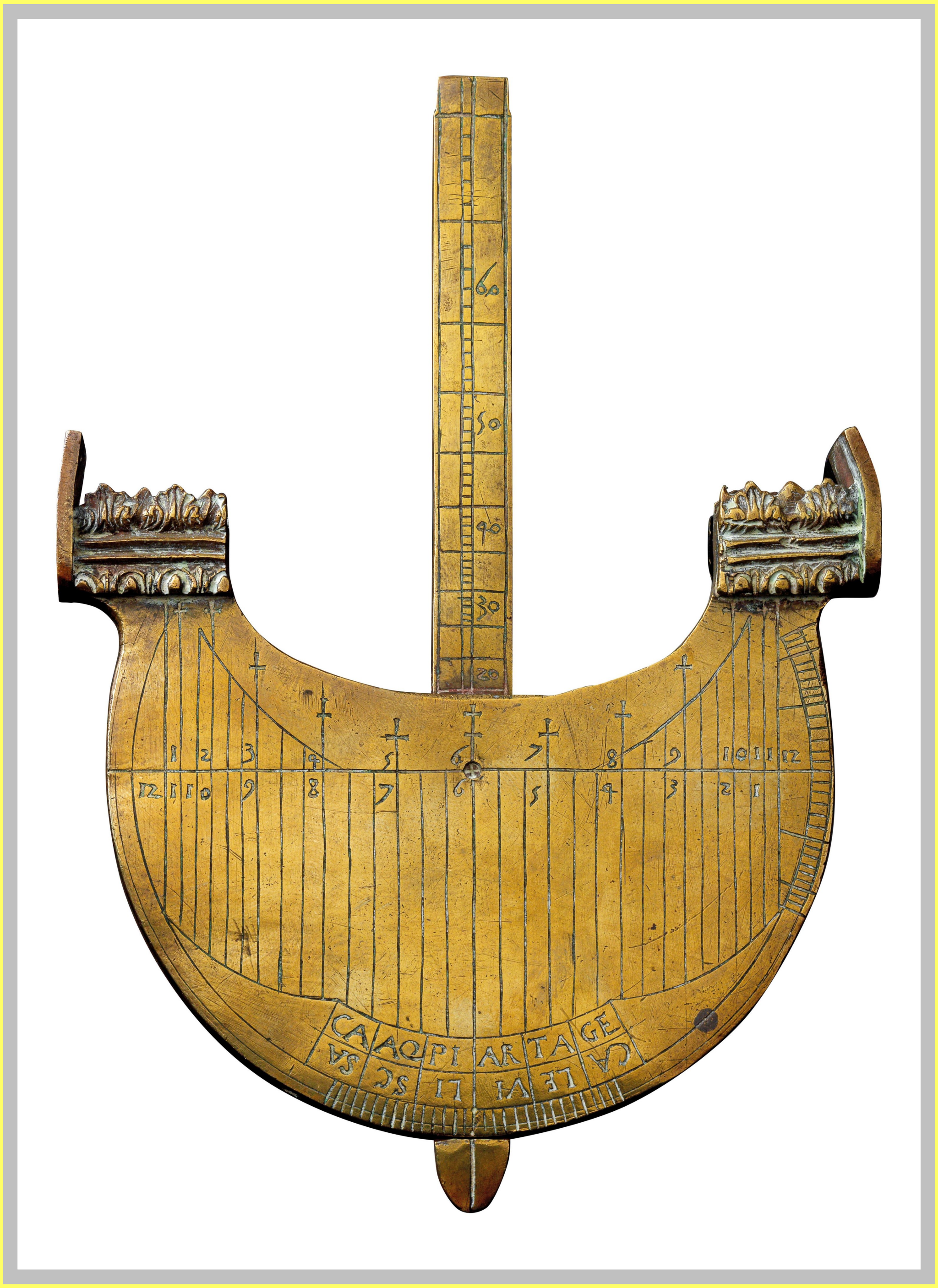
The British Sundial Society
BULLETIN



VOLUME 31(ii)
June 2019

BSS Bulletin 31(ii)
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NOTES FOR DIAL RECORDERS

I am grateful for the number and quality of dial reports that members send in, whether updates to dials already recorded, or new sightings. If you have never sent me a report, please don't be reluctant to get started. The report form can be downloaded from the Society website. Log in with your user name and password, and go to Sundials / Fixed Dial Register / Report Form / Dial Recording Forms, and click on 'MS Word' in the second paragraph. Alternatively just contact me and I will send you a form.

Most members now send emailed reports with digital photographs, but the traditional paper report and printed photographs are still used by many and are very welcome. If you are using email, attach the report as an MS Word document, and photographs as jpgs. In more detail:

Email

- Subject Line: Include the location briefly, and the SRN (Sundial Register Number) if you know it.
- Content: There is no need to include any message but of course put in anything you wish to say.

Report

- Format: Attach as an MS Word doc or docx, or use a compatible format such as odt. Please try to ensure that the report does not stretch to two pages. Please do NOT send your report as a pdf – pdfs are very difficult to reformat to the Register requirement.
- Name: Can be what you like, but it is helpful if you use the same as the email subject line.
- Addenda: Exceptionally you may wish to add a further sheet or sheets giving greater detail, using the same name as the main report plus 'b', 'c', etc. Addenda will usually be in doc or similar format, but may if desired be jpegs (maybe of printed text, or sketches) or Excel spreadsheets. Please only use if they add significantly to your report.

Photographs

- Coverage: As well as a general shot of the dial, please include close-ups of any interesting inscriptions or other details, a longer shot including the pedestal or wall, and a photograph showing the location of the dial.
- Format: Please send your photographs as attachments to the email. Do NOT embed them in the email – they are difficult to view and to extract for the Register structure.
- File type: Please send jpg files only, NOT jpeg, tiff, bmp, pdf or any other graphic format.
- Resolution: As it comes out of the camera. I used to ask members to reduce the file size to around 0.5 MB but this no longer applies, and high resolution photographs are often very helpful.
- Name: There is no essential format for the name, but please make the names of all the photos with one report start the same. For example IMG_56789.jpg, IMG_1234.jpg etc is fine, as are Ruston.jpg, Ruston sig.jpg, Ruston pedestal.jpg. But please avoid choosing names that do not start with the same few letters, such as Gnomon.jpg, Plate.jpg, Pedestal.jpg.

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01622 858853

***Front cover**: A previously unrecorded navicula, sold at auction last year and now in the Bayerisches National-museum (inv. L 2018/12). Despite this example being Continental and from the Renaissance period, it closely follows the medieval English pattern and style rather than the later designs shown by Oronce Finé. See the article by John Davis on pages 13–16. Photo copyright BNM.*

***Back cover**: Ancient sundial with four deviating vertical faces (Photo: Gerd Graßhoff, Elisabeth Rinner), and a 3-D reconstruction of the dial. See the article by Ortwin Feustel on pages 2–6.*

Editorial team: John Davis, Frank King, Christine Northeast and David Brown

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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

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CONTENTS

EDITORIAL

As is customary for the June *Bulletin*, this issue has an extensive report on the recent Conference, this one being extra special because it marked our 30th anniversary. It was held in Bath in April, one week after the Easter Weekend. We had a very full programme with talks on all three days and two tours, one of which was in an old London Routemaster bus. Bath is an exceptionally elegant city and it was a special treat to visit the Pump Room and the Roman Baths on the Sunday morning.

For me, there were two decided firsts at a BSS Conference: I was invited to unveil a plaque that David Brown had placed at the foot of his newly refurbished armillary dial in Parade Gardens and, during the dinner, I was asked to cut the magnificent 30th anniversary cake which had been baked by Pauline and Michael Faraday.

This issue begins with an erudite article by Ortwin Feustel about 3D reconstructions of ancient multiple dials and we have three articles by Martin Jenkins; two of these are to remind us that he is still travelling the world and the third is an Obituary for Anton Schmitz, our noted member in Germany who sadly died recently. We are fortunate that Doug Bateman previously provided us with an extensive profile of Anton in the June 2015 issue of the *Bulletin*.

I was also very sorry to learn of the death of Jim Marginson who was a very popular Newbury regular and always a source of good stories.

Two distinguished non-members have also died recently: Reinhold Kriegler of Bremen in Germany and Gianni Ferrari of Modena in Italy. Gianni supplied some of the data in the BSS *Glossary* and I have had many extended email exchanges with both these eminent diallists. I shall greatly miss being able to call on them for advice on dials in Mainland Europe and in the Islamic world too.

Frank King

3D RECONSTRUCTIONS OF ANCIENT SUNDIALS WITH MULTIPLE FACES: PART 1

ORTWIN FEUSTEL

Amongst the ancient sundials catalogued by Sharon L. Gibbs and Eva Winter are some specimens with the striking feature that they are multi-faced. Five especially interesting dials were selected in order to analyse and create correctly-scaled 3D reconstructions of the dial faces and gnomons. Each of the chosen specimens[1,2] is made of marble, with well-preserved detail.

3D models of these dials are freely available from the 'Topoi Sundials Community Project Ancient Sundials (D-5-60)'.[3] Thereafter, software GOM Inspect[4] was used to obtain the required measurements from the 3D models.

Editor's Note

The reader is strongly recommended to visit the site where the referenced models can be viewed, rotated, magnified and lighting direction changed, allowing an extraordinary level of detail to be viewed on one's computer's screen. For example, visit http://repository.edition-topoi.org > Ancient Sundials > Search > scroll to page 13 > select Dialface ID 248 > Click on 3D Models/cite

Kevin Karney

Symbols Used[5,6,7,8]

φ	geographical latitude
δ	sun's declination
d	declination of a plane face (angle between the plane and the east–west direction)
ρ	cylinder's radius
R	sphere's radius
G	pin gnomon length
α	half opening angle at the cone's vertex
c	count of a temporal hour line
w	subscript for winter solstice
e	subscript for equinoxes
s	subscript for summer solstice
1,2,3 etc	subscript for temporal hours

Four Planar-Vertical Deviating Faces (Figs 1 and 2)

Characteristics

Four planar-vertical deviating sundials are strung together in a zigzag so that two faces point south-east and two south-west. Thus, the declinations of the planes are +45° and −45° and the two planes of the central dial form a right angle. Three gnomons are aligned north–south within the meridian planes. Each face is engraved with solstitial and equinoctial declination lines and six temporal hour lines.

