ISLAMIC SUNDIALS SIGNED BY AL-MANSUR CARRYING DATES IN THE LATE 17th CENTURY

An Examination of their Gnomonic and Historical Anomalies

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The Muslim religion prescribes that the faithful perform five daily prayers at certain times of the day and night. In detail, the definition of these times has varied according to countries and periods of history, but it is mainly solar astronomical criteria that have been used.[1] The *Mu'aqqits*[2] therefore used astrolabes, or sundials, to help them in their task of determining the times of prayer each day. Some of these figures are known for their expertise in astronomy and gnomonics, such as Ibn Al-Shatir, the *Mu'aqqit* of the Great Mosque of Damascus, who, around 1371 AD, was the first person known to date to have employed a polar gnomon.[3,4]

Mosque sundials are remarkable in that they present, in addition to time information (in unequal or equal hours depending on the period), additional lines corresponding with the times of all, or some, of the five canonical prayers.[5,6,7] In practice, the crossing of one of these lines by the tip of the gnomon shadow can indicate, depending on the line, the beginning or the end of a favourable period for a prayer that takes place during the day (*Zhur*, *Asr*), or that takes place at night (*Maghrib*, *Isha*, *Fajr*); in the latter case, the indicators announce this prayer several hours in advance, while the Sun is still above the horizon. It can be assumed that the *Mu'aqqit* would then start counting the hours with an hour glass or a clepsydra.

Mosque dials are therefore sophisticated, rare and valuable instruments that have been systematically inventoried in a number of Muslim countries. The inventories for Turkey by Cam,[8] Egypt by 'Abd-l-'âtî,[9] Tunisia by Jarray,[10] Morocco by Kharbouche,[11] and India by Sarma[12] list a few hundred mosque dials in total. Apart from the early centuries of Islam[13,14] and towards the end of the nineteenth century,[15] they are generally instruments of good scientific quality, made by skilled craftsmen with a mastery of the science of gnomonics.

The recent appearance on the art market of a dozen mosque sundials dated in the 17th century has therefore attracted our attention. These sundials are believed to come from North Africa (Morocco to Egypt), according to the Qibla indicated on the dials themselves (see below). But these instruments present a number of anomalies that clearly

Ref.	Hegira year	AD year (approx.)	Size (cm)	Sources of data (sales ...)	Qibla (°)
7	1082	1671	24 × 24	Paris June 2010	105
9	1082	1671	25 × 25	Londres April 2008; London Oct. 2008	107
6	1082	1671	60 × 50	Paris June 2015	116
1	1085	1674	32 × 32	(private property)	113
8	1085	1674	57 × 38	London Oct. 2008	119
2	1085	1674	50.5 × 41	Munich Dec. 2009; London Dec. 2015; London May 2016; Hattem April 2018	135
3	1090	1679	32 × 32	Cannes Aug. 2009	118
4	1090	1679	40 × 60	Paris May 2018; Paris March 2019	120
10	1090	1679	25 × 25	Paris Feb. 2021	119
5	1092	1681	28.5 × 28.5	Paris Nov. 2017; Paris March 2018	100

Table 1. Main characteristics of the dials studied. The numbers are arbitrary and refer to Fig. 1 and the text.

