Floating Sundials From Down Under

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The two portable sundials shown in figures 1-5 are "floating dials" designed for use in the southern hemisphere. Floating dials are so named because the working parts of the sundial are fixed to the upper surface of a compass card that freely turns or "floats" on a pivot. A magnetized needle is glued beneath the compass card, orienting it and the coupled sundial to magnetic north. The attached sundial is usually the common horizontal variety, but other types are possible; we know of one case in which a small cube dial is mounted on the floating card (figure 6).[1] All floating sundials are self-orienting.

History

Floating dials date from the early to mid-18th century. Although Nicolas Bion was not likely the inventor, the earliest known reference to a floating dial appears in the fourth edition of Bion's *Treatise on the Construction and Principal Uses of Mathematical Instruments*, posthumously published under the supervision of Bion's son in Paris in 1752.[2] (figure 7) Bion's instrument consisted of a light-weight cardboard spool with a horizontal sundial drawn on its upper surface. Beneath the gnomon, a brass or glass cap received the brass point on which the spool turned. The magnetic needle on Bion's dial was similar to those found on marine compasses. It was formed from wire bent into a diamond shape, and was glued to the base of the spool after taking magnetic declination into account. Whereas most makers attached their needles to flat cards, Bion preferred the spool configuration, which kept the center of gravity low. He claimed that with the needle well below the pivot point, the device turned very easily and better kept its level. The pivot was planted in the base of a round, wooden box, roughly two inches in diameter, and the floating dial was set on the point. It was then covered with a crystal similar to those found on pocket watches but here domed to accommodate the raised gnomon. A turned wooden lid protected the crystal.

Bion explained that the crystal was necessary to screen the floating dial from disturbances in the air, but he acknowledged that rays of sunlight were bent by refraction in passing through the crystal before falling on the gnomon and casting a shadow. The consequent error would be greater near sunrise and sunset than near noon. Even so, Bion described the error as "not very sensible" and considered it a minor inconvenience. He suggested that sticklers for accuracy could shelter their sundials from the wind, read the hours with and without the crystal in place, and write down the differences in time. Once the errors were tabulated, they had the means to correct their instruments on future occasions. This was a good plan, but few would have gone to this trouble. Refraction of sunlight by the crystal limited the sundials' accuracy, but was of little concern to users for whom the accuracy of these pocket dials was already confined by their small size.

Many floating sundials of English, French, and German origin survive from the late 18th and early 19th centuries. Their makers included William Fraser and sons, Samuel Porter, Charles Essex and Company, and Thomas Staight in London; Coulomb in France; and J.P. Stockert and E.C. Stockert in Bavaria. Like the one Bion described, these were pocket-sized instruments, typically 5-6.5 cm in diameter. Most, however, used bar needles glued to flat cards rather than diamond-shaped wire needles glued to spools. The small floating cards were mounted within cylindrical boxes with pressure-fitting, domed covers made of

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[1] Floating dial signed "I. F. Briot" and made in France in the 18th century; History of Astronomy Collection of the Adler Planetarium and Astronomy Museum, Chicago, N-10.

[2] Nicolas Bion, *Traité de la construction et des principaux usages des instrumens de mathèmatique*, 4th ed. rev. (Paris: 1752), book 8, chap. 5, pp. 386-387, plate 32, figs. 7-9. The "horizontal sundial that orients itself" did not appear in image or text in earlier editions of Bion's work (1709, 1716, 1723). In fact, the figures are squeezed onto plate 32 in the limited space left between existing engravings. Since Bion died in 1733, it's unclear whether this addition was made by him or his son, who edited and published posthumous editions of Bion's works. Our discussion, therefore, does not distinguish between the two. See Maurice Daumas, *Scientific Instruments of the Seventeenth and Eighteenth Centuries and Their Makers*, trans. Mary Holbrook (London: B. T. Batsford, 1972), 79-80.

turned wood, ivory, bone, or brass. The lower half of the box (containing the card) was routinely glazed with a hemispherical glass dome.[3] (figure 8)