Fig. 1. Ancient sundial with four deviating vertical faces. Photo: Gerd Graßhoff, Elisabeth Rinner.

Parameters of 3D-Model ObjID242[9]

Fig. 2 shows the measurements of distances and angles:

- distance 1 = 123.11 mm = D_{we} = distance at the meridian between the intersection points of winter solstice and equinox declination lines
- mean value (distance 2 + distance 3) / 2 = 230.83 mm = D_{62} = distance between the

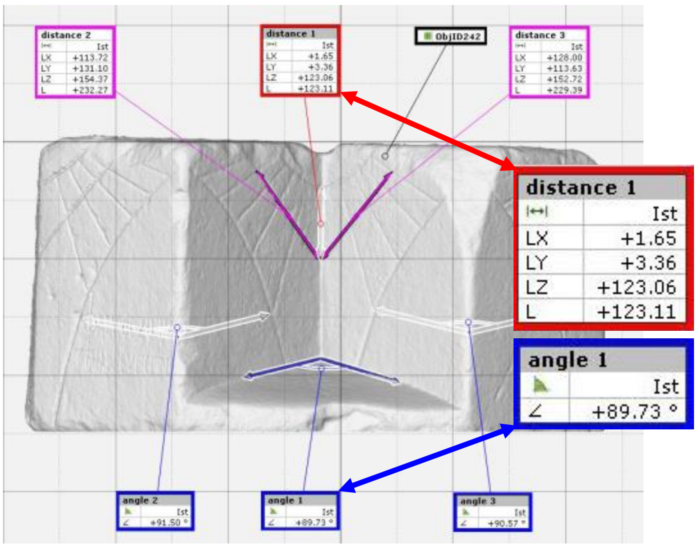

Fig. 2. Front view of the Topoi 3D-Model ObjID242 with the measurements of angles between deviating faces and distances between declination lines along the meridian. The GOM Inspect software allows measurements to be taken from the model (in ° or mm using a right-handed system of x-y-z coordinates). See insets as examples of measurements taken.

intersection points of the sixth and second hour lines and the equinoctial declination line,

- mean value (angle 1 + angle 2 + angle 3) / 3 = 90.6° » d = +45° and −45°.

Values of the geographical latitude, the sun's declination at the winter solstice and the gnomon's length were found by trial and error in relation to the measured values of D_{we} and D_{62}. The calculated values in mm are summarised in Table 1; the chosen parameters for the dial's reconstruction are red-coloured.

	G	145	150	155	160	165
$\phi = 37.5°$	D_{62}	204.0	211.0	218.1	225.1	232.2
$\delta_w = -23.7°$	D_{we}	107.5	111.2	114.9	118.6	122.3
$\phi = 37°$	D_{62}	208.7	215.9	223.1	230.3	237.5
$\delta_w = -23.7°$	D_{we}	111.0	114.9	118.7	122.5	126.4
$\phi = 37°$	D_{62}	208.7	215.9	223.1	230.3	237.5
$\delta_w = -24°$	D_{we}	112.0	115.9	119.8	123.6	127.5

Table 1. Calculated distances D_{62} and D_{we} in dependence on different values for the parameters G, ϕ and δ_w.

Graphical reconstruction

Using the chosen parameters, Fig. 3 shows the 3D reconstruction of the four faces with their three gnomons.

Review

This unusual fourfold dial has the following remarkable features:

- The four faces are so arranged and oriented that at least one will always indicate the time.
- Morning and afternoon time is visible from the sides of the dial.
- The two central faces have a common sixth hour line (= meridian line).
- No auxiliary equipment is necessary to install the dial; the same indication on two faces gives the correct orientation.
- The gnomons are not perpendicular to the faces.
- The line nets of the two central faces run symmetrically about their common meridian line.

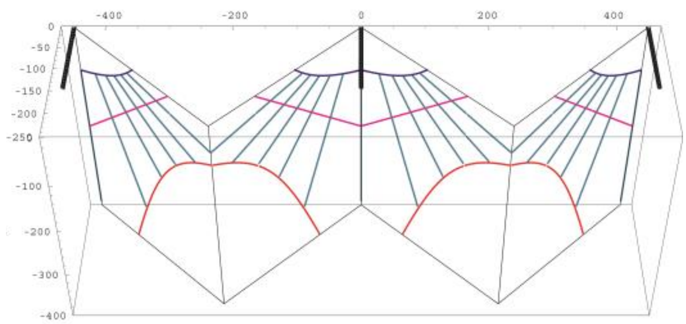

Fig. 3. 3D reconstruction of the sundial in Fig. 1 with solstitial and equinoctial declination lines and all temporal hour lines from c = 1 to 11.

Two Transposed Hollow Spherical Faces (Fig. 4)

Characteristics

Two halves of a hollow hemisphere form the shadow-receiving areas of the dial. They are positioned side by side such that the normal of each cutting plane points to the east and the west, respectively. Each face consists of solstitial and equinoctial declination lines and five temporal hour lines: c = 1 to 5 and c = 7 to 11, respectively.

The two gnomons have a common origin on the dial's southern top side. Each of the gnomon tips is at the centre of the respective hemisphere.

Fig. 4. Ancient sundial with the two halves of a scaphe as faces; Delos, Greece. Photo: Gerd Graßhoff, Elisabeth Rinner.

Parameters of 3D-Model ObjID77[10]

Fig. 5 reveals the measurements of diameters and radii:

sphere 1 = 290.01 mm » R = 145 mm
sphere 2 = 290.58 mm » R = 145 mm

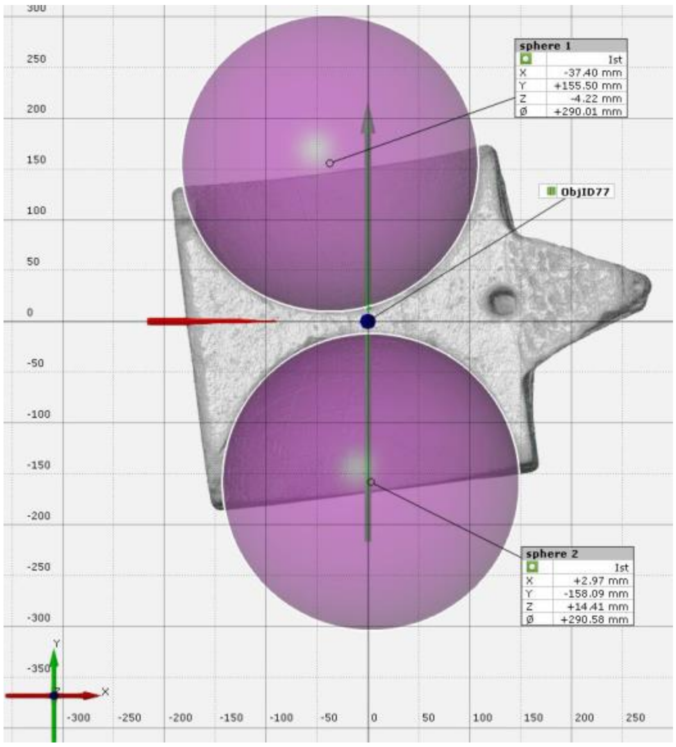

Fig. 5. Top view of the Topoi 3D-Model ObjID77[10] *for the measurements of hollow sphere's diameter.*

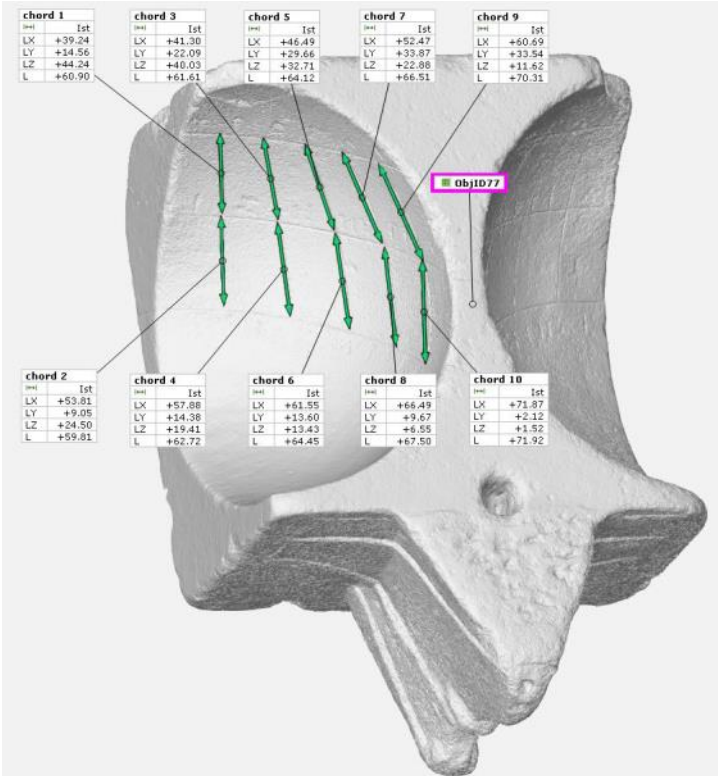

Fig. 6. Topoi 3D-Model ObjID77[10] for the measurements of distances between solstitial and equinoctial declination lines along the hour lines c = 7 to 11.

