

# The British Sundial Society

## BULLETIN

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June 2012

# Historical Note: The First International Conference on Sundials

## Towards a History of the Sun-dial 22-24 May 1985, Vicenza and Brugine, Italy

22 May

10:15 A.J. Turner: 'Sun-dials, History and Classification'.

11:30 E. Büchner: 'Recent Archaeological Discoveries in Gnomonics'.

p.m. Visits to (a) the special exhibition of sundials and dialling literature at the Biblioteca Bertoliani, and (b) the ancient Roman sun-dials at the Museo Archaeologico, Aquileia.

23 May

10:00 J. Field & M. Wright: 'A Byzantine sun-dial and geared calendar recently acquired by the Science Museum, London'.

11:15 A. Aveni: 'Meso-American sun-dials'.

11:30 J.-P. Verdet: 'Les cadrans solaires Indiennes'.

14:00 B. Goldstein: 'The sun-dial of Ahaz in the Bible and subsequent interpretation'.

15:00 J.D. North: 'The human sundial in Chaucer'.

16:00 C. Maccagni: 'Sun-dials from the Volpia family of instrument-makers'.

24 May

09:30 T.E. Settle: 'Ignatio Dante's Santa Maria Novella gnomons'.

10:15 G. Tabarroni: 'La Meridiana di Gian Domenico Cassini in San Pietronio a Bologna'.

11:00 D. Vaughan: 'Horizontal quadrant sun-dials of Humphrey Cole'.

11:15 A.R. Somerville: 'Scottish polyhedral dials; a problem of origins and diffusion'.

14:00 M. Archinard: 'Construction geometrique des cadrans solaires de direction'.

14:45 B. Chandler: 'Dialling, perspective and projective geometry'.

15:30 F. Maddison: 'Complementing sun-dials: the nocturnal'.

Many of the names on this list will be familiar to BSS members though unfortunately some are no longer with us. The conference, which predated the foundation of the Society by four years, was a small private one for invited attendees only. There were no published proceedings, which is a shame. The topics discussed are still of interest today—perhaps it is time for a re-run?

**Front cover:** The vertical 'great decliner' on Redesdale (Market) Hall at Moreton in Marsh, as seen on the BSS Conference tour of the Cotswolds. The dial (SRN 0933) declines by around 83° to the East—as the tour was in the afternoon, there is no shadow visible. The Hall was erected in 1887 by the 1<sup>st</sup> Baron Redesdale, grandfather to the Mitford sisters. The dial is almost certainly contemporary with the Hall and carved from the same warm local stone. The picture to the right shows our Chairman and Secretary taking a last admiring look at the dial as other members of the tour party head for the coach.  
Photos: Chris Lusby Taylor & John Davis.



**Back cover:** A near-replica of the Hever Castle 'Roman' scaphe sundial (see the article in the March 2012 Bulletin). It was made for David Brown Sundials by Tim O'Regan, a stonemasonry student at Weymouth College. The picture shows it incomplete, with the hour and seasonal lines roughly pencilled in, as it was displayed at the Cheltenham Conference. See page 44 of this issue for an article by Jérôme Bonnin on another replica Roman dial.  
Photo: John Davis.

# BULLETIN

## OF THE BRITISH SUNDIAL SOCIETY

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### EDITORIAL

The recent Membership Survey included a question about the *Bulletin*. The Secretary has extracted responses to this for me (preserving anonymity) and I have read through carefully to see where improvements might be made—I am grateful to everyone who replied. It seems that the general view is quite positive so we will need to be careful not to make changes in response to one input which might upset a number of 'silent' people who like things as they are! For example, one reader would prefer not to have photographs on the covers but my understanding, having listened to a number of members, is that this is a well-liked feature.

In some areas the comments are mutually contradictory, such as readers wanting either more or fewer articles on foreign dials—a signal for me to keep the ratio about the same! Similarly, the readers who thought the overall tone was too technical or formal were balanced by an equal number who clearly wanted to maintain at least some scholarly input and not 'dumb-down' the journal.

One area where there was a consensus of several readers was the wish for more design and construction articles.

This I am happy to try to comply with and I have already approached several makers of interesting dials to tell us how it was done. Craftsmen (and women!) are usually at their happiest when making something but I hope I can drag them from their workshops for long enough to write an article for us—watch this space!

Other ideas which were proposed were a beginners' series, some 'sundial trails', inputs from the *Register* and the *Recorder*, and more book reviews and readers' letters. If these strike a chord with you, please let me know and I'll see if something can be arranged. As always, the limitation is what authors are prepared to produce and this is why not all papers from our conferences appear here. But I do try!

An area where there is ongoing debate is a desire in some quarters for a digital version of the *Bulletin*. This is technically feasible and will surely come, especially with increasing postal costs. The trick, though, will be to do it without making the printed version, which many members like, financially unviable due to a reduced print-run affecting the economies of scale.

# GAOCHENG CALENDRIAL OBSERVATORY, CHINA

ALLAN MILLS

## INTRODUCTION

Every culture has a need to keep track of the time of year, as well as the time of day. Thus, a settled farming existence demands knowledge of when to plant crops, and in any given area experience teaches the optimum interval that should be allowed to elapse following a natural event such as the Winter Solstice. For agricultural purposes a comparatively rough technique involving monitoring the length of the shadow thrown by a vertical stick is adequate: pegs are placed in the ground to mark the tip of its daily noon shadow, and when a lengthening shadow pauses before retreating once again the solstice has passed. A well-known historical photograph<sup>1</sup> shows Dyaks doing this in Borneo in 1908.

## Religious Applications

A more sophisticated determination is required in connection with Easter Sunday. The Roman Catholic Church defined that day (marking the beginning of its calendar and commemorating the resurrection of Christ) as the first Sunday following the first full moon following the vernal equinox. But determination of the equinoxes requires bisection of the angle subtended between the winter and summer solstices – and is *not* halfway along a horizontal line joining these positions of a noon shadow. Solution requires either trigonometry or an accurate angle-measuring instrument, and can hardly be left to the average parish priest! To notify their flock well in advance, bishops needed predictions of dates of future Easter Sundays, in turn requiring accurate data defining the motion of the Earth in its elliptical orbit around the Sun. This was obtained from special noon marks involving projection of the solar image by apertures fixed high up in large, darkened buildings. Their own churches were both large and available, so we find ‘meridians’ installed in a number of Italian and French cathedrals.<sup>2,3</sup>

### GAOCHENG CALENDRIAL OBSERVATORY

Latitude: 34° 23' 52" N

Longitude: 113° 08' 44" E

Elevation: 253 metres above mean sea level.

Geographic position: Northern outskirts of Gaocheng town, 12 km SE of Dengfeng city, Henan Province, China.

Built: 1276 AD by the Chinese astronomer and engineer Guo Shoujing

## Divination

Another endeavour that demanded accurate measurements and forecasting of the positions of sun, moon and planets relative to the stars was divination and prophecy. Medieval Chinese culture put great faith in heavenly portents relating to affairs of state, so a continuous quantitative watch on the heavens was considered vital. Stars, moon and planets were studied at night at ‘all sky’ observatories, but keeping accurate track of the motion of the sun – and the associated solar/lunar calendar – was initially the purpose of dedicated gnomons.



Fig. 1. Inscribed stele at Gaocheng, erected 723 AD.

## THE MOUNT SONG HISTORICAL SITE

This area was once regarded as the ‘centre of the Earth’, meaning that its geographic coordinates gave a numerologically significant ratio of solstitial shadow lengths.<sup>4</sup>

## Tang Dynasty

The astronomer Yixing of the Tang dynasty (618 – 960 AD) arranged that 20 standardized steles be erected across China for surveying and calendrical purposes. One of these was situated at Gaocheng (Fig. 1) being set up in 723 AD by the central government official Nangong Yue. Its height of 8 *chi* was such that, at noon on the summer solstice, the shadow of its apex fell just within the perimeter of the base. (The contemporary Chinese unit of length, the *chi*, was equal to 24.4 cm.)

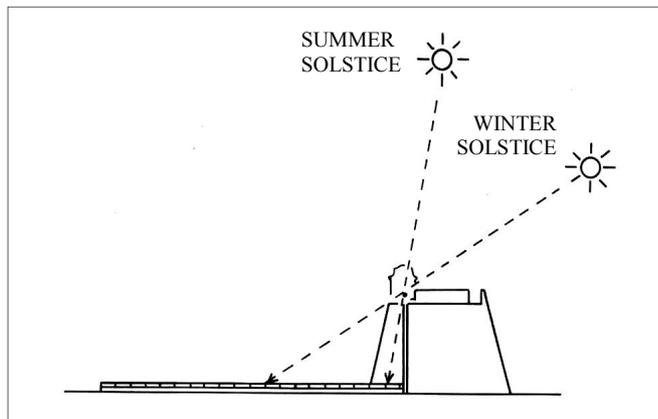
## Yuan Dynasty

A need for still greater accuracy must have been felt, for in 1276 Kublai Khan ordered a great calendrical observatory of novel design built to the plan of his distinguished



Fig. 2. Guo Shoujing, 1231-1314 AD. (Probably an imaginary likeness.)

Fig. 5. Principle of the Gaocheng calendrical observatory.



astronomer Guo Shoujing (Fig. 2). Known as the *Tall Gnomon*, an auspicious site for it was found near the existing gnomon and astronomical complex in Gaocheng. The structure still exists, and although rather remote (no rail link runs there) is becoming better known to the Western world. The Chinese authorities have included it along with other places of archaeological interest to form the Mount Song Historical Complex, and have applied for World Heritage classification.<sup>5</sup>

### The Gaocheng Calendrical Observatory

In accordance with China's appreciation of its scientific and technological heritage, the Tall Gnomon has been restored and now appears as shown in Figs. 3 & 4. We recognize a monumental noon mark in the shape of a truncated brick pyramid, with the shadow thrown by an elevated horizontal gnomon falling upon a masonry platform running north-south. The principle is similar to the cathedral meridians, and is diagrammed in Fig. 5. It will be apparent that the noon shadow falls nearest to the tower end of the scale at the summer solstice and will be at its longest and most distant on the day of the winter solstice.

Fig. 4 (right). The 'shadow-receiving scale'. Present-day (conserved) condition.

Fig. 3 (below). Gaocheng calendrical observatory in its present (conserved) condition.



However, this simple story glosses over many complex questions, some of which can only be partially answered at the present time. The centre of Chinese power migrated away from the region as new dynasties came and went, and the observatories were abandoned and neglected. Revival of interest in the West owes much to the work of Joseph Needham, who wrote and edited a massive multi-volume work entitled *Science and Civilisation in China*.<sup>6</sup> Volume III mentions the Gaocheng Observatory – but only in a couple of pages, along with monochrome photographs such as those reproduced in Figs. 6 & 7 (over-page). When these were taken (1944?) the horizontal metal gnomon had disappeared, the eastern staircase had collapsed, the shadow track had settled unevenly, and the land around was being used for cultivation. Restoration was begun in 1975.

Visits from 1981 onwards by archaeoastronomer E.C. Krupp of the Griffith Observatory, with subsequent publication in the well-known journal *Sky and Telescope*,<sup>7</sup> helped draw further attention to this important site.

### REFINEMENTS

A long shadow should result in greater sensitivity and accuracy, and is the prime reason for large structures of this type. However, a large size brings certain penalties, which





Fig. 6. The structure in the 1920s.

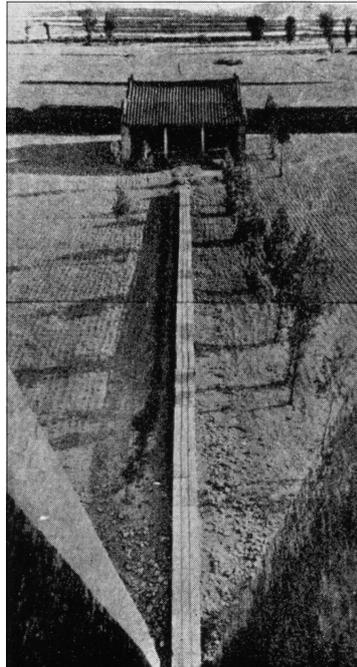


Fig. 7. View along the scale in the 1920s.

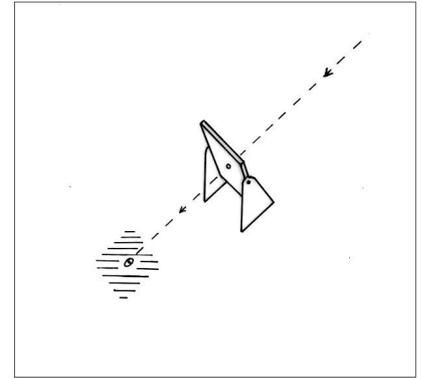


Fig. 8. Principle of the 'shadow-definer'.

must be overcome if the expected accuracy is really to be achieved.

### The 'shadow-definer'

A fundamental difficulty with large sundials and noon marks is that the finite diameter of the Sun's disc (about  $\frac{1}{2}^\circ$ ) causes shadows to be less than razor sharp.<sup>8</sup> This becomes ever more serious with increasing length of shadow, and may negate the very reason for which they were constructed. The Chinese knew how to overcome the problem with a *ying-fu*<sup>4</sup> or 'shadow definer', and we may be confident that it was invented before the expensive Gaocheng structure was begun. Nevertheless, this simple aid does not appear to have been known to the makers and users of the cathedral meridians in Europe.

Needham<sup>6</sup> quotes Maspero<sup>9</sup> for a translated account of the device:

"The shadow definer is made of a leaf of copper 2 inches wide and 4 inches long, in the middle of which is pierced a pin-hole. It has a square supporting framework, and is mounted on a pivot so that it can be turned at any angle, such as high to the north and low to the south (i.e. at right angles to the incident shadow-edge). The instrument is moved back and forth until it reaches the middle of the (shadow of the) gnomon, which is not too well-defined, and when the pin-hole is first seen to meet the light one receives an image no bigger than a grain of rice in which the gnomon can be noted indistinctly in the middle. With this method one can obtain the silhouette of the horizontal gnomon projected upon the centre of the solar disc without any error."

The 'shadow-definer' is, then, simply a pinhole in a thin opaque sheet mounted in a tiltable frame (Fig. 8). The sheet provides a shadowed area within which the pinhole lens casts an elliptical image of the Sun. A pinhole has no definite focal length, so adjustment of the frame and its holder will superimpose a silhouette of the horizontal gnomon across the image of the solar disc. Edges or centre may be chosen, and an instantaneous distance recorded as the extreme excursion of the shadow. I have confirmed experimentally that the device works well.

### The Gnomon

This is situated between two chambers at the top of the tower, with a tiled roof giving further protection from the elements (Fig. 9). It consists of a bronze bar about 3 inches in diameter, with a closed channel for water at the top to ensure that it is installed horizontally (Fig. 10). It is supported between vees in the shape of gaping dragon's jaws.<sup>4</sup> A pointed plumb-bob hung from the centre of this bar defines the zero of the scale, and records show the gnomon to have been elevated 40 *chi* (9.75 m) perpendicularly above it. (i.e. 5× the height of the earlier stele exemplified in Fig. 1). This end of the scale is shown in Fig. 11.

A broad terrace to the south of the tower may be glimpsed in Fig. 3, and will be considered further in a subsequent section.

### Orientation

The Gaocheng Observatory – just like other sundials and noon marks – required accurate alignment along a N-S axis or meridian.



Fig. 9. Two chambers and a roof protect the elevated gnomon.



Fig. 10. Horizontal bronze gnomon, showing levelling trough.

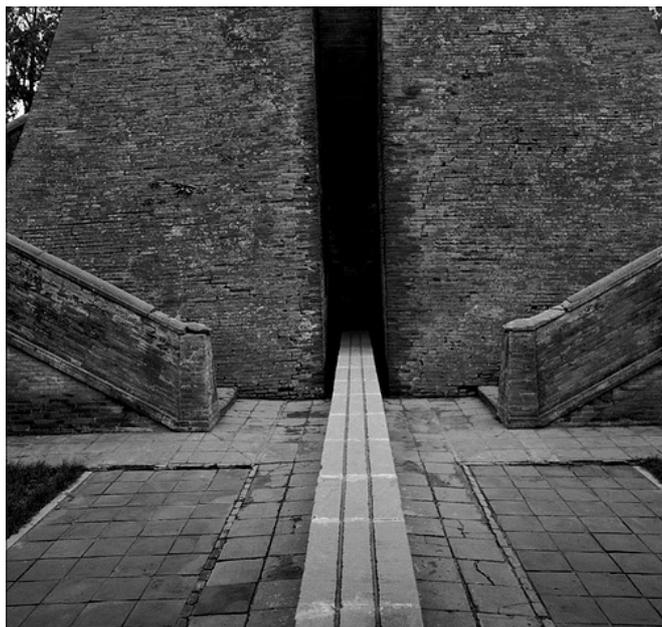


Fig. 11. Southern end of scale, where a plumb-line dropped from the gnomon defined the zero.

### Magnetic Compass

The Chinese invented the magnetic compass and used it for navigation. But changing variation, as well as nearby unsuspected ferrous objects, render the instrument treacherous for determining the direction of geographic north. Even as late as 1636 two experienced scientists using a compass set the Marseilles meridian  $3^\circ$  in error!<sup>10</sup>

### The Pole Star

*Polaris* is currently about 44 arcminutes from the Northern Celestial Pole (NCP), so even sighting directly upon it should nowadays align the polar axis of a sundial to better than  $1^\circ$ . However, the apparent displacement varies with time due to precession – the slow ‘wobble’ of the Earth’s spin axis about the ecliptic pole. This motion appears to make one turn in 25,700 years, so in the 13<sup>th</sup> century *Polaris* would have been about  $10^\circ$  from the NCP. Early astronomers therefore did not use it in quantitative work: only travellers employed this star as a rough guide to the north. An error of only  $0.1^\circ$  would put the end of a 31.2 metre scale more than 5 cm from its true position, so some precise method of alignment was sought.

### Horizontal and Vertical Gnomons

Imagine wooden (bamboo?) tripods constructed to be two *chi* high. One (I) supports a rigid horizontal rod, the other (II) a plumb-bob hanging by a linen thread. A pointed plummet facilitates centring over the approximate meridian found as above, with marking of a temporary zero, following which the weight is immersed in a pot of water to damp unwanted oscillations.

We now have two shadow-casting gnomons:

- I: Horizontal bar. The solar altitude monitor, or *noon detector*. This casts a shadow at right angles to a scale, with its distance from the support end slowly decreasing. At *local noon* this shadow pauses before moving in the opposite direction. The ‘shadow catcher’ above should be used by the assistant in charge.
- II: Vertical string. The azimuth gnomon or *north detector*. The tripod is placed astride the temporary meridian and watch kept on the shadow of the string, aided by another ‘shadow catcher’. When noon is called from I a mark is made, and a better meridian set out. The procedure may be reiterated at subsequent noons until the best possible meridian, and the length of the noon shadow upon it, have been defined. An accuracy of a minute of arc should be possible.

The direction of the meridian could then be pegged-out on the ground. The length of the noon shadow at the winter solstice thrown by a scale model would enable the maximum length of the scale to be easily found by proportion, for medieval Chinese astronomers and mathematicians do not appear to have been familiar with (Arab) trigonometry.<sup>4</sup> Higher temporary gnomons could be arranged on the rising tower as building proceeded. It would be interesting to check the alignment of the current meridian – see below.

### The Meridian Bench and Scale – and an anomaly

The illustrations given above clearly show a long masonry bench (*Shigui* or ‘sky measuring scale’) arranged along the meridian to the north of the elevated gnomon. That it is truly horizontal in both N-S and E-W planes was achieved by building-in water troughs on both sides of the central scale. These channels may be seen in Figs. 4, 7 & 11. They would only have been filled during construction, and at later tests.

Needham<sup>6</sup> gives the dimensions of this bench as 0.53 metres wide by 31.2 metres (128 *chi*) long, as do more modern authors.<sup>4</sup> Yet an elevation of the horizontal gnomon of 9.7 metres, and a (modern) latitude of  $34^\circ 24'$ , give a calculated maximum length of the noon shadow at the winter solstice of 15.55 metres (69 *chi*). This is only one half the constructed length of the bench. A prudent designer would certainly allow some extra working space, but this appears excessive! It would accommodate the noon Sun at the winter solstice at a latitude of  $50^\circ$  N, which corresponds with the present-day border between Mongolia and Siberia. Perhaps the design of the *Tall Gnomon* began as an instrument

that would serve all sites within China, from the northern boundary to the South China Sea.

## RESULTS

### Definition of the Solstices and Equinoxes

The Earth moves around the Sun in an ellipse, the plane of which defines the *ecliptic*.<sup>13</sup> The Earth itself revolves on its axis once a day, and this spin axis is inclined to the ecliptic by  $23^{\circ} 27'$ . The prolongation of the Earth's equator into space gives the *celestial equator*, so this plane is inclined to the ecliptic by the same angle. Where the two planes cross we have equal day and night: that at the ascending node is called the *vernal equinox* and acts as the zero point for many celestial measurements. Opposite is the *autumnal equinox*. The maximum separation between the two planes – and so the greatest positive or negative elevation of the Sun – is achieved at these two *solstices*. Literally the 'standing still of the Sun', the word comes from the very slow daily change of elevation of the Sun around the *summer* and *winter solstices*.

It will be appreciated that these points are literally instants in both space and time, and are nowadays measured and quoted in terms of Greenwich Mean Time and the Greenwich meridian. The 'day of the vernal equinox' is taken to be the 24-hour period containing the true equinox, but some locations may be close enough to the Date Line for the actual celestial event to occur on the previous calendar day! Fortunately, the great majority of the human race neither know nor care, and nowadays accept the dates laid down by authorities as:

Vernal equinox	20 March
Summer solstice	21 June
Autumnal equinox	23 September
Winter solstice	22 December

Easter Sunday could in some locations be a day earlier or later than computed from the celestial vernal equinox for that location.

### The Tropical Year

This is defined as the period between successive vernal equinoxes. Nowadays it may be defined in seconds, these units in turn being defined from a certain number of oscillations of caesium 133 atoms. There is no reason why there should be an integral number of days or 'moonths' in the tropical year – and there are not! Hence the complexity of the calendar, and the valiant efforts made by successive astronomers of all cultures to keep track of their various calendars.

It will also be clear that there is no reason why an equinox or solstice should coincide with noon at a given locality – and again they do not! Half the time the true instant occurs at night! The distance measuring the solar altitude at local noon will vary from one winter solstice to the next, and very rarely approach the maximum distance given by coincident noon and winter solstice. So what to do?

The best solution would appear to be to measure the noon distance *every clear day*, and then plot a graph of observed distance versus date. For (say) ten days either side of the solstice the points should be symmetrical enough for:

- The best-fitting curve to be drawn.
- Its maximum estimated.
- Corresponding time and distance read from the appropriate scales.

Unfortunately, graphical methods of this nature were unknown in 13<sup>th</sup> century China.<sup>4</sup> Gao Shoujing and his colleagues therefore evolved a clever method of successive fractional interpolations. If you want to see it you must refer to Sivin's book<sup>4</sup> or a 2001 thesis by Ng Say Tiung.<sup>14</sup> It was very successful, for these medieval Chinese scholars obtained a value for the tropical year of  $365^{\text{d}} 05^{\text{h}} 49^{\text{m}} 20^{\text{s}}$  (365.2425 days). Our (2000 AD) value is  $365^{\text{d}} 05^{\text{h}} 48^{\text{m}} 45^{\text{s}}$ . Allowing for precession, the Chinese value is only  $32^{\text{s}}$  too long, and centuries had to pass before Europeans could do as well.<sup>15</sup> The angle between the maximum and minimum true solstice points gives twice the obliquity of the ecliptic.

The direct contribution of the Gaocheng Observatory to these measurements is uncertain, for surviving records suggest Beijing Observatory as the main source of data.<sup>16</sup>

### Leap Years

It can be seen that the tropical year is close to 365.25 days, which is compensated by our leap year system of adding a day every 4 years. However, the exact duration of the year is slightly *less* than 365.25 days, so the rule states that years that are evenly divisible by 100 are *not* leap years, unless they are also evenly divisible by 400, in which case they *are* leap years.<sup>17</sup> The Chinese calendar is luni/solar, so is even more complex. It can be seen why so much effort and expense was devoted to calendrical observations.<sup>4,18</sup>

### Lunar and Planetary Positions

Measurement of the projected shadow of a gnomon is only practicable with the Sun: the intensities of the Moon and planets are far too low. Yet the Chinese calendar and astrology required positions, and forecasts of positions, for these bodies.

We have seen that Gaocheng Observatory is provided with easy access to the top of the tower, where two roofed chambers and a projecting terrace are situated. Interference with the gnomon would certainly be discouraged, and the roof makes observation of the stars overhead and towards the north difficult. These southerly viewing areas were for the study of the Moon and planets as they moved along the zodiac against the background of certain stellar constellations. Accurate measurements of position and time would be required.

To record position in the celestial sphere, Chinese astronomers of the period employed what is now familiar to modern astronomers as the equatorial system. One angular coordinate is measured around a plane parallel to the



Fig. 12. 15<sup>th</sup> century replica of Guo Shoujing's 'simplified instrument', now installed in the grounds of the modern Purple Mountain Astronomical Observatory.

Earth's equator (the celestial equator), the other at right angles to this plane. These directions are now known as *right ascension* and *declination* respectively, and share a common origin (0°) at the crossing point of the vernal equinox. To accomplish these measurements, Guo Shoujing designed an equatorial mounting of a long sighting beam, where an inclined polar axis carried graduated circles of large diameter. These circles are present in the armillary sphere, but for simplicity he omitted the ecliptic system and to facilitate access he physically separated the graduated circles. He therefore called his measuring apparatus the *simplified instrument*. A fifteenth century copy of the instrument is now mounted at China's modern observatory complex at Purple Mountain (Fig. 12). The method of use is discussed by Needham<sup>6</sup> (who rather confusingly refers to it as a torquetum), Sivin<sup>4</sup> and Temple<sup>19</sup>.

Timing is more problematic, for the temperature fluctuations associated with such a position are not conducive to the accuracy of the water clock specified by the records, due to changes in viscosity. A chamber within the massive supporting structure would be much superior, but there does not appear to be any trace or record of such a room. Perhaps time was (additionally?) measured astronomically, for example with the above instrument monitoring the apparent rotation of *Polaris* around the true celestial pole, or with a nocturnal looking at the *Pointers*. Small windows may indeed be seen in the northern wall.

### ACKNOWLEDGEMENTS

I am grateful to Professor Nathan Sivin for suggesting a number of scholarly improvements.

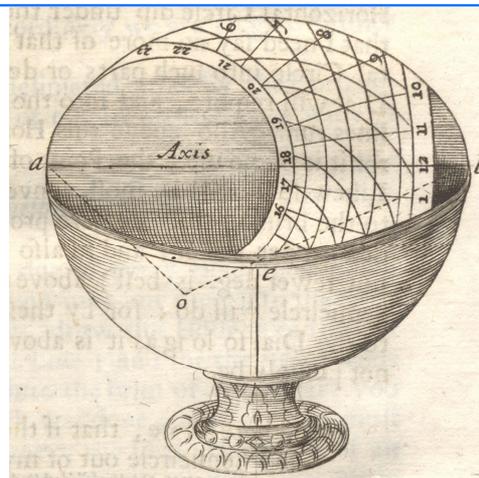
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For a biography and portrait of the author, see *Bulletin* **23**(iii), September 2011.



A scaphe dial from Leybourne's *Dialling*, showing a variety of equal hours.

# SAMUEL SAUNDERS

## A Study of a London Sundial Maker - Part 2

MACIEJ LOSE

### Nordiska Museum Ring Dial (RD1)

The equinoctial ring dial from the collection of Nordiska Museum in Stockholm (Fig. 6, left) is signed “S. Saunders Londini Fecit”, the form that by itself suggests Samuel Saunders I to be the maker of the dial. This is further supported by a number of features:

- font detail of the capital letters ‘S’, with its arc-shaped decorative serifs, a feature that is present on the horizontal sundial in Segovia (HD3),
- reduced *fleur-de-lys* marks in the form of three inward-directed arrows, which follow the half hour marks in the Spanish horizontal dial’s inner time ring,
- script style of Roman numerals, matching exactly the one used on all previously discussed horizontal dials.

The dates of the summer and winter solstices, read from the label of the central bar, indicate that the dial was made for the Julian calendar, and can be dated before 1752, when the Gregorian calendar was officially adopted in England.