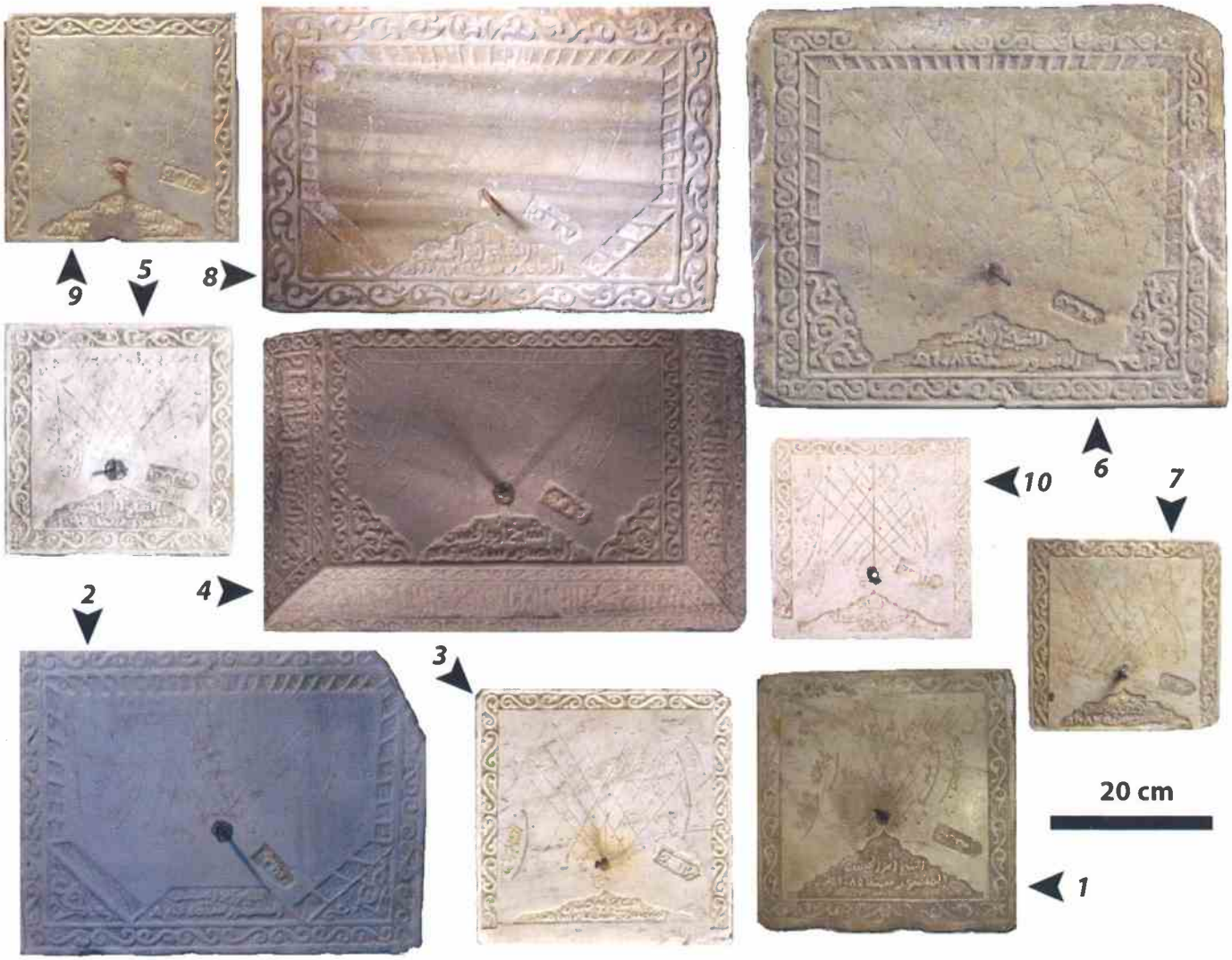

Fig. 1. The ten dials signed al-Mansur illustrated at the same scale.

differentiate them from the rest of the production of the period, which is why we would like to present and discuss them here (Fig. 1 and Table 1).

General Presentation of the Dials Studied

Fig. 1 shows, at the same scale, the ten dials that we will discuss. Nine of them (nos. 2 to 10) were offered at auction between 2008 and 2021 in London (GB), Paris (F), Cannes (F), Hattem (NL) and Munich (D). Some have been sold several times (nos. 2, 4, 5 and 9: see Table 1). Dial 1 is kept in a private collection and we do not know where and when it was acquired, but as it has the same signature and the same anomalies as the other nine, we have chosen to include it in this study.

They are horizontal sundials cut in marble and are characterized by a careful decoration, marked in particular by ornamental friezes, which contrasts with the mosque dials known from elsewhere, which generally do not present any decorative elements in order to avoid any disturbance in the reading of the astronomical information. Furthermore, all these dials are signed by a single gnomonist: al-Shaykh Abu al-Hasan al-Mansur, and dated between 1082 and 1092 AH (i.e. 1671–1681 AD). With ten known instruments, this diallist is by far the best represented in the inventories. He does not appear in the list of authors of astronomical works in the Muslim West,[16] he is not recorded in the *Répertoire des facteurs d'astrolabes*[17] and, curiously, none of his works are known preserved in a mosque. Yet mosque dials are considered *hubous* in Muslim jurisprudence, roughly equivalent to being inalienable. The vicissitudes of history may explain why a handful of these instruments may have left their original location to join private or public collections, but the apparently targeted and systematic nature of the looting that affected the dials of al-Mansur seems quite astonishing. Finally, it should be noted that during the period when the ten dials from al-Mansur were offered for sale (2008–2021), it would appear that no other mosque dials appeared on the art market.

Analysis of the Qibla: Origin of the Sundials

Mosque dials are used to determine the time at which Muslims should perform their prayer. In the case of horizontal dials, they usually indicate the direction of Mecca (*Qibla*) towards which worshippers should orient themselves to pray.