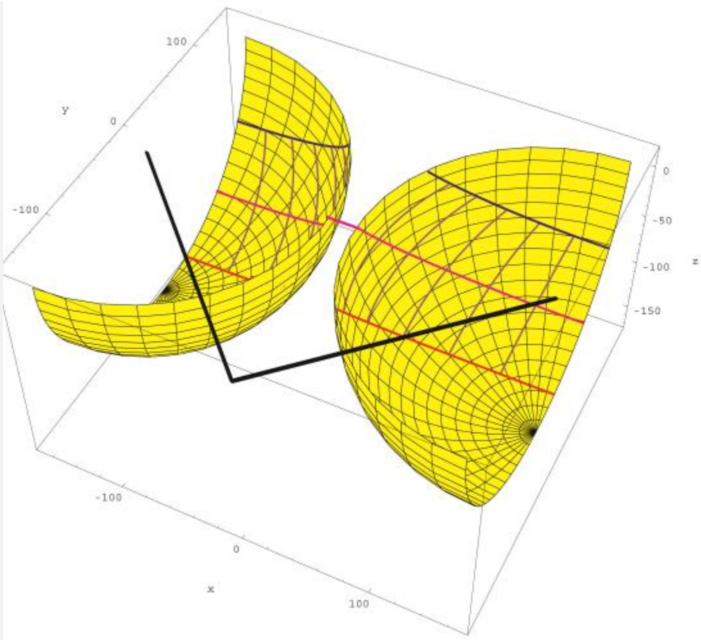

Fig. 7. Appropriate 3D reconstruction of the sundial in Fig. 4 with solstitial and equinoctial declination lines, together with temporal hour lines c = 1 to 5 and c = 7 to 11: the calculation is based on the reconstruction parameters φ = 37.38°, –23.7° ≤ δ ≤ 23.7°, R = 145 mm.

Fig. 6 shows the measurements relating to chords 1 to 10.

Table 2 shows measured and calculated values, based on the reconstruction parameters of φ = 37.38°, –23.7° ≤ δ ≤ 23.7°, R = 145 mm. The percentage deviation Δ = 100 × (1 – calculated value / measured value).

The results show that the values chosen for the reconstruction parameters are suitable.

chord	1	3	5	7	9
mes	60.90	61.61	64.12	66.51	70.31
cal	60.074	61.614	64.093	67.401	71.411
Δwe	1.356	0.000	0.041	–1.339	–1.566
chord	2	4	6	8	10
mes	59.81	62.72	64.45	67.50	71.92
cal	60.074	61.614	64.093	67.401	71.411
Δes	–0.442	1.763	0.553	0.147	0.707

Table 2. Percentage deviations Δ between calculated (cal) and measured (mes) values for the chords 1 to 10 in Fig. 6.

Graphical reconstruction

Fig. 7 shows the reconstruction viewed from the south-east onto the two faces, together with their gnomons.

Review

Unlike this dial, a hemispherical dial mapping the sun's path on the gigantic celestial sphere is usually seen as an inverted image (laterally reversed and turned upside down) in the stone dial's little scaphe. Thus one must look down on the scaphe.

Fig. 8 shows further details of the present dial:

- It is possible to read the time even if the dial is installed at eye level on a pillar.
- The sixth hour line (meridian) is not engraved on either side. If there is no gnomon shadow at noon, the dial is correctly oriented.
- Greek inscriptions mark the solstitial and equinoctial declination lines.
- An engraved line connects the equinoxes across the top of the dial.

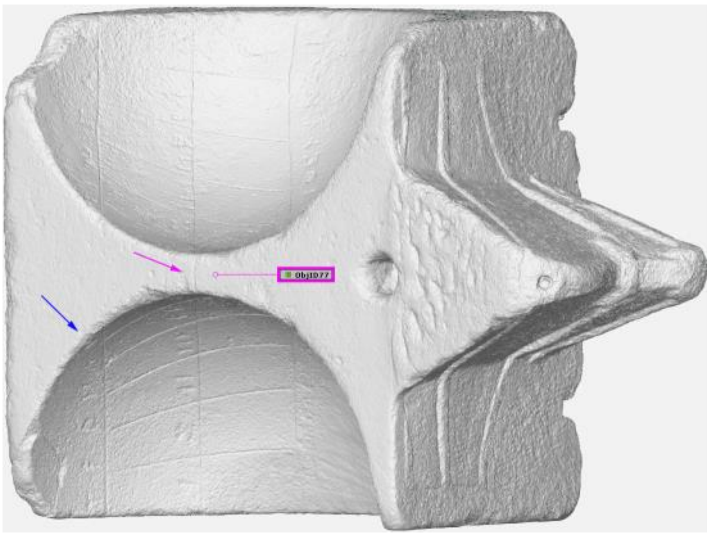

Fig. 8. Top view onto the faces of the Topoi 3D-Model ObjID77;[10] magenta arrow = connection between the two equinoctial lines, blue arrow = winter solstice line marked with the Greek inscription τροπαι.

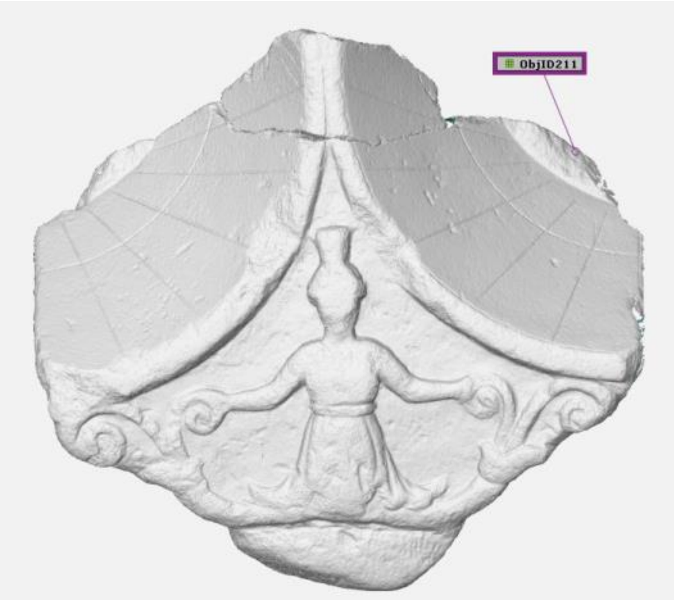

Fig. 9. Front view of the fragment of an ancient sundial with the two halves of a hollow cone as faces represented as Topoi 3D-Model ObjID211.[11]

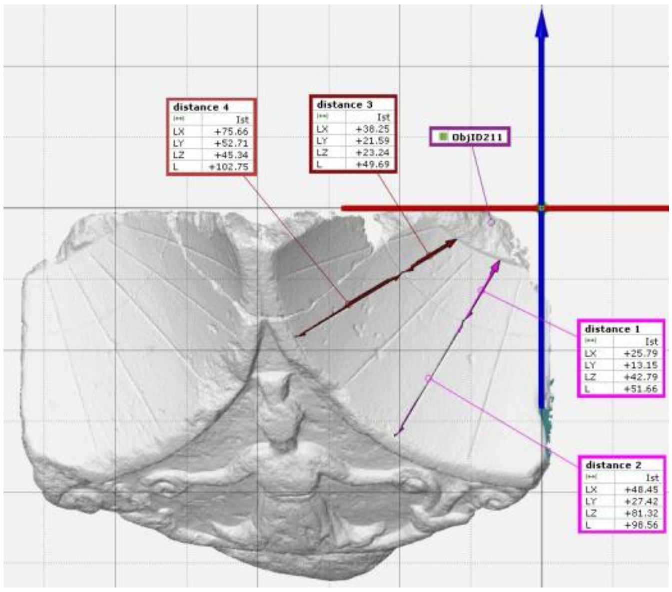

Fig. 10. Slightly inclined front view of the Topoi 3D-Model ObjID211[11] *for the measurements of distances between the declination lines along the hour lines c = 2 and 4.*

Two Transposed Hollow Conical Faces (Fig. 9)

Characteristics

Two halves of a hollow cone form the shadow-receiving areas of the dial. They are positioned side by side whereas the normal of each cutting plane points to the east and the west, respectively. Every line net consists of the solstitial and equinoctial declination lines and six temporal hour lines $c = 1$ to 6 and $c = 6$ to 11, respectively.

The axis of each conical face lies within the meridian plane and points to the North Pole. Each gnomon is located both in the meridian plane and within a horizontally-oriented intersection plane through the cone; its tip is on the cone's axis.

Parameters of 3D-Model ObjID211[11]

It was not possible to measure the cone's half opening angle α using the GOM Inspect software: the conical surface ends at the winter solstice declination line. Instead, the distances along the $c = 4$ and $c = 2$ hour lines between the points where they intersect the solstitial and equinoctial declination lines were measured.

Fig. 10 reveals the results:

distance 1 = 51.66 mm
distance 2 = 98.56 mm
distance 3 = 49.69 mm
distance 4 = 102.75 mm

From which the following were found by trial and error:

$\alpha = 38.5°$
$\varphi = 36.42°$
$-24° \leq \delta \leq 24°$
$G = 90$ mm

Based on these reconstruction parameters the percentage deviations Δ between calculated and measured distances are:

$\Delta_{we4} = 100 \times (1 - 47.848 / \text{distance 1}) = 7.38\%$
$\Delta_{es4} = 100 \times (1 - 99.017 / \text{distance 2}) = -0.46\%$
$\Delta_{we2} = 100 \times (1 - 51.261 / \text{distance 3}) = -3.16\%$
$\Delta_{es2} = 100 \times (1 - 102.536 / \text{distance 4}) = 0.21\%$

Graphical reconstruction

Fig. 11 shows the complete hollow cone, even though in reality the cone's vertex is situated outside the dial. Only that part of the cone's envelope needed for the gnomon's shadow is used.

An interesting feature: if the temporal hour lines were extended beyond the winter solstice line, they would lead to the foot of the gnomon; to illustrate this, the lengthened hour lines c = 0 and 12 are shown.