Fig. 6. Equinoctial sundial (RD1) from the collection of the Nordiska Museum, Stockholm on the left, and the central bridge of the ring dial from the NMS (RD2) on the right. Size of dial’s images proportional to scale. Both dials share  $0.5^\circ$  latitude scale and the same engraving style of the months’ initials. The comparison of the engraving styles of the numerals, as well shape and details of central bridges, points to the Nordiska Museum dial as the earlier one, probably from the beginning of Saunders’ career. Photos: Stockholm Nordiska Museum (left) and National Museum of Scotland (right).

It is also worth noticing that another *fleur-de-lys* -like mark, resembling a grass wisp, is engraved on the bracket of the dial (Fig. 6), which also marks  $5^\circ$  intervals on the meridian ring’s latitude scale (the side not visible in Fig. 6).

### Butterfield Dial (BD)

Let us make here a little side jump to another interesting dial, of Butterfield type. The instrument was auctioned by Bonhams in 2009 and is currently in the private collection of an established researcher. The dial (Fig. 7) is made of brass in an oval shape, measuring a respectable  $95 \times 72$  mm. It is fitted within a restored, quite worn mahogany case, which may be original.

It is engraved with three time scales, the two inner with Arabic numerals for latitudes of  $41^\circ$  and  $48^\circ$  and the outer, main one with Roman numerals, for latitude  $51^\circ 32'$ . The specific latitude implies that the dial was not a standard line production, but a custom made, nobility commission for a London citizen.

Both the numerals on the dial and the description of the directions within the oversized compass, decorated with a complex rose, are inward facing – which is in line with the

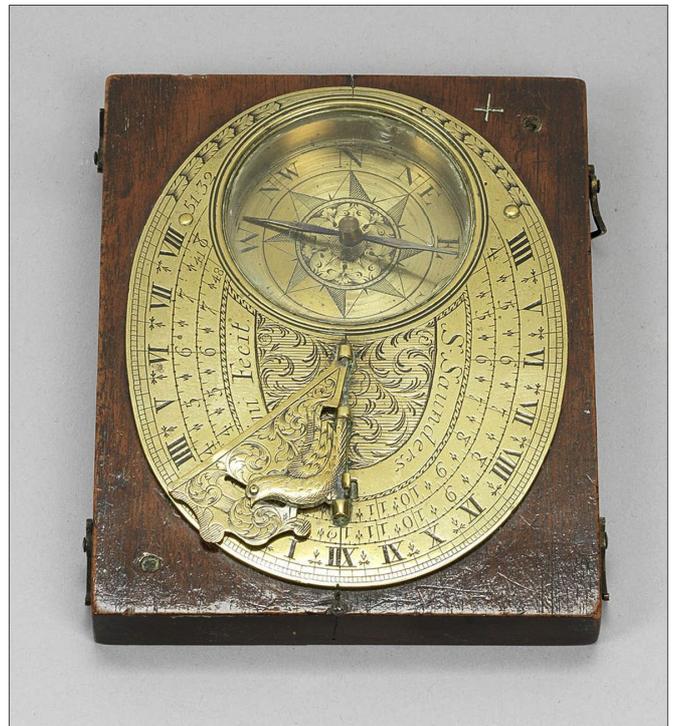


Fig. 7. Butterfield sundial (BD). Notice the two types of *fleur-de-lys* marks that are typical for Saunders’ portable instruments. Photo courtesy of Bonhams.

French Butterfield dials, but interestingly contrary to those made by Rowley. The back of the dial does not have an engraved list of locations with their latitudes, as is typical for French dials.

The central, decoratively engraved area of the dial on both sides of the gnomon foot is surrounded by a signature “S. Saunders Londini Fecit.” The serifs of all the ‘S’s exactly copy the detail of the Segovia horizontal dial; the same is true for the *fleur-de-lys* marks of the main hour ring, engraved in the form of inward-directed arrows. The *fleur-de-lys* of the inner hour rings duplicate the ‘grass wisp’ shape known from the bracket and meridian ring of Nordiska Museum ring dial (RD1).

Compared with previous instruments attributed to Samuel Saunders I, an interesting development of the engraving style of the Arabic ‘8’ can be noted, evolved from double ovals to a pattern typical for Parisian Butterfield dials.

### National Museum of Scotland Ring Dial (RD2)

The second Saunders signed equinoctial ring dial is in the collection of the National Museum of Scotland in Edinburgh (Fig. 6, right). The inventory description dates it ca. 1760, and attributes it presumably to Samuel Saunders II, compass-maker to the Admiralty at London’s Deptford Dock.

The dial has a different system of latitude adjustment compared to that of Nordiska Museum dial (RD1). The latter has a screwed suspension rim within which the meridian ring rotates, while the NMS dial’s bracket moves in the grooved rim of the meridian ring.

The dates of the solstices engraved on the central bridge are for the Julian calendar, dating it to before 1752.

The signature “S. Saunders London Fecit” includes characteristics for Saunders I details of the letter “S”. However, the use of “London Fecit” instead of “Londini fecit” may imply a later date. Details of the Arabic numerals and *fleur-de-lys* marks follow closely those of the Butterfield dial (BD). The signature includes also a tail-like, decorative stroke at the end of a word “Fecit\_”, present on the other instruments firmly attributed to Saunders I (see Table 1 in Part 1).

### RD3 Ring Dial

The third identified Saunders equinoctial ring dial was listed by Christies in 1994 and today only a brief un-illustrated description from the auction catalogue is available. The dial was incomplete – it lacked its bridge. The recorded signature “S. Saunders Londini Fecit” and a diameter of 152.5 mm – similar to the Nordiska Museum dial (RD1) – suggest Samuel Saunders I as the maker.

### Chinese Palace Museum Plane Table (PT)

The plane table (Fig. 8) from the collection of Chinese Palace Museum in Beijing includes an azimuth dial and is, along with the Segovian horizontal dial, worthy of further



Fig. 8. Plane table (PT) from the collection of the Beijing Palace Museum. Top view and detail of the signature, Arabic numerals and fleur-de-lys marks. Photo courtesy of the Beijing Palace Museum.

study by experts. The provenance of this instrument in Beijing Museum is interesting in itself – maybe it made its way far east as a commission from the East India Company?

The plane table, complete with tripod stand and dial with vertical sights, includes: 32-point compass, an azimuth sundial, and an azimuth scale as well as other surveying scales along its perimeter. The form of maker’s signature on the instrument: “S. Saunders LONDINI Fecit” and distinctive ‘S’ and ‘t’ letters are characteristic for Saunders I. Also, the Arabic numerals match his standard script style. The *fleur-de-lys* follow the ‘grass wisp’ like shape known from the ring (RD1) and Butterfield dials (BD).

### Other Instruments

Other recorded instruments signed by Saunders include: two drawing instrument sets (IS1, IS2), a circumferentor (CF), a sector (SC) and a mariner’s compass (MC). Illustrated documentation was obtained only for one of the instruments sets (currently in a private collection) and a circumferentor offered at Bonham’s sale in 2009.

The shagreen cased and gilt decorated instrument set (IS1) is a craftsmanship masterpiece containing various silver,

ivory and steel instruments. It was presented at the exhibition *Compass and Rule: Architecture as Mathematical Practice in England, 1500–1750* by the Oxford Museum of the History of Science and Yale Center for British Art in 2009.<sup>9</sup> The importance for this study is the fact that it includes two signatures – one on the rule and the other on the inner side of the case cover (see Fig. 9).



Fig. 9. Samuel Saunders' signatures on selected instruments. The instruments are identified according to the first column of Table 1. Notice the characteristic flourishes of letters 'S' and 't', as well as the double 'll' on HD2 and HD3 dials.

The rule's short signature "S. Saunders Fecit" features capital letters 'S' with its arc-shaped serifs and 't' with decorative stroke. Both features, coupled with style of Arabic numerals already known from the previous instruments, indicate Samuel Saunders I to be the maker. But most interesting is the floral script of the second signature "S. Saunders Londini Fecit" on the inner side of the case. This fancy script has no analogies in previously discussed instruments. The presence of two different signature styles on one instrument gives an important clue to the researcher that dating instruments based on script differences only may not be suitable for this maker.

The circumferentor's (CF) short signature "S. Saunders Fecit" features this same full set of characteristic features of 'S' and 't' letters and Arabic numerals style of Samuel Saunders I. Another feature that points to this maker is the extensively decorated, floral compass rose, which might be regarded as his trademark.

For the last three instruments listed in the Table 1, the collected data was not sufficient to establish the maker. The Webster database, following E.G.R. Taylor,<sup>10</sup> suggests that the mariner's compass (MC) was made by Samuel Saunders II, which seems very likely given his position of a Master Compass Maker to the Admiralty.

In the conclusion of the above survey it has to be stressed that both script style of Arabic numerals and formal features of time interval markings used by Samuel Saunders I are not specific only to his workshop. Similar features can be found on some instruments of other London makers from the first decades of the 18<sup>th</sup> century including Rowley, Wright or Culpeper, to mention just three. What makes the attribution of studied instruments to Samuel Saunders I more trustworthy is the combined characteristic set of features on instruments (signature, script, markings); similarity to other early 18<sup>th</sup>-century sundials by other makers and support from historic sources coupled with EoT data that was obtainable for some of them. Some variations to the engraving style on instruments seem to represent a natural aesthetic evolution of the maker during four decades of his career, together with influence of other contemporary makers and probably some individual input from the apprentices who most likely were engaged in the instruments' creation.

### Saunders' Tree of Knowledge

Samuel Saunders I received instructions first from Jonathan Roberts of the Broderers' Company, to whom he was bound on 5 February 1699, then on 4 October 1703 he was passed to John England (Instrument Maker to Queen Anne) of the Stationers' Company. On 14 June 1708 he was freed by Patrimony in the Masons' Company. Saunders is thus an interesting example of a maker that passed training in two guilds and continued his professional activity in the third one through a family link, and where he had educated 10 apprentices, including a known sundial maker, John Fowler. (Table 2).

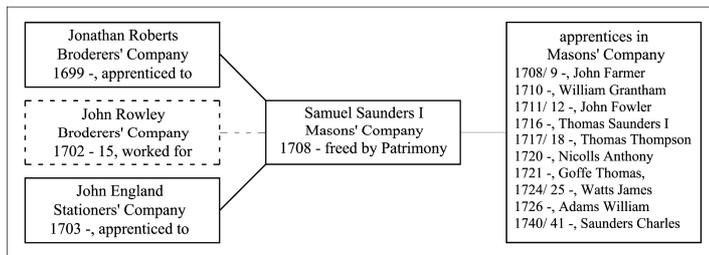


Table 2. Samuel Saunders I tree of knowledge.

M.A. Crawforth suggests that, together with the lack of new apprentices in the Broderers' Company around 1730, the guild's chain of knowledge and craftsmen was transferred to the next generations of London instrument makers only by those who passed it to another companies, like Samuel Saunders.<sup>11</sup> It is interesting then to examine which features of Saunders' instruments represent Broderers' style and come from his first training, and which from the other at the Stationers'.

Unfortunately, no instruments by the first master (Jonathan Roberts of the Broderers) are available for comparison. Also, the reasons for changing master and Company are not known, although it is suggested by Crawforth that such transfers could have been a result of the incompatibility of the master and his apprentice or in order to improve skills and gain knowledge that could not be learnt from the first master.

Instruments by Samuel Saunders have few visual similarities with the ones by his Stationers' master John England in the collections of the Oxford Museum of the History of Science Museum (OMHS) and the Whipple Museum in Cambridge. The Nordiska Museum equinoctial ring dial, for example, has similar shape of a central bridge and pin-hole slide to England's dial from the OMHS and both also share similar design of all the *fleur-de-lys* marks. However, John England Arabic numeral style is simpler, typified by his late 17<sup>th</sup> century analemmatic and horizontal dials made for Trinity Observatory (ca. 1703), as well as his double horizontal dial (ca. 1700),<sup>12</sup> and are of very different design standards compared to Saunders'.

Interestingly, the most visible influence on Saunderson's craftsmanship is that of John Rowley (of the Broderers' Company) who wasn't his master but with whom Saunders is believed to have had a close working relationship and for whom he worked between 1702-1715.<sup>6</sup> Of the many common features with Rowley's instruments, the most evident include: signature forms, most *fleur-de-lys* marks, the use of the chapter ring with 'geographic' noon times on horizontal dials, script style of Arabic and Roman numerals, aesthetic similarities of gnomon designs, rich floral decoration and overall engraving quality.

The above indicates that the thesis put forward by Crawforth on the passing of knowledge between companies is supported by Saunders' case. However, even though the Broderers' chain of knowledge was passed to a different company by Saunders, it happened not as a direct result of his earlier apprenticeship at the Broderers' but due to the

later and prolonged employment by Rowley – the influential member of this Company.

## Conclusion

It is satisfying for the author that, starting with only a couple of recorded instruments and questionable attributions of them in some of the registers, it was ultimately possible to identify with high level of certainty ten instruments as being made by Samuel Saunders I and a further one, based on a written description, with high likelihood.

Furthermore, considering the relatively short period of study and limited access to the printed English sources, it is obvious that there should be more unrecorded instruments by this fine, though largely unknown maker.

The number of instruments attributed to Samuel Saunders is not a surprise and seem adequate to the size of his workshop, which must have been considerable, taking into account the relatively large number of ten apprentices that he had educated during his professional career. The activity of the Saunders' workshop is further confirmed by a preserved advertisement.<sup>11</sup>

It is interesting that none of the instruments for which any illustrated documentation was obtained was crafted by any of the other masters bearing the same name – Samuel Saunders II or III. Hopefully, further studies of existing museum inventories, combined with new acquisitions and auction sales catalogues will provide some information on their works.

The research performed for the needs of this article has allowed the updating of the inventory description of the equinoctial dial in Nordiska Museum in Stockholm. The description of the similar dial in the National Museum of Scotland, in my opinion inappropriately dated ca. 1760 and attributed to S. Saunders II, is pending verification in light of this short study. The Webster database of the Adler Planetarium seems to incorrectly attribute most gnomonic instruments to the S. Saunders II and also requires an update. Also, biographical sources on Samuel Saunders I can be enriched with information on his instruments of exquisite quality and beauty.

Finally, after this lengthy prelude and with my archives cleaned up a little we can proceed – in a future *Bulletin* – to a proper article on two restorations, historic and recent, of Samuel Saunders' horizontal sundial (HD2).

## ACKNOWLEDGEMENTS

This article would not have been possible without the assistance of the following people, to all of whom I am greatly indebted for their input: Susanne Gronnow from Erddig Hall, Margaret Wilson and Alison Morrison-Low from the National Museums of Scotland, Amy McDonald from Yale Center for British Art, Marie Tornehave and Leif Wallin from Nordiska Museum, Wrexham-based photographer Keith Evans, Michał Goncerzewicz and diallists: John Davis, John Foad, Mike Cowham, Howard Dawes, Reinhold Krieger, Conxita Bou Vilalta and Luis Vadillo.



# A VERY EARLY DESCRIPTION OF A HORIZONTAL DIAL IN ENGLISH

JOHN DAVIS

Quite soon after the introduction of the polar-aligned gnomon into Europe in the early 15<sup>th</sup> century, descriptions of how to lay out vertical-south dials and, less often, horizontal ones began to appear in manuscripts from numerous monasteries. Most of these descriptions were in Latin, the standard language of both the monasteries and universities across all of Europe. It is this *lingua franca* that allowed rapid diffusion of the knowledge in just a few decades. The manuscript which is the subject of this article is unusual in that it is in English and, being dated to c.1440, it may be the earliest description known in our native tongue.

The manuscript is now in Aberdeen University Library (MS 123) and has clearly had a hard life, with parts of pages missing and repaired and many badly waterstained. Nevertheless, most of it is still legible and the description of how to make a horizontal dial, complete with diagrams, gives an invaluable insight into the earliest ‘scientific’ (i.e. showing modern, equal hours by use of a polar-aligned gnomon) dials of this country.

This small codex (approx. 160 × 105 mm of text per page) contains around 160 leaves written by several hands and on a miscellany of topics. Although some of these are on quite general subjects, including moralised tales and questions and answers about liturgical practice, a good fraction of them deal with science and astronomy. These include Chaucer’s *Treatise on the Astrolabe* (first published 1399), descriptions of how to make quadrants and the navicula,<sup>1</sup> working luni-solar volvelles as well as the sundial description. Chaucer’s *Treatise..* is often regarded as the first scientific treatise in English and it may be the presence

of this text that convinced the MS 123 scribe to produce an English version of the sundial text.

The volume is dated at c.1440 by means of several references within the individual texts and it is believed to have been written in the area around Chester by the dialect used in some of the English language texts. A note on one folio, physically quite close to the sundial one, links it to the Augustinian friary of Warrington.<sup>2</sup> Another note shows that the manuscript had been owned by one William Fitton of Gawsorth, Cheshire.<sup>3</sup> It was given to the University of Aberdeen in 1723 by Robertus Barclay of Urie (Urry).

The description of the sundial begins on f.66r in Latin. It is a fairly standard description with the incipit *Instrumentum per quod sciuntur hore diei per vmbram*. The same text is also known, for example, in the Bodeian Library MS Digby 29 ff. 118v-119r. The Aberdeen version runs to about one and a half pages and then uniquely continues in a different hand with a translation into English. An example of the text is shown in Fig. 1. The text continues to folio 67v and includes two diagrams, one of the finished dial (Fig. 2, f. 67r) and one of the construction method (Fig. 3) after the text on f. 68r. A transcription of the text, and a translation into more modern English, is shown in Fig. 4 (over page).

The basic method used to draw the dial is a simple geometric one which became widely used, which a number of variants, over the following two centuries. Sawyer has recently given a good description of these methods.<sup>4</sup> Fig. 5 gives a modern interpretation of the method in the manuscript, which provides a rather garbled account. It employs an equatorial circle, uniformly divided into hourly 15° segments, which is projected onto a tangent line. The

key step is to determine the radius of this circle to be  $\sin \phi$ , relative to that of its horizontal projection, to suit the latitude for which the dial is being designed. Mathematically, we require:

$$x = \arctan(\sin \phi \tan h)$$

where  $x$  is the angle of the hour-line from the noon line,  $\phi$  is the latitude and  $h$  is the hour angle.

The first step is to draw circle ABCD which will eventually become the chapter-ring of the dial and which is taken to have unit radius. The line EF is then drawn such that  $\angle AEF = \phi$ . At

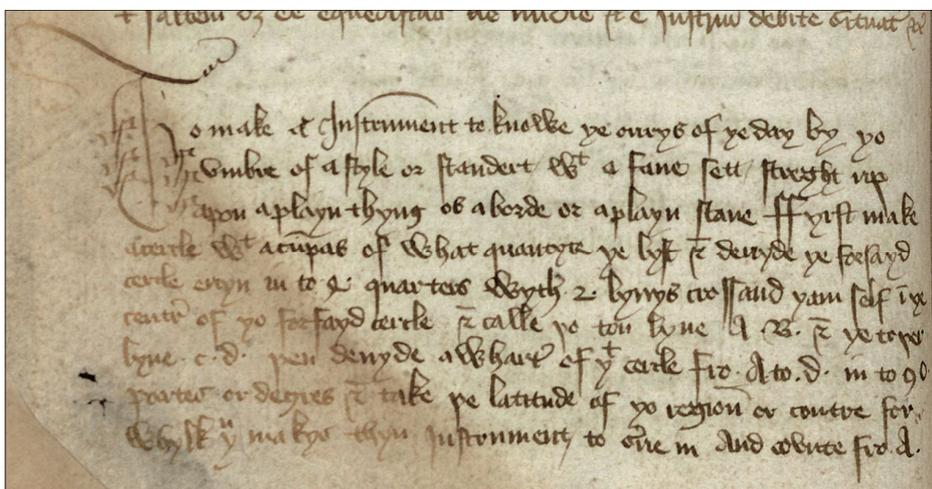


Fig. 1. Image of the English text from Aberdeen MS 123 f.66v. Copyright Aberdeen University Library.

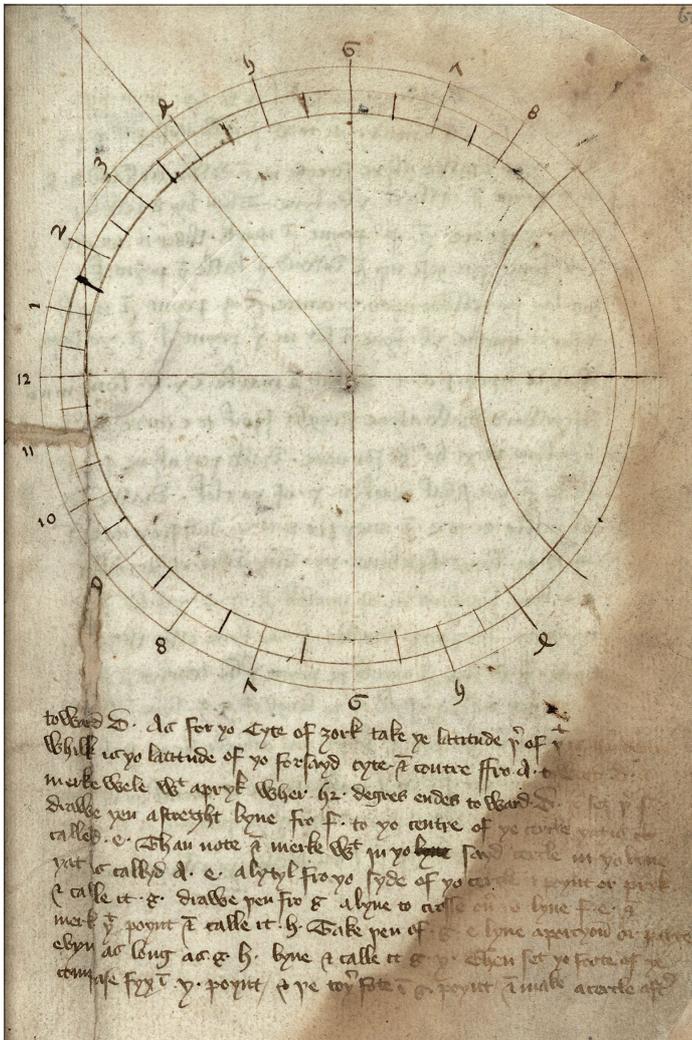


Fig. 2. Image of the dial drawing. Aberdeen MS 123 f.67r. Copyright Aberdeen University Library.

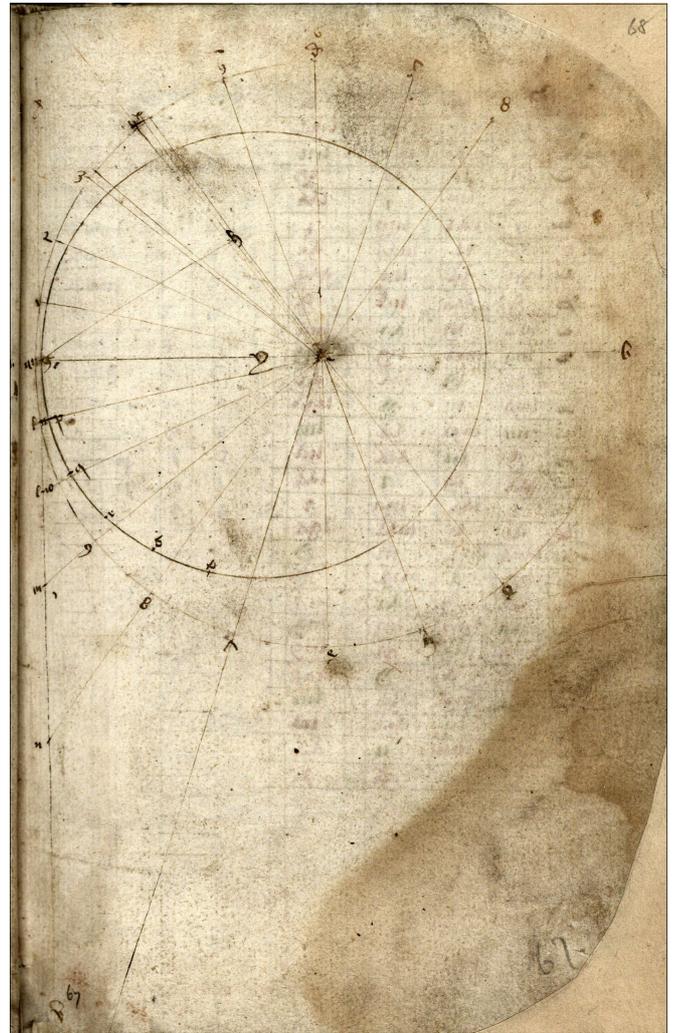


Fig. 3. Image of the construction method. Aberdeen MS 123 f.68r. Copyright Aberdeen University Library.

the time, laying out this angle without the benefit of a protractor would have been the most difficult part of the design, involving much halving of angles and trial-and-error stepping out with the dividers. By dropping the perpendicular AG to this line we define this distance as  $\sin \phi$  which can be transferred with compasses to AY to give the centre Y of the equatorial circle, tangential to the dial circle at A.

The equatorial circle is then divided into  $15^\circ$  increments ("24. euen pts") such as p,q,r,s,t. Lines from centre Y through these point are drawn to meet the vertical tangent line at l, m, n etc. Then hour-lines from the dial centre E can be drawn to these points, fulfilling the required trigonometrical relationship. Note that these hour-lines are described with Roman numerals in the text but labelled with Arabic numerals, of medieval form, in the drawings.

This basic method of delineating the dial is a very standard one and leads automatically to a design with the origin in the centre of the dial-plate so that the 6am-6pm line forms a diameter. It was almost two centuries before the origin was moved towards the south of the dial-plate in order to make better use of the available space.

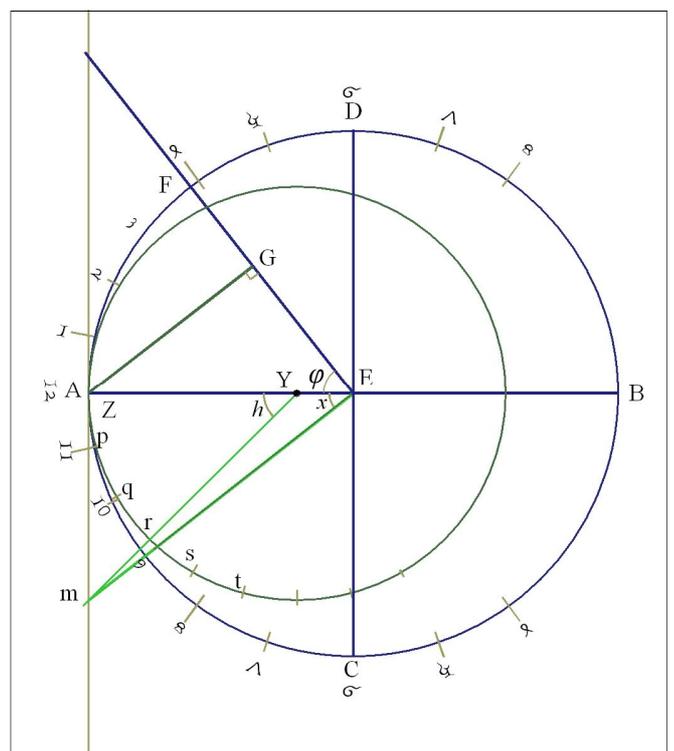


Fig. 5. Modern interpretation of the design method.