In theory, to determine the Qibla of a place, one needs to have the geographical coordinates of Mecca and the

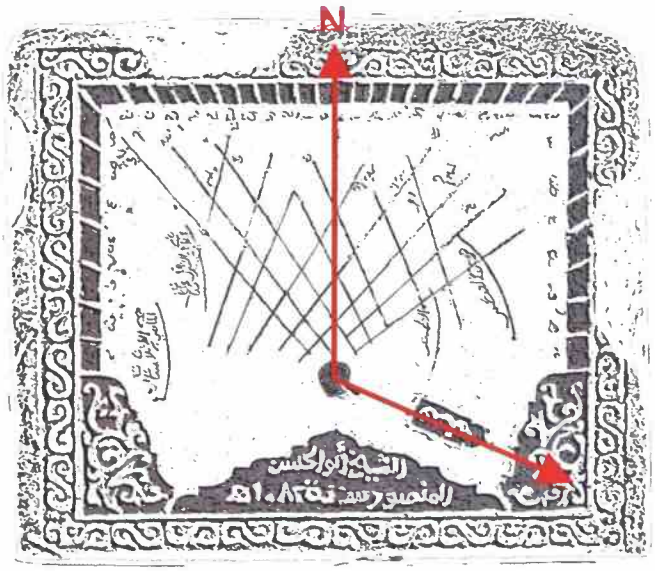

Fig. 2. Principle of reading the Qibla on a dial, illustrated from dial 7.

place in question, and then perform complex calculations using spherical trigonometry. In practice, the geographical coordinates remained very uncertain until the nineteenth century,[18,19,20] and diallists therefore generally used approximate methods for the calculations, so that the direction mentioned on the dials is very usually a 'traditional' value, variable over the centuries and always quite approximate.[21]

It is standard, on the dials of al-Mansur, that the direction of the Qibla is indicated by a small stylised mihrab (Figs 2 and 3) whose orientation with respect to the meridian line is measurable on the dial. What is remarkable is the variability of this orientation. It corresponds to values that were used, in the 17th century, in countries very far from each other, with Morocco and Egypt as extremes. This could suggest, in a first analysis, that al-Mansur had an activity covering the whole of North Africa; but this conclusion is very surprising insofar as diallists listed to date had only a purely regional activity (a radius of only a few dozen kilometres).[22]

Fig. 3. Examples of the Qibla direction indication. The writing is here cursive (dial 6) and geometric kufic (dial 3).

Epigraphic Analysis

These sundials pose problems with regard to the style of writing and the form of the various inscriptions that appear on them (see Table 2).

Like other Muslim sundials of this period, all the instruments signed by al-Shaykh Abu al-Hasan al-Mansur are commemorated by an inscription using the same relatively abbreviated epigraphic form and limiting itself to the essential elements: the name of the craftsman and the date in Hegira year.[23] This text appears, on all the dials studied, in a triangular commemorative escutcheon, written

Table 2. Table of the types of writing used on the dials of al-Mansur

Sundial number	Date	Craftsman's signature	Type of handwriting (C = cursive; K = kufic) Qibla	Koranic verses	Other inscriptions
1	1085/1674	C	C	-	C
2	1085/1674	C	C	K	C
3	1090/1679	C	K	-	C
4	1090/1679	C	C	K	C
5	1092/1681	C	C	-	C
6	1082/1671	C	C	K	C
7	1082/1671	C	C	-	C
8	1085/1674	C	K	-	C
9	1082/1671	C	C	-	C
10	1090/1679	C	K	-	C

Fig. 4. Example of a commemorative crest typical of those on the dials studied (dial 1). Note the date in the form of 1085 H. at the bottom left.

in cursive script, where the date of manufacture can be read (Fig. 4). This date employs a surprising formalism that consists in indicating the abbreviation of the word *hijri* (of the hegira) by the letter 'H' followed by a dot (e.g. "1082 H."). This form poses a problem since it seems to be known only from the 20th century, when it appeared under Western influence.[24] It should also be noted that such a form is historically improbable. In Muslim countries, in a mosque in the seventeenth century, Muslims are not spontaneously inclined to specify that the date is counted after the Hegira; nor, at the same time, in Europe, do the dates inscribed in churches specify that they are years after the birth of Christ!

Finally, it should be noted that three dials (2, 4 and 6) have inscriptions with Qur'anic verses carved in relief around the perimeter or on the outer faces of the slab. These Qur'anic inscriptions are remarkable for the fact that they are carved in relief in flowery, kufic script, very characteristic of medieval inscriptions and particularly of those of the 4th–5th/10th–11th century (i.e. at least six centuries before the studied sundials).