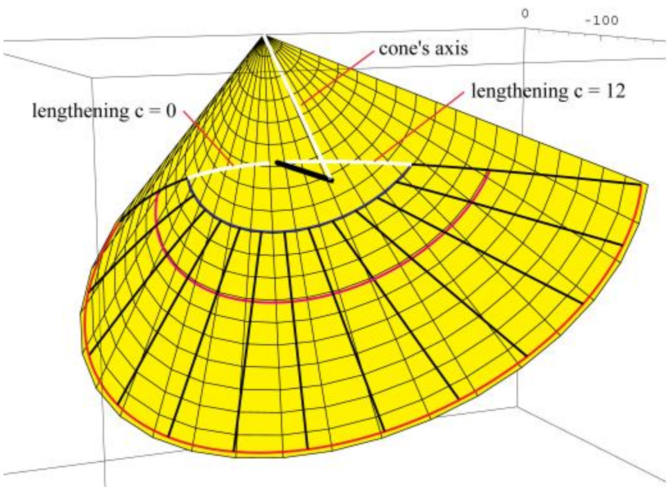

Fig. 11. Modified 3D representation of the sundial in Fig. 9: the halves are joined together; the calculation based on the reconstruction parameters $\phi = 36.42°$, $-24° \leq \delta \leq 24°$, $G = 90$ mm, $a = 38.5°$, $c = 0$ to 12.

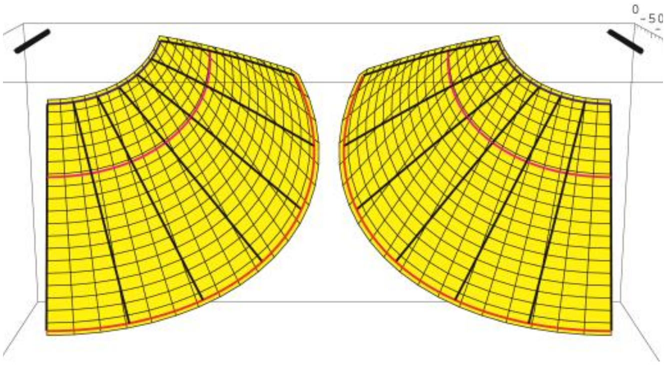

Fig. 12. 3D reconstruction of the sundial in Fig. 9 with solstitial and equinoctial declination lines and temporal hour lines c = 0 to 12; the calculation is based on the reconstruction parameters $\phi = 36.42°$, $-24° \leq d \leq 24°$, G = 90 mm, a = 38.5°.

Fig. 12 shows the southern view of the calculated 3D faces together with their gnomons.

Review

Between them Gibbs and Winter have catalogued 46% more hollow cone than hollow sphere sundials. This specimen adds further variety. The following aspects should be noted:

- No auxiliary equipment is necessary for the correct installation of the dial; the time indication on both faces at noon means the correct dial's placement.
- It is possible to read the time even if the dial is installed at eye level on a pillar.

A further two dials will be examined in Part 2.

REFERENCES and NOTES

1. S.L. Gibbs: *Greek and Roman Sundials*. Yale University Press, New Haven and London (1976).
   Four planar-vertical deviating faces: 5002G, pp.346-7.
   Two transposed hollow spherical faces: 1072G, pp.189-90.
   Two transposed hollow conical faces: 3106G, pp.318, 325.
   Three vertical hollow cylindrical faces: 7006G, pp.388-9.
   Two vertical hollow cylindrical and spherical faces: 7004G, pp.381-2.
2. Eva Winter: *Zeitzeichen: Zur Entwicklung und Verwendung antiker Zeitmesser*, Walter de Gruyter GmbH & Co. KG, Berlin/Boston (2013), Band 2.
   Four planar-vertical deviating faces: Athen 21, p.309.
   Two transposed hollow spherical faces: Delos 5., pp.332-3. Dating: 1st half of 2nd century BC.
   Two transposed hollow conical faces: Rhodos 5, pp.513-4. Dating: 1st century BC.
   Two vertical hollow cylindrical and spherical faces: Herculaneum 1, pp.371-2.
3. *http://topoi.org*
4. *http://www.gom.com/de/3d-software/gom-inspect.html*
5. O. Feustel: 'The calculation of declining and inclining sundials – an unusual approach', NASS *Compendium*, 21(2), 35-9 (June 2014).
6. O. Feustel: 'Mathematical analysis of hollow sphere and hollow cone sundials with pin gnomon and hole gnomon – part 1', NASS *Compendium*, 21(3), 23-30 (September 2014).
7. O. Feustel: 'Mathematical analysis of hollow sphere and hollow cone sundials with pin gnomon and hole gnomon – part 2', NASS *Compendium*, 21(4), pp.29-37 (December 2014).
8. O. Feustel: 'Rekonstruktion einer vertikalen Sonnenuhr mit drei halben Hohlzylindern', *DGC Jahresschrift 2018 Band 57*, 173-82.
9. *http://repository.edition-topoi.org/collection/BSDP/single/0153/0*
   3D-Model ObjID242 of Dialface 248. Holder: British Museum, London, United Kingdom. Site: unknown. Dating: ca. 300 AD.
10. *http://repository.edition-topoi.org/collection/BSDP/single/0050/0*
    3D-Model ObjID77 of Dialface 74. Holder: Archaeological Museum of Delos, Delos, Greece. Site: Delos, Greece, φ = 37.39°. Dating: unknown.
11. *http://repository.edition-topoi.org/collection/BSDP/single/0163/0*
    3D-Model ObjID211 of Dialface 208. Holder: Archaeological Museum, Rhodos, Greece. Site: Paleochristian Basilica, Rhodos, Greece, φ = 36.42°. Dating: unknown.

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Spotted in a Shop Window

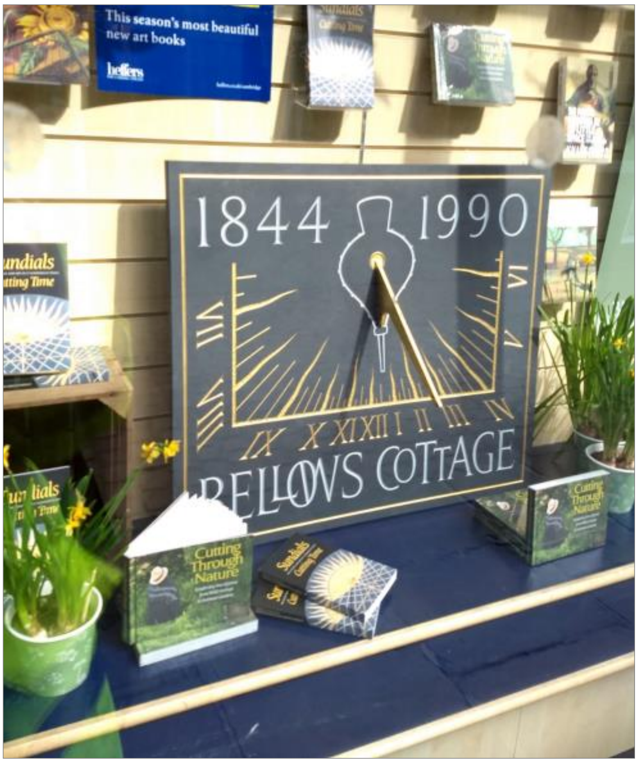

Photo: Frank King.

In April 2019, Heffers Bookshop in Cambridge featured a display of two books recently published by the Cardozo Kindersley workshop, of which one was *Sundials: Cutting Time* by Frank King and Lida Cardozo Kindersley,[1] but it was the large slate sundial that caught the attention of passers-by. The dial, with gilded gnomon and hour lines in the form of flames, had been intended for a Buckinghamshire smithy which, sadly, burnt down before it could be installed.

1. Ben Jones: Book Review, *BSS Bulletin*, 31(i), p.39 (March 2019).

THE ABHAYAGIRI MONASTERY SUNDIAL AT ANURADHAPURA, SRI LANKA

MARTIN JENKINS

My wife Janet and I have very long-standing friends in Sri Lanka. On one of our visits to see them in 2012, we got them interested in sundials. On another visit to see them in 2014, we made the acquaintance of one of their close friends Prof. Sarath Chandrajeewa of the University of the Visual and Performing Arts, Colombo. Now, all three of them, Anoma, Nimal, and Sarath are 'into' sundials!

Sarath knew of an ancient sundial at the Abhayagiri Museum at Anuradhapura and subsequently asked some of his academic colleagues, who were making a visit to the ancient site of Anuradhapura, to bring back details and measurements of the dial. Nimal then made a replica of the dial. With this replica and the permission of Prof. T.G. Kulatunga, Project Director of Anuradhapura Central Cultural Fund, Anoma, Nimal and Sarath were able to carry out the first in-depth research and analysis of this ancient sundial. Incidentally, at Ruwanwelisaya, a Great Stupa, some fragments of a stone slab have been found in the upper courtyard; these are also now believed to be a sundial. In 2015, another ancient sundial was found at Rajagala Vihara at the Ampara archaeological site; research is ongoing. Their work on the Abhayagiri sundial was published in book form in 2015; a copy is lodged in the BSS library.[1]

In January 2019, Janet and I again visited Sri Lanka and decided to visit Anuradhapura to see the sundial.

A Brief History of Anuradhapura

Anuradhapura was the capital city of North Central Province of Sri Lanka and the capital of Anuradhapura District. Anuradhapura is one of the ancient capitals of Sri Lanka, famous for its well-preserved ruins of an ancient Sri Lankan civilization. It was the third capital of the kingdom of Rajarata, following the kingdoms of Tambapanni and Upatissa Nuwara. The city, now a UNESCO World Heritage site, was the centre of Theravada Buddhism for many centuries. The city lies 205 km (127 miles) north of the current capital of Colombo in the North Central Province, on the banks of the historic Malvathu River. It is one of the oldest continuously inhabited cities in the world and one of the eight UNESCO World Heritage Sites of Sri Lanka. It is believed that from the fourth century BC until the beginning of the 11th century AD it was the capital of the Sinhalese. During this period it remained one of the most stable and durable centres of political power and urban life in South Asia. The ancient city, considered sacred to the Buddhist world, is today surrounded by monasteries covering an area of over 16 square miles (41 km^2).[2]

The Refectory, Site of the Sundial

The refectory complex in the monastery consists of two courtyards, dining room, kitchen, rice and curry collection room, fireplace and store room. Between the rice and curry collection room on the left and the dining room on the right is the east courtyard which runs north–south. This courtyard is accessed via an entrance at the north end such that one would have to pass the sundial before entering either the rice and curry collection room or the dining room (Figs 1 and 2). Interestingly, the sundial is closer to the

Fig. 1. North entrance to the refectory.