Two Antipodean Examples

The Australasian instrument that we will call Sundial A is 5.5 cm (2.15 inches) in diameter. (figures 1-4) Its turned brass box was lacquered on the outside. A gored, English chart with corrections for the equation of time is pasted inside the lid and reads, "Fast means that the Clock should be faster than the Dial. Slow, slower." The interior of the bottom half of the box is painted red. A slot and hole in the side of the box suggest that the instrument originally had a mechanism (now missing) by which to lift the floating card off its pivot, push it up against the brass retaining ring, and lock it in place for transport in order to prevent damage to the pivot point. The brass ring may have been held in place with a spring wire and may have supported a glass dome (both now missing).

The floating compass card consists of a disk of heavy paper or card beneath which a sheet of mica was laminated as a stiffening agent. The mica disk is about 6 mm smaller in diameter than the paper card. A bar magnet was glued to the mica surface and held in place by a circular sheet of paper (now partially torn off). In place of the original paper, two paper strips secure the needle to the card. The magnetic needle has a jeweled pivot cap. The underside of the card has traces of sealing wax, which were likely applied to keep it level. The upper surface of the card carries a brass gnomon that points toward the south pole and has an angle of 42°. The circular hour scale is divided into quarter hours and labeled with Roman numerals running from V through XII on to VII (hereafter abbreviated V-XII-VII). XII is near the south point of the windrose. A solar face is delineated near the north point between the V and VII marks. Surrounding the horizontal sundial is a sixteen-point windrose marked in English initials with a fleur-de-lis at north. Beyond the windrose the circle is divided unevenly into two concentric scales of 54 and 27 parts respectively. The instrument maker may have planned to divide the windrose into 64 and 32 points, which were traditional, but his poor execution made these markings no more than ornamental additions to the compass card. They are worn around the edge where the card rubbed up against the brass retaining ring.

All markings on the upper surface of the card are hand-painted, including the hour lines. We measured their positions and calculated latitudes of 34° ± 2°. The seven o'clock line has the largest deviation, being placed for 38°. Some scatter is to be expected in any handcrafted instrument, but these hour lines are well off the mark established by the 42° gnomon. Given the errors introduced by hand-painting short hour lines and the likelihood of a novice getting their placement mathematically wrong, we believe that the gnomon is the more reliable indicator of the maker's intent. We suggest, therefore, that Sundial A was intended for use at latitude 42°S, which would suit those living in Christchurch, New Zealand or Hobart, Tasmania.

This sundial is unsigned, but English in style. The bar needle and the paper disk used to secure it underneath the compass card are typical of those employed by Samuel Porter circa 1824. Very similar equation-of-time charts appear in the lid of an inclinable dial made by Casella, London, circa 1845 and another signed Charles Nephew and Company, Calcutta, dating from about the same time.[4] We also know of a comparable floating dial made by A. Beverly, Dunedin (southern New Zealand). We conclude, therefore, that Sundial A was made in the second or third quarter of the

[3] Sara Schechner Genuth, *Sundials and Time-Finding Instruments*, vols. 3 and 4 of *Historic Scientific Instruments of the Adler Planetarium*, ed. Sara Schechner Genuth with Bruce Chandler (Chicago: The Adler Planetarium, forthcoming), see N-8, N-9, T-21, T-46, W-191, W-225; David J. Bryden, *Sundials and Related Instruments*, The Whipple Museum of the History of Science, catalogue 6 (Cambridge: 1988), nos. 36-43; Museo Poldi Pezzoli, *Orologi-Oreficerie* (Milan: Electa Editrice, 1981), nos. 199-208; Georges Baptiste, et al., *De Tijdmeting in Belgische Verzamelingen*, catalog of an exhibition organized by the Generale Bankmaatschappij, Brussels, 1984 (Brussels: Generale Bankmaatschappij, 1984), nos. 134-136.

