavations were made in the area in 1777-1780 for the local landowner, the Baron del Nero, by Prince Sigismondo Chigi, with the agreement that the landowner would retain one-third of the finds (Bressand and Ridley 2015, p. 40-41; Bignamini 2004, p. 97). In 1783 another excavation was sponsored there by the Reverenda Camera Apostolica under Pope Pius VI. If Settele's "about 25 years ago" is accurate, the sundial came to light later than these major excavations. It is not known how the sundial came into Soane's possession. Bignamini (2004) and Bignamini and Hornsby (2010) give some idea of the complexity of the digging and dealing in the Papal States in this period. Many excavators, restorers and dealers were active. The legal situation changed several times, with the invasion by the French and their subsequent expulsion, and also with efforts of the Vatican to extract benefits from and more tightly regulate the antiquities trade. The fact that a plaster cast of the sundial was given to the Vatican Museums suggests that the export was a legal one and that there is some hope that documentary evidence could be turned up in the future, as it has for a few other ancient sundials exported from the Papal States around the same period.

Soane M1254 as It Is Today

Soane M1254 was expertly cleaned and restored in 2016. In particular, an old repair to the upper right corner of the dial was re-done. The older repair can be discerned in fig.4. But, as we shall soon see, a far more substantial change in the dial had been made around 1800, before the dial was acquired by John Soane.

A digital 3D model of a sundial's surfaces (comprising a set of vertices of a mesh of triangles approximating the surfaces) is a convenient resource for obtaining measurements and determining the quality of construction without requiring physical contact with the object. In the present instance, a textured model of all surfaces of the Soane sundial except its bottom was generated by photogrammetry from fifty photographs.[10] Two qualitative tests of the sphericity of the dial surface can easily be carried out on the model using the mesh editing software Meshlab and in particular Meshlab's tool for deleting all mesh within a rectangular region of view.[11] Firstly, after removing all mesh except the dial surface, one can delete a series of parallel "slices" of the surface in an arbitrary orientation, and view along an axis perpendicular to the slices to test the circularity and concentricity of a series of planar cross-sections. Secondly, one can delete all mesh on one side of the meridian (or any ostensible great circle arc), and view along an axis perpendicular to the plane of the cut to test the circularity of the cross-section.[12]

In figure 8 we have taken orthographic slices through the sundial bowl at equally spaced distances. For a spherical shape, these slices should give concentric circles. As can be seen, this is not really quite the case. Thus, the spherical shape was somewhat roughly realized. It is not terrible, but not as good as some other ancient spherical dials that have been tested. Figure 9 is a view from Atlas's left side, with the digital model sliced away along the plane of the meridian circle. A key thing to note is that the cross-section is reasonably circular between the tropic circles but there is a pronounced flattening near the celestial pole. The region around the pole is less spherical than the remainder of the dial.

Nevertheless, this sundial is a reasonably well-constructed instrument for telling time in equinoctial hours. The latitude of the findspot (Tor Paterno) is 41.7° and the latitude of central Rome is 41.9°. The angle between the slanted upper edge of the bowl and the horizontal is about 45°. This edge is roughly parallel to the axis of the spherical surface. Thus, we can say that the tilt of the axis implies a latitude of 45°–only about 3° different from the latitude of Rome. The roughly equally spaced hour lines, with 6 intervals on either side of the meridian circle, are appropriate for marking equinoctial hours. But it should be noted that the hour lines are rather crudely laid out. In ancient fashion, we will denote the meridian (noon) line as the 6-hour line. The lines of 3, 6 and 9 hours are emphasized, by being drawn slightly longer, so that they extend below the lowest inscribed parallel circle.[13] And, of course, the 0- and 12-hour lines, which are defined by the upper edge of the bowl, may also be thought of as emphasized.

Let us call the four inscribed parallel circles *a*, *b*, *c* and *d* (with *a* being the lowest and largest). Table 1 gives our measurements along the meridian (i.e., the noon or 6-hour line), along the hour 3 line, and along the hour 9 line. The measurements, made with a flexible ruler, are expressed in millimeters and are taken from the celestial pole.

10 In a textured model, a color bitmap image generated from the source photographs is mapped on each triangle of the mesh so that the model preserves the apparent coloration as well as the shape of the object. Our model of the Soane sundial, generated using the software Agisoft Photoscan Professional 1.4.1, is available at https://archive.nyu.edu/handle/2451/48011.