Fig. 2. Eastern courtyard; rice and curry room on the left, dining room on the right.

Fig. 3. Close-up showing the proximity of the dial to the rice room steps and the rice 'canoe'.

steps leading into the food collection room than to the steps leading into the dining room. This probably ensured that one did not collect one's food and enter the dining room before being sure that it was the correct 'time' (Fig. 3). Note also in Fig. 3 the very long rice 'canoe' from which the monks took their meal. It is estimated that it held 5800 alms bowls of rice, which would nicely concur with old records indicating that some 5000 monks lived at the Anuradhapura complex.[3]

The Sundial

Buddhist monasteries were spiritual centres of the country. Most ancient is the Maha Vihara (Great Monastery) founded by King Devanampiyatissa (250–210 BC) and secondly the Abhayagiri Vihara. These monasteries used sundials to perform their daily spiritual commitments within specific times.[4]

The Abhayagiri Monastery sundial is mentioned in the Eleventh Report of the Archaeological Excavations of the Abhayagiri Vihara Complex in 1987.[5]

"*A well preserved stone sundial (surya thatiya) instrument has been found at the refectory hall of the Abhayagiri monastery complex:*

"*Towards the north-east of the stone pavement there is a specially made square stone object measuring 43 × 43cm. This chiseled smooth stone slab has a small square socket in the centre. Radiating from the socket are sixteen carved lines pointing to sixteen directions equidistant from each other and connected by shallow incised circles, giving the appearance of a cob-web. There are also equidistant sixteen vertical lines incised in between the first and second circular lines running up to the outer edge of the slab.*"

Fig. 4. Close-up of the dial face.

Fig. 5. The dial atop its plinth in the museum.

It is quite amazing that this sundial was found so recently. The original stone sundial is now placed in the Abhayagiri museum (Figs 4 and 5). As can be seen in Fig. 4 the dial is quite worn. The dial is made from quartzofeldspathic gneiss. When compared with other stepping stone slabs at the refectory, the sundial slab is much more deteriorated and so it is believed that the sundial belongs to a much earlier period in the monastery's history.[6] Fig. 5 shows how thick the sundial is, approximately 150 mm. A cement mix copy has been inserted into the ground at the original location (Fig. 6).

The latitude of Anuradhapura is approximately 8° 24′ N, quite close to the equator. This results in the shadow of the tip of the gnomon tracing straighter lines than would be the case on a horizontal dial in British latitudes (Fig. 7). Another peculiarity at such equatorial latitudes is that the shadow tip travels both north and south of the gnomon depending on the date.

As can be seen in Fig. 8 the dial is nicely orientated north–south along the line of the courtyard. In fact, Anoma and

Fig. 6. Close-up of the copy.

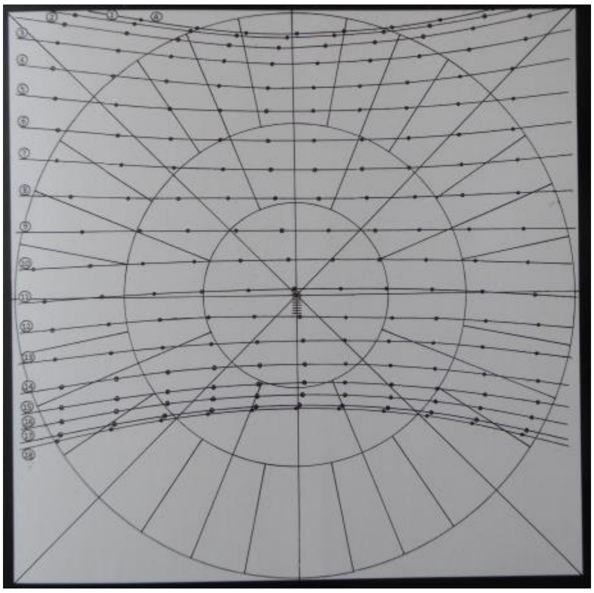

Fig. 7. Traces of the shadow tip throughout the year. North is at the top, 'WS' indicates the winter solstice, 'EQ' the equinox, and 'SS' the summer solstice. Copyright A. Jayasinghe, N. Jayasinghe.

Fig. 8. Orientation of the dial.

Nimal have determined a deviation of the order of 1°. According to Buddhist discipline, monks should finish taking their meal by noon, so the sundial was probably used to check the time before the noon meal, useable within a few hours either side of 'indicated' noon. One must bear in mind that this dial is delineated with equispaced lines and a regular geometric pattern so did not give 'correct' time as we would consider it. Another complexity is that in the Abhayagiri period (2–9 AD), the daytime was divided into thirty hours yet the dial is divided into 32 segments. As the courtyard was probably used at other times throughout the day, it seems likely that the gnomon was detachable and only placed in the dial close to the time-keeping period.[7]

Anoma, Nimal, and Sarath have suggested that the dial was also used to indicate auspicious times such as the Fall of Sinhala and Tamil New Year. In addition, given the tradition of painting sculptures and walls the dial may also have originally been decorated with lines and motifs.[8]

Summary

This is indeed an interesting and intriguing sundial. It may never be known exactly how it was used and what it indicated other than the time signal for acceptable eating time. It is clearly ancient and of great historical value such that it is securely kept in the museum. For those BSS members who may wish to know more about this dial then I can do no more than to recommend the published work by Anoma, Nimal, and Sarath.

ACKNOWLEDGEMENTS

I would like to thank my dear friends for allowing me to bring this dial to the attention of the BSS.

REFERENCES

1. A. Jayasinghe, N. Jayasinghe, S. Chandrajeewa: *An Investigation of the Sundial at Abhayagiri Monastery in Anuradhapura, Sri Lanka,* The Contemporary Art and Crafts Association of Sri Lanka, Colombo, Sri Lanka (2015).
2. *http://www.off2srilankadaytours.com/home/place/2*, accessed February 2019.
3. R. De Silva: '*Battanava* or *Bathoruwa*', in G. Dhammapala and R. Arangala (eds): *Kamburupitiye Vanaratana Mahimi Abhistava Sangrahaya*, Ministry of Cultural Affairs, Colombo (1996).
4. T.G. Kulatunge: *Purana Abhayagiri Viharaya,* Central Cultural Fund, Colombo, p.160 (2014).
5. S.B. Hettiaratchi, *Eleventh Report of the Archaeological Excavations of the Abhayagiri Vihara Complex (January 1987 – June 1987)*. UNESCO Sri Lanka project of the Cultural Triangle, Colombo, p.23 (1987).
6. Ref. 1, p.32.
7. Ibid, p.46.
8. Ibid, p.72.

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IN THE FOOTSTEPS OF THOMAS ROSS

Part 27: The Ladyland Sundials

DENNIS COWAN

Ladyland House is a private home near Kilbirnie in North Ayrshire in the west of Scotland. It dates from the early 19th century and was built in the grounds of the ruined Ladyland Castle. It has changed hands a number of times, most recently in 2017.

Thomas Ross identified two sundials at Ladyland, and in volume 5 of *The Castellated and Domestic Architecture of Scotland*,[1] he says of the first one that:

"*This fine specimen of a lectern dial* [Fig. 1] *is mounted on a pedestal unlike those of the general type, and resembling those often found among the horizontal dials. It is dated 1673, and contains the initials M.P.C., but we are not in a position to say whose they are.*"

This sundial was originally at the castle and it could be that it was commissioned to commemorate the completion of modernisation works started there in 1669, when a pitched roof was added and other works were carried out to convert the castle from a defensive structure to a more 'modern' home.

The date of 1673, however, is on the pedestal so it is a possibility that it may not refer to the sundial itself, and anyway I am not convinced that it is original to the sundial – the stone just seems to be slightly different. Ross comments that it is not on a pedestal like the others of the lectern type, but I would contest that there is not really a common style of pedestal for these dials as there are several different types used. It is correct to say, though, that the pedestal of this sundial is of the type more commonly seen with horizontal dials.

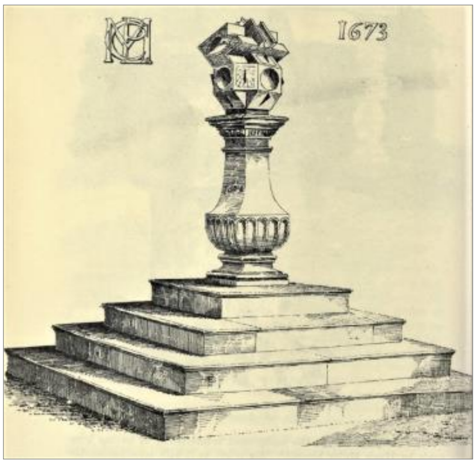

Fig. 1. Ross's sketch of the Ladyland House lectern sundial, including the monogram and date.

Fig. 2. The lectern sundial today, still on the same four-stepped base as it was in Ross's day.

The sundial today is just off the drive in front of the house and still stands on the four-stepped base that it was on in Ross's day, although the steps now have a significant amount of moss and lichen (Fig. 2). Thankfully none of that is on the sundial itself which unfortunately has lost all of its metal gnomons. Other than that it is in quite a reasonable condition.

Lectern sundials fall into two main types – those with a star on top and those without. This one is of the star type as can be seen in Fig. 3. It has a varied mixture of different types of dial faces (Fig. 4) including reclining, inclining, sunken heart and geometric shapes, hemi-cylinder and vertical, but as usual with lectern sundials, there is no horizontal dial. A fair number of the hour lines survive and the numerals that do are of the Arabic type.