[4] Adler Planetarium and Astronomy Museum, Chicago, T-46, W-176, N-24. The only difference is that the text on the inclinable dials is set out in a paragraph rather than in a circle.

19th century. It may have been manufactured in England for export to a colony in the southern hemisphere or may have been produced locally in Australasia for use in the vicinity of Christchurch or Hobart.

While we cannot be conclusive about the point of origin, we may determine more decisively at least one location where the sundial was used. Here we are helped by information concerning the deviation of magnetic north from true north.

In theory, if one were to use a floating sundial at a site where magnetic declination was not zero, some correction would be required to align the dial with true north. During the manufacturing process, instrument makers like Bion slightly rotated the magnetic needle beneath the card to accommodate the current magnetic declination of the region in which their customers lived. But as declination changed over time, the floating card would no longer align with the north-south meridian, and the sundial would become less accurate. In dials this size, however, such changes in reading were hardly noticeable, and generally beyond users' expectations for the accuracy of their timepieces. Very few floating dials had a mechanism by which to adjust for changes in magnetic declination.[5] Like most floating dials, our Australasian instrument lacks such a mechanism, but unlike most, it belonged to an owner who apparently cared. In order to correct for changes in magnetic declination, this owner ripped off the paper disk that held the bar needle in place, rotated the needle, and taped it down in a new position. The needle is currently positioned about 8.5° east of north, which is roughly the magnetic declination found in Tasmania in 1900.[6]

Sundial B is another unsigned, Australasian floating dial. (figure 5) It too is English in style, but better executed than Sundial A. It was probably made during the second quarter of the 19th century. Sundial B is 5.7 cm (2.24 inches) in diameter and housed in a cylindrical wooden box with a pressure-fitting lid. The lower half of the box is glazed. The floating card carries a south-pointing gnomon, a circular hour scale, and a sixty-four point windrose. All lines are printed rather than painted. The hour scale is labeled in Roman numerals V-XII-VII and is divided into quarter-hour intervals. English initials identify fifteen points of the windrose. A fleur-de-lis and solar face mark the direction of north on Sundial B as they do on Sundial A.

We could not remove the glass dome in order to peek at the underside of the compass card, but were able to have the dial x-rayed. The x-ray photograph reveals that the magnetic needle glued beneath the card is solid and diamond-shaped (like those found today on cheap pocket compasses). It declines roughly 10° east of north.

By measuring through the glass dome, we found the angle of the gnomon to be approximately 37°, and the hour lines to be laid out for roughly 39°S. Melbourne may have been the dial's home, since it has a latitude of 37.8°S.

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The antipodean dials are owned by Dr. Norman Heckenberg, Reader in Physics at the University of Queensland, Brisbane QLD 4072, Australia. Heckenberg maintains a small museum on the university campus, and a web site (see below).

Museum hours are limited, and visitors are advised to contact Heckenberg for an appointment. Sundial A was first brought to the attention of Robert Terwilliger and Dr. Sara Schechner Genuth through a request for information from the Answer Box of the National Association of Watch and Clock Collectors. A freelance curator, Schechner Genuth is presently completing a two-volume catalog of the sundials and time-finding instruments at the Adler Planetarium and Astronomy Museum in Chicago.

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[5] See the silvered-brass floating dials signed "Fraser, London" at the Museum of the History of Science in Oxford and the Whipple Museum of the History of Science in Cambridge. Illustrated and described in Gerard L'E. Turner, *Nineteenth-Century Scientific Instruments* (London: Sotheby Publications, 1983), 35; and Bryden, *Sundials*, no. 37.

[6] J. A. Jacobs, ed., *Geomagnetism*, 4 vols. (London: Academic Press, 1987-1990), 1: 443 gives 6° east of north in 1850, whereas J. Bartholomew, *The Advanced Atlas of Modern Geography* (London: Meileljohn, 1953), 24 gives 10° east of north in 1950. In New Zealand, which is on the same latitude as Tasmania, declination varied from 14° - 17.5° east of north during this same period. (These declinations are accurate to within a degree.)