Let us examine sundial no. 2 in detail. The commemorative shield, with the signature and date, is carved in relief in cursive script. The outer border of the instrument contains a Qur'anic text executed in floral kufic script. It is part of verse 189 of Sura II, *al-Baqara* The Heifer ("*Believers ask you about the new moons. Answer them: They are landmarks in time for men and the Pilgrimage*"). It is highly probable that the sculptor was satisfied with this part of the verse, which is very appropriate to the function of this instrument.[25]

The coexistence of different types of writing and historically distinct periods is also evident on dials 3, 8 and 10 where the signature of the craftsman is in cursive script, while the indication of the Qibla is carved in simple kufic or geometric script. This association of two types of writing (cursive, and flowery or geometric kufic) which belong to different periods and influences and which are historically incompatible seems to us to be very curious and has no historicity/historical reference.

Gnomonic Analysis of Dials: the time function

Some of the dials in the series studied (2, 4, 6 and 8) have a band on the outer edge where the hour lines begin to appear. On ancient Muslim dials, the spacing of the hour lines corresponds to 5 drej (= degrees[26]) or 20 minutes of equal time. Three graduations thus correspond to one hour. The drawing of these lines is usually sufficiently precise to calculate, to within one or two degrees, their latitude (in North Africa between 27° and 37°).

The time lines, especially those running East–West and North–South, i.e. 6 am, 12 noon and 6 pm, should intersect at the point where the polar style is located. Usually, on mosque dials of the 17th and 18th centuries, one can observe at this particular point:

- either a hole, or a sealed loop to which a string can be attached which, when properly fixed to a support outside the dial, serves as the polar style,
- or the gnomon (the function of which will be discussed later), the base of which serves as a device for fixing the string-polar style.

Let us insist on the fact that it is absolutely necessary that the string which acts as a style starts from the crossing of the lines noon and 6 h–18 h, i.e. the place where the segments of the hour lines converge, without which one observes a shearing off from the segments by the shadow, instead of a perfect alignment. So if there is even a slight shift, as in the case of dials 2 and 4, where the right style is off-centre, the dial is unusable for reading the time. In the case of dial 2 of al-Mansur that we choose here as an example (Fig. 5), we do not observe any device intended to fix the polar style at the point of convergence of the hour lines; the gnomon is shifted towards the North on the meridian line preventing de facto the deployment of the polar style. A curious fact is that dials 2 and 8 only have extended time segments for the evening (from 6 pm until sunset) and no segments for the part from sunrise until 6 am.

At the other end of the polar style, one expects to find a 'high' hanging point to ensure the tension of the string which is normally located at the 'north' of the dial on the noon line representing the meridian. It is not seen on the

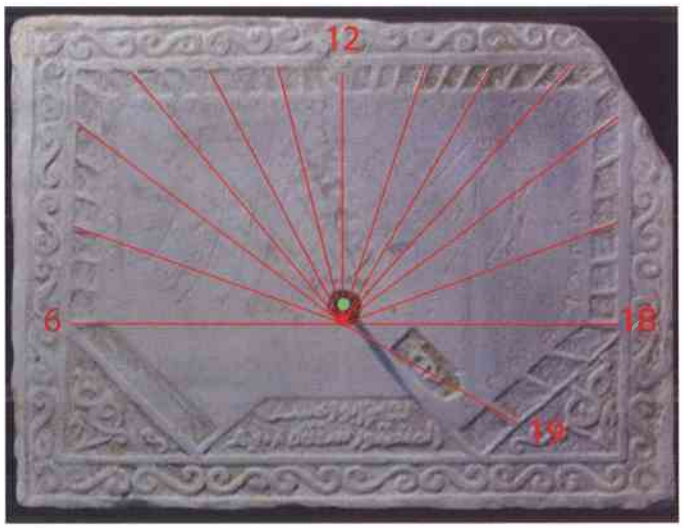

Fig. 5. The hour lines of dial 2; they converge slightly to the south of the gnomon (green circle) which is therefore an obstacle to the installation of the polar style.

al-Mansur dials. It is nevertheless possible that the system is independent of the dial, as is the case on Tunisian dials. The position of this attachment point is fundamental as it ensures the correct inclination of the string, which must be equal to the latitude of the place. If the system is faulty, in other words if the string is not stretched at the correct angle, the reading of the time is sometimes considerably altered: for example, in the case of a horizontal dial drawn for a latitude of 35°, if the string-style is too close to the dial by 5°, the error reaches a maximum of ± 21 minutes in summer for the 8 o'clock and 4 o'clock lines.

Finally, let us note that the drawing of the hour lines of dial 2 (Fig. 5) is very approximate and the latitude that we calculate, according to the measured hour angles, is about 60°, i.e. close to the polar circle! As for dial 6, the same analysis still shows a great inaccuracy in the plot, but provides a latitude of the order of 40°, which is more acceptable. As for dials 4 and 8, the number of graduations is aberrant; between 6 and 18 o'clock, we find respectively 34 and 37 intervals instead of the expected 36 (= 3 × 12). None of these dials can be used to determine a time, even an inaccurate one.