### Transcription

[66v] To make an Instrument to knowe ye ourys of ye day by ye / umbre of a style or standert w<sup>t</sup> a fane sett streght up / upon a playn thyng os a borde or a playn stane Fyrst make / a cercle w<sup>t</sup> a cu[m]pas of what quantitye ye lyst & deuyde ye foesayd / cercle croyn in to 4. quarters wyth 2. lynys crossand yem self in ye / centr of ye forsayd cercle & calle ye tou lyne .A.B. & ye uther / lyne .c.d. þen deuyde a whart of ye cercle fro A to .D. in to 90 / partes or degrees & take þe latitude of ye region or contre for / whylk y<sup>u</sup> makyr thyn Instrument to one in And cobute fro A. / [67r] toward D. As for ye ?yte of z or l take ye latitude & of ye ..... / whilk is ye latitude of ye forsayd syte & contre Fro A towards D / merke wele wt a pryk wher 52. degrees endes toward D. set ye ? / Drawe yen a streght lyne fro f. to ye centre of ye cercle / called .e. Then note & merk w<sup>t</sup> ?u ye lyne sayd cercle in ye line / yat yo callyd .A.e. a lytyl fro ye syde of ye cercle ? poynt or pryk / & calle it .g. Draw then fro g a lyne to crosse .. a lyne f.c. & / merk y<sup>t</sup> poynt & calle it .h. Take þen of g.e. lyne a peiryed or .... / ebyn as long as.g.h. lyne & calle it g.y. Then set ye foote of ye / compase fyyi .y. poynt & ye toy fote in g. point & make a cercle aft? / [67v] that quantitye Deuyde then yor serkyl in to .24. euynt pts / y<sup>at</sup> is to say yw [w<sup>th</sup>] aquarter in to .6. & calle those pts .p.q.r / s.t. then drawe alyne streght up & down acostrand .A.B. / in g. point & calle it .y.b lyne. Then lay a rewlar / upon y centre & .p. poynt & merk wher it touches / y. b. lyne yat gose up & downd. & kalle y<sup>t</sup> poynt .k. / Zet lay þy rewlar upon .y. centre & .q. poynt & merk / wher it touches .y.b. lyne & set in þ<sup>t</sup> poynt .l. & ye same / way Do upon .v.s.t. poynts & marke it y.? lyne m.n.o / Aftyrward draw alyne streght fro .k. to e centre & þ<sup>t</sup> lyne ? / betokyns þe XI. ho<sup>s</sup> be for none. Draw þen alyne fro l. / to e. & þat sthal be tokyn .X. of þe klok. Drawe ?t / alyne fro m. to e. & anoþr fro .n. to e. And fro o. to e. & / these .?. lynes b tokyns IX bm? & by? of ye klok & / t.e. lyne be to kyns 6? of ye klok & g.e.XII ho<sup>s</sup> þat is / mydday Forsp.... drawe f.e. lyne owt whilst it / touche .y.b. lyne & merke þe poynt þ<sup>c</sup> he touchys & set / þ<sup>t</sup> .z. then make þy style of ye lenth of .g.z. lyne & set it / streght up in .g. poynt Knyt þen a threde fro þe style top / to a centre. Or if y<sup>u</sup> wyl make a fayne of metal or of borde / mak it ebyra & playn & 3 cornerd of ye quanate of e.g.z. / trou ye umbra of þat schal schewe yo aways truh

### Translation

[66v] To make an Instrument to know the hours of the day by the / shadow of a style or standard with a vane set vertically / upon a flat surface or a board or a plane surface. First make / a circle with a compass of whatever size you like & divide the foresaid / circle circumference in to 4 quarters with 2 lines crossing in the / centre of the foresaid circle & call the two lines **AB** & the top / line **CD**. Then divide the part of the circle from **A** to **D** in to 90 / parts or degrees & take the latitude of the region or country for / which you make the Instrument. And count from **A** / [67r] toward **D**. As for the height of arc take the latitude & of ye ..... / which is the latitude of the foresaid site & country. From **A** towards **D** mark well with a prick where 52 degrees ends toward **D**. Set the ? / Draw then a straight line from **F** to the centre of the circle / called **E**. Then note & mark with ju? said circle in the line / that you called **AE** a little from the side of the circle ? point or prick / & call it **G**. Draw then from **G** a line to cross .. a line **FC** & / mark that point and call it **H**. Take then of **SE** line a peiryed? or .... / ebyn? as long as line **EH** lyne & call it 8.y?. Then set the foot of the / compass fyyi .y. poynt & ye toy fote ? 8. point & make a circle aft? / [67v] that quantity. Divide then your circle in to 24 even points / that is to say with aquarter in to .6. & call those points **P, Q, R / S, T**. Then draw a line straight up & down across and **AB** / in 8 points & call it line **YB**. Then lay a ruler / upon the centre & .p. point & mark where it touches / line **YB** line that goes up & down & call that point **K**. / Next lay your ruler upon the centre **ZQ** point & mark / where it touches line **YB** line & set in that point **l**. And [in] the same / way do upon **V, S, T** points & mark it y.? line **M, N, O** / Afterward draw a line straight fgo.k. to **E** centre & that line ? / indicates the XI hour before noon. Draw then a line from **P** / to **E** & that shall indicate X o'clock. Drawe ?t / A line from **M** to **E** & another from **N** to **E**. And from **O** to ? & / these **M** lines indicate IX am & ?? of the & / **TE** line indicates 6? o'clock & the XII hours that is / Midday. Forsm.... draw line **FE** line out where it / touches line **XB** & mark the point which touches & set / the **Z** then make the style of the length of line **GZ** & set it / straight up at point **G**. Tie then a thread from the style top / to a centre. Or if you will make a vane of metal or of board / make it ebyra? & plane & 3 cornered of the size of **EGZ**. / Through the shadow of that shall show you aways true

Fig. 4. Transcription and translation of the English text from Aberdeen MS 123, ff.67v – 68r.

Note that the text in some places is difficult to decipher and thus this reading must be taken with some caution. The author would welcome further input from scholars familiar with 15<sup>th</sup>-century texts.

There are several features of the Aberdeen MS 123 text which are particularly noteworthy. The first is that the equatorial circle is drawn inside that of the actual dial, rather than externally tangential to it, as in the majority of the vertical dial (*horologium murale*) descriptions of the period. Geometrically, the two schemes are completely equivalent but the internal scheme has the advantage of saving space – and expensive vellum – but with the disadvantage of being less clear, with two sets of lines overlapping. A scribe would clearly copy the version of the text that he was presented with and not seek alternative layouts so this fact may provide a clue into the lineage of the text. Later writers developed the design method so that the extreme length of the tangent line for times approaching 6am and 6pm was not needed.<sup>4</sup>

A second feature is that the text is explicitly for a latitude of 52° and the diagram is drawn to this value. However, the latitudes of Chester and Warrington are both 53° 11' so it must be that the original design was for a different location and it has been copied without modification. Since the latitude quoted for Oxford<sup>5</sup> at this period was 51° 50', it seems very likely that the description may have originated there, or possibly at the nearby Benedictine monastery of St Albans.

A third noteworthy feature is that the first form of gnomon described uses a string (a *threde*) stretched from the origin to the top of a post on the noon mark. This strongly suggests that the designer had a portable dial, or one for indoor use, in mind rather than an outdoor pedestal design. Only as an alternative does he suggest a plate gnomon (a *streight fane*) in the form of a right-angled triangle.

The description is very much a theoretical one with no detailed discussion of the manufacturing methods. It is also notable that a subdivision to half-hours is shown on the final design but not described in detail. These marks could be constructed from 7.5° divisions of the equatorial circle though it is equally likely that they were drawn by dividing the hours by eye. The arc at the south of the finished dial, crossing the chapter ring at about 3am and 9pm, is unexplained – these times are beyond the earliest (latest) sunrise (sunset) times at this latitude.

The language of the text is interesting and quaint to modern eyes. Naturally, the spelling is rather variable (e.g. fane/fayne, cercle/serkyl/zerk[l] etc.) being basically phonetic. One point worth noting is the use of two forms of the 'thorn' or 'th' character, initially a 'y' but later a 'þ'. Some abbreviations and omission signs are used which seem to indicate that the writer was mainly trained in Latin and was applying the same methods.

#### ACKNOWLEDGEMENTS

It is a pleasure to thank Kim Downie, University of Aberdeen Library, for providing copies of this manuscript. Catherine Eagleton (British Museum) is thanked for her encouragement as is Harry Wells for information on Warrington Friary.

#### REFERENCES & NOTES

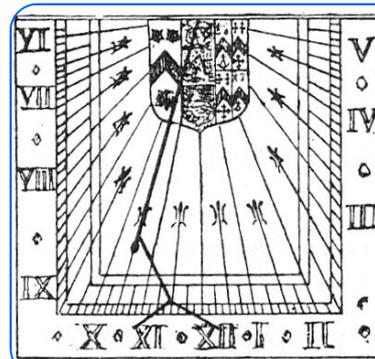
1. The MS 123 text for the navicula (the 'Little Ship of Venice', a rare, universal altitude dial which seems to be a medieval English development) can be found in C. Eagleton: *Monks, Manuscripts and Sundials: the Navicula in medieval England*, Brill Academic Publishers (2010). It was this book which first alerted me to the existence of the horizontal dial description.
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#### ANNEX – Warrington Friary

Warrington Friary was a house of Hermit Friars of St Austin, founded by William Fitz Almeric le Boteler. It was established by 1291. The boundaries of the Friary land are uncertain, but land grants suggest that the property was extensive. The Friary was suppressed in 1536 during the dissolution of the monasteries and granted to Thomas Holcroft in 1540. Holcroft sold it to John Cawdwell on the condition that the townspeople could still use the Friary church (Jesus Church) and that he was allowed to remove the stone of any unroofed walls. This Church is mentioned again in around 1640, though how long it was used is uncertain. The last remaining structure was the arch of Friary gateway, which was demolished in the late 18<sup>th</sup> century.

The Prior of Warrington is known to have ordered a clock for the Priory sometime before 1400.<sup>2</sup> It did not live up to expectations and so its maker, Thomas Graver of Manchester, was sued to recover its cost of 100 shillings. Despite this failure, the interest in timekeeping at the Priory is clear.

The most famous incumbent at Warrington was Thomas Penketh (d.1487) whose entry in the Oxford DNB describes him as an Augustinian friar and theologian who studied theology at Oxford just before 1466. He later travelled to study in Padua, where he was appointed lector in metaphysics at the university. Although there is no known link between Penketh and Aberdeen MS 123, the association with Oxford and with international travel show that what might appear to be an insignificant provincial friary did indeed have connections to the European-wide academic scene.



#### Brasenose College Oxford

Originally made in 1719 for under £9, with the painting and gilding costing £7 7s. Drawn here by Robert Gunther in 1923.

It is SRN 0988, most recently recorded in 2000.

# CHILDREN'S SUNDIAL COMPETITION

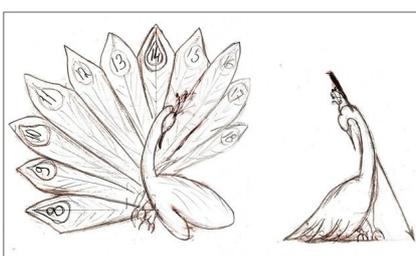
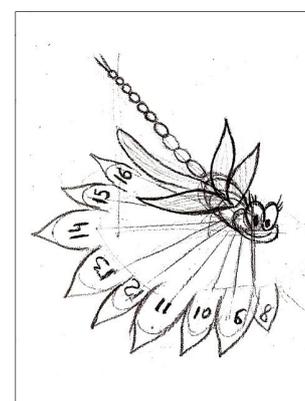
## VALERY DMITRIEV

The children are students of the Childrens Art School in the village of Siversky and they were the participants of the first Russian children's competition for the best drawing of a sundial for their village.

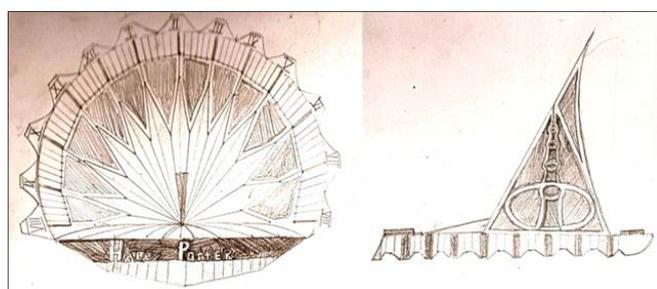
Siversky carries an informal title of country capital and is located 70 km from St Petersburg on the bank of the beautiful river Oredezh. Nearby, there is the village Rozhdestveno with the manor of the writer Vladimir Nabokov and the village Vyra where there is the museum 'House of the Station Inspector', as inspired from the A.S. Pushkin story of *The Station Inspector*.

The competition began on 13 November, 2011 with my talk on sundials and a display of the best (in my opinion) sundials from different countries. The listeners were rather enthralled. Within a month, under supervision from their teacher, Elena Eskelinen, the children pondered themes and drew sundials. Seventeen children took part in the competition with age from 9 to 13 years. Some examples are shown on the right (including a 'Harry Potter' design!).

It is obvious to professional sundial makers that the drawings of the children are slightly simplistic but that is to be expected. They have made fine and impressive first steps.



Shimolina Irina with her sundial medal and 'Butterfly' cake prize and (right), her design.



The competition ended on 17 December. Shimolina Irina, with her sundial 'Pushkins', was judged the winner. Irina received a commemorative medal and the main prize of the competition – a sundial cake 'The Butterfly'.

P.S. I helped Irina a little with the preparation of the sundial project. I hope that adults will be benevolent and the first sundial in the Siversky village, 'Pushkins', will be built in the Spring of 2012.

[sundials\\_spb@mail.ru](mailto:sundials_spb@mail.ru)

# THE SCOREBOARD SUNDIAL

JOHN FOAD

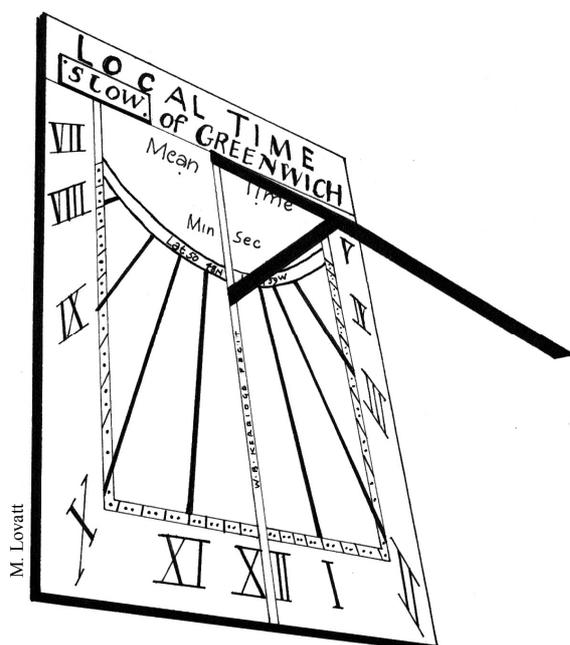
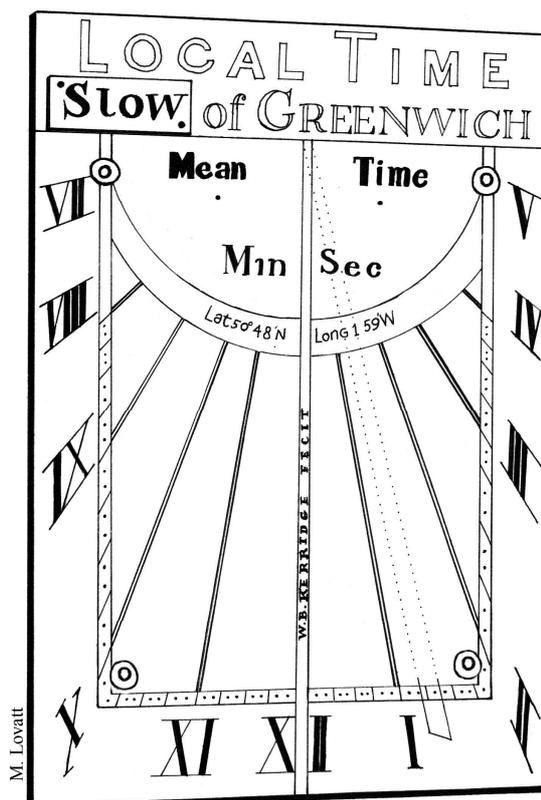
William Benjamin Kerridge (1857-1946) came from a well-respected family of Dorsetshire clockmakers. He, his father Benjamin, and his sons Kenneth and Ralph, had premises in Wimborne Minster, and were all in turn trusted with the maintenance of the astronomical Minster clock. William, indeed, made several models of the clock, one of which is still on view.

Recently a sundial was found in the town, with W.B. Kerridge's name along the noon gap line, and engraved with Wimborne's latitude and longitude. It is an unassuming direct south vertical slate dial, some 18" by 27", and half an inch thick; but it has a feature that I have not seen before or since. At the top, around the gnomon root, we see

LOCAL TIME  
 '.....' of GREENWICH  
 Mean Time  
 Min Sec

The '.....' represents a space to hang either of two iron plates, which were found with the dial, one inscribed 'FAST', and the other 'Slow'. Immediately below each of the words 'Mean' and 'Time' are two small holes. It would seem that these may have been the means by which further plates, giving the day's EoT in minutes and seconds (plus longitude correction), were suspended in the manner of the runs and wickets on a village cricket score board. This arrangement, while highly labour intensive, would provide an unusually speedy way for any passer-by to check his

watch. Plates for the Minutes and Seconds were not found with the dial, and nor are there any obvious signs of scratches that might have been left by this procedure. It could be that in practice the times were written in chalk or with a slate pencil, either being easily changed each day.



Such a dial does not feel like one for individual personal use. Might it have been mounted outside one of the Kerridge shops (they had two, at different times), for the benefit of customers? Or could it have been set up at the Town Hall or the Post Office, or even at the railway station? Enquiries at the town museum, and of the Wimborne Railway Society, have drawn a blank. Yet the dial shows signs of having been set up out of doors somewhere, for quite some time. This can be seen from the weather-staining of the slate, and from rust-staining at the fixing holes for the Fast/Slow plates, and at the four mounting holes at the corners of the chapter ring. The dial appeared for a short time on eBay last year, and its present location is unknown. The original location also remains a mystery, and awaits investigation by some local historian.

## ACKNOWLEDGEMENTS

Thanks to Margery Lovatt for the illustrations.



# SONNENKOMPASS 41

KUNO GROSS & MALCOLM BARNFIELD

During the investigation and writing of the article 'The Sundial Goes To War', a picture (Fig. 1) of a mystery German sun compass instrument turned up. Its origins were untraceable and even after exhaustive enquiries nothing further could be learned about it. Thus a description of the instrument was not included in that piece. However, the search did not end there. Almost a year later and after further delving it turned out that Kuno Gross, author of the 'Bagnold Sun-Compass',<sup>1</sup> was also on the trail of *Sonnenkompass 41*. Simultaneously we discovered the source of information on the instrument. Jean-Patrick Donzey<sup>2</sup> discovered it for me and Kuno, being a German speaker, was able to find the obscure book 'Taschenbuch für den Krieg in Wüste und Steppe' (Instruction for War in Desert and Steppe).<sup>3</sup> This joint Gross/Barnfield addendum to the original sun compass article stems directly from that find.

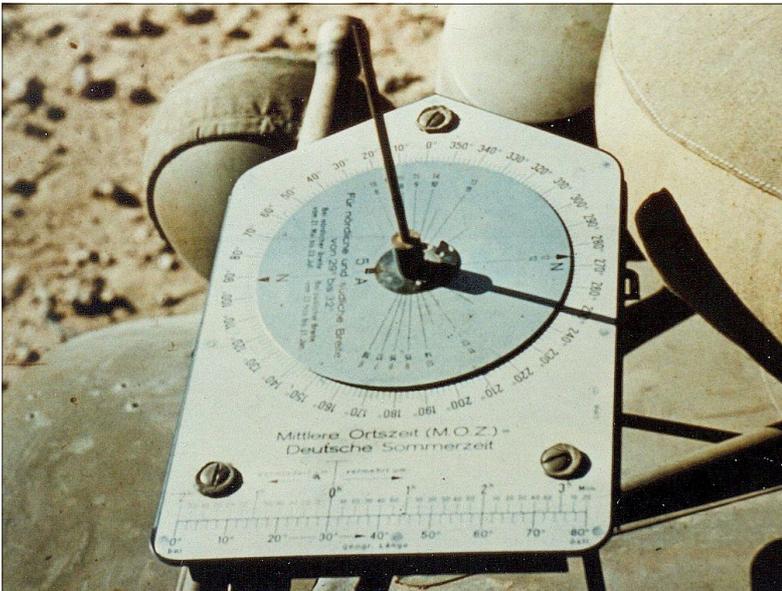


Fig. 1. *Sonnenkompass 41*. Colour photo by an unknown *Sonderkommando Dora* member, North Africa 1942. Photo courtesy of Michael Rolke.

## The Users

The *Sonderkommando* ('special unit') *Dora* was established in June of 1942. Its mission was to survey and map the southern deserts of Libya, secretly, and to evaluate the possibilities of crossing the desert with bigger army units, plus to find out if there could be a viable path to the main front at the Mediterranean coast from the south. It was composed of expert surveyors, hydrologists, cartographers, navigators, mechanics and so on. They were tasked in addition, to avoid any contact with British forces but they did end up in a single combat against a patrol of the Long Range Desert Group. On 15 January 1943, S1 patrol (LRDG Rhodesia)<sup>4</sup> under Captain Ken Lazarus with 16

men in five Chevrolet trucks were following the Wadi Zemzem on its way from Zilla in Libya to Tunisia when it was sighted by one of the planes of *Sonderkommando Dora*. The pilot informed the protective group attached to the special unit about the imminent danger and they decided to intercept the enemy column. Despite the fact that the German soldiers had absolutely no battle experience, they managed to ambush the LRDG patrol. In the initial fire-fight the Germans lost their single armoured car but in the following skirmish, they managed to get the upper hand. S1 patrol and a detachment of the PPA (Popski's Private Army) had to withdraw, losing nearly all their vehicles and Sergeant Henderson who was killed. *Sonderkommando Dora* was disbanded in January of 1943 when Axis forces were pushed out of Libya and shortly before the Axis surrender in North Africa in May 1943 but not before they had evaluated all vehicles, kit and equipment destined for the desert conflict and mapped large parts of the area.

The *Sonnenkompass 41* was issued to the unit. It was based on the analemmatic sundial as are most sun compasses but it had an interesting adaptation of the theory since, like the Cole and Abrams compasses, the shadow from the stylus was kept on the appropriate LAT tick on the dial plate. In those two compasses the rotating pointer was moved to the desired direction of march around a 360° calibrated outer ring. Here, the whole base-plate of the instrument was rotated to the desired direction, its pointed 'nose' indicating that bearing (see Fig. 2). Ma.N = Magnetic North. Ge.N = True North. Zielpunkt = target or direction of march.

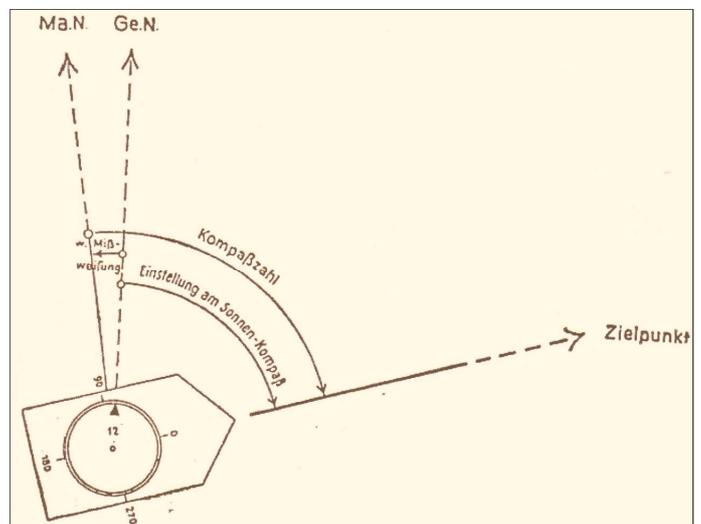
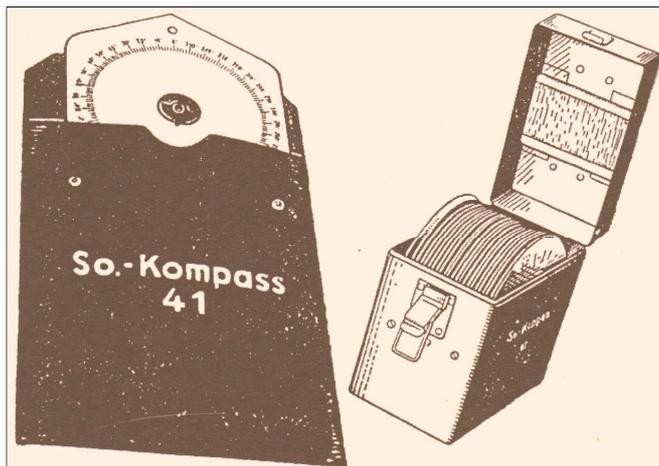


Fig. 2. The basic functioning of the compass.

Bei nördlichen Breiten	bei südlichen Breiten	Buchstabe
21. Mai – 23. Juli	23. Nov. – 21. Jan.	A
24. Juli – 8. Aug.	22. Jan. – 5. Febr.	B
9. Aug. – 21. Aug.	6. Febr. – 17. Febr.	C
22. Aug. – 4. Sept.	18. Febr. – 3. März	D
5. Sept. – 19. Sept.	4. März – 18. März	E
20. Sept. – 6. Okt.	19. März – 3. April	F
7. Okt. – 30. Okt.	4. April – 27. April	G
31. Okt. – 11. Febr.	28. April – 26. Aug.	H
12. Febr. – 7. März	27. Aug. – 9. Sept.	G
8. März – 23. März	10. Sept. – 26. Sept.	F
24. März – 7. April	27. Sept. – 11. Okt.	E
8. April – 21. April	12. Okt. – 25. Okt.	D
22. April – 4. Mai	26. Okt. – 6. Nov.	C
5. Mai – 20. Mai	7. Nov. – 22. Nov.	B
21. Mai – 23. Juli	23. Nov. – 21. Jan.	A



Figs. 3 & 4. Detail of the boxed sets of dial cards and compass.

### The Instrument

The dimensions of this instrument are not given in the handbook so the reader will have to extract them from Fig. 1. The base is of pressed steel, etched with the 360° compass in 2° divisions. Sets of etched steel removable dial plates for differing latitudes and seasons are provided. These included adjustments for German Summer Time (daylight saving time) and Central European Time. From this it then becomes plain that German troops abroad were expected to adhere to the German time zone conventions. There is no steppe or desert in Germany. Five sets of card dial plates for the differing latitudes of 0-9°, 10-16°, 17-22°, 23-28° and 29-32° north were provided. Each set contained 8 date/season cards (see Figs. 3 & 4). These clipped into place with the small central lever visible in Fig. 1. From the latitudes, it may be deduced that the instrument was specifically designed for the North African zones although it was usable in both hemispheres, the bearings for southern latitudes being coloured red. There were two models of the compass, one with a screw-in stylus and the other with a folding stylus.

### Usage

The instructions for usage were rather convoluted, more so because of the German summer time adjustments. Directions to users were to establish magnetic/grid variation from local knowledge – this is rather naïve in an area

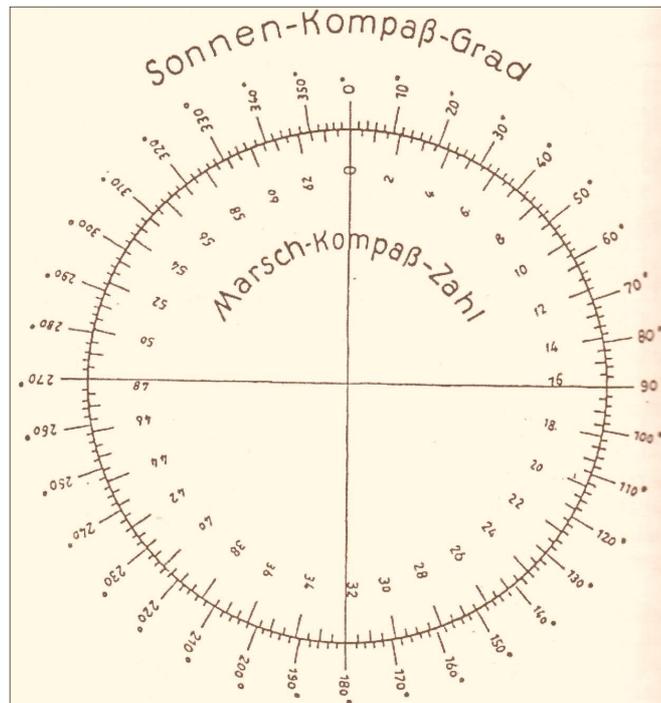


Fig. 5. Sun compass mils/degree converter.

sparingly populated by nomadic tribesmen. Latitude and longitude had to be established from a map, difficult as there were no maps of any great accuracy. LAT was established from the known longitude but the Equation of Time is nowhere mentioned. Perhaps these adjustments were cleverly included in the date plates in some way. This little refinement would have made usage easier for the common soldier. No dial plate could be found for analysis so this point could not be investigated. The required bearing was then converted to ‘sun compass degrees’ using the chart in Fig. 5. When true north and the direction of march had been established and the compass set, the driver then drove at a distant object in the selected direction and stayed on that track for 30 minutes. The convoy was then stopped and the compass reset to accommodate the ever-changing solar azimuth. This procedure would have been very time consuming and would have delivered a rather zigzag path. Like all other analemmatic compasses, the Sonnenkompass 41 was not usable around noon at lower latitudes and an admonishment not to use it at that time was given in the handbook.