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Figure 1. Sundial A, an Australasian floating sundial. *On left*, the upturned cover showing the equation-of-time calibrations. *On right*, the sundial in its box.

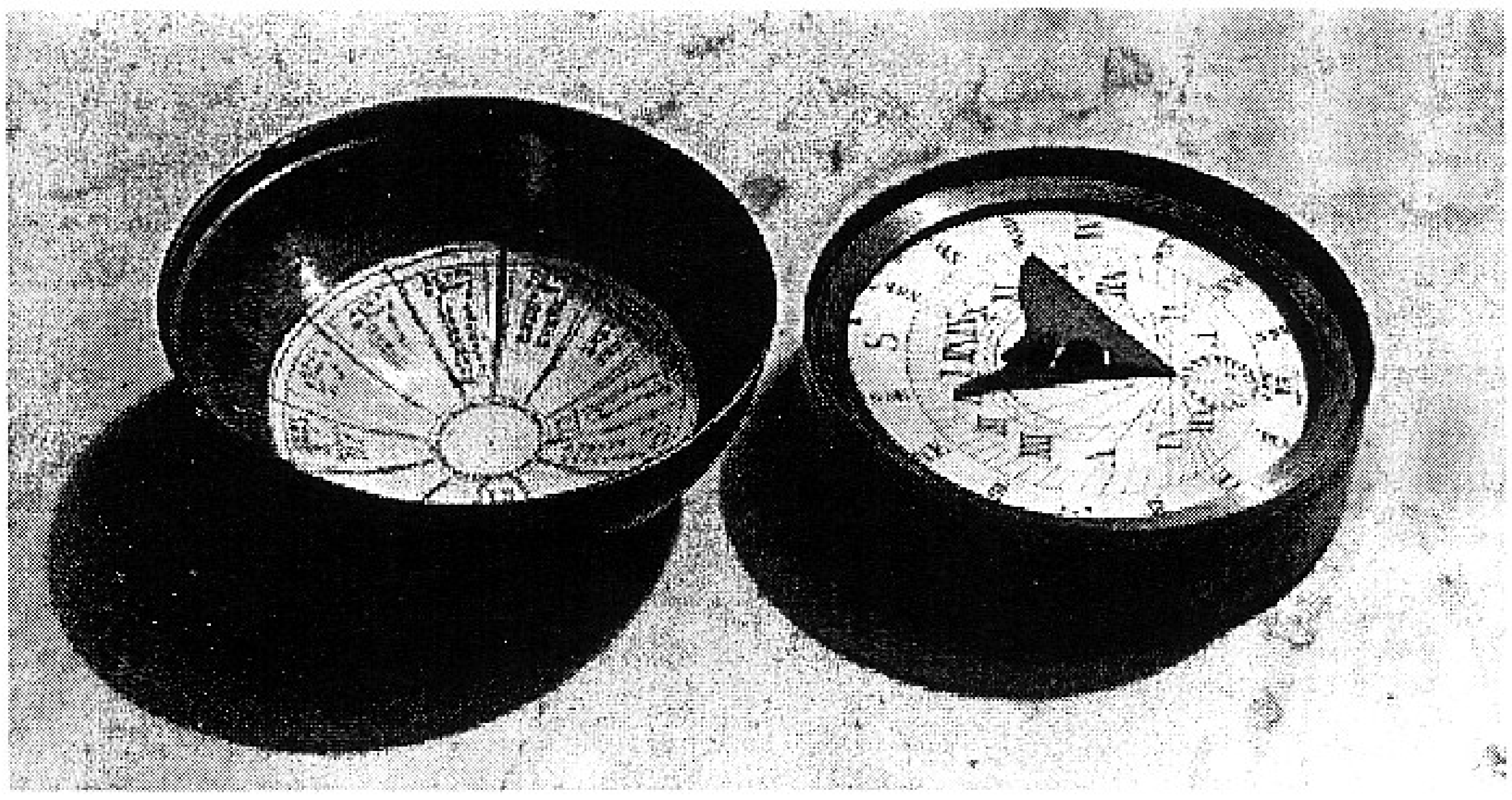


Figure 2. Sundial A: The dial enclosed in its box.