Gnomonic Analysis of Dials: the religious function

Muslim dials of the 17th–18th century are equipped with a gnomon perpendicular to the dial plate, the shadow of which will mark the passage of the prayer hours. It should be noted that these are not always represented every fifth hour, and sometimes the religious indications are reduced. Among the most frequent indications, there is a network of straight lines that indicate hours since sunrise (it is the end of the favourable period for the Fajr prayer), and hours to sunset (it is the beginning of the Maghrib prayer). This network, which is the equivalent of the Italian and Babylonian hours of Western gnomonics, is systematically present on the dials of al-Mansur.

The shadow holder of such a grid is necessarily a gnomon, and this grid must include an imaginary East–West line, through which crossings of the grid pass (this is the line of the equinoxes; see Fig. 6). Note that the Italian 18 and Babylonian 6 lines cross on the noon line and on the equinox line. Moreover, the hour lines cannot be parallel as is the case on several of the dials studied here (e.g. dial no. 3 in Fig. 7).

The numerical values corresponding to the different lines of the network are rarely indicated on the dials of al-Mansur. On dial 3, for example (Fig. 7), only Babylonian 3, 4 and 5 are identified. They are clearly wrong: they are lines 4, 5 and 6. Let us see how to find the correct values by identifying at least two lines (Fig. 6): the oblique lines closest to the right style (gnomon), which start just above (to the North), i.e. very close, and which are the 17 h Italian (or 7 h before sunset) and 7 h Babylonian lines. From here the other lines are easily identified; usually the dial shows the Italian 22 as the extreme right-hand line, while the Babylonian 2 is most often the first line on the left.

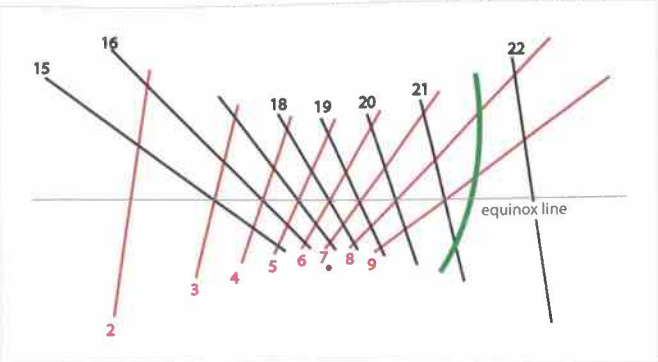

Fig. 6. A correct Italian-Babylonian network. In red the Babylonian lines and in black the Italian. We have added the correct position of the Asr indicator which is entirely included in the space of the Italian-Babylonian grid and intersects the Italian line for the 21st hour.

Most mosque dials indicate the Asr prayer. It takes place in the afternoon, so it should be located in the eastern part of the line: it is a curved arc. Fig. 8 illustrates the curved position of Asr superimposed on the grid of the Italian and Babylonian hours. When the tip of the shadow of the gnomon reaches this curve, it means that its length is equal to the sum of the height of the gnomon and the length of the shadow at noon;[27] it is therefore the beginning of the favourable period for the Asr prayer according to the tradition of the mainstream of Islam.

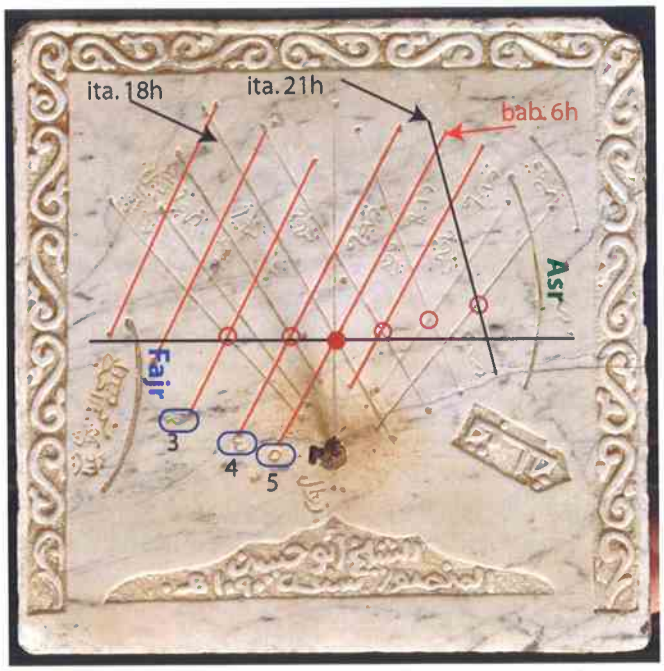

Fig. 7. On this dial by al-Mansur (No. 3 has been taken as the example), the Babylonian lines have been highlighted in red. They are almost parallel which is totally incorrect. Similarly, we have encircled the chaotic intersections of the Italian and Babylonian lines around the straight line of the equinoxes, although the latter line is not shown on the dial. We have labelled Babylonian hour 6, and Italian hours 18 and 21, and highlighted in blue boxes the labels 3, 4 and 5 for the Babylonian hour lines which are actually 4, 5 and 6. Note also that the Asr line does not intersect the Italian hour line 21. Moreover, the curved Fajr line on the left (probably intended to indicate dawn) is far too low (to the South) to be able to function throughout the year (see the explanation in the text).