### Conclusions

Most of the Sonderkommando Dora members were scientists of one sort or another and so their conclusions are valid. In a later report<sup>5</sup> they raised two complaints against Sonnenkompass 41.

1. The screw-in gnomon’s shadow was too thick to get an accurate reading of the bearing calibration on the compass. They suggested that it should be filed down to 5 mm diameter.
2. In the folding gnomon pattern the gnomon blew down in windy conditions so the compass became unusable.

Their verdict was that Sonnenkompass 41 was unsuitable for desert use. Thus it disappeared into oblivion until rediscovered by Michael Rolke a few years ago. No extant example can be found and Fig. 1 is the only known picture of it.

Sonderkommando Dora was a unit set up by the German *Abwehr* (military intelligence) and was not a part of the *Panzerarmee Afrika*. There was intense rivalry between the different divisions of the German forces and thus it is easy to see why the Sonnenkompass 41 was employed when the proven Plath and Goerz<sup>6</sup> sun compasses were in production and being used by both the Luftwaffe and *Panzerarmee Afrika*.

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# SUNDIALS IN GCSE ASTRONOMY

JULIEN KING

There has been a 16+ qualification available in Astronomy since the days of O-levels, with the latest incarnation, GCSE Astronomy, dating from nearly twenty five years ago. Declining popularity for the qualification in the early years of the millennium saw it reach a nadir of only a few hundred candidates each summer; candidate numbers have risen very steadily ever since with around 2500 students sitting last summer's examination.

Throughout the development of the Astronomy qualification over the years, the sundial has provided an excellent introduction for students to the relationship between 'sun time' and 'clock time' and thus to ideas such as the Equation of Time and the effect of longitude. Simple numerical conversions between local solar time and Greenwich Mean Time have long proved successful as questions in the written examination paper.

The assessment of the current GCSE Astronomy qualification comprises a single two-hour written examination paper taken in June – which accounts for 75% of the final mark – along with two short observational tasks which comprise the Controlled Assessment section which accounts for the remaining 25%. Students choose their two tasks, one Naked Eye and the other using some kind of optical or other aid from a dozen suggested titles of each type, provided by Edexcel, the examining body for GCSE Astronomy.

In the early days of the GCSE, the course was almost exclusively attempted by Sixth Form students and adults. However, a number of changes to the qualification structure in the UK have had a dramatic effect on the subject's clientele. Firstly, Sixth Form students are now encouraged to study an increased number of subjects in the first year of

their A-Level courses and have the pressure of modular examination right from the start of their study, leaving little time for 'extras' such as GCSE Astronomy. Secondly, the designation of a large number of secondary schools as Science Specialist institutions has heightened interest in GCSE Astronomy as a means of extending the range of scientific courses available to students.

In common with many other GCSE subjects, the syllabus for GCSE Astronomy has recently undergone a slight revision, although topics related to time and the sundial have remained. The observational work, which students have always completed as part of the GCSE Astronomy qualification, has seen the biggest changes in this recent revision. In order to improve the security of the work submitted in this section, students must now complete their written reports on their observations under 'controlled conditions',



Fig. 1. A graph of shadow stick results from a student completing the Shadow Stick task.

i.e. under supervision at their school or college, rather than writing everything up in their own time. Fortunately the observational part of their work can still be completed outside school hours – an essential feature for most astronomical observations!

The use of the position of the Sun in the sky to indicate the time of day and the relationship of this time to the mean time shown on a clock are at the heart of two Controlled Assessment tasks available to candidates:

### Shadow Stick

*‘Use a shadow stick to record the direction of the Sun at different times on at least two days and hence determine (a) the time of local noon and (b) the observer’s longitude.’*

### Sundial

*‘On at least three widely-spaced dates, compare the time shown on a correctly-aligned sundial with local mean time. Use these data to determine the accuracy of the sundial used.’*

(from Edexcel GCSE Astronomy specification, 2008)

The **Shadow Stick** task basically requires students to record the decreasing and the increasing length of a shadow on either side of local noon. Once the Equation of Time has been allowed for, the remaining difference is attributed to the observer’s longitude and is used to make an estimate of it. Students are encouraged to perform the measurement on a number of occasions to improve the reliability.

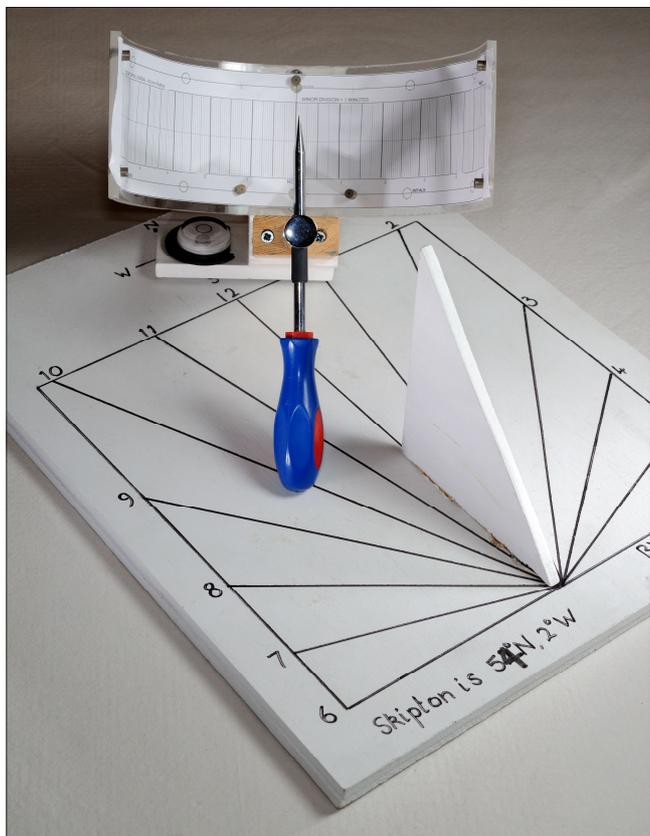


Fig. 2. Some sundials which students attempting the Sundial task have made in the past.

The **Sundial** task requires students to make a systematic comparison between the time on a convenient sundial and that of a clock. Students can build their own sundial if they wish, although the quality of their construction is no longer assessed as part of the task. Having assembled an appropriate body of data, students can then use their figures to assess the accuracy of their chosen sundial, once the Equation of Time and longitude have been allowed for.

In recent years, both tasks have proved popular choices amongst GCSE Astronomy students and are both particularly effective at helping students new to the study of astronomy to understand the link between the motion of the Sun in the sky and the measurement of time. In my experience, some of the younger students starting the GCSE Astronomy course (around Year 9: 13-14 years old), although they can recall that the Sun ‘rises in the east and sets in the west’, are genuinely surprised to see the shadow of a stick in the ground move noticeably over a period of fifteen minutes or so.

There is no doubt that this area of the GCSE Astronomy syllabus plays a vital role in ensuring that candidates see how aspects of astronomy are directly related to their everyday lives – a central focus for the whole GCSE itself.

### Further information

Copies of the syllabus for GCSE Astronomy, along with sample examination papers and other support materials can be found on the Edexcel website at: [www.edexcel.com](http://www.edexcel.com).

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### LEGO Equatorial Dial



Sundials can be made of many materials and a whole range of designs has been designed by Don Rogerson of Red Oak, Iowa (USA) from standard Lego bricks. Don is hoping to interest the company in producing special sets of bricks for sundials. The example shown here is described as a ‘Large Equatorial’ and is constructed from 1x4 bricks and a 1x2 hinge plate. The grey and white blocks designate

the hours. For further examples see [www.flickr.com/photos/62bricks/sets/72157624121483459/](http://www.flickr.com/photos/62bricks/sets/72157624121483459/)

# THE BRUNSON UNIVERSAL SUN COMPASS

DAVID LE CONTE

Malcolm Barnfield's interesting articles on sundials used in wartime<sup>1</sup> reminded me of an elaborate army surplus instrument which I acquired in America in the 1960s: the Universal Sun Compass, model number 7637B, manufactured for the United States Army by Brunson Instrument Company of Kansas City, Missouri. The Company, which still exists, was founded in 1927 and specialises in precision engineering, especially of calibration and surveying equipment.<sup>2</sup> It claims that it is in a 300-million year old building, being buried in a 200,000 square foot limestone cave, free from traffic vibrations, and where temperature and humidity stability is easy to maintain.

The US Army Engineer Research and Development Laboratories (ERDL), based at Fort Belvoir, Virginia, was responsible for the development of topographic instrumentation. In 1947 it developed lensatic compasses, experimental models of which were produced by two companies, that of the Brunson Company faring better in tests. The Company went on to produce experimental models of wrist compasses for the Army in 1950. Following cold weather tests at Fort Churchill in Manitoba, Canada, large quantities of these compasses were provided to the Army in 1951.

Simultaneously with these developments the Company was engaged by the Army to produce experimental and test service models of "an improved sun compass that could be used in all latitudes, as opposed to the instrument suitable only between latitudes 45° north and south." Arctic winter tests were again conducted at Fort Churchill in February 1950, and desert tests were carried out at Yuma Test Station in Arizona in August 1952. The project was closed by the Army laboratories in June 1954.<sup>3</sup>

Nevertheless, production of the sun compass appears to have continued for some years. Company President Deighton Brunson has advised me that, although it now has little information about the compass, its serial number (61231) indicates that it was probably made in 1961. In the early 1960s the Company was contracted to supply the US Army with a number of items, including lensatic compasses, M2-type compasses, theodolites, and solar-reading devices that attached to theodolites.

The major innovation of the Brunson Universal Sun Compass, in addition to being usable at all latitudes, was the incorporation of a clockwork mechanism to counteract the Earth's rotation.

The comprehensive operations manual describes it as "a mechanical device for obtaining true azimuth with the aid of changing but easily calculated directions of the sun or stars with relation to the time and place of observation", which "can be used for navigating predetermined courses; for determining the azimuth of required directions of travel; and for intersection or resection of topographic or man-made features by azimuthal plotting of rays from known points on or within sight of the course."

The compass is housed in a substantial metal box, and weighs 6 kg, including the box base. In operation it was fixed to a military vehicle or tank, either directly using a trivet ring or by bolting the base of the box onto the body of the vehicle. Although it had the advantage of not suffering from magnetic effects, it was not intended as a replacement for the magnetic or gyro-compass, but as a complement to them.

Figure 1 is a general view of the instrument. Figure 2 identifies its various parts. Figure 3 shows the compass mounted on a US Army amphibious cargo carrier.

The heart of the instrument is a 24-hour clock, rotatable to display one of two faces. One face is for use in the northern hemisphere, and is graduated clockwise; the other, for the southern hemisphere, is graduated anti-clockwise. A micrometer adjustment allows the clock face to be tilted to correspond to the observer's latitude, to an accuracy of about 0.2°.

From the centre of each clock face protrudes a gnomon rod, to which various sighting assemblies can be attached. Three such

Fig. 1. The Brunson Universal Sun Compass.



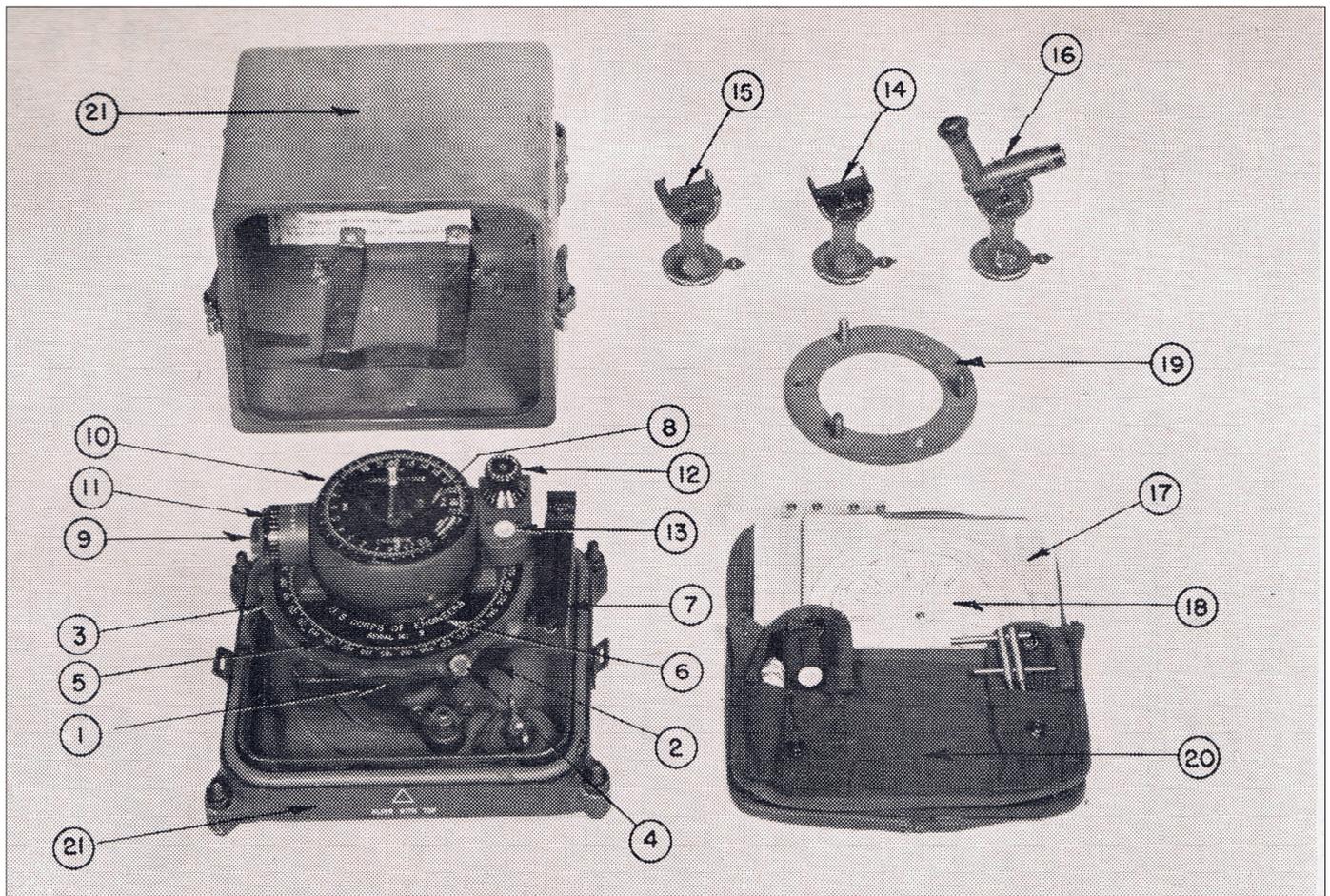


Fig. 2. The parts of the compass:

- |                                     |                            |                                 |
|-------------------------------------|----------------------------|---------------------------------|
| 1. Base housing assembly            | 8. Mean time 24 hour clock | 15. Alternative gnomon assembly |
| 2. Levelling clamp                  | 9. Winding key             | 16. Star sight assembly         |
| 3. Lower motion housing assembly    | 10. Clock hands            | 17. Sun time correction chart   |
| 4. Lower motion clamp               | 11. Latitude scale         | 18. Hour angle star chart       |
| 5. Azimuth circle                   | 12. Latitude micrometer    | 19. Trivet (mounting) ring      |
| 6. Upper motion index plate         | 13. Circular level bubble  | 20. Canvas accessory case       |
| 7. Object sighting device (alidade) | 14. Gnomon assembly        | 21. Metal carrying case.        |

assemblies are provided: one with a graduated frosted shadow screen (for observing the shadow cast by a slotted bar), one with an opaque shadow screen and prismatic sighting device (for sighting the Sun directly when it is not bright enough to cast a shadow), and a non-magnifying elbow tube (for observing stars).

Once it is levelled, the clock wound, the latitude and zone time set, and the appropriate sighting device mounted, the sun's declination and the time adjustment for longitude are determined by the 'Sun Time Correction Chart' (Fig. 4), one side of which is for East longitudes, the other for West longitudes. The sliding part of the chart is set so that the closest date appears in a window. The sun's declination is then directly read in an adjacent window, and is set on the sighting device.

The time correction combining the Equation of Time and that due to the longitude difference from the time zone meridian is read on the same line on the chart. The gnomon assembly is offset by this amount on the 'Time Correction' scale on the clock hands. The result, although not referred to as such in the manual, is the Local Apparent (Solar) Time.

If it is desired to follow a route determined by a particular azimuth, the north index line on the Azimuth Circle is set to that azimuth. The instrument is then unclamped and rotated to align the gnomon assembly with the sun. A distant object can be sighted with the alidade, and the vehicle driven towards it. The clock drive ensures that the correct orientation is maintained with respect to the sun.



Fig. 3. The Brunson compass mounted on a US Army amphibious cargo carrier.

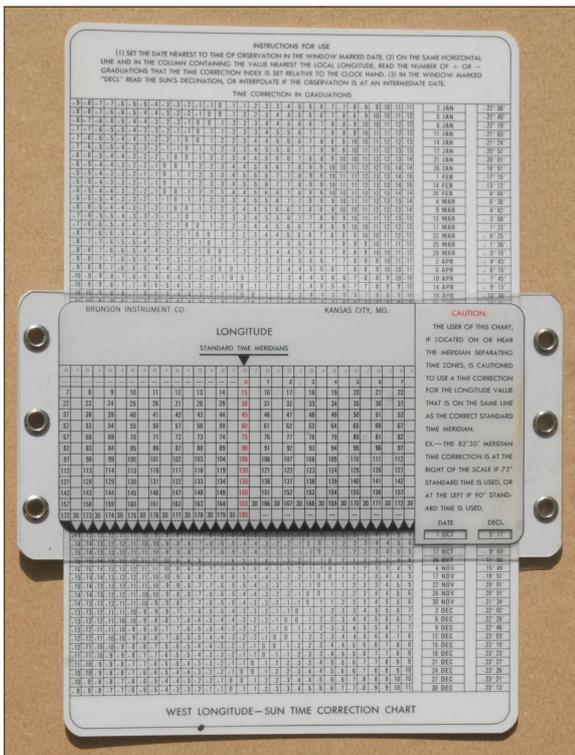


Fig. 4. 'Sun Time Correction Chart'.

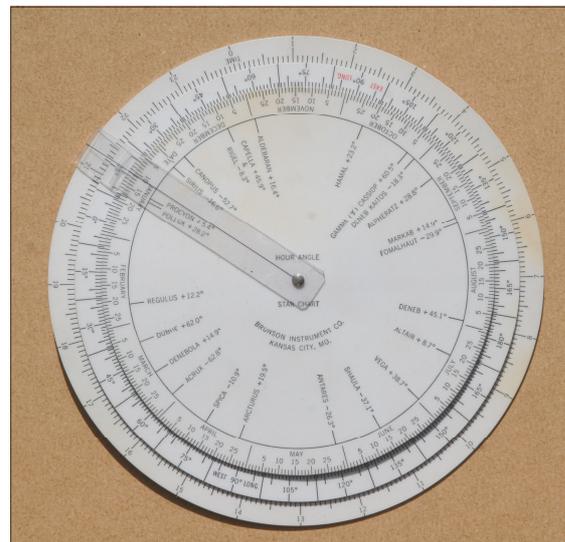


Fig. 5. 'Hour Angle Star Chart'.

Alternatively, the instrument may be used to determine the azimuth of a direction, by lining up the alidade with a distant object and reading the azimuth against the north index mark.

For navigation by the stars, the Star Sight Assembly is attached to the clock shaft. Any one of two dozen navigation stars are identified on north and south star charts provided in the manual. Reference is then made to the Hour Angle Star Chart (Fig. 5), which consists of three co-axially mounted plastic discs, with scales for: (a) standard time and hour angle, (b) longitude, and (c) date, with a transparent pointer pivoted on the chart centre.

The star's declination is listed on the chart, and this is set on the declination scale of the Star Sight Assembly. The hour angle of the star is then determined by aligning the time, date and longitude scales, then, using the transparent pointer, reading the hour angle on the time scale against the position of the star. The index line on the Star Sight Assembly is set to the hour angle on the clock face. The star is centred in the star sight's field of view, and the north index line is aligned as for solar observation.

The manual (which seems to lack only a glossary) includes a description of its operation in considerable detail, instructions for its care and adjustment, disassembly and reassembly, a complete parts list, and a map of world time zones. The instrument was supplied with a basic tool kit, a bubble level, and a 4x magnifier for reading the scales.

I have used the sun compass to determine the direction of true north when researching the design of the Guernsey Liberation Monument.<sup>4</sup> It was not difficult to use and gave reliable results at the reduced scale needed for the experiments. The clockwork system was particularly beneficial as the compass essentially looked after itself after initial setting up. I have been unable, however, to determine the

extent of its military use. The results of an Internet search implies that it is probably now quite rare. While the Company has one, and there is another at the US Army 1<sup>st</sup> Infantry Division Museum at Cantigny in Illinois, I know of no others.

**REFERENCES**

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3. John T. Pennington: *History of U.S. Army Engineer Topographic Laboratories (1920 to 1970)*, Topographic Laboratories, Fort Belvoir, Virginia, (1973).
4. D. Le Conte: 'The Guernsey Liberation Monument', *BSS Bull.*, 97.3, 43 (July 1997).

Guernsey-born **David Le Conte** worked at the Smithsonian Astrophysical Observatory, the Smithsonian Institution in Washington, and Kitt Peak National Observatory, Arizona, before returning to the island of his birth to work on environment and heritage as a civil servant. He is now a Jurat of the Royal Court of Guernsey. He can be contacted at [dleconte@guernsey.net](mailto:dleconte@guernsey.net)



**Meccano Butterfield Dial**

This working Butterfield dial was made from the components of a Pocket Meccano set as a challenge issued to the late Noel Ta' Bois when he was in hospital. The item is currently held by the BSS, courtesy of another Meccano enthusiast, member Pat Briggs.

# MINUTES OF THE 23<sup>rd</sup> BSS ANNUAL GENERAL MEETING

## Cheltenham, 15 April 2012

The meeting was opened by the Chairman, Frank King, at 12:20 pm.

### 1. Minutes of Previous AGM

The Minutes of the 22<sup>nd</sup> Annual General Meeting, held at Wyboston Lakes, Huntingdon on 1<sup>st</sup> May 2011, had been published in the *Bulletin* of June 2011, were taken as read, and were approved.

### 2. Council member's reports for 2011-12, and 2011 Accounts

The reports of Council members and Specialists had been circulated with the Conference papers, and are shown below. The Chairman expressed his extreme gratitude for the work done for the Society by all these members. There were no comments from the floor on the reports. On the Accounts, Doug Bateman was concerned that these had not been included in the conference pack.

#### Chairman

My first year as Chairman has been a mixture of the enjoyable, the unfamiliar and the quite unexpected.

Happily, there was much to enjoy in our traditional core activities: four superb issues of the *Bulletin*, the excellent main conference and the Newbury meeting.

A large number of essential but less visible activities continued as well and I would like to thank all our volunteers, the Society's true heroes, for their commitment and dedication. Without them there would be no Society.

The Society can look forward with pride to celebrating its silver anniversary in 2014. Looking further ahead we face challenges and these have been noted by both the Secretary and me in the *Newsletters*. My primary duty as Chairman has to be to ensure that the Society's past success continues into the future.

Accordingly, my first substantive act as Chairman was to propose a survey to sound out the views of the membership. We cannot determine our future direction or expect new volunteers to come forward without an active and real involvement by the membership in the affairs of the Society. The survey is the start of the process and the Discussion Forum at Cheltenham is a second step. In my experience of other charities, I have been accustomed to keeping an almost permanent eye on a strategic plan. This necessarily has to adapt to changing circumstances (such as changes in the expectations of the membership and, sometimes, changes in the regulatory environment). The Council is now turning its attention to such a plan.

My biggest unexpected surprise was to receive two resignations from Council and it is always sad when those of long standing feel obliged to resign. I would like to take this opportunity, on behalf of the entire membership, to pay tribute to the stalwart service, in numerous roles, that Graham Aldred and Patrick Powers have given the Society over many years. I look forward to all of us working together to ensure the continuing success of the Society we all enjoy and value so much. In particular, I hope that the Council and the membership will have shared goals and that more will wish to serve as volunteers. There can be no better or fitting run up to 2014!

*Frank King*

#### Secretary

Why am I Secretary? Out of respect for our previous Chairman who personally asked me. I was aware that only our present Chairman had responded to Chris's appeals at the 2009 and 2010 AGMs for new Council blood. Someone else had to step up to the plate as well. Believing my ideas and experience could contribute I became part of the 2011-12 Council's new blood – the first infusion for a long time.

My first task was a rapid and exhaustive induction. The best part of two solid man weeks was devoted to devouring the previous five years' worth of Council papers and minutes as well as the Charity Commission's website.

As Secretary I have been very mindful that any governing body, to be effective and successful, has to balance and meet four very different responsibilities

- day to day operational management;
- longer-term strategic management;
- communication with the membership; and
- regulatory compliance.

Recent years Councils' agendas, priorities, time allocation, and decisions have concentrated on operational management and regulatory compliance. These are necessary but not sufficient for good governance. In consequence I have endeavoured to balance the scorecard and address blind spots and no-go areas on the strategic and communications fronts.

During 2011-12 Council's agenda has evolved towards a broader focus and balance. In October Council started our strategic evaluation and the March Council spent the majority of its time considering our future direction and two-way communication with members.

My most enjoyable task has been contact with individual

**STATEMENT OF FINANCIAL ACTIVITIES  
FOR THE YEAR ENDED 31ST DECEMBER 2011**

	Notes	Unrestricted Funds £	Restricted Funds £	TOTAL 2011 £	TOTAL 2010 £
<b>INCOMING RESOURCES</b>					
Voluntary Income	<b>2a</b>	1,266	527	1,793	1,775
Investment Income	<b>2b</b>	407	0	407	312
Incoming Resources from Charitable Activities	<b>2c</b>	45,541	0	45,541	30,586
<b>TOTAL INCOMING RESOURCES</b>		<b>47,214</b>	<b>527</b>	<b>47,741</b>	<b>32,673</b>
<b>RESOURCES EXPENDED</b>					
Charitable Activities	<b>3a</b>	39,044	0	39,044	30,762
Administration Costs	<b>3b</b>	5,710	1,544	7,254	8,311
Governance Costs	<b>3c</b>	705	0	705	540
<b>TOTAL RESOURCES EXPENDED</b>		<b>45,459</b>	<b>1,544</b>	<b>47,003</b>	<b>39,613</b>
<b>NET INCOMING/ (OUTGOING) RESOURCES</b>		<b>1,755</b>	<b>-1,017</b>	<b>738</b>	<b>-6,940</b>
Total Funds Brought Forward		71,516	9,578	81,094	86,321
Adjustment to Prior Year figures	<b>13</b>	0	0	0	1,713
<b>TOTAL FUNDS CARRIED FORWARD</b>		<b>73,271</b>	<b>8,561</b>	<b>81,832</b>	<b>81,094</b>

Movements on all reserves and all recognised gains and losses are shown above. All of the organisation's operations are classed as continuing.

Note: These summary Accounts are an extract only. The full accounts are available on the Society's website or on request from the Treasurer.

members. It was a pleasure to read your membership survey returns as they came in, as were all the discussions and exchanges I had with individual members. The survey's results indicate that Council needs to govern with a greater awareness of the membership's opinions, priorities and wishes. The survey was a central component of the March Council's deliberations.

Looking to the future, it is hoped that the March Council's deliberations, the membership survey, the Cheltenham Forum, and a further infusion of new blood will all provide the impetus to the 2012-13 Council and membership, working together, to make a real difference to the Society's future.

*Chris Williams*

### Treasurer

Last year's report dealt with the changes that were necessary to be implemented in this year. That I have very little to say now can be taken as no news being good news. Overall, our transactions have made for a steady turnover and against the trend of the times, income has kept ahead of expense.