11 We used Meshlab version 2016.12.

12 For these techniques applied to several ancient roofed spherical sundials see Jones 2019.

13 Other ancient dials with every third hour emphasized include 3022, 3067 and 3076 in Gibbs 1976.

Figure 8. Orthographic slices of the digital model of the sundial bowl.

Figure 9. View, at right angles to the meridian plane, of the digital model split along the meridian.

Arc lengths (mm)	Along meridian	Along hour 3 line	Along hour 9 line
From pole to circle *d*	26	26	26
From pole to circle *c*	72	74	73
From pole to circle *b*	124	123	124
From pole to circle *a*	201	197	194
From pole to lower edge	241	232	234

Table 1. Measurements along the 3-, 6-, and 9-hour lines of Soane M1254.

As can be seen either by inspecting the photograph or from Table 1, the parallels were not executed with great precision.

Now, the whole arc from the pole to the lower edge of the bowl is approximately a quarter circle. We may convert the arc lengths to angles (measured at the center of curvature) as follows. The angle corresponding to the 26 mm from the pole to circle *d* is $(26/241)x90° = 9.7°$. The remaining angles are given in table 2.

Arcs along Meridian	Angles (°)
From pole to circle *d*	9.7
From pole to circle *c*	26.9
From pole to circle *b*	46.3
From pole to circle *a*	75.1
From pole to lower edge	90.0

Table 2. Angles along the meridian of Soane M1254.

Now, we make an overlay (possibly on tracing paper, but really as a moveable image in a computer drawing) showing three rays diverging from a common vertex *V*, with the central ray separated from the extremes ones by 24° (fig. 10). These rays will represent sun rays on the equinox (central ray) and the two solstices. Next we construct a drawing of the quarter circle of the meridian, from the pole *P* to the lower edge, and mark on it the points *a*, *b*, *c*, *d* to represent the four circles. Then we place the overlay of the three sun rays on top of the dial drawing to see whether the circles actually do correspond to the celestial equator and two tropics. (The circles might after all just be decorative, or suggestive, without any intention that they represent the equator and tropics). Sliding the ray drawing up and down, while keeping vertex *V* on the axis and the equinoctial ray perpendicular to the axis, we find that there is an excellent solution that allows the three rays to pass through points *a*, *b*, and *c*. (It was by no means guaranteed that there would be a solution if the three parallels were just arbitrarily drawn circles.) Thus, circle *a* really is the tropic of Cancer, *b* is the equator, and *c* the tropic of Capricorn.

It is to be observed that we have a spherical dial with a non-central gnomon tip. The non-centrality of the projection shows up most obviously in the fact that the tropic of Cancer is larger than the equator. Distance *PV* is the required length of the missing gnomon, supposing that the dial worked in the normal ancient fashion, with only the tip of the gnomon being significant. In real scale, $PV = 47$ mm. In most modern dials of this type, the gnomon would be a central rod along the whole length of the axis; but a bead could be placed at *V*, the shadow of which would indicate the parallel of declination on which the sun lay on a given day. There is a small hole at the celestial pole *P* where a gnomon could have been inserted; but it has been filled, perhaps during an earlier restoration, as may be seen in figure 4.

Soane M1254 as It Was in the Second Century

It seems clear that Soane M1254 has been modified and that the dial that we have today was not the object that existed in the 2nd century. Figure 11 is a photograph of Soane M1254 taken from Atlas's left side. As can be seen, two wedges of stone have been cemented under the base of the statuette. The lower wedge seems to have been intended to change the inclination of the axis. Just above this wedge is a smaller wedge, which may have been part of a repair to the damaged base of the statuette, but which probably also contributed to a change in the orientation of the axis. These wedges both go all the way around, and are visible from the left, back and right. According to Helen Dorey, Deputy Director of Sir John Soane's Museum, who kindly re-examined the object for us, the stone of the wedges is a little less worn than the stone of the main parts of the object.