Looking again at Fig. 3, it appears to be a hybrid of a lectern sundial and the capital of an obelisk sundial. The only one that I can think of that has this same feature is at Hensol House near Kirkcudbright. It is thought that this

Fig. 3. Close-up of the lectern sundial showing the star on top and sunken geometric dials.

Fig. 4. Close -up of the lectern sundial showing reclining, inclining, sunken heart, hemi-cylinder and vertical dials.

sundial was originally at Stewarton, which co-incidentally is only about ten miles from Ladyland House.

Like Ross, I have been unable to ascertain the owner of the initials M.P.C. inscribed on the pedestal. However, there may be an additional letter in the monogram, a "D", which I believe can be seen in Fig. 5 with the curve of the "D" hidden behind the right leg of the "M". David Cuninghame owned Ladyland in 1654, so that could be D.C. for David Cuninghame and M.P. or P.M. for his wife. Unfortunately, I have been unable to confirm her name. In any case, I am not entirely convinced, so it will have to remain a mystery for now.

The second sundial at Ladyland is in what was the walled garden, but which now belongs to the privately owned converted stable, and separate from Ladyland House itself. Ross says:

"*This dial* [Fig. 6]*, in the garden of Ladylands, has a very graceful pedestal finished with a volute capital. On the pedestal occur the initials of William Cochrane of Ladylands, and his wife, Catherine Hamilton, and on the opposite side the year 1821; but it is believed to be of an older date. The dialstone on the top does not appear to us to be an appropriately formed termination. It will be observed that it is like the capital of an obelisk dial, and has the appearance of being merely placed there, and not of being specially designed for its position.*"

Fig. 5. Close-up of the lectern monogram. Is it M.P.C. or is there a D there too?

I certainly agree that this is the capital of an obelisk sundial and does not belong to the pedestal. It is currently sited in an overgrown part of the garden (Fig. 7) and is quite badly covered in lichen (Fig. 8). There are no visible hour lines or numerals on any of the dial faces.

I am not sure of the relevance of the date of 1821 as according to the Parish records, William Cochrane and his wife married in 1815.

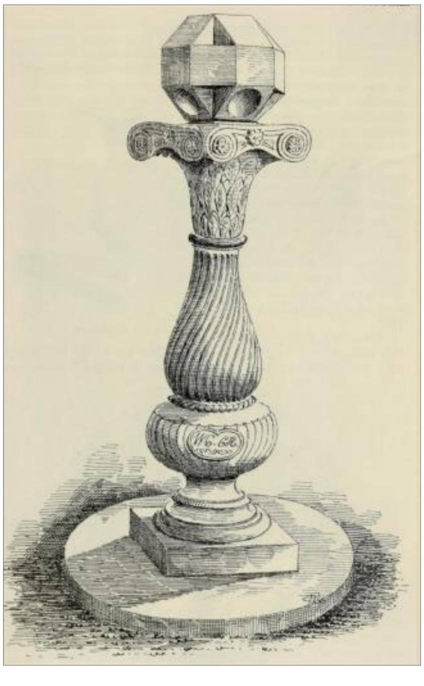

Fig. 6. Ross's sketch of the obelisk capital on its graceful pedestal.

Fig. 7. The rather neglected obelisk capital in the overgrown part of the garden.

There is another sundial at Ladyland not described by Ross, but of no great significance. It too is in the garden now belonging to the converted stable and appears to be a globe with the top third cut off (Fig. 9). The remains of the gnomon can be seen on the horizontal surface (Fig. 10), but nothing else remains. It does not appear to belong to the pedestal on which it sits.

Fig. 10. Close-up of the cut-off globe-shaped sundial showing the remains of the gnomon.

Fig. 8. Close-up of the lichen-encrusted obelisk capital.

Fig. 9. The cut-off globe-shaped sundial that Ross didn't see.

ACKNOWLEDGEMENTS

Many thanks to Mr Gordon Smith, owner of Ladyland House, who made me most welcome at the time of my unannounced visit in 2017, prior to the time of its last sale.

REFERENCE

1. D. MacGibbon and T. Ross: *The Castellated and Domestic Architecture of Scotland,* David Douglas, Edinburgh (1892).

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A RENAISSANCE NAVICULA

JOHN DAVIS

Naviculae are one of the most interesting forms of portable altitude sundial. The design originates in medieval England in the late 14th or 15th centuries although it did experience a brief revival in Continental Europe during the Renaissance, as was discussed in an earlier *Bulletin* article.[1] Both forms are very rare so the previously unrecorded example of the latter group which was sold at auction by Dorotheum in Vienna in 2018 is worth studying.[2] This example, shown in all the figures, was purchased by the Bayerisches National-museum (BNM) in Munich[3] and I am grateful to Dr Raphael Beuing, their curator for weapons, watches, scientific instruments and base metals, for his assistance.

Description

The dial came from the collection of a northern Italian family and has an overall width of 98 mm with the 'mast' having a total height of 139 mm. As can be seen in Fig. 1, it has the same general ship shape form as the medieval English examples shown in the earlier *Bulletin* article, even to the extent that the plates at the 'prow' and the 'stern' which form the sights are slightly curved. However, the 'castles' are rather more elaborately decorated castings and the numerals for the hours and the latitudes (on the mast) have their 'modern' (i.e. post-1550) forms rather than their medieval ones – note especially the 4, 5 and 7. There is no sign of the rivets which, on a medieval English navicula, connect the two plates that make up the 'hull' to their spacer pieces; instead, it is assumed that the instrument is soldered.

The horizontal hour scale shows 12–6–12 (equal) hours. Between 2 and 10 they are divided into thirds (20 minutes or 'mileways' if it were an English instrument) with the hour lines emphasized by a cross at the top, as was the

Fig. 1. Front (left) and back (right) of the Dorotheum/BNM navicula, inv. L 2018/12. © BNM.

Fig. 2. Details of the castle casting and one of the sights. © Dorotheum.

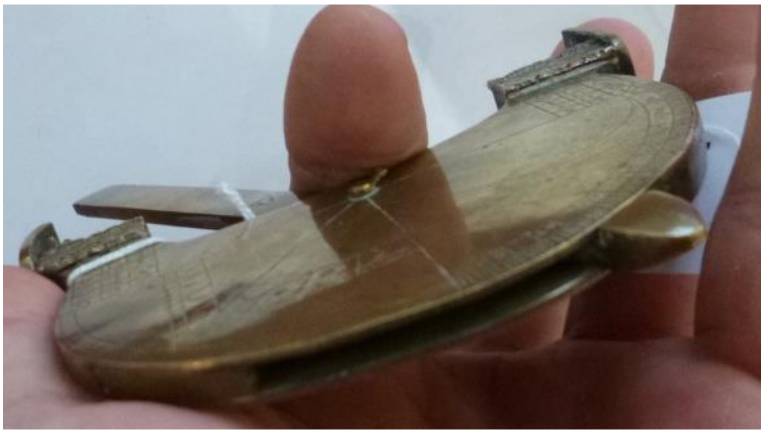

Fig. 3. Close-up of the bottom of the navicula showing the construction of two spaced plates allowing the mast to swing between them. © Dorotheum.

Fig. 4. Close-ups showing (a) the latitude numbering on the front of the mast, (b) the foundry mark on the back of the mast, (c) the zodiac signs for setting the mast to the correct declination, (d) the foresight, with the pair of holes set to avoid obstruction by the mast. © BNM and Dorotheum.

Sign	Day	Month
Capricorn	13 (13; 12)	December
Aquarius	11 (11; 10)	Ianuary
Pisces	10 (12; 9)	February
Aries	12 (12; 10)	March
Taurus	12 (12; 11)	April
Gemini	13 (13; 12)	May
Cancer	13 (13; 12)	Iune
Leo	15 (15; 14)	Iuly
Virgo	15 (15; 14)	August
Libra	15 (15; 14)	September
Scorpio	15 (15; 14)	October
Sagittarius	14 (14; 13)	N*ovember

*Table 1. Dates for the entry of the sun into the signs on the dial. The first date in the second column is the value of the BNM navicula; the first value in parenthesis is that found in most navicula manuscripts of the 15th century and the second is that in a later ms of 1513 (see ref. 4, pp.39-40). * Note that the 'N' of November is engraved in reverse.*

earlier English tradition. The more cramped ends of the scale show only the half hour between 10 and 11.

At the bottom of the hull there is a scale for setting the angle of the mast for declinations in the range ±23° but labelled for the zodiac signs divided into 5° intervals of solar longitude. The signs for the second half of the year are written upside-down, showing that the scale is running right to left: again, this is typical of earlier English instruments.

The scale on the right-hand side, for setting the position of the sliding bead on the plumb-bob string, is similarly divided for the zodiac divisions, divided to 5° steps. It is unlabelled though, which would make using it very difficult.

The mast is lacking both its slider, from which the string plumb-bob with its indicating bead would hang, and the top castle which would have retained it. Looking closely, it can just be seen that the top of the mast is slightly narrowed where the top castle would have fitted. The front is divided for latitudes from 20° to 70° with the range above 30° divided to individual degrees. The back of the mast does not have the small gazetteer of places and latitudes found on most English naviculae and is blank other than an intriguing foundry(?) mark – Fig. 4b – which is unidentified. In fact, given the central position of the punched mark, it may not be from the foundry producing the brass sheet at all but could be an instrument maker's or owner's mark. No doubt it will be identified at some stage.

The back of the hull has the standard table giving the dates of entry of the sun into each sign – this is divided into two, just under the castles. The engraved dates are given in Table 1 and can be compared with those on the earlier English examples listed by Eagleton, as well as a slightly later table, both shown in parentheses in the table.[4] It can be seen that, other than Pisces, the engraved values match the ones in 15th century manuscripts rather than the single copy of the early 16th century. This suggests that the BNM instrument may have been made by following the original English manuscripts.

The rest of the space on the back is filled with a shadow square of 12 units, numbered in threes, and a universal 'old quadrant' which has unlabelled unequal hour lines. There is an associated altitude scale in degrees around the circumference and the hanger for a missing plumb-bob remains.