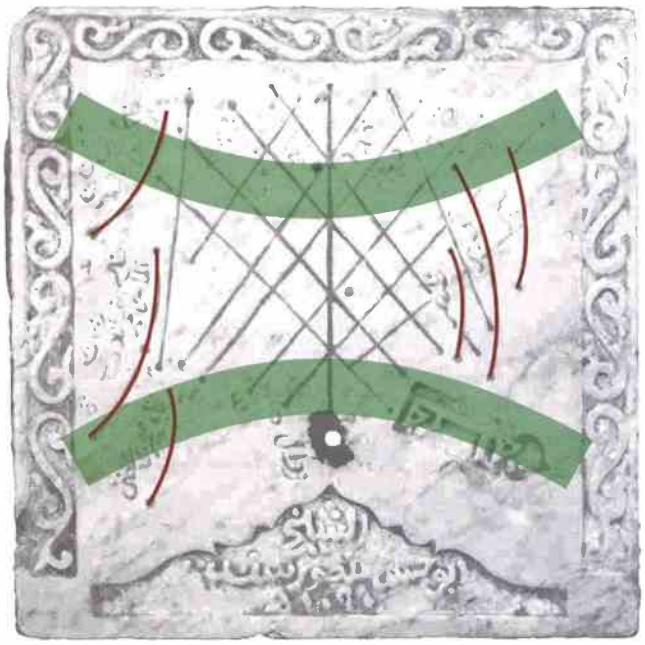

Fig. 8. Example (dial 10) of fanciful drawings of prayer curves which are not limited by the arcs of solstices (in green, positions evaluated from those of the gnomon and the Italian-Babylonian network).

In the area on Earth between the Tropic of Cancer and the parallel of latitude 38° (a portion which includes all of the Maghrib, Egypt, Syria, etc.), the curve of Asr always intersects the Italian line 21 h (or line 3 h before sunset) and always the Babylonian lines 8 h and 9 h, or even 10 h for latitudes which are closer to the Tropic of Cancer. However, it can be seen in Fig. 7 that the Asr curve does not intersect the 21 h Italian line. This curve can never go, in true solar time, below 14 h 27 m (21 h 44 m Italian and 7 h 08 m Babylonian) and beyond 15 h 54 m (20 h 35 m Italian and 11 h 14 m Babylonian) in the range of latitudes 24°–38°. Its curvature is, on a horizontal dial, necessarily turned towards the lower right edge of the dial (south-east direction).

Tables 3 and 4 allow us to determine, according to the latitude, where the two extremities of the Asr curve should be approximately situated in relation to the network of Italian and Babylonian lines. The latitude, the time of Asr in true solar time and the correspondence in Italian and Babylonian time are given successively. None of the dials of al-Mansur respect the indications of these tables.

In addition to the above indications (sunrise and sunset, Asr), one can find, on mosque dials, indications corresponding to other prayers. We will take as an example the Fajr prayer which corresponds to dawn (first light before sunrise). This moment cannot of course be indicated directly by a sundial, but Muslim diallists can indicate it by one or more curves shifted in time (typically 'Fajr' is 3 h, 4 h ...). Their curvature is necessarily South-East. As the vertices of these curves are limited to the two hyperbolas of the solstices (which are not necessarily drawn), it is thus impossible to have curves much shifted in height (see Fig. 8): the bottom of a curve cannot be at the level of the vertex of another one as on the dials studied here. It should be noted, however, that on some horizontal mosque dials of high scientific quality (e.g. the one in Fig. 9), one finds curves that are very much offset in height from each other, but this is due to the fact that the dial works with several straight styles (in Fig. 9: one gnomon for Asr and the