On the sundial itself, the semi-circular region bounded by the tropic of Capricorn (which includes the pole) was probably also not of original issue. There are several arguments to offer in support of this view. First, the polar cap is a separate piece of stone from the main part of the sundial, which is easily seen from

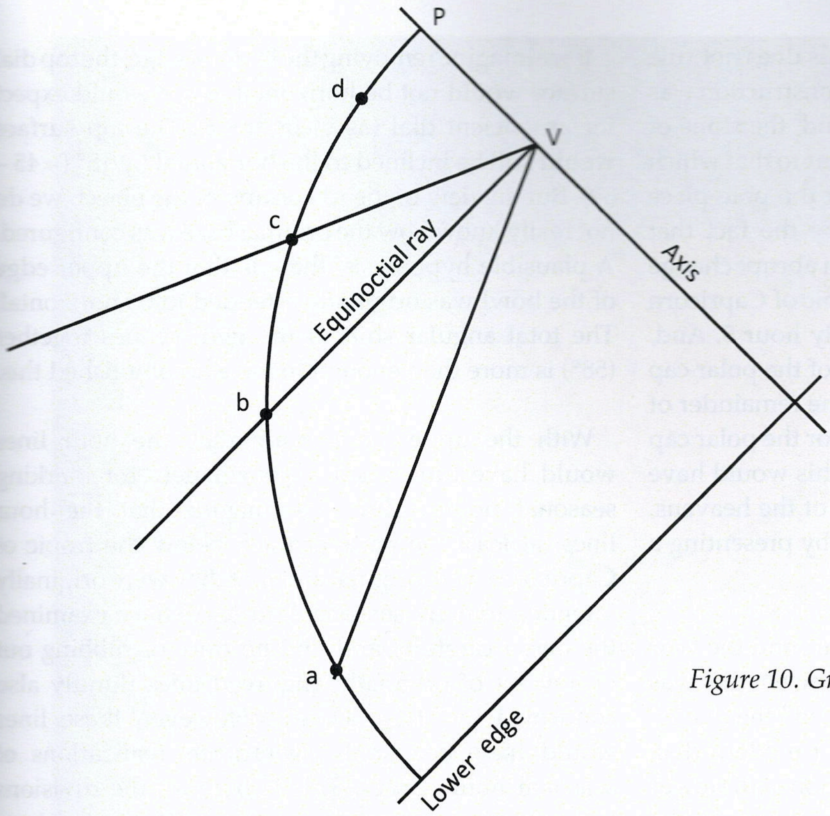

Figure 10. Graphical analysis of the sundial.

Figure 11. View from Atlas's left side, showing the wedges that were inserted beneath the base of the statuette. Photo: Taylor Pearce Restoration Services for Sir John Soane's Museum.

the back (fig. 2). By itself, of course, this does not rule out the possibility that the two-piece construction was part of the ancient handiwork.[14] Second, the stone of this semi-circular region appears similar to that which was used for the wedges. Third, that the pole piece was not original is also suggested by the fact that some of the hour lines show a kink (an abrupt change in direction) as they pass over the tropic of Capricorn and onto the pole piece. See especially hour 5. And, fourth, as noted above, the curvature of the polar cap falls away from the general trend of the remainder of the dial.[15] Perhaps the best argument for the polar cap being part of the original dial is that this would have helped emphasize the spherical form of the heavens, for the sake of the Atlas iconography, by presenting a quarter-sphere to view.[16]

The conclusion to be drawn is that around the year 1800 a recently-discovered, damaged ancient dial was repaired and that the restorer "improved" the dial by making it resemble a common kind of modern dial. This involved, most crucially, the addition of the lower wedge, seen clearly in figure 11, to make the axis of the spherical segment more nearly align with the celestial axis in the latitude of central Italy, and possibly also the addition of the semi-circular region around the pole.

Here we pause to introduce some more measurements:

angle between horizontal and the upper face of lower wedge	30°
angle between horizontal and upper face of upper wedge	58°
angle between horizontal and top bowl surface	45°
angle between horizontal and lower bowl surface	44°

Table 3. Orientations of the principal planes of Soane M1254.

If we imagine removing the lower wedge, the top dial surface would not be horizontal as we would expect for an ancient dial (as in figure 1). The top surface would still be inclined to the horizontal by 15° (= 45 – 30). But, in view of the reworking of the object, we do not really know how the original base was configured. A plausible hypothesis, then, is that the upper edge of the bowl was originally intended to be horizontal. The total angular shift of the two wedges together (58°) is more than enough to have accomplished this.