Our changeover of bank from Santander to the Co-Op has proceeded smoothly, but it will not be complete until all subscription standing orders have been migrated. Many people have already done this – for which, thanks – and I hope that nobody shall have to re-instruct their bank to this effect. We have also made our entrance into the world of

**BALANCE SHEET  
AS AT 31ST DECEMBER 2011**

	Notes	Unrestricted Funds £	Restricted Funds £	31-Dec-11 Total £	31-Dec-10 Total £
<b>Fixed Assets</b>					
Tangible assets		16,635	0	16,635	16,635
<b>Current Assets</b>					
Debtors	7	0	0	0	0
Cash at bank and in hand	6	57,197	8,561	65,758	64,999
<b>Total Current Assets</b>		<b>57,197</b>	<b>8,561</b>	<b>65,758</b>	<b>64,999</b>
<b>Creditors:</b> amounts falling due within one year	8	561	0	561	540
<b>NET CURRENT ASSETS</b>		56,636	8,561	65,197	64,459
<b>NET ASSETS</b>		<b>73,271</b>	<b>8,561</b>	<b>81,832</b>	<b>81,094</b>
<b>Funds of the Charity</b>					
General Funds		73,271	0	73,271	71,516
Restricted Funds	4	0	8,561	8,561	9,578
<b>Total Funds</b>		<b>73,271</b>	<b>8,561</b>	<b>81,832</b>	<b>81,094</b>

**Trustees Responsibilities**

The Charities Act 2011 require the trustees to prepare financial statements for each financial year which give a true and fair view of the state of affairs of the trust and of the surplus of the trust for that period. In preparing those financial statements the trustees are required to:

- Select suitable accounting policies and apply them consistently
- Make judgements and estimates that are reasonable and prudent
- Prepare financial statements on the going concern basis unless it is inappropriate to presume that the trust will continue in existence.
- state whether applicable accounting standards and statements of recommended practice have been followed , subject to any material departures disclosed and explained in the financial

The trustees are responsible for keeping proper accounting records, which disclose with reasonable accuracy at any time the financial position of the trust. They are also responsible for safeguarding the assets of the trust and hence for taking reasonable steps for the prevention and detection of fraud and other irregularities.

These accounts were approved by the Trustees and signed on their behalf on the 15-4-12

Signed Frank H. King Dr. F. King. Chairman.

Signed [Signature] G. Stapleton. Treasurer

e-commerce with the establishment of a PayPal account. This is being monitored for suitability before we open it to wider use. We certainly hope that this will make life simpler for some people, but I would like to repeat that the traditional cheque remains our preference where possible.

The most agreeable transaction of the year was a grant to the National Maritime Museum of a sum that will go a substantial way towards the installation of a permanent sundial at the Old Royal Observatory. I hope that there will be projects emerging elsewhere to make this a repeated occurrence.

*Graham Stapleton*

### Membership Secretary

At present we have a membership of 420 of which 396 are paying and 24 receive a complimentary copy of the *Bulletin*. These are mainly other societies with which we have an exchange of journal agreement. Of these members, 289 are in the UK and 65 in the rest of Europe. There are 66 in the rest of the world; 41 in the USA, 5 in Canada, 6 in Australia and others spread far to include Japan, Brazil, Russia, New Zealand, South Africa and Bermuda.

Since the last conference we have welcomed 22 new members; this is encouraging as the previous year only saw 12 joining us and the two years prior to that there were 20 each year. This may seem like good news, but there have been many leaving, mainly due to health reasons such as too frail, failing eyesight and 5 have died. Last conference I reported a total membership of 434. We have an ageing membership and need to do more to encourage the newly-retired to join us, those in their early sixties.

*Jackie Jones*

### Editor

2011 was a quiet year on the publishing front. The usual four issues of the *Bulletin* were distributed with minimal problems. As always, I am very grateful to, and entirely dependent upon, all the authors and contributors of material, as well as the band of proofreaders who weed out my glaring typos and mistakes; any that remain are my responsibility. A number of small tweaks to the presentation of the *Bulletin* have been introduced and seem to be popular. There have been slightly more articles from overseas authors this year which I hope reflects the international nature of our interests.

There have been good sales of the *Bulletin* Archive DVD containing electronic copies of the first 75 issues. Further issues have been added to the master-file and a new edition is due soon. [Now available!]

One new monograph (Alan Cook's 'Addendum to Mass Dials on Yorkshire Churches') has been published since the last AGM and three more on a variety of subjects and at different levels are in the pipeline for 2012/3.

*John Davis*

### Registrar

Thanks once more to our doughty recorders, who have sent

in over 250 reports in the year. Half have been for previously unrecorded dials, including an 18<sup>th</sup> C horizontal by Robert Cutbush, a 19<sup>th</sup> century Heath and Wing, a Pilkington Sol Horometer, and two formed from twisty tree trunks! Reports are being sent increasingly by email, easier and cheaper for you and easier for me, so if you have not tried it yet, please do not hold back.

We have now 6,796 recorded dials, over three quarters with one or more photographs. The total number of images in the *Register* grew by 10% in the 2010/11, and has grown by 10% again in this last year, thanks to an on-going exercise of re-visiting early reports, and scanning the web for copyright-free images.

*John Foad*

### Mass Dial Group

There has been plenty of activity in the Mass Dial Group. Entry into the Mass Dial Register is proceeding county by county. Essex, Hertfordshire, Bedfordshire and Northamptonshire have been entered recently. Kent is in hand.

It became necessary to replace the existing computer, and the upgraded XP operating system was sourced via the Royal Astronomical Society with help from John Foad following information from Patrick Powers – many thanks.

It is hoped to initiate a parallel entry system to deal with the outstanding backlog of entries and the alterations necessary to the database are in hand with John Foad. A further computer and scanner have been acquired and it is hoped Ian Butson can undertake the parallel entry.

Maureen Harmer managed to uncover the existence of a complete listing of Kent mass dials held by the Kent Archaeological Society and following some negotiation we acquired a copy on CD which has also been printed out.

Group members Ian Butson, Jill Wilson, John Lester, Irene Brightmer and Lyn Stilgoe have provided reports and a small but steady stream of reports appears from non-members, mainly via e-mail after discovering our site on the Internet. (Re-photographing with a digital camera is very welcome: much better pictures are now possible.) In particular, the Church Recorders of NADFAS deserve special mention for contacting me whenever they come across a dial of any sort.

Chris Williams has continued his statistical survey of mass dials. A couple of dials from monasteries have appeared leading to hopes of other such dials coming to light.

Two recent dials deserve particular attention:

1) Bristol, St James's Priory. Pre-dissolution and not a mass dial but apparently an equatorial, which raises all sorts of questions!

2) Hertfordshire, Caldecote. A horizontal mass dial, carved on a seat in the porch. This is only the second horizontal mass dial noted in England and its being in a porch raises several questions although a simple re-use of a cross base is quite likely.

Tailpiece: Recently a NADFAS lady reported two new

dials at a church which had been gone over separately by Powers, Butson and Wood – come on, chaps! Finally, thanks to everyone who has been in contact over the last year.

*Tony Wood*

### **BSS-SotI Sundial Trail Competition**

The combined British Sundial Society and Sundials On The Internet sundial trail competition was run again in 2011 and judges were duly appointed to comment on the entries.

Three trails have been submitted by the deadline of 31<sup>st</sup> January. They may be accessed on the SOTI website at <http://www.sundials.co.uk/competition.htm>

The two winning entries will be announced at the end of the 2011 Conference Dinner on the 14<sup>th</sup> April 2012.

*Patrick Powers*

### **Conference Organisation**

The Council first implemented the idea of a follow-up conference questionnaire at our Exeter Meeting in 2010. That first poll gave a strong (86%) backing for trying to find an all under one roof venue and the Wyboston Conference of 2011 was our first such meeting. It was considered a particular success.

100% of the replies received from the Wyboston questionnaire indicated that delegates had found it enjoyable, 100% also liked the accommodation, 93% rated its ‘value for money’ as Good to Excellent, and 88% of delegates thought we should continue the use of such venues. This year’s choice of the Cheltenham Chase Hotel in the Cotswolds is the outcome of that and with its special conference suite it promises to maintain or even better that Wyboston standard. I would very much like to receive input from this year’s delegates about their perception of this latest conference.

Again this year, we have continued to place particular emphasis on giving more advance information about the arrangements by running a special conference web page and trying to improve the organisation of presentations by having them submitted to the conference organiser in advance of the meeting. Another first for this year has been the introduction of facilities for payment by PayPal.

This year we have once again been fortunate in securing talks by many of the Society’s most accomplished speakers. In addition we have been able to add presentations by Roger Bailey, by our own Chairman Frank King and for our Andrew Somerville Memorial Lecture, by Prof John Heilbron, Emeritus Professor of the History of Science and Vice-Chancellor Emeritus at the University of California, Berkeley.

This year too we are to have an auction of sundial related material. We are particularly fortunate in having the ‘old team’ of Chris Daniel as Auctioneer and David Young as Auction Manager, back in action. As usual all proceeds go to the Society without any deductions.

This Cheltenham Conference is the last BSS Conference to

be organised by me; Chris Lusby Taylor is picking up the baton for 2013. I would like to say a big thank you to all who have helped me with ideas and assistance over these past three conferences and with a very wide variety of other Council matters over my 15 years on the Council.

*Patrick Powers*

### **Webmaster**

The main activity this past year has been to bring the Dial of the Month up to date, thanks to contributions from John Foad. Photos and descriptions would also be welcome from the general membership, as would suggestions on how to further improve the website.

In 2011, we had 24,623 visitors, who visited 78,204 pages, and downloaded 706,404 files of total size 22.10 Gbytes.

The top pages visited were: How sundials work; Bulletin; Web links; Glossary; Dial makers; Register; Publications; Contacts.

We are still the number one sundial site on [www.alexa.com](http://www.alexa.com) (see Top Sites | By Category | Science | Astronomy | Calendars and Timekeeping | Sundials) which is a great credit to all those who have contributed to the website – thank you all.

*Richard Mallett*

### **Restoration and Grants**

Altogether 30 enquiries for advice have been received this year. Some are rather transparent requests for valuations (which we are unable to offer) often for mass produced sundials of little merit. Others relate to historic sundials of considerable merit for example the unique pillar dial in the Abbey Gardens at Bury St Edmunds or the vertical dial at All Saints, Stamford, both of which the Society is likely to support with a grant in the future. Some enquiries simply require assistance in setting up an old dial in a new location either in a family home or a public place e.g. Taplow Court.

Other enquiries require physical work like a replacement gnomon and in this case we assist the enquirer in the selection of two or three possible makers from the BSS list. The restoration advisor is often the conduit for dialling enquires of a general nature which are passed on to the Registrar or the Editor who can provide more specific details. Aided by a BSS grant the restoration project of the *Meridies Media* noon-mark mean-time sundial at the Royal Observatory at Greenwich has now started.

Members are once again reminded that Grants can be made towards any restoration or educational project which meets the given criteria. I shall be retiring from this post at the AGM and would like to repeat a request for a successor to take over this interesting task that contributes considerably to the Society’s essential Public Benefit Profile.

*Graham Aldred*

### **Librarian**

A small batch of books was added to the collection in July, mainly bound copies of the *Bulletins* and other BSS publi-

cations. There are now 485 dialling books and pamphlets in our Library. The security system, part-funded by the BSS, is installed and working with a monitor system at the desk. This security upgrade has enabled the whole collection to be housed in one room at last where we have been generously allocated more space. I shall be retiring from this post in April and I am very pleased to welcome (and help) my willing successor who will be formally appointed after the AGM.

*Graham Aldred*

### Advertising

Advertising in the *Bulletin* is still at low level but we have carried one extra advert this last year.

In an attempt to get new members we have tried a joint advert, in the form of a flyer, circulated in the March issues with the Scientific Instrument Society. Each Society is offering a trial first-year membership at half price. If this is successful we may try this with other related societies. (The results are not known yet.)

*Mike Cowham*

### Safari Organisation

The BSS visit to Catalonia is coming together nicely. The Catalan Sundial Society have been very helpful and have done a lot of work in organising our Safari there in September. At present we have 33 people going but there is still space for a few more if any latecomers are interested (subject to the hotel in Girona having rooms for them).

*Mike Cowham*

### 3. Election of Officers

By the Constitution the Chairman, Secretary and Treasurer hold post for only one year. Frank King, Chris Williams and Graham Stapleton were the only members nominated for these positions for 2012/13, and were elected by a show of hands.

### 4. Election of other Members of Council

In the same way all other Council members are elected for only one year, and up to four may be elected or re-elected to take their place. Graham Aldred and Patrick Powers had resigned, and John Davis did not stand for re-election. Jackie Jones, John Foad, Chris Lusby Taylor and David Brown were nominated for the Council, and there being no other volunteers these members were elected by a show of hands.

### 5. Appointment of Scrutineer for the 2012 Accounts

The appointment of Independent Examiners Ltd, who examined the 2010 and 2011 accounts, was approved by a show of hands.

### 6. Any Other Business

The Chairman accepted Doug Bateman's request for an 'AOB' agenda item and Doug raised the following points:

- He felt that the Accounts for the last 2 or 3 years had been presented to the membership too late and lacked detail. For example he would wish to know the amount held in the Andrew Somerville Fund, and the profit or loss made by the last Conference.

- At the Saturday morning discussion forum, he regretted that more time had not been allowed for Jackie Jones' paper on the future of the Society.

- He was informed that the Society's library at Nottingham had received no visitors in the last ten years, and suggested that an independent assessor should advise on its future

The Chairman thanked Doug for these points and said that they would be borne in mind for the future.

No other points being raised from the floor, the Chairman closed the meeting at 12:35 pm.



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## Postcard Potpourri 22 – Enniskerry, Co. Wicklow

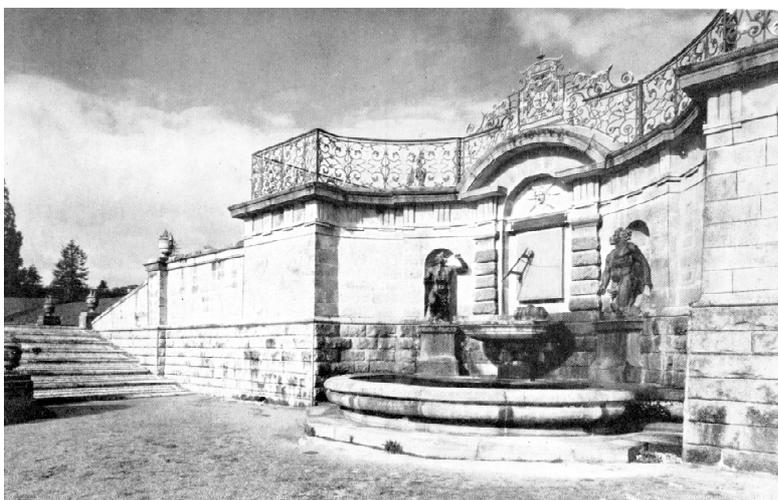
### Peter Ransom

This postcard comes with the enticing title of 'Sundial and Spitting Men, Powerscourt, Enniskerry'. An internet search reveals that the Italian Garden at Powerscourt was designed by Daniel Robertson with the terraces laid out during the 1840s and took over 100 men twelve years to complete. The 'Spitting Men' were originally from Milan and bought in Paris in 1872 and between them is the sundial which reads, "Horas Non Numero Nisi Serenas" (I only mark the sunny hours).

This dial is listed in the 2010 *Register* as SRN 3933. It declines 50° E so only shows the hours from 5am to 1pm. One wonders therefore with that motto if the sun never shines after 1pm!

There is no dating evidence on the postcard but it does mention that it is copyright 'Country Life' and reproduction is not permitted – oops!

*pransom@btinternet.com*



# IN THE FOOTSTEPS OF THOMAS ROSS

## Pt 1. Scotland's Oldest Sundials – the forerunners to lectern sundials?

DENNIS COWAN

Between 1887 and 1892, the architects David MacGibbon and Thomas Ross produced their definitive work, a five volume piece entitled 'The Castellated and Domestic Architecture of Scotland'.<sup>1</sup> The fifth and final volume was published in 1892 and the latter half of it contained details and sketches of the ancient sundials that they had seen during the production of their work.

In 1890, Thomas Ross presented a shorter version of the sundial section to the Society of Antiquaries of Scotland. This was published by them that year and for this reason, although the junior partner, Ross is mostly credited with the production of the whole section on sundials.

I have given myself the task of tracking down 'his' sundials and photographing them in their current locations. It is not always an easy task as his descriptions of the sundials often lack detail of the locations, many have been moved to other locations and many more are now missing. But it does take me to many interesting places that otherwise I would not visit. My wife, Evelyn, although she has no interest in sundials at all, thoroughly enjoys accompanying me to these out-of-the-way locations.

Scotland's oldest reliably-dated and authenticated sundial is the multi-faceted example from 1623 at Dundas Castle near South Queensferry, a few miles west of Edinburgh (SRN 1209). However, Ross identified three sundials which were almost certainly from the 16<sup>th</sup> century; those at Cockburnspath in the Scottish Borders, and Oldhamstocks and Seton

Palace both in East Lothian. They were all of a similar type and he described the first two at length as follows:

*This is perhaps the proper place to introduce the two very remarkable dials which are found on the churches of Cockburnspath and Oldhamstocks, situated about two miles apart.*

*These are sloping dials, and, so far as our observation goes, they are unique amongst attached dials, which are all upright; and as these two dials probably date from early in the sixteenth century, they may be regarded as the forerunners of the "lectern" dials, to be considered under a separate head.*

*The dial at Cockburnspath [Fig. 1] forms the terminal of the angle buttress at the south-west corner of the church; its face leans forward, and the sides are splayed away; the upper surface slopes backwards to the skew of the gable, and is hollowed like a half cylinder. A singular piece of stone sticks out like the stump of an amputated arm from the west side. Whether this was meant to tell the time by its shadow on the gable cannot be determined, as the wall is "harled" over. The west end of this church, including the buttress and the singular round tower as well as the east end, probably date from about the beginning of the sixteenth century, and without doubt the dial is a part of the original structure.*

Ross's "stump of an amputated arm" is still in place (SRN 1230, Fig. 2) and the harling noted by him has since been removed from the church wall. However, I can say that although it seems possible, there is no evidence at all that this arm's purpose was to cast a shadow on to the gable as there is nothing visible on the wall that would indicate this.

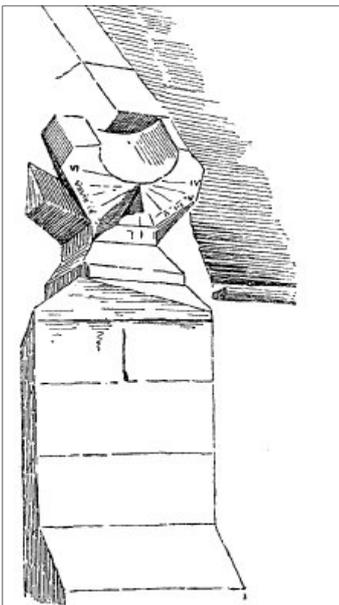


Fig. 1. Cockburnspath dial, sketched by Thomas Ross in the late 19th century.



Fig. 2. The Cockburnspath dial now.

Its purpose must remain a mystery for now. The hour lines and Roman numerals from 6am to 6pm can be easily seen on the main face of the dial, but only a slight stub remains of the gnomon. Otherwise everything is as described by Ross.

Ross continues as follows:

*The Oldhamstocks dial [SRN 1231, Fig. 3] is placed on the south wall of the church at the west corner; it leans forward, and has the top hollowed like a cylinder. Its proclining face having been cut out of a square stone, sufficient material has been left to form a gnomon, which is moulded like a Gothic rib. The face of the gnomon has itself formed a dial. Stone gnomons are of frequent occurrence on unattached dials, but are rare in those of this class. The stone is notched out and splayed away on each side, and has dials on the splays. Above each splay a portion of the stone is left square like horns at each side of the dial face; these horns act as gnomons.*

The dial is still pretty much as Ross described it in 1892 although there are no longer any signs of hour lines or numerals on the main dial face or on the gnomon as indicated by Ross and his sketch. Faint hour lines can still be seen on the east facing right hand 'splay' and the effect of the 'horn' gnomon can be easily seen in Fig. 4.

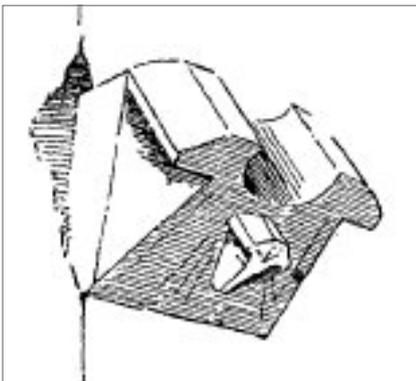


Fig. 3. The Oldhamstocks dial by Ross and, below,

Fig. 4, the dial today.



Ross continues once more:

*Cockburnspath [Fig. 5] and Oldhamstocks [Fig. 6] churches seem to be both of the same date. Oldhamstocks has a square projecting tower-like belfry in the centre of the west end, the position occupied by the round tower at Cockburnspath. It has a chancel with*



Fig. 5 (top). Cocksburnpath church.

Fig. 6 (bottom). Oldhamstocks church.

*an east window filled with rude flowing tracery. Alongside this window there is an inserted stone with arms, and the date 1581, "probably," writes the Rev Mr Hutton, "the date of the death of Margaret Sinclair, wife of Thomas Hepburn, incumbent of Oldhamstocks."*

*Without doubt the chancel is earlier than this date, and it is almost equally certain that the west gable is also earlier. The body of the church was partly rebuilt and repaired in 1701, that date being over the doorway in the south wall. Now, this is too late a date for the angle buttress at Cockburnspath, where buttress and dial are part of the original structure; and as there can be no doubt but that both dials are contemporaneous, the date 1701 is out of court altogether, and we have to fall back on some date previous to 1581 as the period of these dials. They measure horizontally about 20 inches in breadth.*

Ross went on to describe the dial at Seton Palace, which is about twenty-five miles north-west from the previous two, as follows:

*This dial [Fig. 7], of the same type as the two last mentioned, has not been so well preserved. It stands on a bastion tower, built at an angle formed by the walls of the old garden of Seton Palace. The tower is probably about 10 feet high. There have been cylinders on the upper sloping surface, but they have been smashed and broken so as hardly to be recognisable. On the flat top of the stone there is a horizontal dial seen from the inside of the bastion by ascending a stair.*

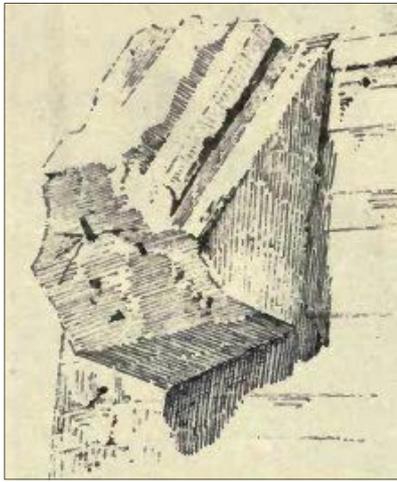


Fig. 7. The Seton Palace dial by Ross and

Fig. 8, the dial today.



Seton Palace is near to Longniddry and stands beside the main A198 between North Berwick and Musselburgh and the dial (not in *Register*, Fig. 8) is easily seen from the roadside. It still stands on the bastion tower but unfortunately it is badly eroded as indicated by Ross. Possible hour lines reminiscent of a mass dial can be seen on the proclining surface. No other markings are visible. It was not possible for me to be able to ascend to the top of the tower so I was unable to determine whether the horizontal dial as identified by Ross is still in place.

But there is a fourth dial of this type of which Ross was not aware. It is situated on the church at Fogo, a tiny hamlet in the Scottish Borders about twenty miles south-west from Oldhamstocks and Cockburnspath. Fogo is off the beaten track and can only be reached, regardless from which direction you approach, by narrow single track roads.

It is unclear when this church was built for there are no surviving records, but the foundations and the lower walls are thought to be well over 800 years old. It is possible that the current building was built around 1570<sup>2</sup> and it is known that there were extensive alterations in the late 17<sup>th</sup> century.

The dial itself (not in *Register*, Fig. 9) is located on the south west corner of the church adjacent to the unusual outside stairs to the 'Laird's Loft' (Fig. 10) and it is very similar to the three dials described earlier. It is, however, badly eroded and no hour lines or numerals can be seen on the main proclining face. It does have the remains of a stone

gnomon, very similar to that at Oldhamstocks, on its main face and there are horns at the sides of this face again with similarities to Oldhamstocks, with the addition of a sunken triangular face at each side.

With the exception of the very few mass dials in Scotland, it is almost certain that these four dials are the oldest in Scotland. Were these four dials all made by the same hand? It seems that is possible – they are all similar, probably of a similar age and their locations are not too far apart. Were they the forerunners of the lectern dials? Again, it seems possible – Ross certainly thought so. There are similarities between aspects of these four dials and the later lectern dials such as the half-cylinders and the sunken geometric faces, but it is likely that we will never know.

#### REFERENCES

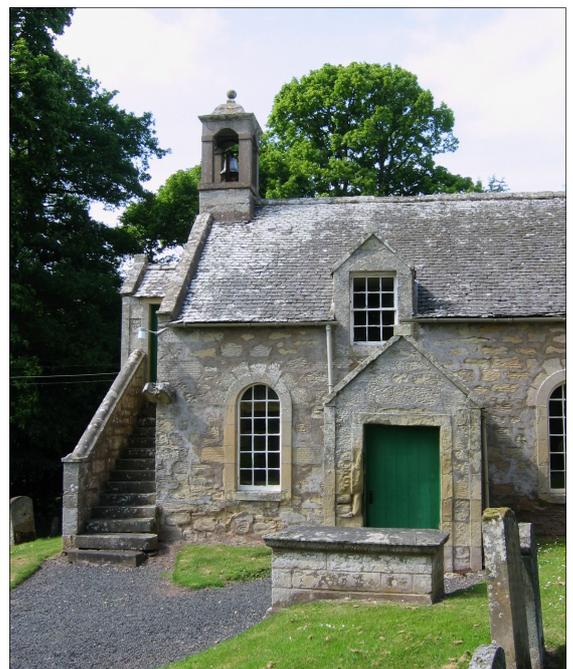
1. Text in *italics* is reproduced from D. MacGibbon and T. Ross: *The Castellated and Domestic Architecture of Scotland*, David Douglas, Edinburgh (1892).
2. British Listed Buildings: [www.britishlistedbuildings.co.uk/sc-10512-fogo-kirk-church-of-scotland-including-in](http://www.britishlistedbuildings.co.uk/sc-10512-fogo-kirk-church-of-scotland-including-in) .

For a CV of the author, see *Bulletin* 23(iv) p.40.



Fig. 9. The dial at Fogo.

Fig. 10. Fogo church with the dial next to the steps to the 'Laird's Loft'.



# THE FORSYTH SUNDIAL – FAVERSHAM

CHRISTOPHER DANIEL

In the last year or so, with one or two exceptions, I have tended not to accept new sundial commissions, since most of them have some form of demanding priority. Indeed, I have even given away a prestigious sundial project in the City of London to one of my colleagues in the Society. So how I came to accept a private commission to design a sundial for the owner of a private garden in Faversham, I don't quite know. Nevertheless, on 21 February 2011, I received an e-mail from a certain Mrs Kathryn Forsyth of 40 Court Street, Faversham, enquiring as to whether I would be available to undertake a commission to design a sundial for her husband's 40<sup>th</sup> birthday.

Mrs Forsyth is no ordinary lady, having, for a start, been a captain in the British Army in Military Intelligence, with experience in a warfare zone in Sierra Leone. She had evidently bought a copy of my Shire book on sundials and her husband, Campbell, had read it and shown an interest in the subject. She was positive and enthusiastic about the idea of commissioning a sundial: in these circumstances, I could hardly say "no". There was just one problem: this was to be a surprise for Campbell, so that the commission had to be kept secret, except for those involved in its construction. The date of this particular birthday was 8 December 2011, so there was not too much time to play with. A vertical wall dial was ruled out, particularly as this would have to be set up before Campbell's birthday, with the result that it would not have been a surprise. Also, such a dial could hardly be removed if the Forsyth's decided to live elsewhere. Consequently, a so-called 'garden' sundial was agreed upon; but it had to be very special to mark this important event.