Figure 3. Sundial A: The underside of the compass card, showing the taped bar magnet.

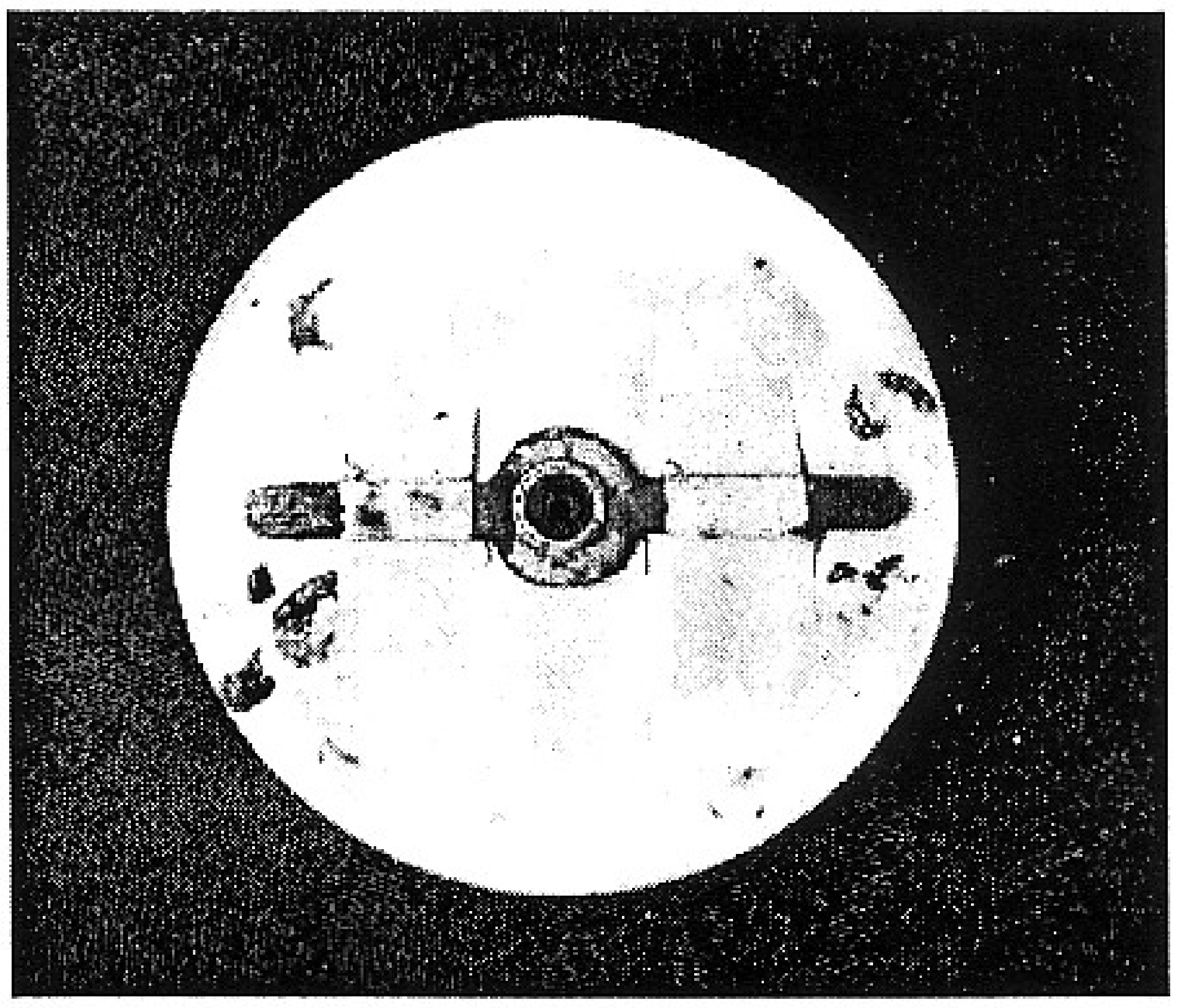


Figure 4. Sundial A: The lower half of the box with the retaining ring.