With the upper edge horizontal, the hour lines would have functioned approximately for marking seasonal hours. Thus we imagine that the hour lines (at least the parts of them below the tropic of Capricorn) were original and that they were originally intended to mark seasonal hours. We have examined the object carefully and find no trace of rubbing out of any set of originally engraved lines (kindly also confirmed by Helen Dorey). However, these lines would have been only *approximate* realizations of seasonal hour curves. This is because the divisions between the seasonal hours should be made along circles parallel to the equator (as in figure 1); but on Soane M1254, if the top face of the dial is made horizontal, the divisions between the seasonal hours are being made along vertical circles. The time told by this dial would not correspond accurately to seasonal hours. But it would not be far off. The time would be fine at sunrise, noon, and sunset. For the intermediate hours there would be errors, but these would not be very noticeable. It seems, then, that the designer found a way to incorporate the visual imagery of meridian circles (in keeping with the symbolism of Atlas and the globe), at the price of a modest reduction in quality of the time-keeping function. In the Roman world, it is not at all uncommon to find nonstandard, i.e., imperfectly designed, sundials.

Were the parallel circles original? We believe that they were not and that the original dial had only hour curves.[17] The lowest and largest parallel, which

14 The small hole on the line of symmetry just below the polar cap in fig. 12 held a screw and wire, which were used to fasten the object to the wall and thus keep it from tumbling off its shelf at the museum. Whether former curators exploited an ancient hole already present or drilled a new one is not known.

15 One might also be tempted to note, from fig. 11 and 12, that the polar cap is slightly lighter in color than the remainder of the dial. However, the treatment of the back of the dial during the restoration makes this comparison unmeaningful. Because the upper back was still very black after the first cleaning, a coat of synthetic clay was applied to it and then scraped off, and the area was re-steamed. Finally, the back was given a very thin wash of acrylic paint to help unify the color with the front (Taylor Pearce Restoration Services, 2016).

16 Here we offer the view of Matt Nation of Taylor Pearce Restoration Services, the firm that cleaned and repaired the object: "I am not sure whether the various stone parts are exactly the same stone as each other, other than that they are marble, have been part of that object for a long time, have aged in a very similar manner, and look very similar. It may well be all of the same date, but it does seem a funny place to put a joint in around the polar cap – so it is likely to be a later repair, as is the wedge." Helen Dorey notes, "The cap is indistinguishable from the rest, I would say, both on top edge and front."

17 Some ancient dials with only hour lines and no day curves include 1046, 1063, 3017, 3018, 3066, and 3088 in Gibbs 1976, as well as 7, 10, 11, 27, 42 in Schaldach 2006.

Figure 12. View from the back. Photo: Taylor Pearce Restoration Services for Sir John Soane's Museum.

serves as the boundary beyond which some of the hour lines are not continued, seems the most likely to be original. But it is important to recognize that when the dial was in its ancient form, the parallel circles were not parallels of constant declination; that is, they did not correspond to the tropics and equator. It is likely that the parallels were modern additions and that the hour curves were re-engraved, to make them look more like the newly engraved parallels. This would explain the rather rough character of the hour lines as they exist today.

Although we cannot know for sure, the gnomon tip probably was located at the center of the sphere; and the polar cap probably was not part of the original dial. With the tip of the gnomon located at the center of the sphere, the noon winter solstice shadow would have (approximately) touched point c (or fallen a wee bit short, or spilled just a bit beyond it). The shadow would have stayed on the dial face in the early morning and late afternoon. Around the summer solstice, by contrast, the dial would have functioned only for the hours around noon (roughly 3¼ seasonal hours before and after noon). In the early morning or late afternoon, the end of the shadow would have fallen off the dial face. It is not unusual to find ancient dials that did not function all day long, all through the year. This is particularly a problem with vertical plane dials

Probably, John Soane did not quite know what he was getting - an ancient dial modernized in restoration. It is possible that the restorer, whoever that was, made an innocent mistake, not understanding ancient dials well enough. Or it could have been a deliberate fraud, designed to mislead a collector by providing a dial that seemed familiar. We have, however, no reason to doubt that the original object is genuine - an Antonine garden statuette. Settele provides a near contemporary attestation of the findspot. And the art-historical analysis by Vermeule, made without any awareness of Settele's article, arrived at an Antonine date, quite in keeping with what we now know to have been the findspot. Finally, we note that the wedges reinforce the conclusion that this is a genuine ancient object altered in restoration; for if it were a fabrication *ab initio*, there would have been no need to use wedges.

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