Designing a sundial is perhaps rather similar to composing a piece of music, where, so often, other artists enable the final work to be brought to life. Taking into account the wishes of the client, the design of a dial is largely a matter of imagination and personal taste, underwritten by a good grounding in astronomy and a sound knowledge of the construction of sundials. The design should necessarily include the delineation of the dial, which should not be an inde-

pendent factor, as some suppose. Nevertheless, this commission would be a challenge, as I had no inclination to produce a common or garden horizontal dial. Furthermore, quite apart from the fact that the date of Campbell's 40<sup>th</sup> birthday was the key to the design, Faversham's local histo-

rian, Dr Arthur Percival, and others had, for some time, expressed their views that it would be desirable to have one of my sundials in Faversham! Thus, with the figure '40' firmly in mind, I set to work to achieve this, conceiving a dial based on that of a horizontal dial in latitude 40° N, which could be carved entirely out of slate by an experienced sculptor or stone mason.



*Fig. 1. Campbell Forsyth's sundial.  
Photo by Richard Riddick, the DPC Greenwich.*

Since my design called for a substantial piece of slate, which could be placed, but not fixed on the circular capital of a stone pedestal, I decided to approach two individual stone masons to undertake these separate tasks. This division of labour would mean that the work could be carried out in parallel, thus saving time, since I could ill afford to fail to meet the deadline for the delivery of the sundial! I commissioned Ben Jones, the noted Devonian sculptor and sundial maker of Exeter to make the dial in Cumbrian green Kirkstone slate particularly as he had already made the beautiful memorial polar sundial to my late wife, which is in Sidcup cemetery. I approached a local Faversham stone mason, Clive Sherwood of West Street, to make the pedestal in Nabresina limestone – sometimes called Roman stone – which would allow one to monitor progress more easily. Of course, there were a number of problems that arose in both cases; but these were easily resolved. Clive set up the pedestal some days before Campbell's birthday, which was explained away to Campbell as 'a bird table'. Ben duly delivered the sundial itself to me on Tuesday 29 November, giving me just enough time to have studio photographs taken of it and to produce a small explanatory leaflet. This was for the benefit of Campbell and Kathryn's guests for distribution at Campbell's birthday party on the Saturday.

## The Sundial

The sundial which Kathryn Forsyth gave to her husband Campbell for his 40<sup>th</sup> birthday was designed and made as a work of scientific art to mark this event. It may not be particularly beautiful or elegant; but it is undoubtedly unique. Firstly, the base of the dial is 40 cm square and, secondly, it is constructed as a horizontal sundial for latitude 40 degrees north. To achieve this, the dial-plate is tilted about the east-west axis by 11½°, such that it will face southwards to indicate the correct *local apparent time* in Faversham. Thus, it may well be described as an *inclining* sundial or even a *lectern* dial.



Fig. 4. Dial set up in situ on its pedestal.  
Photo by the author 6 Jan 2012.

However, perhaps the most unusual ‘hidden’ feature of the sundial is the fact that, on Campbell’s birthday, on 8 December at 12 o’clock noon, the shadow of the indicator or *gnomon* will be contained within the gilded ‘box’, formed by the 12 o’clock hour-lines, whilst the edge of the shadow, cast by the horizontal tip of the gnomon, will coincide with the gilded horizontal line at the top of the ‘box’. This line is denoted with the gilded cipher “C. VIII. XII. MMXI. F.” indicating not only the time by the Roman numeral XII; but also the date: VIII. XII. MMXI. The prefix letter ‘C’ and the suffix letter ‘F’ represent, of course, the ‘split monogram’ of Campbell Forsyth.

The customary *furniture* of the sundial includes the ‘signatures’, as well as the latitude and longitude of the place for which the dial was made, and also the name of the town, i.e. ‘Faversham’. The dial-plate itself is delineated with gilded *xiphoidal* hour-lines, reminiscent of Ancient

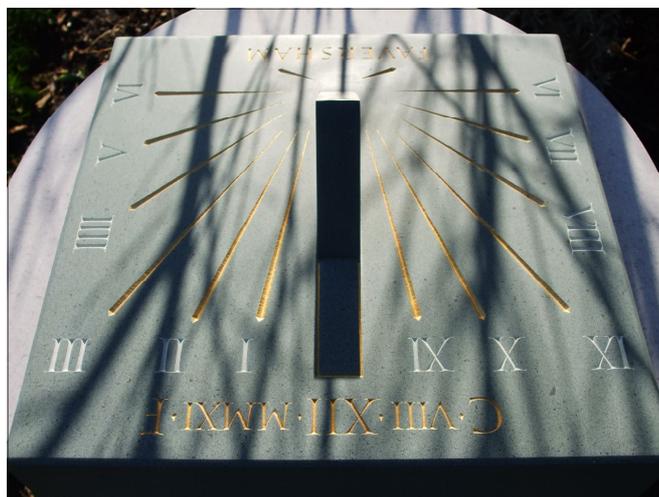


Fig. 5. Photograph taken by the author at 12 o’clock noon on 6 January 2012, when the sun’s declination was almost identical to the reciprocal declination on Campbell Forsyth’s 40<sup>th</sup> birthday on 8 December 2011. The extraneous shadows, cast by a nearby redwood shrub, are a little disconcerting; but the shadow of the gnomon completely fills the gilded ‘box’, indicating both the hour and the date, as it would have been on 8 December.

Greek weaponry, or the rays of the rising sun, although each hour is denoted by a plain painted Roman numeral. In the morning, the trailing edge of the gnomon’s shadow will indicate the hour of the day, as it passes over the centre of each hour-line, whilst in the afternoon, the leading edge will give the time. However, no attempt has been made, neither was there any intention, to provide the means to determine accurate time, whereby ‘clock’ time might be ascertained.

Enlisting the help of Clive Sherwood, I was able to have the sundial brought to the door of the Forsyth’s house in Court Street on 7 December, when it was taken inside and placed on a table, prepared with birthday wrapping paper. All that Kathryn needed to do was to fold the paper over the dial-plate. Whether Campbell was allowed to open his present on the following day, I do not know. However, at the party on 10 December, both Campbell and Kathryn expressed their delight with the dial. As it happened, a few days later, in noon-day winter sunshine, I was able to set it up and align it in the meridian. On 6 January 2012, I was even able to take photographs at noon, when the sun was almost at the reciprocal declination to that of 8 December 2011. Apart from some extraneous shadows from a nearby redwood bush, I was pleased to see that the dial was giving an accurate reading. Of course, as the dial is on private property, I have not exactly fulfilled the wishes of those mentioned earlier in this article – I apologise !

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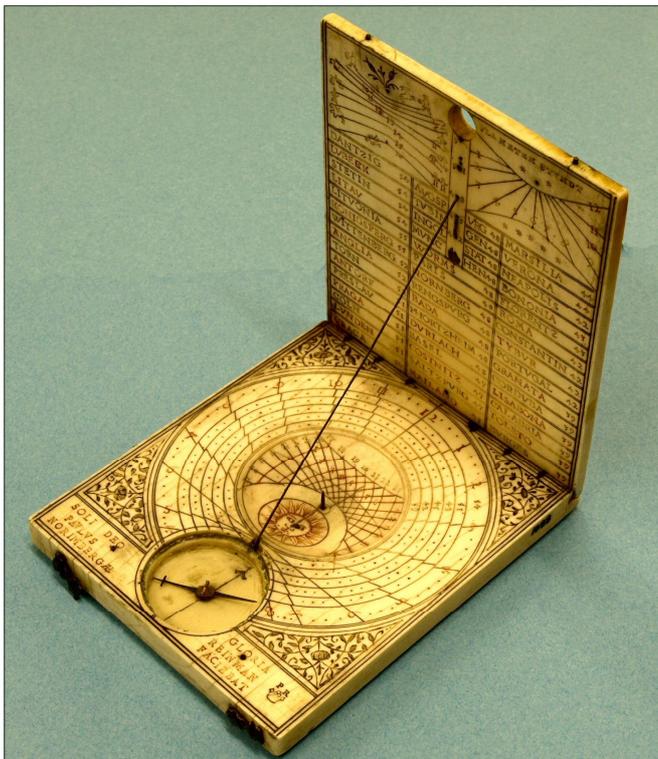


# IVORY SUNDIALS OF NUREMBERG INCORPORATING A SCAPHE SUNDIAL

ORTWIN FEUSTEL

Some of the numerous ivory sundials of Nuremberg<sup>1,2</sup> have, in addition to the typical horizontal sundial and distinct vertical sundials, a pin gnomon sundial with a spherical bowl (a ‘scaphe’). It is equipped with three declination lines for the solstices and equinoxes as well as Babylonian and Italian hour lines, counting the equinoctial hours from sunrise or sunset, respectively; the small vertical pin gnomon is positioned at the scaphe’s nadir. Whereas the various time scales of the horizontal dial have been marked with the applicable latitude, this clue is missing for the scaphe dial. Hence it is of interest to put the question: what is the latitude for which the scaphe has been designed?

Taking the vectorial representation (component notation) for the intersection point where the sunray strikes the spherical surface, its coordinates will be derived. Three-dimensional configurations of a model scaphe illustrate the shapes of the declination and hour lines.



J. Davis

Fig. 1. The indications of this Reinmann dial are mainly on the inner side of the upper leaf: a pin gnomon dial for day length and by zodiac symbol for the planetary hours, six string attachment points for different latitudes and on the inner side of the lower leaf a string-gnomon (it has to be aligned with the earth’s polar axis  $\Rightarrow$  pole-string) horizontal dial with six scales as well as a scaphe dial at the centre of the horizontal dial, a compass bowl.<sup>1</sup> Wh. 1688, courtesy of the Whipple Museum of the History of Science.

Because of the small dimensions of the scaphe, it is practically impossible to measure spatial distances within the spherical cap for the sake of comparing the measured values with the calculated ones. Therefore selected straight line distances measured with an image processing program from photographic plan views will be used for the analysis of three scaphe sundials from different makers.

## Characteristics of the Diptych Sundials Analyzed

A Nuremberg ivory diptych sundial consists of two plates equal in size which are joined together with a hinge. The instrument opens for making a time measurement so that the plates form a right angle; the sundial is then positioned horizontally and aligned southwards with the help of the built-in compass. The engraved scales on the inner sides of the plates of a typical diptych sundial are shown and described in Fig. 1. On the outer sides there are a windrose, marked with cardinal points, as well as a lunar volvelle, an engraved disc with associated time correction scales in hours and minutes, a table of epacts for the years 1608 to 1626, and four bun feet.<sup>1</sup> Some additional relevant characteristics of the present sundials are listed in Table 1.

It deserves mention that towns with such different latitudes as Wien (Vienna, 48.2°), Augsburg (48.4°), Paris (48.9°), Speyer (49.3°), Heidelberg (49.4°), Nürnberg (Nuremberg, 49.5°), and Frankfurt (50.1°) have all been assigned in the latitude tables to 48°. Gouk has commented “For example, on most sixteenth-century instruments with latitude tables, Nuremberg is represented as being at 49°. However, on later examples Nuremberg is regularly assigned to latitude of 48°. The reason for this change seems to have been in order to place towns into standardized groups and to limit the number of latitudes shown. By this method of simplification Nuremberg, Vienna, Augsburg and Paris – some of the major centres of Europe – were all considered to be at 48°.”<sup>3</sup>

It is possible that the scaphe lines were designed for a latitude of either 48° or 49°. Below, we will investigate which is the most likely for these three scaphe sundials.

## Fundamentals for Calculation<sup>5</sup>

Horizon system  $\Leftrightarrow$  equator system

Symbols used:  $a$  = azimuth of the sun ( $a = 0^\circ$  = at the local meridian, positive values western of the meridian),  $h$  = altitude of the sun,  $\delta$  = sun’s declination,  $\tau$  = hour angle ( $\tau = 0^\circ$  = midday, positive values western of the meridian),  $\phi$  = geographical latitude.

reference catalog no.	1 Wh. 1688	2 AST0438	2 AST0476
dial maker	Paul Reinmann	Michael Lesel	Lienhart Miller
maker's mark	crown	crown	fleur-de-lis
year	1608	c. 1612	1628
Babylonian scale	1 - 16	1 - 16	1 - 16
Italian scale	8 - 23	8 - 23	8 - 23
latitude range*	39° - 54°	42° - 54°	42° - 54°
number of towns**	45	30	24
overall dimensions L × W × T	111 × 91 × 15	111 × 72 × 14	110 × 71.5 × 14
scaphe diameter	44.3	34.8	34.2
scaphe depth	6.8	5.7	5.7
Illustration	Figs. 1 & 7	Fig. 8	Fig. 9

Table 1. Characteristics of the three dials analysed. W1688 is in the Whipple Museum, Cambridge. AST0438 and AST0476 are in the National Maritime Museum, Greenwich.

c. close approximation, \* horizontal sundial, \*\* table of latitudes. All dimensions in mm.

$$\sin a \cos h = \cos \delta \sin \tau, \quad (1)$$

$$\cos a \cos h = \sin \phi \cos \delta \cos \tau - \cos \phi \sin \delta, \quad (2)$$

$$\sin h = \sin \phi \sin \delta + \cos \phi \cos \delta \cos \tau. \quad (3)$$

#### Babylonian hour angle of the sun

Sunrise is the zero point for counting Babylonian hours from 0 to 24 with equinoctial (equal) hours. Therefore the sun's Babylonian hour angle is

$$\tau_b = -\arccos(-\tan \phi \tan \delta) + b15^\circ, 0 \leq b \leq 24. \quad (4)$$

#### Italian hour angle of the sun

Sunset is the zero point for counting Italian hours from 0 to 24 with equinoctial hours. Therefore the sun's Italian hour angle is

$$\tau_i = \arccos(-\tan \phi \tan \delta) + i15^\circ, 0 \leq i \leq 24. \quad (5)$$

#### Intersection point between the sunray and a sphere

Fig. 2 (the meridian section of a sphere) shows the positions of the vectors  $\vec{M}_K$ ,  $\vec{S}$  and  $\vec{r}_K$ ; they can be presented in vector form

$$\vec{M}_K = \begin{pmatrix} 0 \\ 0 \\ m \end{pmatrix}, \quad \vec{S} = S \begin{pmatrix} -\cosh \sin a \\ -\cosh \cos a \\ \sin h \end{pmatrix} \text{ and } \vec{r}_K = \begin{pmatrix} r_x \\ r_y \\ r_z \end{pmatrix}$$

respectively.

They are correlated through the relation  $(\vec{S} - \vec{M}_K) = \vec{r}_K$  so that we obtain with the absolute value  $|\vec{S} - \vec{M}_K| = R$  the equation of condition for parameter  $S$

$$(\vec{S} - \vec{M}_K) \cdot (\vec{S} - \vec{M}_K) = \vec{r}_K \cdot \vec{r}_K = \left[ \begin{pmatrix} -S \cosh \sin a \\ -S \cosh \cos a \\ S \sin h - m \end{pmatrix} \right]^2 = R^2. \quad (6)$$

Using the solution of this quadratic equation with the negative value of the square-root term, a sunray intersects the sphere at a point with coordinates

$$x_p = -(m \sin h - \sqrt{m^2 (\sin^2 h - 1) + R^2}) \cos h \sin a \quad (7)$$

$$y_p = -(m \sin h - \sqrt{m^2 (\sin^2 h - 1) + R^2}) \cos h \cos a \quad (8)$$

$$z_p = (m \sin h - \sqrt{m^2 (\sin^2 h - 1) + R^2}) \sin h. \quad (9)$$

Fig. 2 shows the points  $P_s$ ,  $P_w$  and  $P_e$  where the sunray hits the meridian at the summer and winter solstices and the equinoxes, respectively.

#### Parameters of the Spherical Cap

For the calculation of coordinates (7) to (9) the physical parameters  $R$  and  $m$  are needed; they can be derived with the help of Pythagoras' theorem on the basis of measuring values for depth  $ON = G$  (the gnomon length) and diameter  $UV = D$  of a spherical cap, see Fig. 2:

$$R = \frac{4G^2 + D^2}{8G}, \quad (10)$$

$$m = R - G. \quad (11)$$

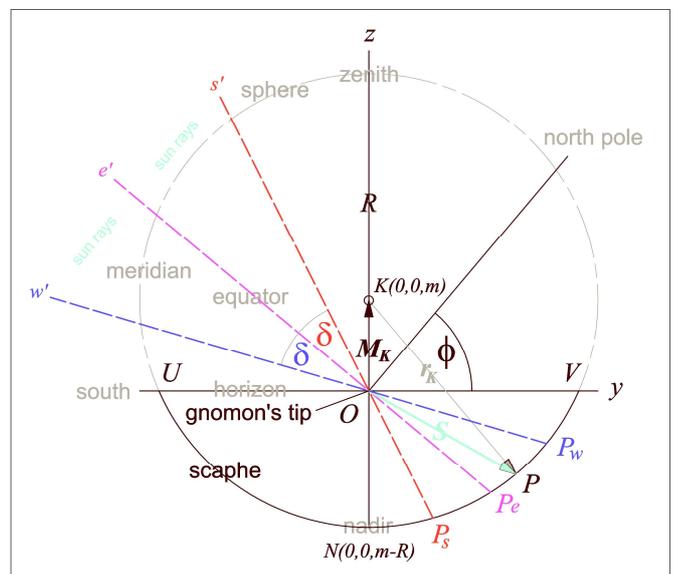


Fig. 2. A sphere's intersection plane of the meridian (= yz-plane of the right-handed system) with sunrays  $w'$ ,  $s'$  at the solstices and  $e'$  at the equinoxes which touches the gnomon tip  $O$  (origin of the coordinate system) and intersects the sphere surface (scaphe) at the points with subscripts  $w$ ,  $s$  and  $e$ , respectively. Further symbols and their meanings are:  $\phi$  = geographical latitude,  $\delta$  = declination,  $R$  = sphere's radius,  $K(0,0,m)$  = sphere's centre,  $N(0,0,m-R)$  = sphere's nadir,  $U$  and  $V$  = intersection points between the meridian and  $y$  axis. Note that the geometrical summation of the sphere's centre radius vector  $M_K$  plus its point vector  $r_K$  equals the sun vector  $S$ .

#### Declination lines and hour lines

Using the relations (7) to (9) one gets the dependence of the hour angle  $\tau$  with the fixed values for the declination  $\delta$  the coordinate triples  $x_p(\tau)/y_p(\tau)/z_p(\tau)$  for three-dimensional representations of the declination lines, see Figs. 3 and 4.

Substituting in (7) to (9) the hour angle  $\tau$  with the Babylonian hour angle  $\tau_b = f(\delta)$  according to equation (4) and the Italian hour angle  $\tau_i = f(\delta)$  according to equation (5), respectively, yield each for the  $b$ -th and  $i$ -th hour ( $b$  and

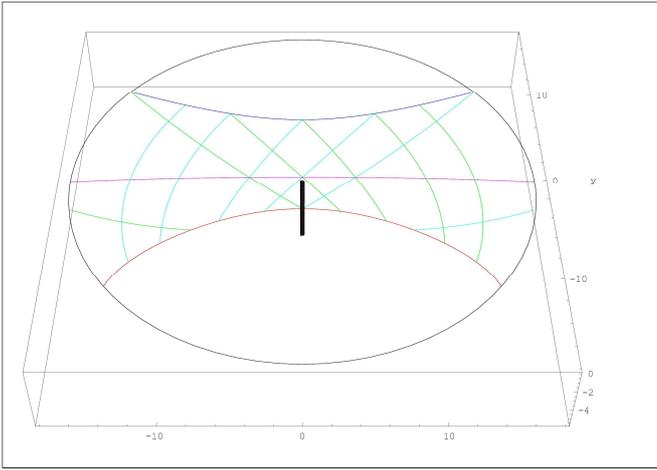


Fig. 3. 3D representation of a scaphe sundial with the pin gnomon at the sphere's nadir; (7) to (9) have been used with  $R = 29.41$  mm,  $m = 23.71$  mm, ( $\Leftarrow D = 34.8$  mm,  $G = 5.7$  mm),  $\phi = 49^\circ$ ,  $\delta = \pm 23.5^\circ$ ,  $\delta = 0^\circ$ ,  $b = 1, 2, 4, 6, 8, 13$  (blue) and  $i = 11, 16, 18, 20, 22, 23$ , (green) respectively, for the calculation of the declination and hour lines. The 3D direction of sight is from south with an angle of  $45^\circ$ .

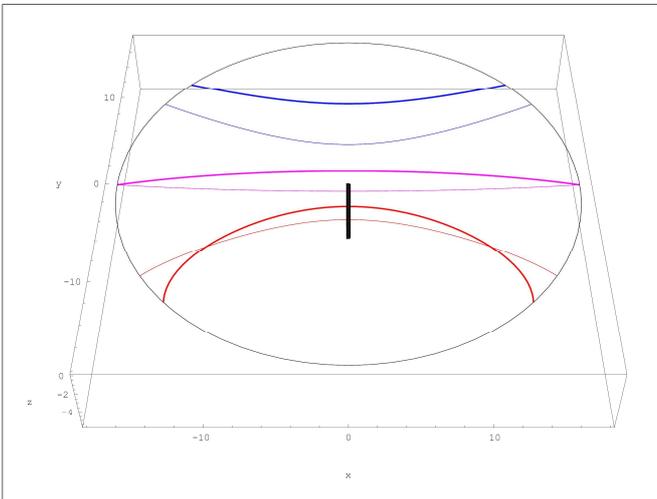
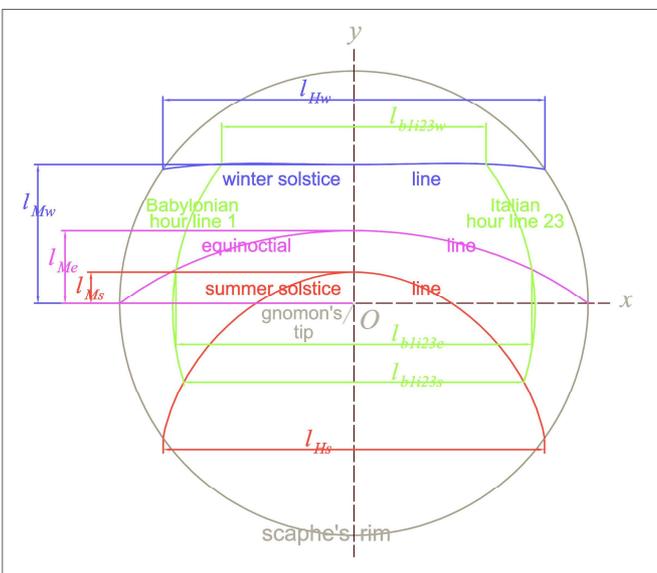


Fig. 4. 3D representation of solstitial and equinoctial declination lines for  $\phi = 54^\circ$  (thick lines) and  $\phi = 42^\circ$  (thin lines); (7) to (9) have been used with  $R = 29.41$  mm,  $m = 23.71$  mm, ( $\Leftarrow D = 34.8$  mm,  $G = 5.7$  mm),  $\delta = \pm 23.5^\circ$  and  $\delta = 0^\circ$ , respectively, for the calculation. The 3D direction of sight is from south with an angle of  $45^\circ$ .



$i$  = characteristic values for counting hours), respectively, the following coordinate triples  $x_{pb}(\delta)/y_{pb}(\delta)/z_{pb}(\delta)$  and  $x_{pi}(\delta)/y_{pi}(\delta)/z_{pi}(\delta)$ , respectively – see the 3D representation in Fig. 4.

Fig. 5 is an orthogonal projection of three declination lines and two hour lines onto the  $xy$ -plane of a Cartesian coordinate system (pairs of coordinates  $y_P(\tau) \Leftrightarrow x_P(\tau)$  and  $y_P(\delta) \Leftrightarrow x_P(\delta)$ ), respectively, i.e. it is synonymous with the top view of a scaphe.

### Distinguishing Features of a Scaphe Dial

#### Directly Visible Characteristics

Referring to Fig. 3, the  $yz$ -plane functions as the plane of symmetry for the scaphe's spherical curve points on both sides of the  $yz$ -plane. Fig. 5 represents the orthogonal projection of the spatial curves onto the  $xy$ -plane. The lines on the right side of the  $y$ -axis are axially symmetrical to the line on the left side of  $y$ -axis, i.e. the  $y$ -axis (meridian) is the axis of symmetry for the scaphe's net of lines. In detail, this means:

- The pin gnomon is positioned at the centre of the spherical cap.
- The distance between the intersection points of the equinoctial line and rim of the spherical cap is equal to the diameter; the intersection points are on the  $x$ -axis.
- The distance between the intersection points for the winter solstice line and rim is equal to the distance between the intersection points of summer solstice line and rim  $\Rightarrow l_{Hw} = l_{Hs}$ .
- Babylonian and Italian hour lines whose hour numbers  $b$  and  $i$  yield the sum 24, run symmetrically to the  $y$ -axis, see Fig. 3, so  $\Rightarrow |x_P(\phi, \delta)_b| = |x_P(\phi, \delta)_{i=24-b}|$  and  $y_P(\phi, \delta)_b = y_P(\phi, \delta)_{i=24-b}$ .
- Depending on latitude  $\phi$  and declination  $\delta$ , Babylonian and Italian hour lines cross at the meridian if  $b_M + i_M = 24 \Rightarrow \tau_b = 0^\circ = -\arccos(-\tan \phi \cdot \tan \delta) + b_M \times 15^\circ$  and  $\tau_i = 360^\circ = \arccos(-\tan \phi \cdot \tan \delta) + i_M \times 15^\circ$ .
- A scaphe's net of lines for  $\phi = 49^\circ$  and  $\delta = \pm 23.5^\circ$  shows the following striking appearance (see Fig. 3): the Babylonian hour lines 1 to 8 intersect the solstice lines, the Babylonian hour lines 8 to 16 intersect the summer solstice line as well as the scaphe's eastern rim ( $\Rightarrow b_{wH} = 8$  and  $b_{sH} = 16$ ); the Italian hour lines 8 to 16 intersect the summer solstice line as well as the scaphe's western rim ( $\Rightarrow i_{sH} = 8$  and  $i_{wH} = 16$ ); the Italian hour lines 16 to 23 intersect the solstice lines; hour lines cross at the winter solstice line if  $i_w - b_w = 16 \Rightarrow \tau_{iw} = \tau_{bw}$  (subtract  $360^\circ$  at  $\tau_{iw}$ ), hour lines cross at the equinoctial line if  $i_e - b_e = 12 \Rightarrow \tau_{ie} = \tau_{be}$  (subtract  $360^\circ$  at  $\tau_{ie}$ ), hour lines cross at the

Fig. 5. Orthogonal projection of a scaphe's solstitial and equinoctial declination lines as well as two hour lines onto the  $xy$ -plane; furthermore the straight line distances are inserted which are necessary for the analysis. The meanings of the symbols used are:  $H$  = horizon (rim of the spherical cap),  $M$  = meridian,  $w$  = winter solstice ( $\delta = -23.5^\circ$ ),  $e$  = equinoxes ( $\delta = 0^\circ$ ),  $s$  = summer solstice ( $\delta = 23.5^\circ$ ),  $l$  = distance measured between scaphe points onto the  $xy$ -plane,  $b1 = 1^{st}$  Babylonian hour,  $i23 = 23^{rd}$  Italian hour.

summer solstice line if  $i_s - b_s = \delta \Rightarrow \tau_{is} = \tau_{bs}$  (subtract  $360^\circ$  at  $\tau_{is}$ ); hour lines with  $b_M = 4, 5, 6, 7, 8$  and  $i_M = 20, 19, 18, 17, 16$  respectively, cross at the meridian because  $i_M + b_M = 24$  (it corresponds to the length of daylight).

These facts give an initial indication, by visual inspection, whether the scaphe is engraved correctly (see Figs. 7 to 9).

### Effect of Latitude on the Shape of the Lines

Fig. 6 makes clear, for example, that the  $y$ -coordinates of the intersection points between the summer solstice line and the meridian differ only slightly from each other for various latitudes. Thus it is questionable – and dependent on various tolerances – whether the distance measured from a scaphe’s photographic plan view can give the design latitude. Table 2 gives an overview of the coordinate differences between the intersection points of lines for  $\phi_1 = 42^\circ$  and for  $\phi_3 = 54^\circ$ , using lines for  $\phi_2 = 48^\circ$  as the reference.

### Errors in Measurements

Assuming that the scaphe’s net of lines has been designed correctly – for instance with the aid of pair of compasses and ruler as described by Georg Hartmann (1483-1564) in his ‘Book Five - The Hemispherium’<sup>4</sup> – the following causes for errors may be possible:

- The scaphe’s stereometry does not equate to a spherical cap.
- Some of the declination and hour lines are engraved inaccurately.
- As a result of the small overall dimensions of the scaphe, the measurements of diameter and depth are made with insufficient accuracy.
- Using a camera lens with pincushion or barrel distortion, i.e. lens error.
- Focal length and object distance are chosen unfavourably  $\Rightarrow$  perspective distortion – the scale is not constant across the image.
- Taking a photograph of a diptych dial the horizon plane (object plane) of the dial and scaphe are not aligned exactly parallel to the image plane of the camera  $\Rightarrow$  small tilt angles cause quite noticeable deviations of the measured values especially close to the scaphe’s nadir.
- The measurements of distances on a scaphe’s photographic plan view (using either a photograph or a picture at a monitor) require a scale factor and therefore they are connected with unavoidable tolerances.