Lati-tude	Asr time (true time)	Asr time (Italian time)	Asr time (Babylonian time)
24°	15 h 18.8 m	20 h 34.2 m	10h 3.5 m
25°	15 h 21.7 m	20 h 34.9 m	10h 8.5 m
26°	15 h 24.6 m	20 h 35.6 m	10h 13.6 m
27°	15 h 27.4 m	20 h 36.2 m	10h 18.6 m
28°	15 h 30.1 m	20 h 36.6 m	10h 23.6 m
29°	15 h 32.8 m	20 h 37.0 m	10h 28.5 m
30°	15 h 35.3 m	20 h 37.2 m	10h 33.5 m
31°	15 h 37.9 m	20 h 37.3 m	10h 38.5 m
32°	15 h 40.4 m	20 h 37.3 m	10h 43.4 m
33°	15 h 42.8 m	20 h 37.2 m	10h 48.4 m
34°	15 h 45.2 m	20 h 37.0 m	10h 53.4 m
35°	15 h 47.5 m	20 h 36.6 m	10h 58.4 m
36°	15 h 49.9 m	20 h 36.2 m	11 h 3.5 m
37°	15 h 52.1 m	20 h 35.6 m	11 h 8.6 m
38°	15 h 54.4 m	20 h 34.9 m	11 h 13.8 m

Table 3. Time in true time, Italian and Babylonian of Asr at the summer solstice (low point of the Asr curve).

Lati-tude	Asr time (true time)	Asr time (Italian time)	Asr time (Babylonian time)
24°	14 h 59.5 m	21h 44.2 m	8h 14.9 m
25°	14 h 57.7 m	21h 44.5 m	8h 11.0 m
26°	14 h 55.9 m	21h 44.9 m	8h 6.9 m
27°	14 h 54.0 m	21h 45.2 m	8h 2.8 m
28°	14 h 52.0 m	21h 45.4 m	7h 58.5 m
29°	14 h 49.9 m	21h 45.7 m	7h 54.1 m
30°	14 h 47.8 m	21h 45.9 m	7h 49.6 m
31°	14 h 45.6 m	21h 46.1 m	7h 45.0 m
32°	14 h 43.3 m	21h 46.3 m	7h 40.2 m
33°	14 h 40.9 m	21h 46.5 m	7h 35.3 m
34°	14 h 38.5 m	21h 46.7 m	7h 30.3 m
35°	14 h 36.0 m	21h 46.9 m	7h 25.1 m
36°	14 h 33.3 m	21h 47.0 m	7h 19.7 m
37°	14 h 30.6 m	21h 47.1 m	7h 14.1 m
38°	14 h 27.8 m	21h 47.3 m	7h 8.4 m

Table 4. Time in true time, Italian and Babylonian of Asr at the winter solstice (high point of the Asr curve).

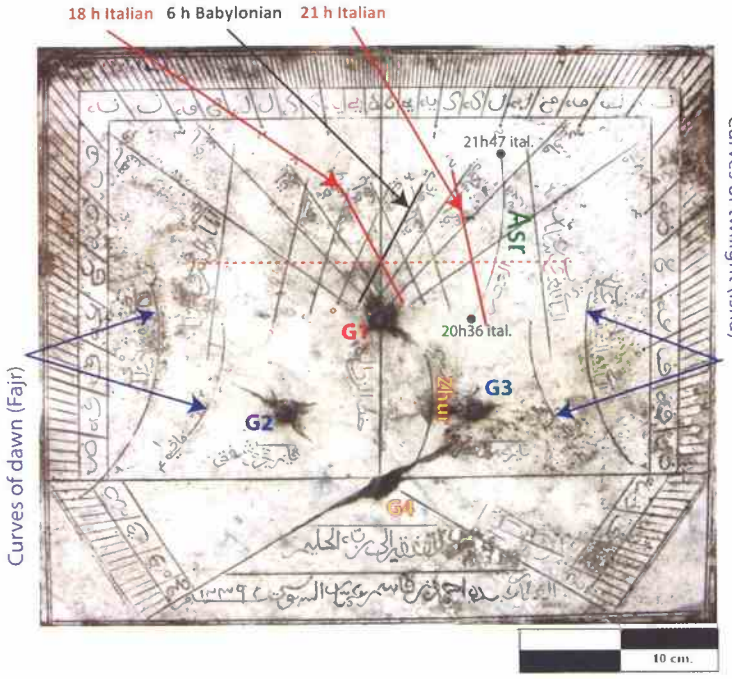

Fig. 9. This correct sundial, kept in the reserves of Sousse Ribat in Tunisia, dates from 1823/1824. It shows that the Asr curve intersects the Italian line at 21 h (or 3 h before sunset); similarly, the equinox line has been drawn in dotted lines where the Italian line at 18 h and the Babylonian line at 6 h intersect. The intersections of the other lines are perfectly aligned with the line of the equinoxes. As for the left and right side curves, they work with the right styles G2 and G3; and indicate the time elapsed since dawn (Fajr) or how long it takes for night twilight (Isha). At the two vertices of the Asr curve the correspondence in Italian time has been indicated. Furthermore, the time band is correctly calculated and corresponds to the latitude of Sousse.