Metallurgy

The composition of the copper-alloys comprising the BNM navicula were measured by the Museum using X-ray fluorescence (XRF) and the abridged results are shown in Table 2. They show that the material is a fairly standard brass with a reasonably high zinc (Zn) concentration for the time. The two sights are a slightly different alloy from the rest of the instrument. Some aspects of the composition are not fully understood – whilst the 'not reported' tin (Sn) and

Area	Cu	Zn	Sn	Pb	Ag	Ni	Fe	As	Sb	Bi	Au	Comments/Others
Front plate	74.8	23.6	nr	1.16	nr	0.28	0.06	nr	0.03	nr	0.02	Cd 0.01; Nb 0.01
Back plate	74.1	24.0	nr	1.39	nr	0.27	0.04	nr	0.03	nr	0.02	Hg 0.03; Nb 0.01
Mast	75.1	23.2	nr	1.10	nr	0.27	0.10	nr	0.04	nr	0.02	Hg 0.02; Nb 0.01
Foresight	75.9	20.5	nr	0.60	nr	0.16	0.51	0.57	0.02	nr	0.03	Hg 0.08; Nb 0.01
Backsight	75.8	22.4	nr	0.62	nr	0.15	0.53	0.14	0.02	nr	0.03	Hg 0.06; Nb 0.01

Table 2. Alloy compositions of the navicula components as measured by XRF by the BNM. nr = not reported.

silver (Ag) levels are probably just due to limited sensitivities of the analyser, the presence of small gold (Au) and mercury (Hg) concentrations is surprising as there is no indication that the instrument was ever gilded (in which case the levels would be significantly higher) but these elements would not be expected in a normal brass.

Discussion

After Oronce Finé's publication in 1532[5] there seem to have been a number of naviculae made in Europe, possibly for princely and aristocratic collectors. For example, the inventory of the Kunstkammer of the Duke of Bavaria in 1598 lists "Ein Compaßstockh in form eines schiffs" which would read as "A sundial in form of a ship".[6] 'Compaßstockh' of course alludes to a compass, but the whole term designates sundials, whether they incorporate a compass or not. It is not impossible that this dial is the BNM one or at least similar to it. The general appearance of the dial is much closer to the medieval English examples than, for instance, the example in the Museo Galileo (Florence) or Finé's 1524 ivory example in the Museo Poldi Pezzoli (Milan).[7] It is not clear, though, whether the BNM instrument was constructed using Finé's geometrical construction method or by those of the original English manuscripts. The design would need to be carefully reverse-engineered to discover this. Whichever is the case, it is a fascinating instrument which shows that the design had lasting appeal.

ACKNOWLEDGEMENTS

I am grateful to Simon Weber-Unger and Maria Elisabeth Lipp (Dorotheum GmbH) for their help in obtaining some of the photographs and permission to use them here. Dr Raphael Beuing at the Bayerisches Nationalmuseum also provided much assistance, photographs and discussion. Dr Joachim Kreutner, head of metal conservation, provided the XRF data.

REFERENCES and NOTES

1. J. Davis: 'The Navicula – Made in Medieval East Anglia?', *BSS Bull*., 29(ii), 15-23 (June 2017).
2. Dorotheum GmbH & Co KG, Dorotheergasse 17, A-1010 Vienna, *www.dorotheum.com*. Auction on 4 April 2018, lot 491. Estimate $12,500.
3. Bayerisches Nationalmuseum, Prinzregentenstraße 3, 80538 München, *www.bayerisches-nationalmuseum.de*. The navicula is now *inv. L 2018/12.*
4. C. Eagleton: *Monks, Manuscripts and Sundials: the navicula in medieval England*, Brill Academic Publishers (2010).
5. Oronce Finé: *Protomathesis*, Paris (1532). It also appeared in his 1560 *De Solaribus Horologis*, Paris (1560).
6. Raphael Beuing, personal communication, 28 July 2018.
7. See illustrations in Davis, *The Navicula*, ref. 1.

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Postcard Potpourri 47
Dean Row Chapel, Wilmslow

Peter Ransom

This three-faced dial on a sandstone pillar (SRN 0152) at Dean Row Chapel, Wilmslow, Cheshire dates from 1899 and was restored a century later to celebrate the Millennium.

When I bought this card on the Internet, its description mentioned that it came from a collection of locally published photographic cards produced by an amateur photographer. There is no publisher mentioned on the reverse, yet it does have the standard printing with space for a stamp and instructions where the address should be written and that it is for inland postage only. Dating it is difficult, but I feel that it is pre-First World War. The photograph was taken around 4 pm, given the evidence of the shadow, and a high-resolution scan shows that the gnomon on the west face is missing, despite the supports being present.

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A STUDY OF THE SHORTEST DAY

ALASTAIR HUNTER

On a family walk in the Pentland Hills near Edinburgh just before Christmas in 2018, cousin Ian asked me about sundials. He said he had heard an item in the news about the shortest day. It was in December, but the latest sunrise would be in January. "Oh yes," I replied, "the media like to bring that one up every year. But you needn't worry, 21st December is the shortest day." Little did I realise that the news item was actually an interview with our BSS Chairman Frank King; sundial news travels far.[1]

The idea that sunrise keeps getting later, while daylight must be getting longer, is confusing. I first heard about it more than thirty years ago from a colleague at work. He used to say how much he liked having more daylight in January after the dark days of December. I think he learned about the times of sunrise from the information printed in his desk diary, which we all used to use at that time.

It seems to me I ought to get my story straight now. Someone else may want to ask about it. This study tries to put an explanation for sunrise and the shortest day into words and numbers for sundial people. Astronomers may approach their explanation in a different way.

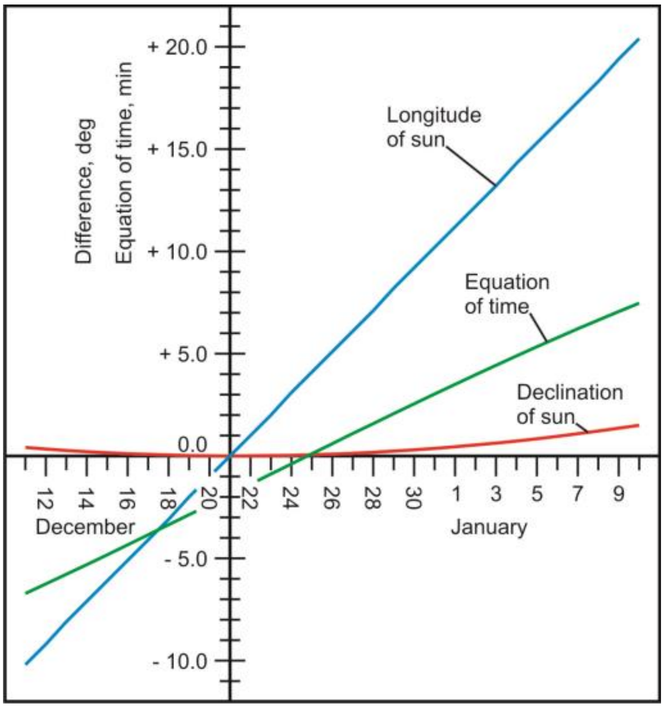

Fig. 1. Solar data over a period of 31 days. Longitude and declination of sun plotted as difference from respective values on 21 December. Equation of time plotted directly. Source of data: BSS Sundial Glossary.

Calculations

Aim and formula

The aim of this study is to calculate the time of sunrise and the length of day on the shortest day of the year, in the northern hemisphere, and to see what happens over a period of days before and afterwards. The basic calculation comes from the formula for sunrise, $\cos(h_{sr}) = -(-\tan\varphi \cdot \tan\delta)$ given in the *BSS Sundial Glossary* – where h_{sr} is the hour angle at sunrise (negative because it is before noon), φ is the angle of latitude, and δ is the declination of the sun.[2]

Even if you are uncomfortable with formulae, the ideas are understandable. Hour angle (h) is familiar from the equatorial sundial, where the hour lines are spaced apart by 15°. Latitude (φ) alters the time of sunrise, later in the day in winter in the north than in the south, for latitudes above the equator. Declination (δ) also affects the time of sunrise, which is latest in midwinter when the sun is lowest in the sky.

Now, sunrise is a number of hours before noon, sunset is the same number of hours after noon, and daylight is between sunrise and sunset, so length of day is the sum of the two. Note, the formula finds when the centre of the sun is on the horizon: it ignores twilight.

Data values

To use the formula and carry out calculations, data values are needed, which the *BSS Sundial Glossary* provides in convenient form. These are tables of values for declination of the sun, longitude of the sun, and equation of time, for 365 days of the year.[3] Transforming these values into a graph shows clearly how they vary over a period of days (Fig. 1). Note that 21 December has been used as a reference date, when the nominal value of sun declination is −23.4° and sun longitude is 270°. For the purposes of this study, and for clarity on the graph, sun declination and longitude have been plotted as differences from their respective BSS data on 21 December. The equation of time has been plotted directly.

The time period is 31 days from 11 December to 10 January. It shows a slow change in declination of the sun before and after its minimum midwinter value. The increase in longitude is almost linear day by day, reflecting Earth's orbit around the sun. The increase in equation of time is also almost linear over this period; it passes through zero on 25 December.