### Visual Examinations, Measured Distances and Calculated Latitudes

The dimensions of the scaphe sundials under consideration are very small:  $5.7 \text{ mm} \leq G \leq 6.8 \text{ mm}, 34.2 \text{ mm} \leq D \leq 44.3 \text{ mm}$ . This means that it is practically impossible to review curves or to measure spherical distances within the spherical cap. Hence the photographic plan view of each scaphe will be used both for visual examination of lines and measuring of straight distances between intersection points of declination lines with rim of the scaphe,  $y$ -axis (meridian) and hour lines, respectively (see Fig. 5). These distances will be compared with theoretical values – based on equations (7) and (8) – using the equations  $l_H = 2 |x_P(\phi, \delta)_{\tau = \tau_{b0}}|$ ,  $l_M = y_P(\phi, \delta)_{\tau = 0}$  and  $l_{b1i23} = 2 |x_P(\phi, \delta)_{\tau = \tau_{b1}}|$ , respectively, where the parameters  $w, e$ , and  $s$  will be assigned as desired to the declination  $\delta$  and the symbols used for the hour angle  $\tau$  mean  $\tau = \tau_{b0}$  setting  $b = 0$  in (4),  $\tau = \tau_{b1}$  setting  $b = 1$  in (4). For all calculations the obliquity of the ecliptic amounts to  $23.5^\circ$ .<sup>4</sup>

The column headings in the Tables 3, 4 & 5 mean:

- ‘quantity of distance’ = measurement quantity as defined in Fig. 5;
- ‘measured value’ = measured distance on the photo of a scaphe multiplied by each scale factor, so that it is directly comparable with the theoretical value;
- ‘calculated  $\phi$  value’ = the calculation of the geographical latitude is done by iteration using one of the above-mentioned equations;
- ‘correction factor  $\Rightarrow \phi = 48^\circ$ ’: multiplying a ‘measured value’ by the applicable correction factor and applying the relevant equation – (7) and (8), respectively – yields a latitude of  $\phi = 48^\circ$  each;
- ‘correction factor  $\Rightarrow \phi = 49^\circ$ ’: multiplying a ‘measured value’ by the applicable correction factor and applying the relevant equation – (7) and (8), respectively – yields a latitude of  $\phi = 49^\circ$  each.

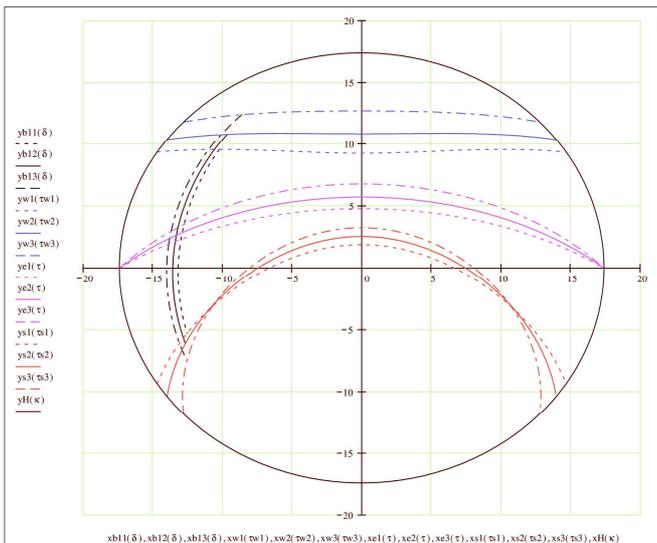


Fig. 6. Orthogonal projection of three solstitial (symbols used  $w = -23.5^\circ$  and  $s = 23.5^\circ$ ) and equinoctial (symbol used  $e = 0^\circ$ ) declination lines as well as Babylonian hour lines ( $b = 1$ ) each onto the  $xy$ -plane. Values of  $R = 29.41 \text{ mm}$  and  $m = 23.71 \text{ mm}$  are used in Eqns. (7) and (8). The numbers 1, 2, and 3 refer to the geographical latitudes  $\phi_1 = 42^\circ$ ,  $\phi_2 = 48^\circ$  and  $\phi_3 = 54^\circ$ , respectively.

$\Delta = f(\phi=48, \delta) - f(\phi=42, \delta)$ [mm]			$\Leftarrow \delta \Rightarrow$	$\Delta = f(\phi=48, \delta) - f(\phi=54, \delta)$		
$s$	$e$	$w$		$w$	$e$	$s$
-0.710	0	-0.710	$\Delta xH$	1.189	0	1.189
0.660	0.929	1.603	$\Delta yM$	-1.858	-1.052	-0.706
-0.124	-0.333	0.556	$\Delta xb1$	-1.044	0.378	-0.113
-0.598	-0.430	0.559	$\Delta xb2$	-1.080	0.506	0.608
-0.779	-0.384	0.692	$\Delta xb3$	-1.280	0.465	0.962

Table 2. Latitude-dependent differences in geometries.

The smallest factors  $>1$  are red and the greatest factors  $<1$  are blue coloured; the most considerable deviations are characterized by two exclamation marks. The appropriate factors are labelled with the symbol #.

A judgement of the following numerical results makes sense only then if the foregoing criteria for potential error in measurements have to be taken into consideration.



J. Davis

Fig. 7. Photographic plan view of the scaphe of Reinmann's diptych sundial, Wh. 1688. Courtesy of the Whipple Museum of the History of Science.

*Reinmann's Scaphe Sundial, Wh. 1688*

The following relevant details are discernible in Fig. 7:

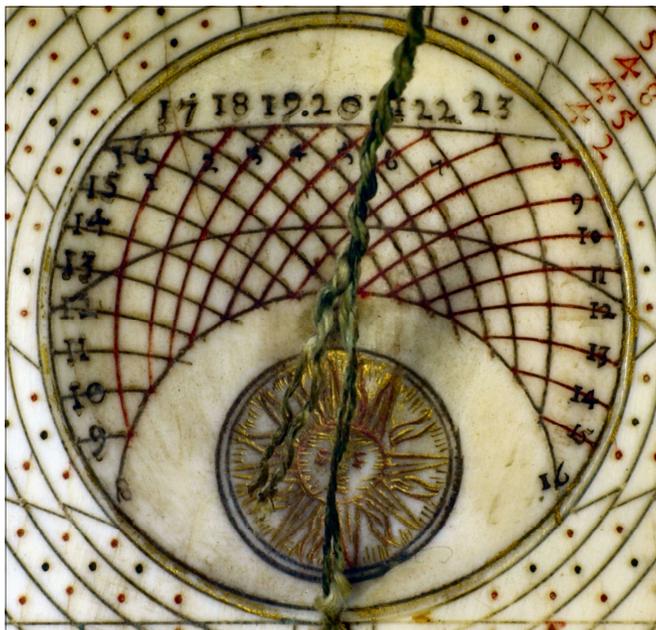
- The net of hour lines does not run symmetrically to the meridian; it is shifted to the right.
- The hour lines according to  $i_M + b_M = 24$  cross each other along a straight line but not at the meridian.
- The condition  $l_{Hw} = l_{Hs}$  is not fulfilled; the summer solstice line was inaccurately engraved.
- The hour lines according to  $i_w - b_w = 16$  and the winter solstice line cross each other except line  $b_w = 8$ .
- The hour lines according to  $i_e - b_e = 12$  and the equinoctial line nearly cross.

length	measured value [mm]	calculated $\phi$ value [°]	correction factor $\Rightarrow \phi = 48^\circ$	correction factor $\Rightarrow \phi = 49^\circ$
$l_{Hw}$	33.65	52.187	1.057	#1.045
$l_{Hs}$	*	—	—	—
$l_{Mw}$	14.97	52.078	0.892	#0.918
$l_{Me}$	7.85	52.558	0.876	#0.902
$l_{Ms}$	3.53	51.509	! 0.862 !	#! 0.901 !
$l_{b1i23w}$	26.35	34.405	#0.920	0.908
$l_{b1i23e}$	35.05	58.258	0.948	#0.953
$l_{b1i23s}$	*	—	—	—
<b>sum</b>			1 #	5 #

Table 3. Analysis of Reinmann's scaphe, W1688.  
\* not measureable (inaccurate engraving): — no result

- The hour lines according to  $i_s - b_s = 8$  and the summer solstice line cross, but not at the correct positions within the  $xy$ -coordinate system.
- The intersection points between equinoctial line and scaphe rim are not aligned with the gnomon foot (the scaphe's nadir).
- The positions of the hour lines  $i_s = 8$  and  $b_s = 16$  at the scaphe rim exist only as an intimation.

The range of percentual deviations  $\Delta$  between real and theoretical values amounts to  $-13.8\% \leq \Delta_{48} \leq 5.7\%$  and  $-9.9\% \leq \Delta_{49} \leq 4.5\%$ , respectively.



J. Davis

Fig. 8. Photographic plan view of the scaphe of Lesel's diptych sundial, AST0438. Courtesy of the National Maritime Museum.

*Lesel's Scaphe Sundial, AST0438*

The following relevant details are discernible in Fig. 8

- The net of hour lines almost runs symmetrically to the meridian.
- The hour lines according to  $i_M + b_M = 24$  approximately intersect themselves at the meridian each.
- The condition  $l_{Hw} = l_{Hs}$  is nearly fulfilled.
- The hour lines according to  $i_w - b_w = 16$  and the winter solstice line intersect themselves each except line  $b_w = 8$ .

length	measured value [mm]	calculated $\phi$ value [°]	correction factor $\Rightarrow \phi = 48^\circ$	correction factor $\Rightarrow \phi = 49^\circ$
$l_{Hw}$	27.58	49.166	1.013	#1.002
$l_{Hs}$	26.63	51.727	1.049	#1.038
$l_{Mw}$	11.81	51.244	0.918	#0.942
$l_{Me}$	5.52	46.813	#1.035	1.065
$l_{Ms}$	1.61	39.380	#! 1.583 !	! 1.654 !
$l_{b1i23w}$	19.31	48.019	#1.000	0.987
$l_{b1i23e}$	25.42	36.613	#1.047	1.051
$l_{b1i23s}$	24.82	38.253	#1.020	#1.020
<b>sum</b>			5 #	4 #

Table 4. Analysis of Lesel's scaphe, AST0438.

- The hour lines according to  $i_e - b_e = 12$  and the equinoctial line partly intersect themselves.
- Although the hour lines according to  $i_s - b_s = 8$  and the summer solstice line intersect themselves, but not at the correct positions within the  $xy$ -coordinate system.
- The intersection points between hour lines and the summer solstice line were inaccurately engraved.
- The intersection points of the hour lines  $i_s = 8$ ,  $i_w = 16$  and  $b_s = 16$  at the scaphe rim are almost correctly engraved.

The range of percentual deviations  $\Delta$  between real and theoretical values amounts to  $-8.2\% \leq \Delta_{48} \leq 58.3\%$  and  $-5.8\% \leq \Delta_{49} \leq 65.4\%$ , respectively.



Fig. 9. Photographic plan view of the scaphe of Miller's diptych sundial, AST0476. Courtesy of the National Maritime Museum.

#### Miller's scaphe sundial, AST0476

The following relevant details are discernible in Fig. 9:

- The net of hour lines almost runs symmetrically to the meridian.
- The hour lines according to  $i_M + b_M = 24$  approximately cross on the meridian.
- The condition  $l_{Hw} = l_{Hs}$  is not fulfilled; the summer solstice line was inaccurately engraved.
- The hour lines according to  $i_w - b_w = 16$  and the winter solstice line cross correctly.
- The hour lines according to  $i_e - b_e = 12$  and the equinoctial line cross only on the right side.
- The equinoctial line on the left side was not correctly engraved.
- The hour lines according to  $i_s - b_s = 8$  and the summer solstice line cross, but not at the correct positions within the  $xy$ -coordinate system.
- The intersection points between equinoctial line and the scaphe rim are aligned with the gnomon foot.
- The intersection points of the hour lines  $i_s = 8$  and  $b_s = 16$  at the scaphe rim are not correctly engraved.

length	measured-value [mm]	calculated $\phi$ value [°]	correction factor $\Rightarrow \phi = 48^\circ$	correction factor $\Rightarrow \phi = 49^\circ$
$l_{Hw}$	27.58	47.598	#0.996	0.985
$l_{Hs}$	24.26	55.548	1.132	#1.119
$l_{Mw}$	10.94	48.694	0.982	#1.008
$l_{Me}$	6.16	50.764	0.925	#0.951
$l_{Ms}$	2.05	43.539	#! 1.241 !	! 1.296 !
$l_{b1i23w}$	18.15	51.103	1.050	1.035
$l_{b1i23e}$	23.67	10.276	#1.110	1.115
$l_{b1i23s}$	23.57	25.217	#1.060	#1.060
<b>sum</b>			4 #	5 #

Table 5. Analysis of Miller's scaphe, AST0476.

The range of percentual deviations  $\Delta$  between real and theoretical values amounts to  $7.5\% \leq \Delta_{48} \leq 24.1\%$  and  $-4.8\% \leq \Delta_{49} \leq 29.6\%$ , respectively.

#### Conclusions

It is obvious that the measured values in connection with the winter solstice line are the most convincing. The causes for the existing relatively small tolerances are equally inaccurate measurements on the whole and engravings. The most unfavourable measuring value is the distance  $l_{Ms}$ . The summer solstice lines have been engraved (or designed?) each too close to the gnomon foot (see also *Effect of Latitude on the shape of the lines* above).

Lesel's scaphe sundial seems to be in principle a copy (reduced in width and depth) of Reinmann's one because in particular it is conspicuous that the hour line  $b_w = 8$  intersects the scaphe rim but it does not intersect just at the winter solstice line. Moreover, it is very interesting that both of the sundials have a crown as maker's mark. Gouk states: "Why he should have adopted the Reinmann crown mark is not yet known; perhaps he worked in the Reinmann workshop or was related to the family by marriage".<sup>1</sup>

All-in-all, referring to the results of the visual examinations and both groups of the applicable correction factors which only differ slightly from each other, it is concluded that Reinmann and Miller have manufactured their scaphe sundials for latitude  $\phi = 49^\circ$  and Lesel has used  $\phi = 48^\circ$ . In spite of existing imponderables, the one thing certain is that the scaphe sundials have obviously been designed for Nuremberg regardless of whether its geographic latitude was assigned to  $48^\circ$  or  $49^\circ$ .

Nevertheless, the tiny scaphe dials are admirable masterpieces of craftsmanship!

#### ACKNOWLEDGEMENTS

The author wishes to thank John Davis for the pictures of dials in the collections of the National Maritime Museum (Greenwich) and the Whipple Museum (Cambridge). Rebekah Higgitt and Claire Wallace, at Greenwich and Cambridge respectively, are thanked for arranging access.

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## LATITUDE DETERMINATION USING AN EQUINOCTIAL RING DIAL

**MIKE COWHAM**

Many of the universal equinoctial ring dials made by British makers had a  $0^{\circ}$ - $90^{\circ}$  altitude quadrant engraved on their reverse. This could be used, in conjunction with a short pin gnomon inserted into a hole in the outer ring, to determine the altitude of the Sun. By taking a reading of its shadow around midday, and deducting the Sun's declination for that date, a figure for co-latitude could be obtained. The exact time around midday was not too critical due to the fact that the Sun's altitude hardly changes over a period of several minutes at that time. This quadrant was a useful tool for the traveller who would like to set his ring dial correctly to get the precise

time. However, to obtain the desired reading, this method did involve some calculations.

A simple solution to this was found by the Dublin surveyor and instrument maker Gabriel Stokes (sometimes called Stoaks). The dial used for illustration is a 4" diameter brass ring dial by Stokes made around 1735. With his design he had achieved a direct readout of latitude by adding a declination scale, S  $23\frac{1}{2}$   $\text{\AA}$   $23\frac{1}{2}$  N, to one side of his ring dials. The suspension point was then set to the correct declination for the day, found from the calendar and declination scales that were engraved on the bridge, across the centre of the inner ring. A direct readout of latitude was now possible. It is also interesting to note that due to the physical layout of this quadrant, readings taken from around  $45^{\circ}$  are nearly twice as sensitive as readings near to



Fig. 1. Ring dial measuring the Sun's altitude as  $42.7^{\circ}$ .



Fig. 2. Ring dial by Gabriel Stokes with his 'new' declination scale. Here the dial is suspended at about  $15^{\circ}$  N.

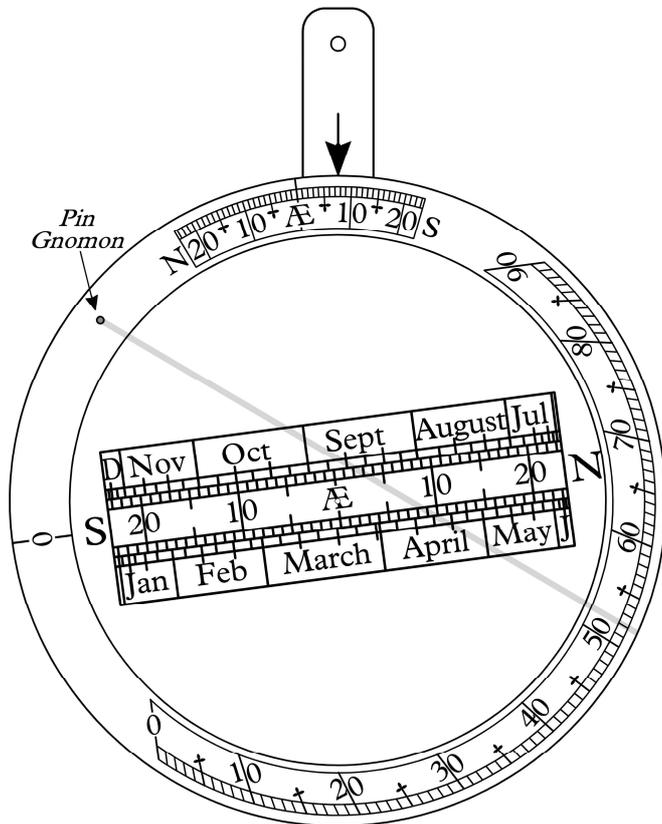


Fig. 3. Model of the latitude-finding scales on Stokes' ring dial. The declination here is set at  $8^{\circ}$  S, (equivalent to Mar 1 or Oct 14 - New Style) and the shadow is showing a latitude, at noon, of  $52^{\circ}$  N.

the ends of the scale due to this part of the scale being further away from the gnomon. This feature is particularly useful at European latitudes.

Although it is a simple solution to the latitude-finding problem, the new declination scale of Stokes does not appear to have been copied by other makers, but at least two unsigned dials with this scale have been seen.<sup>1</sup>

In order to check its usefulness a replica was made, in the format of a disc, including the necessary calendar scales. In practice it was found to be possible to get declination figures to an accuracy of around two days throughout much of the year. With the replica, a reading was taken at noon in January which confirmed the latitude of Cambridge as  $52^{\circ}$  N, certainly close enough for using a ring dial of this type.



Fig. 4. Both sides of the bridge with its gnomon aperture on the Stokes ring dial.



Fig. 5. Stokes' signature on his ring dial.

To use the quadrant scale in the traditional manner to find the Sun's altitude, the suspension may be set to the '0' on the left side of the disc.

Stokes was born in 1682 and lived until 1768.<sup>2</sup> He was the son of a Dublin tailor whose family, it is believed, came from Gloucestershire. It is not known where he received his training in instrument making but he may, at some time, have visited London. He wrote a booklet entitled 'The Description and Uses of the Æquinoctial Ring-dial', which was published in Dublin in 1731. A copy is in the National Library of Ireland. His drawing showing the dial and its calibrations may be seen in the book 'Vulgar & Mechanic' by J.E. Burnett and A.D. Morrison-Low.<sup>2</sup>

Both sides of the bridge, with its sliding gnomon aperture, carry detailed scales. The calendar scale (Old Style) is on one side and the other side has details of the Sun's declination with the local times for its rising and the setting, presumably for the latitude of Dublin.

The author would be interested to know of any other ring dials carrying Stokes' unique scale for finding latitude.

The artwork to make a replica of one of these dials may be downloaded from the BSS website.

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## Another Lego Sundial



This is another example of an equatorial dial by Don Rogerson, this time looking rather like the BSS logo. It is built around a 1x4x5 arch brick. The central pair of blue bricks indicate noon and the outside ones show 6am and 6pm, solar time.

A full explanation is at

<http://lego.cuusoo.com/ideas/view/11492>

# THE DIAL FROM THE ‘PALAIS FARNÈSE’: ROMAN OR MODERN?

JÉRÔME BONNIN

For my doctoral thesis (on Roman *horologia*), I made a listing of the complete corpus of ancient dials known at the present time. Such a corpus contains 563 references. While creating it, I found some dials that were not really ‘canonical’, i.e. that did not bear the main and normal Roman features. The Hever Castle dial studied by David Brown is one of these problematic dials.<sup>1</sup> The dial conserved in the ‘Palais Farnèse’ (Rome) is another. It is a very peculiar dial, firstly due to its position inside the French Embassy in Italy, secondly because of its state of conservation, and finally, because it is known only to a few people, mainly the French Embassy staff and part of the staff of the French School of Rome. I discovered it by chance in October 2010, on the occasion of a first research school grant. I took the opportunity to study it in September 2011, during a second research grant from the school. This paper provides my observations and conclusions about the instrument.



Fig. 1. The ‘Trophée Farnèse’ with the dial on the right. Photo J. Bonnin 2011 with the permission of the French Embassy.

## Actual Situation and Historical Background

The dial is located under the second entry porch of the palace, on the right on the architectural group of the right niche (Fig. 1). A similar composition is present in front of this one, under the left niche of the porch. Those compositions are called ‘Trophées Farnèse’<sup>2</sup> and are composed of an assortment of genuine Roman pieces of architecture.

As far as we know, the ‘Trophées Farnèse’ are ‘modern’ creations, placed in the courtyard of the palace in 1820 in substitution for statues and inscriptions sent to Naples with others pieces of the Roman collection of the palace.<sup>3</sup> Most of the architectural elements of the ‘Trophées’ are, therefore, remains of the collection housed in the palace at the time of Fulvio Orsini (1529-1600), and were found in or near the *Domus Flavia*. Unfortunately, we have very little historical information about the ‘Trophées’, the real origin of the architectural pieces, and, moreover, of the dial. The instrument appears neither in the inventory made by F. Orsini himself, nor in the inventory of his collection made in 1644.<sup>4</sup> In fact, the dial does not appear in any of the published inventories of the palace. It is mentioned only in the recent book on the ‘Palais Farnèse’ made by the French School of Rome,<sup>5</sup> but without any information about its origin or date of erection on the ‘Trophée’. Since historical materials are missing, we have to investigate in another direction in order to discover the origin of this instrument, and, maybe, the reasons of its use on the ‘Trophée’.

## Description of the Dial

The instrument is a spherical dial made of white marble and measures 43×40 cm. It carries eleven hour lines and three declination curves. Two stylised legs in low relief flank the base (Fig. 2). A lip follows the edge of the front circular section. The dial carries no dedication or indication (at least, on its visible parts, for it is placed 2.5m above the ground). It looks like an ancient dial. Indeed, it has the same general shape and could therefore be a genuine Roman dial. However, some features are not appropriate for a Roman (or even Greek) dial.

To begin with, its state of conservation is nearly perfect, apart from chips on the extremities of the left and right wings. It is more than unusual to find an ancient dial in such a good state of conservation, without spots or chips due to neglect and long periods underground. The corners and ridges are perfectly cut, without any traces of long-term



Fig. 2. Detail of the spherical dial from the 'Palais Farnèse'. Photo J. Bonnin 2011 with permission of the French Embassy.

weathering. And last, the stone is clean, too clean for what is supposed to be an old sundial.

Another surprising element is the lack of a fixing hole for a gnomon (cf. Fig. 2). The middle of the upper part of the shadow-receiving surface is absolutely plain. We can hence assume that this dial never had a gnomon and, moreover, that a gnomon was never planned. The lack of gnomon hole is sometimes evidence of an unfinished dial. At least two such dials have been discovered: one in Delos (Greece) and the other in Constanta (Romania). But this dial is not an unfinished dial. It carries all the features of a finished dial, such as the hour lines and declination curves, decoration of the feet and, moreover, the polished aspect of the marble.

#### Dating and Main Observations

Considering what has just been said about the state of conservation and the lack of gnomon hole, we must doubt its Roman origin. Moreover, we can even suppose that the instrument is a modern one, either an 18<sup>th</sup> or 19<sup>th</sup> century creation (at least after 1820). If one assumes that it cannot be a Roman dial but a modern creation, the question of the purpose of such an instrument arises. For it is, undoubtedly a copy of a Roman dial, an instrument created in order to look like one. The artisan responsible for this creation was well informed, wholly aware of the typology of Roman spherical dials. We can even go further and try to find the

original model for the dial. We know that between 1746 and 1750, a Roman spherical dial had been discovered at Castelnuovo (Italy). We also know that this dial was brought to the 'Palazzo dei Conservatori' and renovated in 1751, by order of the Pope Benoît XIV. This dial is still stored in Rome (Inv. 1295) but I was unable to study it in 2010. It is 43×38 cm. Here is the description made in 1976 by Sharon Gibbs:<sup>6</sup>

"Travertine marble, white – Stylized legs in low relief flanks the base. A 12 mm wide lip follows the edge of the front circular section (...) The green and rusty gnomon now in place is probably not original."

The similarity to the dial of the French Embassy is quite compelling (cf. Fig. 3). Of course, this is a hypothesis based only on the stylistic relationship between the two instruments. An archival study on the origin of the French Embassy dial and on the potential links with the dial from Castelnuovo could strengthen such a hypothesis. But this is a huge task, for information has to be sought everywhere inside the archives of the palace.

#### A Symbolic Meaning?

If this instrument is not Roman but an 18<sup>th</sup> or 19<sup>th</sup> copy of a Roman original, it still is an interesting historical piece of evidence. Indeed, it could be (with the Hever Castle dial however, whose authenticity is doubtful), one of the very few modern copies of an ancient sundial made before the middle of the nineteenth century. What is more, its realisation might be linked with the creation of the 'Trophées Farnèse'. And this is very important since the 'Trophées' seem to carry a highly symbolic meaning, about Time and the destruction that Time causes.

But then, how could we explain the lack of gnomon? Thereupon, a hypothesis can be suggested. The sundial might have been expressly ordered to ornament the composition. If so, it was not intended to receive sunlight. A gnomon would have been visually suitable but absolutely useless. As a matter of fact, this instrument is ineffective. So, if the sundial cannot tell the time, then it means that the real signification of the object was less important than its symbolic meaning. In other words, it seems to be more a representation of a sundial than a real sundial. It could mean Time; represent the Time in general, the vainness of human creations or beings. Such an interpretation is not impossible

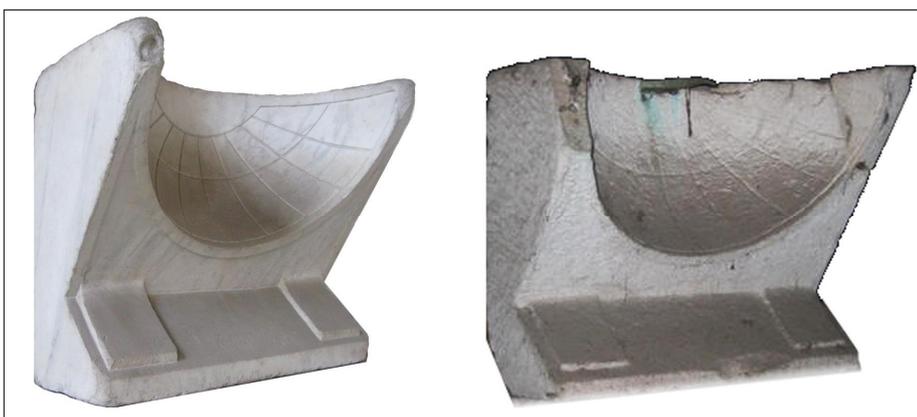


Fig. 3. Left: French Embassy dial (photo J. Bonnin 2011 with the permission of the French Embassy). Right: Castelnuovo dial (© N. Severino).

when one knows the allegorical meanings of many 18<sup>th</sup>-century paintings or sculptures. It would have been an error to place, upon those remains of ancient architecture, a baroque sculpture such as a skull or a sandglass. For that reason, the compromise developed here seems to be the creation of an ‘antiquating’ envelope in order to support a modern meaning. If that is the right interpretation, then the dial from the French Embassy would be unique in art and gnomonic history. But once again, all of this remains hypothetical. Further research might well bring other conclusions. Every new piece of evidence or interpretation is therefore warmly welcome.