Italian–Babylonian network (G1); one for the dawn (Fajr) curves (G2); one for the dusk (Isha) curves (G3); and finally one for the Zhur curve (G4)). The curve shifts observed on the dials of al-Mansur, which have only one gnomon, do not of course fit into this type of explanation.

Conclusions

The ten mosque dials studied in this article are all signed by the same diallist. Nine of these dials were offered for sale over a short period of time (13 years), while no other mosque dials were apparently sold during the same period. Furthermore, no sundial signed by this gnomonist is currently known to be in place in any mosque in the Arab-Muslim world. As mentioned above, this first observation poses a problem, especially as these dials present an epigraphy that is full of anomalies (association of historically incompatible spellings, and improbable date style).

Moreover, and this is probably the most significant fact, these dials are not at all functional and cannot fulfil their mission (indicating the civil time and the division of the day according to the Islamic prayers). While the mosque dials that are still in place, or preserved in museums, testify to the fact that their authors mastered the rules of gnomonics perfectly, particularly elaborate in the case of the indications of prayer times, we have here completely fanciful layouts. This concerns both the drawing of hour lines, when they exist, and the indications of periods favourable for Islamic prayers.

All these dials signed by the same craftsman, sold in Europe, in which anomalies and serious errors are accumulated, must be considered with the greatest circumspection. In fact, they can probably be qualified as 'fakes', like those astrolabes found in the 'souks' (covered markets) of the Arab world and which are unusable. There remains the problem of when these pseudo-sundials were made. Were they made for the first tourists at the end of the 19th century, and introduced at that time in Europe? Or were these objects made much more recently? Only analyses of the dials themselves, with, for example, studies on the metallurgy of the gnomons, or on the traces of engraving could give us this information.

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23. The *Hijra* era counts from the date of Muhammad's departure (*Hijra* = migration), from Mecca to Medina on 16 July 622 which thus became 1 Muharram *Hijra* year 1 in the Muslim lunar calendar.
24. The same anomaly appears on an inscription on a funerary piece that was seized by the Tunisian security services a few years ago, which turned out to be a fake archaeological piece.
25. The translation of the whole verse is as follows (translation: Muhammad Asad): "They will ask thee about the new moons. Say: 'They indicate the periods for [various doings of] mankind, including the pilgrimage.' However, piety does not consist in your entering houses from the rear, [as it were,] but truly pious is he who is conscious of God. Hence, enter houses through their doors, and remain conscious of God, so that you might attain to a happy state" (2:189).
26. A drej corresponds to the time it takes the Sun to travel one degree in the sky during the day, or 4 minutes: (24 h × 60 min) / 360° = 4 min.
27. Savoie, *Recherches...*, n.7, pp. 79-117.

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POSTSCRIPT

Since the above study was completed an eleventh dial has been found in a private collection (pictured below). This example has not yet been examined.

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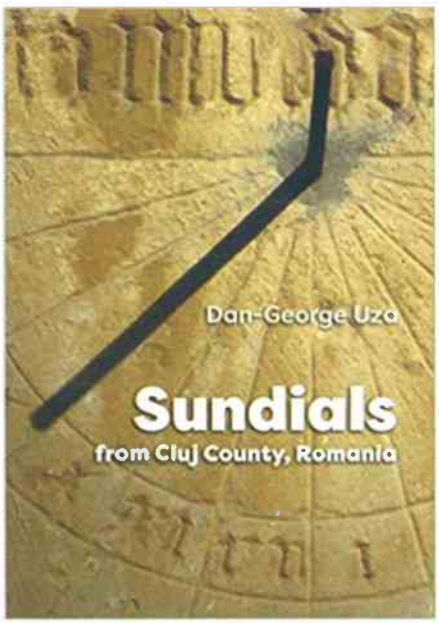
NEW BOOKS (1)

Sundials from Cluj County, Romania by Dan-George Uza, 2020. 69 pp., A5, soft covers, illustrated in colour. ISBN 978-9-730-328783. Price €10 (p&p incl.) from the author with Paypal: *uza@upcnet.ro*



This is the second book Dan-George Uza has written; both books are inventories of sundials.

The first one, *Cadrane Solare*, with text in Romanian and published in 2014, ISBN 978-9-730-176988, is also available direct from the author. It is a nice little book covering quite a large region, the North West part of Romania. Each sundial has a colour picture and a description; latitude and longitude are given. The small size of the book (15 × 15 cm) makes it the perfect companion for dial hunting in Romania.

In this second book, which is published in English, Dan Uza covers a smaller region of Romania: the Cluj County where he was born. Each sundial has a QR code, colour picture and description. So again if you travel in Romania, this small book is a must-have for a sundial lover.

Francis Tamarit