Figure 5. Sundial B, an Australasian floating sundial.

Figure 6. Eighteenth-century, French, floating dial signed *I. F. Briot.* (N-10, Courtesy of the the Adler Planetarium and Astronomy Museum, Chicago.)

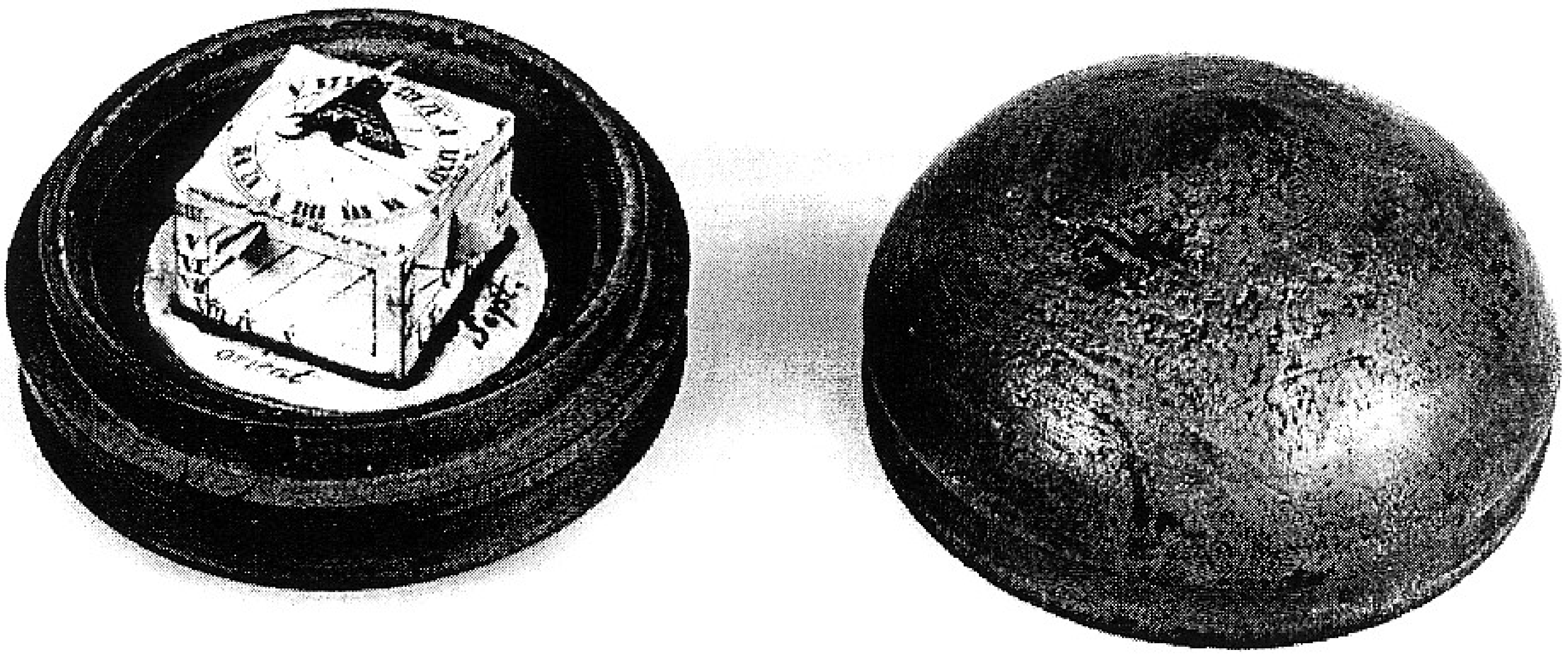


Figure 7. Bion's floating sundial. *On left*, the hollow spool with sundial on top and bent-wire needle (*BC*) below. *A* is the pivot. *Center*, the sundial floating in its turned wooden box with glass cover. *On right*, the wooden lid. Nicolas Bion, *Traité de la construction et des principaux usages des instrumens de mathématique*, 4th ed. (Paris: 1752).