#### ACKNOWLEDGEMENTS

I am very grateful to Christophe Leonzi, Counselor-Minister of the Embassy of France in Italy, for his authorisation to study the dial and his permission to publish it in the *Bulletin* of the BSS. I am also grateful to the staff of the French School of Rome and particularly to Véronique Séjournet for her valuable help. I also wish to thank David Brown, for the discussion we had about the Hever Castle dial and the idea it gave me to write this article. Finally, I wish to thank Philip Spencer for looking over my manuscript.

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**Jérôme Bonnin** is 27 years old, has a doctorate in Roman archaeology, and has a great interest in all time-telling devices. He has recently presented his doctoral thesis at the University of Lille 3 (France) entitled: *Horologia Romana, Archaeological Research on Roman Time-keeping Instruments; Typological, Urbanistic and Social Study*. His interest in sundials is quite recent but increases daily. He concentrates on the social and historical aspects of sundials rather than on technical aspects. He can be contacted at [jeromebonnin@laposte.net](mailto:jeromebonnin@laposte.net).

## READERS’ LETTERS

#### Canterbury Pendant etc

It is gratifying to see my work used in two separate articles in one issue. Signor Arnaldi’s work is impressive: the line drawings of the Canterbury pendant are superior to anything which I possessed when I wrote my little article, and, of course, I had no access whatsoever to his documentary material, and no knowledge at all of the ‘cylinder of Este’. However, there is one feature of my original diagram which Arnaldi does not mention (and rightly so, since I myself made nothing of it): this is the curve which I plotted marking the solar altitude (at 52°) at times when the shadow on a scratch dial indicates Nones or Tierce. I calculated this line by orthography and was struck by its closeness to the Canterbury hour points. I intended to do the same for the noon line but was immediately confronted with total incompatibility so I abandoned the exercise. However, working as I do without the benefit of a computer, using antique drawing instruments, deletion or redrawing was not attractive; so in my text I just took a different tack entirely, reasoning that the original maker (or the preparer of the table from which he/she worked) set out the noon points first and made the Nones and Tierce points half way along. But what if he/she worked the other way, marking the Nones/Tierce points by observation and doubling the distance to make the noon points? Would an ecclesiastic, being constantly around orientated buildings, have any difficulty discerning noon without a dial to reasonable accuracy? It is a thought.

One aspect of Arnaldi’s work which remains contentious is his idea for two positions of the gnomon. The concept of a gnomon ‘infinitely’ adjustable by eye I would buy, but two rigid positions, and so close? Surely no?

To my mind the jerkyness of the points derives from the barbaric rather than the classical (i.e. Greek) character of the work (the Romans were nearly as rough as the Barbarians). In modern terms it is as a difference between ‘precision engineering’ and ‘agricultural standard’.

*Peter Drinkwater, Shipston-on-Stour*

#### From A P Herbert to F Chichester

After my short note in the *Bulletin*<sup>1</sup> which mentioned Francis Chichester in the context of navigating by the sun, Chris Daniel was kind enough to send me a copy of his article about the Chichester Sun Compass published in the Magazine of the Royal Institute of Navigation.<sup>2</sup>

This reminded me that the Quantas pilot had mentioned the gadget to me in 1974. Subsequent enquiry at the Chichester map shop (I think in St James Street in the ’70s) failed to produce a copy but the assistant kindly scoured the basement and returned with the last but one copy of the Chichester Star Compass printed in 1945 and priced at 5s 6d. I think I paid one pound. It is shown in Fig 1. From its paper cover it is interesting to see how many small books on astronavigation were produced by Chichester during



WWII. My thanks to Chris Daniel for leading me from one thing to another!

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1. F. Coe: 'A P Herbert put to the test', *Bull. BSS*, 24(i), 13 (2012).
2. C. Daniel: 'The Chichester Sun Compass', *Navigation News*, p. 21, (May/June 2010).

*Frank Coe, Cambs.*

### Balliol Moondial

I was very impressed and interested by the unusual spherical dial at Balliol College, Oxford, made by David Harber (*Bulletin* 24(i) March 2012). Of particular interest to me was the ability to tell the time by moonlight. However, on a closer study of the photographs shown, it appears to me that it is possible the engravings of 'waxing' and 'waning' on the gnomon are the wrong way round. For example, on the day after Full Moon ("waning +1") I would expect the shadow of the gnomon to fall on the solar 6 o'clock hour line at approximately 6:50pm; but the Roman numeral VII is on the band indicated as "waxing -1". Perhaps I have misunderstood how this feature is meant to work. Please can anyone enlighten me?

*Sue Manston  
smanston@hotmail.co.uk*

David Harber responds:

This is a case of *mea culpa*! Somehow, the engraving of the waxing/waning indications on the swinging gnomon arc have been interchanged and a replacement gnomon has already been made, luckily, without affecting the sphere itself. In mitigation, we do make thousands of dials and very few errors slip through. Congratulations to Sue for her sharp eyesight!

*David@davidharber.com*

### Transit of Venus

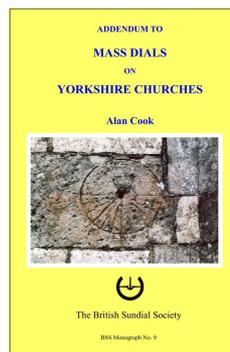
**A**lthough not a gnomonic event, a transit of Venus across the face of the sun is surely one of interest to most lovers of sundials. The next one will occur on 6 June 2012, visible only for a short while soon after sunrise if you are in the UK. Miss it and you will have to wait 105 years for another chance!

The normal warnings not to look directly at the sun apply. A short and informative monograph on the subject by John Woodruff FRAS is available from:  
[www.huxleyscientific.com/books/transit/](http://www.huxleyscientific.com/books/transit/)

## BOOK REVIEW

### Addendum to Mass Dials on Yorkshire Churches

by Alan Cook. BSS Monograph 9.  
ISBN 978-09558872-5-3 (2012). A4,  
pp. 26, soft covers.  
Price £6 + p&p from BSS Sales.



This monograph is an extension of the author's previous publication, BSS Monograph 3, which catalogued all the mass dials in the central area of Yorkshire (OS grid square SE). The same layout is used this time

with a scaled drawing of every dial on all the churches from the four corners of the county, together with a description. Drawings are used because they are generally clearer than photographs but there are pictures of the more photogenic examples. To keep the statisticians happy, there is also a list of those churches which do not have a mass dial, at least not one visible today.

The monograph completes a remarkable piece of work which makes Yorkshire one of the best-surveyed counties in the country, as well as a particularly rich one for mass dials. For anyone interested in these intriguing and still not fully understood dials, this publication is a must!

*John Davis*

### Beautifully Crafted Replicas of **PORTABLE DIALS** at Affordable Prices **SHEPHERD'S DIAL**

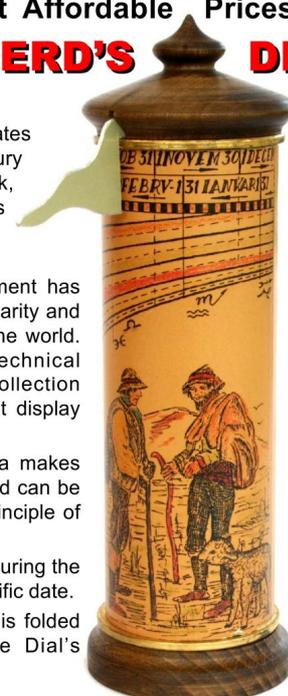
The Shepherd's Dial dates back to the 11th century and the German Monk, Hermanus Contractus (1013-1054), is thought to be its inventor.

Since then, this instrument has enjoyed immense popularity and can be found all over the world. There is hardly a technical museum or private collection anywhere that does not display one.

This inexpensive replica makes an attractive present and can be used to illustrate the principle of operation.

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# BSS ANNUAL CONFERENCE

## Cheltenham – 13-15 April 2012

### Chris Lusby Taylor

The Society's annual Conference was held this year in a hotel-cum-conference-centre in the Cotswolds. This proved very convenient and a surprisingly good location for seeing local dials. The conference followed the long-established pattern in terms of timing and content. Most of the attendees are long-established as well, as is the conference organiser Patrick Powers who did a superb job as ever, but not so our Chairman, Frank King, for whom it was his first in that role.

Frank opened the conference by greeting everyone, particularly first-timers and foreign visitors. He paid tribute, in English thankfully (his *lingua franca* being Latin), to Patrick for the minute detail in which he had planned the conference in order that it, like a swan, should appear effortless.



Chris Daniel, our President, needs no introduction. He commented on the Society's history over nearly a quarter of a century. The founders had in mind the creation of a group of perhaps 30 or 40 members to have fun in sharing their enthusiasm for sundials. The growth, into what is now recognised as a learned society with many hundreds of members and a highly respected journal, wasn't in their minds but has brought great satisfaction. As for the recent members' survey, Chris felt the most important messages were the need to get the young more involved and for anyone with views on things that need to be done to volunteer to do them.

For light relief, Patrick played a recording of an interview on the Chris Evans show on Radio 2. Chris had invited a 'Frank King' to talk about sundials and answer questions for three minutes. Frank's unstoppable enthusiasm gave vent to a performance that would have

won points on *Just A Minute* as he didn't let Chris get a word in. Apparently, he's the first guest ever to go right through for three minutes like that. I particularly liked the way Frank compared complex dials to mobile phones – they both have lots of apps! I'm sure Chris's listeners were amazed at the breadth of the subject.



Allan Mills gave the first talk on dialling. His subject was an ancient observatory in a remote part of China with a huge meridian line [see article on p. 2]. As is essential when trying to get a full appreciation of ancient artefacts, Allan considered the various timekeeping needs of the people who made and used it – for agriculture, divination of auspicious events in the heavens such as eclipses and plain old timekeeping. Luckily, records exist of observations made in the observatory. For instance, in the 14<sup>th</sup> century they established that the tropical year was 365 days 5 hours 49 minutes and 20 seconds. That this is 32 seconds longer than today's figure perhaps implies that the earth's rotation has changed, not that they were inaccurate.

Kevin Karney next brought us bang up to date with a beautifully presented talk on the free software that is available. He showed how Google Sketchup can very quickly make 3D models complete with accurate shadows for any location, date and time, even down to the Equation of Time. Another free program, Nodebox, can be made to draw dial furniture in any form desired.



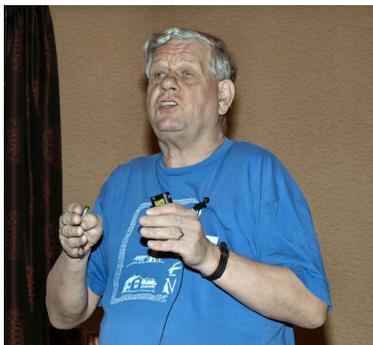
Kevin also entertained us by recounting the many mistakes he made and problems he struggled with in trying to make a dial similar to those that Tony Moss makes effortlessly. Just how do you etch and cut out a gnomon from 5 mm phosphor bronze? He did achieve it, but it was 18 months late, had cost a fortune and sold for just a few hundred pounds.

We repaired to the bar for a nightcap. Jim and Jackie Holland, our most faithful American friends, having discovered its delights on an earlier visit to our continent, asked for Guinness. This took almost as long as a phosphor bronze gnomon but was, they agreed, worth the wait. Jackie Jones showed off her sundials in the form of etched beer glasses. A great idea finely executed.

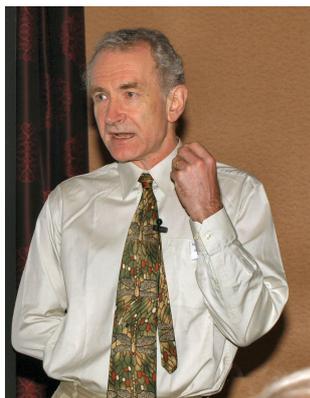
As long-established as much of the conference format may be, Saturday started with a novelty: a discussion forum on the future of the Society. Our Secretary, Chris Williams, has been applying his statistical analysis not to medieval scratch dials but to membership trends and members' responses to last year's survey. Some of the discussion turned out to be rather contentious and may well be documented fully elsewhere. So it is perhaps sufficient here to note that not all agreed that falling membership numbers indicate an alarming trend that we should take steps to reverse. Some excellent suggestions came out of the discussion, such as embracing social media and new technology so as to attract the young, providing members with resources to allow them to teach in schools or to U3A, and

encouraging the BBC to make a programme on the history of dials.

Back to sundials, and Johan Anton Wikander, another regular visitor, told us about two very old horizontal dials found on a Norwegian 'outfarm' – a summer



farm high in the mountains. The dials appear correct except that their 12 o'clock axes are not true north-south. (Summer Time, perhaps?) Johan explained that the magnetic variation in Norway has swung wildly in the past and this allows the dials to be dated, assuming that they were aligned using compasses, to around 1675 and 1875. This seems a most imaginative way to date dials.



Your reporter was on next, presenting more magic with mirrors. This year he has been using just one small mirror tilted, rather like Foster-Lambert gnomons, so as to bisect the angle between pole and zenith. The result is a spot of light that moves in a horizontal or vertical circle, not one parallel to the equator as with the shadow of a nodus. Given the prevalence of horizontal and vertical surfaces, this can make a novel and useful circular dial.

These last sessions had come in under their allotted time, so we had extra to spend admiring and studying the display area during the coffee break. On show were everything from David Brown's replica of a Roman scaphe [see back cover] and a lovely stone-carved dial by Ben Jones to three different heliochronometers. For sale were any number of

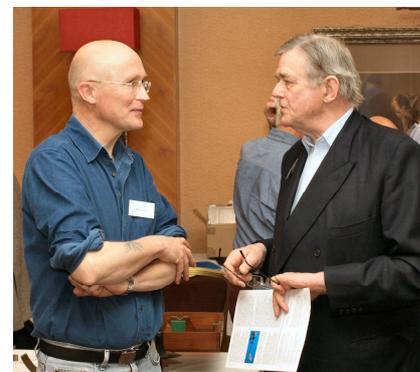


portable dials, astrolabes, nocturnals and so on. Also, educational and beautifully decorated kits to make high quality cardboard replicas of scientific instruments such as an orrery. Rogers Turner Books tempted us with tomes ancient and modern.



After the break John Davis, whose talks are as varied as Allan Mills', spoke on excavated dials. The two main sources are amateur metal detectorists, who mostly find metal dials, of course, and professional archaeologists who mostly turn up stone or pottery fragments. Luckily for us, the former source is well documented in on-line databases which can be searched for sundial-related terms. One such lists 73 sundials found by metal detectors, the majority being pocket ring dials. John notes that lead is almost as common as brass for fixed dials that have been found by metal detectors. Norfolk is rich hunting ground, reflecting the fact that Norwich was at one time second only to London.

Next, Martin Hogbin, a recently-joined member at his first BSS Conference, showed us how he had designed and



Around the display area: Ben Jones' 'Diamond' dial; pre-production educational dials from Tony Moss; Ben Jones talks to our Patron Mark Lennox-Boyd; an array of dials for sale on Leonard Honey's stand.



made a garden heliochronometer, which he defined, reasonably enough, as a sundial corrected and calibrated to give time to within a minute. His design thought-processes were familiar to all those of us who have struggled with the same issues, such as how do you draw more than one analemma per hour without them overlapping. (His answer: draw half analemmas, flip the dial every six months. Chris Daniel would approve.)

Fred Sawyer never disappoints. The title of his talk, 'Elliptical sundials, general and craticular', was a typical tease. Fred ran through the early history of elliptical horizontal dials from Brou Cathedral to our old friend Samuel Foster. Samuel was the first to describe how an equatorial (equinoctial if you prefer) dial can be projected in any direction onto any plane so as to create an enormous variety of dials. Many later



students of dialling (myself included) have reinvented some of these, and Fred has had to inform *Sky and Telescope* magazine more than once that Foster was there over 300 years ago. One genuine recent discovery, though, was Hans de Rijk in 1986 with central projection dials. And craticular? Well, that's Foster's term for a dial with a grid of hour lines and date lines and a fixed nodus, rather than a moveable nodus. Fred showed some of the extreme forms such a dial can take – almost unbelievable when you first see them.

After lunch in the hotel we all piled into a double-decker coach for our tour of local dials. First stop was Moreton-in-Marsh, with a very handsome dial declining almost due East [see front cover]. That's a pity as it was by now 2:30 and the sun had already moved on. Next, we headed to Chipping Campden, famous for having over a dozen sundials. We saw seven of them, all along the main street and bearing dates from 1647 to 1691. All declining East again, and all in shadow. Too bad. But I doubt if there's a street like it in this country for sundials.

Our third stop was a village church with a sundial that revealed a second

dial behind but largely obscured. It was apparent that the blocks of this dial had been rearranged. We had much fun working out the jigsaw puzzle.

The Gala Dinner is the social highpoint of every conference. The winners of the Sundial Trails prize, awarded jointly by the Society and Piers Nicholson, were announced. There are now 53 sundial trails on the Sundials on the Internet website, of which 37 are high quality but some lack detailed directions and descriptions. Piers invited members to improve these as they can be an excellent way to reach out to the public. He suggested that we should do more to publicise them, perhaps working with local authorities. This year's winner was Darek Oczki for a trail in Warsaw. Runner up was Dennis Cowan for a trail in Fife.

Every few years we hold an auction during the conference. And the joy of every auction is seeing David Young, the Society's beloved first Secretary, in action as the auctioneer's porter. Bargains of the night included 'Sundials on Walls' by one Chris Daniel which a mysterious bidder going under the pseudonym of Doreen Bowyer snapped up at just £6. The star lot was a compass and clinometer which started slowly but saw a battle royal between two mightily determined bidders. Chris Daniel, auctioneer, went up in £1 increments so it took ages but this served only to heighten the tension and laughter as the

protagonists fought it out. Eventually the underbidder conceded defeat and a triumphant "Johan Wikander, Norway" won at £105.

Sunday's first session, chaired by Mike Shaw, included two more British sundial designers presenting their dials. First was David Brown, well known for his exquisite hand-carved stone dials. In 2010 he



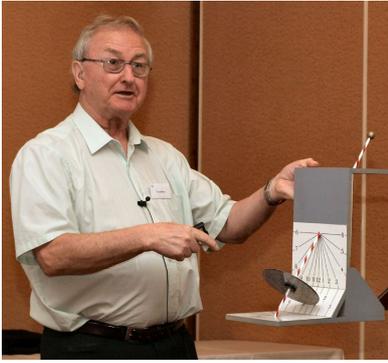
received the prestigious commission to design and make a large human analemmatic dial, complete with 'Bailey Points', for the Silver Garden in the Olympic Park in London. His problems were many, all overcome in his calm manner, except one. The Silver Garden includes lots of silvery things. Indeed the black stove enamelled lettering he specified for the dial's hour points had to be stripped off. But the unresolved problem was that, immediately south of the dial, the planting of a few 'shrubs' turned out to mean silver birches. In just a few years their shade will render the dial useless.

We never really believed it when Tony Moss announced his retirement and he couldn't resist the invitation to make a last few dials for use in schools to teach their geometry. He designed a combination vertical, polar, horizontal and equatorial dial so as to include as many types as possible. He discussed with us the material and design decisions driven by



A selection of the dials in Chipping Campden.





the need to make not one, not many thousands, but a small batch of dials. It was, for instance, worthwhile to make jigs but not to create injection moulds. In fact, now I think about it, Tony Moss has always been a great advocate of jigs for everything.

Lastly, Frank King got to use his Latin. Naples, resting place of Virgil, has a new railway station. And that, in a civilised country like Italy, needs art. So it was that a human analemmatic dial was proposed for the station's forecourt – a very grand and very public place. The contractors knew Frank of old and asked him to design a suitable dial. This he did and, like all common-or-garden horizontal analemmatic dials it was elliptical. No good. The client insisted on a circular dial for artistic reasons. Couldn't Frank stretch the ellipse into a circle? To give him credit he didn't simply say 'no'. He said he'd go back to the drawing board. Talking of which, he showed us a photograph of himself at school doing engineering drawing in a class that later included James Dyson. The school had been most reluctant to allow pupils to do both Latin and Engineering Drawing, but he had insisted and Dyson did the same. The rest is history. Dyson's son also did Engineering Drawing, now called Design Technology, and was taught by our own David Brown. As was my own son. Small world.

Anyway, back to Naples. Frank, reasoning that an analemmatic dial isn't an entire ellipse, found that the portion needed – 8am to 4pm say – can be approximated with a circular arc. Job done. Except that it turned out that the

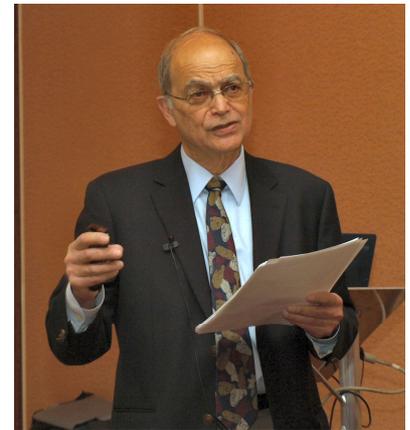


site sloped by 5°. Even if the plan view were circular it wouldn't be truly circular on the ground. More maths. Eventually though, the Carrara marble was in place and the sun shone. Only to reveal that all his exhortations that the site survey must be relative to true north, not magnetic or grid north, had been lost in translation. Grid north it was. Incidentally, both Frank and David told us that using the sun's azimuth had proven more accurate than GPS for aligning a sundial accurately.



A final coffee break and it was time to welcome back Roger Bailey, he of the Bailey Points, from Toronto. He has been studying what are perhaps the very earliest sundials with polar gnomons. Roger feels they are therefore the most important dials in existence. Designed by Ibn al Shatir, the last great Islamic astronomer in Damascus, now in Syria, then part of the Ottoman Empire. Al Shatir's dials of 1371 for the Great Mosque are now in a museum. Complex dials, showing Italian and Babylonian hours, prayer lines for the five times of prayer and equal hour lines for every 20 minutes, they are highly accurate and wonders of geometry. Islamic prayer times are specified by complex functions of shadow lengths. The polar gnomon is not frequently found in Islamic sundials since they were used for much more than telling equal hours time from midnight. Indeed, prayer times were the primary use, for which a nodus, not a polar gnomon, is needed. As a postscript, the death of Princess Neslişah Sultan Osmanoglu, the last imperial member of the Ottoman ruling family, was announced in *The Times* during the conference.

Conferences always end with an invited external speaker of eminence giving the Andrew Somerville Memorial Lecture. This year we were treated to a wonderful exposition on the stunning



story of the meridian line in Santa Maria degli Angeli in Rome. Our speaker was Emeritus Professor John Heilbron of Berkeley and Oxford. He wove a story of such complexity it was difficult to take it all in. In essence, this meridian was created in 1702 by Francesco Bianchini for Pope Clement XI and subsequently embellished on many occasions to record historic events involving the royal families of half Europe including England and Scotland. The Pope had, not surprisingly, attempted to get the Catholic Scottish King James III onto the English throne. James visited Rome where the Pope tried to arrange a marriage between James and his own god-daughter. This fell through as did Plan B when James's next intended married Bianchini instead. All these events and many more were recorded by medallions and other decorations inserted near the meridian line. The Wikipedia of its day.

The line was also a highly accurate astronomical instrument. It was used to measure changes in the obliquity of the earth's orbit and to observe the circumpolar stars. It shows the predicted position of the Pole Star for several hundred years along with many other features relating to the sun and the seasons. What is striking is how this meridian, essentially a sundial, was such an important object in the lives of popes and kings. What a shame we have no such instrument in this country, but how lucky we were to hear this most fascinating story.

To wrap up, to say this conference was as good as any should be praise enough. In many respects it excelled, particularly for lovers of elliptical dials and meridians. I trust this report does it justice and sufficiently expresses our thanks to Patrick Powers for all the hard work he put into conceiving, planning and running it.

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## NEW DIALS

### Ballygriffin, Co. Cork, Ireland

The Nano Nagle Centre is situated at Ballygriffin on the N72 road between Mallow and Fermoy, at 52° 9' North and 8° 31' West. Nano Nagle was the foundress of the Presentation Sisters and the pioneer of Irish Catholic education in the 18<sup>th</sup> century. The Nano Nagle Retreat and Reflection Centre relates the story of Nano Nagle and the Presentation Sisters in a broad historical and religious context. The centre has a 'cosmic walk', a 2 kilometre guided trail through



J. Mason

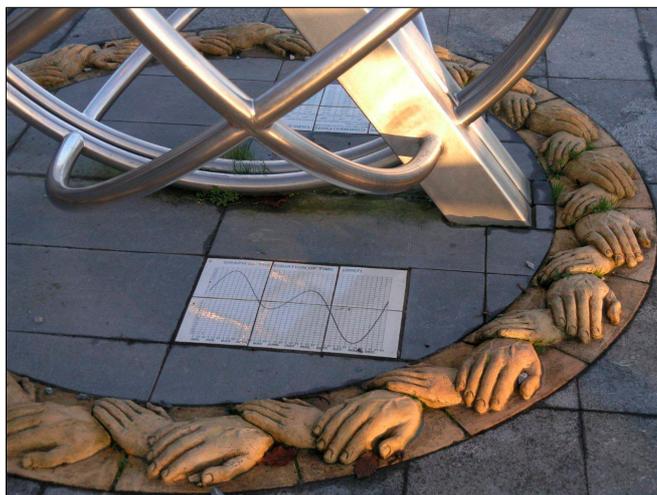
fields, woodlands and riverbank with the story of the evolution of the Universe from its birth to the present day represented by sixteen 'stations'. Designed by Jonathan Mason of Heritage, Planning and Design Services, Lusk, Co. Dublin in 2008, the first station of the Cosmic Walk is a sphere, in the form of a three dimensional Ying Yang symbol, which artist Barry Ormond of Kilmacomma, Clonmel, and Jonathan Mason developed in conjunction with Eddie Nelson of MetalCraft, Walkinstown, Dublin. It symbolises the singularity at the start of our universe, the 'Big Bang'.

The final 'station' on the Cosmic Walk, a stainless steel sundial with the world represented by the ringed globe at the base of the gnomon, was designed by Jonathan using ShadowsPro software. "The idea was to show the equatorials in relation to the gnomon to reinforce the idea that it is aligned with the earth's axis.... In our lifetimes, we all have known people fifty years older than ourselves. The ring of



J. Mason

forty clasped hands around the base symbolises the small number of such intergenerational jumps it takes to link us back to the time of the birth of Christ, reinforcing the sense historical time being short in relation to the deep time which most of the cosmic walk is dealing with."



C. Lalor

The hands were designed and made by Terry Carton of Carton Ceramics, Phibsboro, Dublin. Terry also made the silk screened tiles at the base of the dial with the equation of time and time correction tables. Eddie Nelson did the steel fabrication, while Joe Costelloe of Stonemad, Holycross, Co. Tipperary laid the stone paving, sand blasted the detail and fixed down the stainless steel numerals. Sitting in an 8 m × 10.5 m field of tiles, the 3.2 metre high gnomon (the shadow caster) of the sundial has a centre slit to allow (weather permitting) a shaft of sunlight to appear on the dial face at solar noon when the sun is due south.

There is a 200 mm wide noon gap on the dial face, marked with a narrow row of tiles, to compensate for the thickness of the gnomon. A prism mounted on the tip of the gnomon indicates the seasons through the spectrum it casts on the noon gap marker at solar mid-day.

There are hour lines from 6am to 6pm and half hour lines on the tile dial face, the hours being marked with stainless steel Roman numerals. There are plaques set in the tiles at the base of the gnomon for the Equation of Time plaque and for the Time Correction, with instructions on how to convert sundial time to watch time. The gnomon foundation consists of a block of concrete weighing several tons with three heavy threaded bars embedded in it. These were used to level and orientate the gnomon, the southern bolt serving as a pivot for the base plate.

### ACKNOWLEDGEMENTS

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