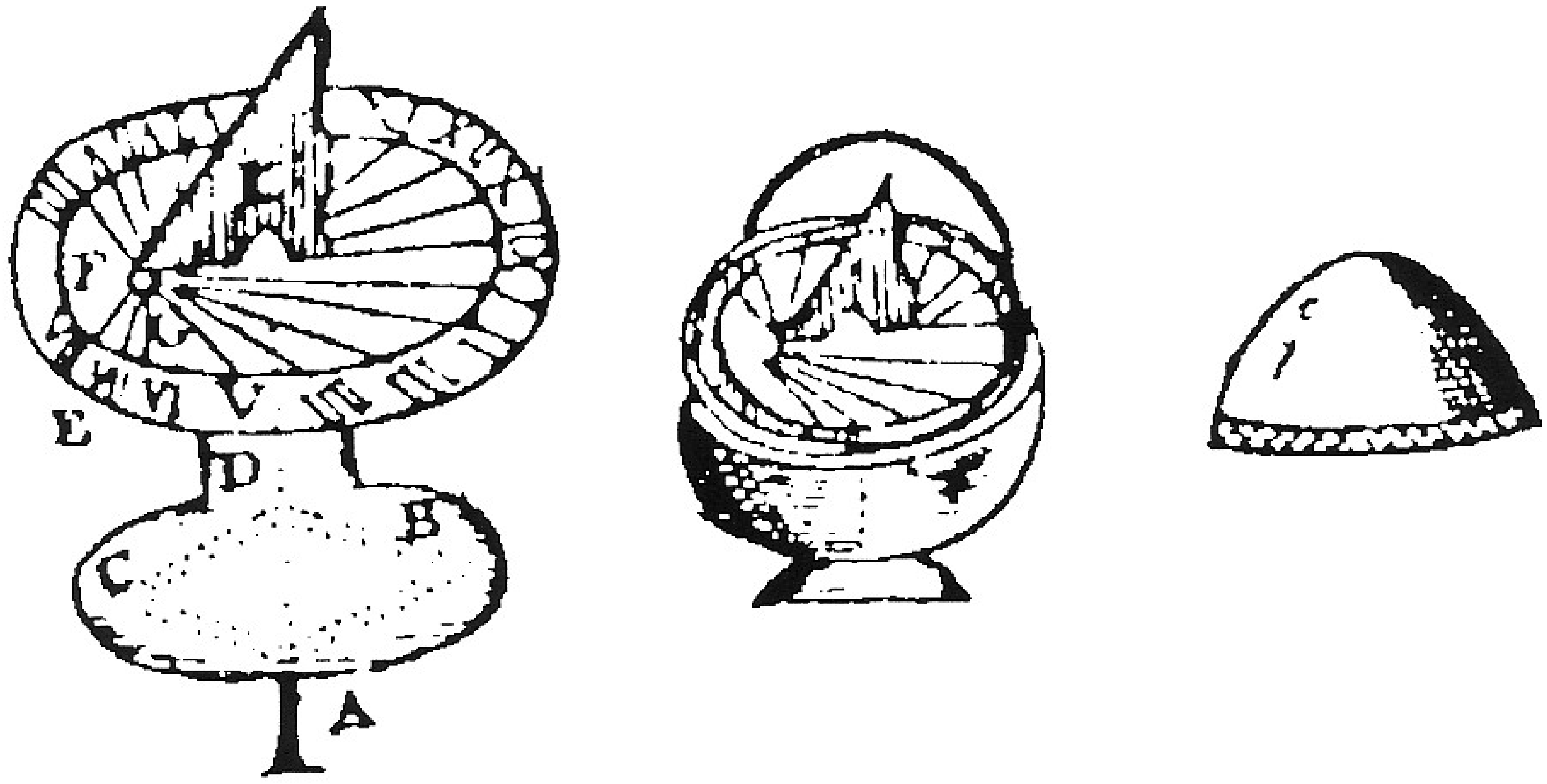
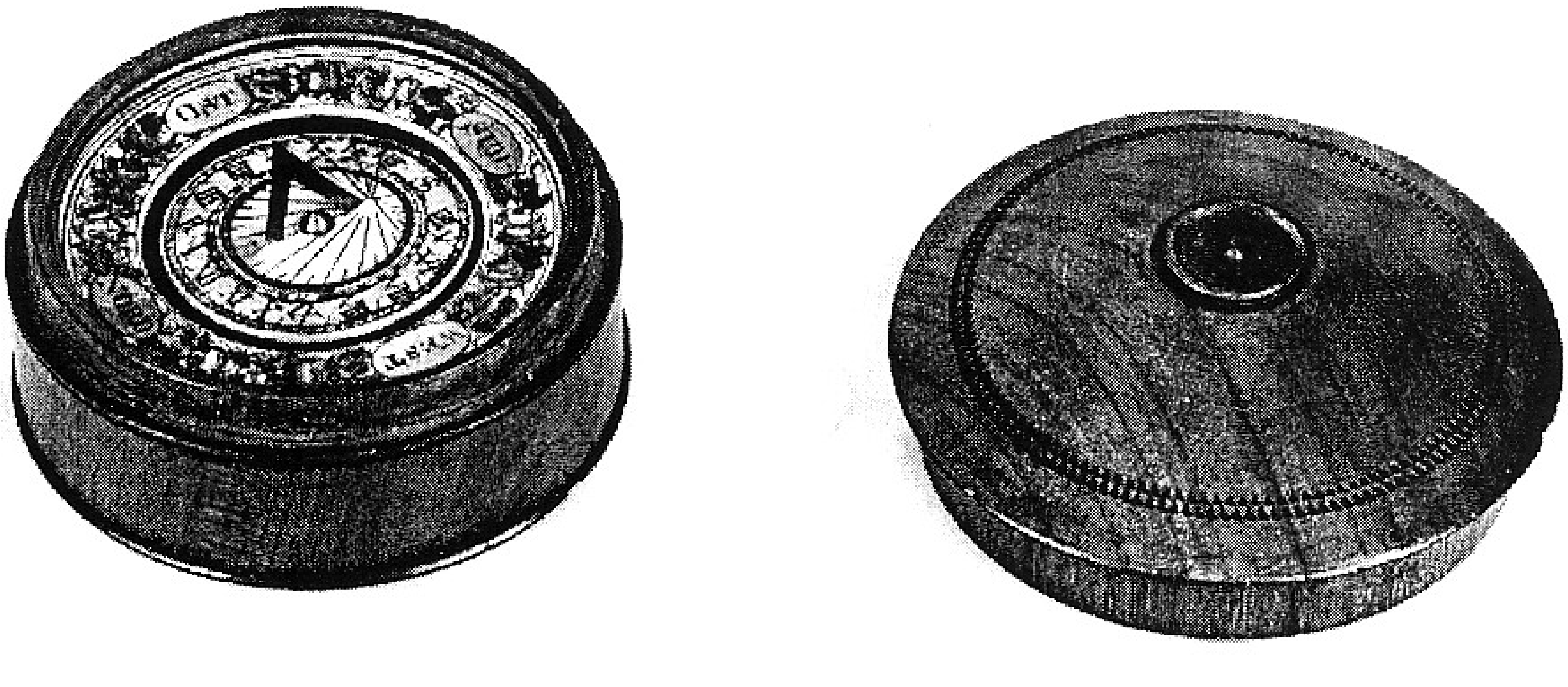


Figure 8. Typical late eighteenth-century German floating sundial; glass dome missing. (N-8, Courtesy of the Adler Planetarium and Astronomy Museum, Chicago.)



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