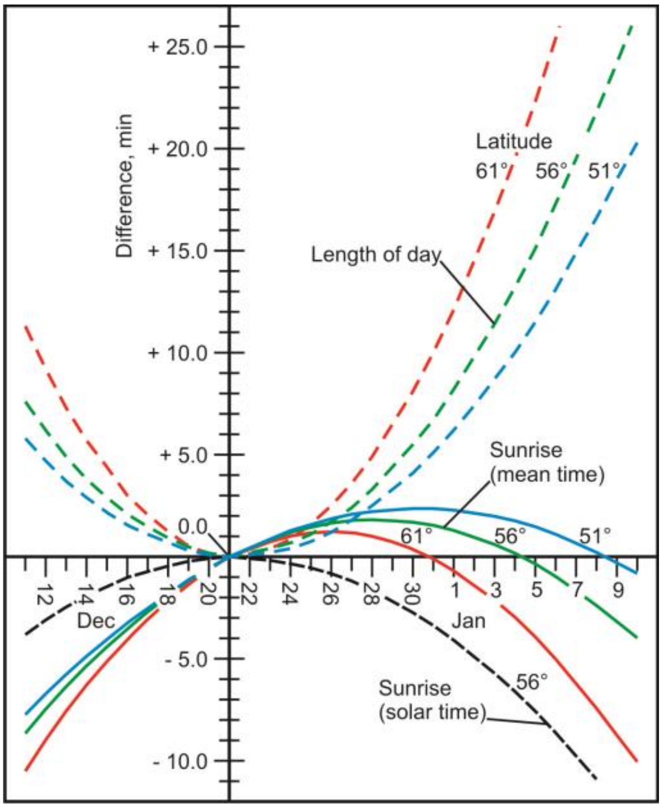

Fig. 2. Calculated values over a 31-day period. Time of sunrise (solar time), time of sunrise (mean time), and length of day, plotted as difference from respective values on 21 December. Selected latitudes 61°, 56°, and 51°. Source of basic data: BSS Sundial Glossary.

Solar time and mean time

Starting with calculations for latitude 56°, appropriate for the location of our family walk near Edinburgh, sunrise (solar time) is latest on 21 December as expected (Fig. 2). This is the shortest day. Before and after this date, sunrise is earlier. It is the broken line, coloured black. Like the plots for sun longitude and declination in Fig. 1, it is shown as a difference.

When solar time is adjusted to mean time with the Equation of Time applied, a new picture appears. The full line coloured green shows sunrise running later in mean time after 21 December, and this lateness continues until 4 January. The latest sunrise is on 28 December when it is just under 2 minutes later than it was on 21 December.

Note that length of day is not changed by the equation of time. The difference between sunrise and sunset is the same, whether measured in solar or mean time, and is shown as the broken line coloured green.

Effects of latitude

Plots for three different latitudes, 61°, 56°, and 51°, show a developing pattern. These latitudes span the British Isles from the north of Shetland to the south of England. At latitude 61° the sunrise curve rises and falls quicker than at 56°, and daylight progresses faster. At 51° it is the other way round: sunrise by the clock is later than it was on 21 December until 8 January.

Calculations for a wider range of selected latitudes are given in Table 1. Winter daylight is very short close to the Arctic Circle at latitude 66°, only 1h 45m. At latitude 66.6°, on the Arctic Circle, the shortest day has no daylight—the calculation formula fails at this point. Further south at 49.1°, there is a curious result that winter sunrise occurs at 8:00 am and winter daylight is 8 hours. This is the latitude of the most southerly point of the British Isles south of the Channel Islands. Continuing into lower latitudes, sunrise is earlier and daylight longer, until at the equator daylight is 12 hours.

Discussion and Summary

The shortest day and winter solstice

The shortest day is when declination of the sun is at a minimum. Strictly, winter solstice and minimum declination correspond to the point when the ecliptic longitude of the sun is 270°, which is a moment in time. The date of the shortest day is when this happens.

The date follows a leap year cycle. Winter solstice is about six hours later each year, which generally moves the date from 21 to 22 December in the fourth year. The leap year then re-adjusts the date. For example, winter solstice in 2018 was on 21st at 22:23 pm, this year 2019 it will be on 22nd at 4:19 am, and next year 2020 the leap year re-adjusts the date to 21 December at 10:02 am.

The shortest day is a convenient notion, but it is not a very exact event. For latitude 56°, the change in day length is less than 1 minute in 6 days from 18 to 24 December, which is not a big change. Winter solstice on the other hand is a precise moment in time.

Sunrise and sunset

Sunrise in the morning (mean time) gets later after the shortest day, then reaches a turning point and gets earlier again, as explained above and shown in Fig. 2. This is the

Latitude angle	Time of sunrise (solar time)	Hours of daylight
66°	11:07 am	1h 45m
61°	9:26 am	5h 8m
56°	8:40 am	6h 40m
51°	8:09 am	7h 42m
49.1°	8:00 am	8h 0m
40°	7:25 am	9h 9m
30°	6:58 am	10h 4m
20°	6:36 am	10h 47m
10°	6:18 am	11h 25m
0°	6:00 am	12h 0m

Table 1. Calculated time of sunrise and hours of daylight for 21 December at selected latitudes. Source of basic data: BSS Sundial Glossary.

Date in December	Sunrise (mean time)	Day length	Sunset (mean time)	Comment
14	8:33	6h 44m	15:17	Earliest sunset
21	8:38	6h 40m	15:18	Shortest day
28	8:40	6h 43m	15:23	Latest sunrise

Table 2. Summary of sunrise, day length, and sunset, on selected dates. Calculated for latitude 56°.

time of sunrise we see on the clock. Because of the effect of the EoT, it is quite correct to say that mornings continue getting darker after the shortest day. When sunrise passes its turning point, it is sensible to say that mornings have started getting lighter again. The date when sunrise returns to the time it was on the shortest day, which may be in January, is simply obtained by calculation.

Sunset in the evening (mean time) gets later when days are lengthening, as expected. But, in a mirror of what happens with sunrise, the time of sunset reaches a turning point *before* the shortest day. Again this is an effect of the EoT. In December, while days are still shortening, sunset gets earlier before its turning point and then becomes later, which continues through the shortest day and afterwards. It is therefore correct to say that evenings are becoming lighter before the shortest day.

Table 2 provides a summary of these curious sunrise and sunset effects. The numbers in the table reveal that both effects, sunrise getting later after the shortest day, and sunset getting later before it, are marginal. In the example given in the table for latitude 56°, the effects last for one week in each case. The time difference is only 2 minutes for sunrise, or 1 minute for sunset, but after two weeks on 28 December sunset is 6 minutes later, which may be noticeable.

Solar hours and mean hours

One final thought: solar hours are not precisely the same length as mean hours. Is it possible that, because of the EoT, day length alters as well as sunrise and sunset? Like many details of sundials, the answer is yes and no. There is a change but the difference is insignificant.[4]

Summary

The shortest day of the year is when the sun is lowest in the sky, as measured by the declination of the sun. In the northern hemisphere, the date is in midwinter on or around 21 December. On the shortest day sunrise is at its latest, in solar time. By the clock, in mean time, the latest sunrise is a few days afterwards, and sunrise may not return to its time on the shortest day until January. On the other hand, sunset begins to get later ahead of the shortest day, and evenings are lighter. These curious effects arise from the EoT, which changes quickly near the solstice. Day length and the times of sunrise and sunset also vary with latitude. This study has been interesting to carry out. Now that it is complete our family will have plenty to talk about, when we go out for our next winter walk.

ACKNOWLEDGEMENT

In his interview Frank King referred to the times of sunset before the shortest day. The discussion of sunset in this article was prompted by his broadcast, after listening to a replay on the BSS website.

REFERENCES and NOTES

1. Frank King: Radio interview, BBC Radio Scotland, broadcast on 21 December 2017, also on BSS website *http://sundialsoc.org.uk/news/winter-solstice/*
2. John Davis (ed.): *BSS Sundial Glossary: A source book of dialling data*, 2nd edn, British Sundial Society (2004).
3. The data in the tables are average values computed for the years 2000 to 2047, as explained in the *Glossary*.
4. The length of a solar day, from noon to noon, is variable while a mean solar day is 24 hours. When solar time runs slower than the clock, solar days are longer than 24 hours, and vice versa. The equation of time provides accurate figures for adjusting the time and is made up of daily increments. These increments are the actual amounts that the solar day is longer or shorter than 24 hours. The largest increment is +30 seconds in 1 day, that is 1¼ seconds in 1 hour. Therefore, the maximum length of 1 solar hour is 1h 0m 1¼s, instead of 1h 0m 0s, which is an insignificant difference.

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BSS 30th Birthday Cake

This is the largest of many cakes made by Pauline and Michael Faraday for the 30th Anniversary Conference in Bath this year. For pictures of all the cakes they baked, and of the ceremonial cutting of this one, see page 43. *Photo: Mike Shaw.*

A SOLAR TRANSIT ON THE MERIDIAN LINE, BASILICA OF SAN PETRONIO, BOLOGNA

DOUGLAS BATEMAN

A visit to Bologna gave the opportunity to observe and time the transit of the sun across the famous meridian line in the Basilica of San Petronio precisely at solar noon. A great deal has been written about the basilica and the line, and this article makes particular reference to two authors, Giovanni Paltrinieri[1,2] and John Heilbron,[3] but a brief summary will be useful.

Construction of the basilica started in 1390, and in 1514 there was a proposal to revise its plan with the intention of outdoing Saint Peter's Basilica in Rome. According to tradition, Pope Pius IV halted this project and the facing of the main (north) façade was never finished (Fig. 1).

Whilst one thinks of Cassini in connection with the current meridian line, an earlier version had been constructed 80 years before by Ignazio Danti (Egnatio or Egnazio).

Danti (1536–86) was an Italian priest, mathematician and astronomer, who was invited by Pope Gregory XIII to be pontifical mathematician and to advise on the reform of the calendar. He had designed a large-scale meridian line in the church of Santa Maria Novella in Florence with a hole just beneath the façade's rose window. This aperture served as the hole of a pin-hole camera and caused an image of the sun to fall on the church floor. The meridian line was probably not completed by the time Danti left in 1575 to become professor of mathematics at the University of Bologna. It was here that he designed and had built a meridian line in the basilica.

Fig. 1. A Google Earth view of the Basilica of San Petronio (looking south) showing the famous unfinished façade.

Coincidentally, in the same issue of the *Bulletin* as one of the articles by Paltrinieri, there is a reference to Danti by Girolamo Fantoni.[4] The subject is the Gregorian reformation of the calendar and quoting:

"*To confirm the Pope's perplexities, the great Vatican astronomer Egnatio Danti, using a meridian line constructed and still existing in the 'Tower of the Winds' in the Vatican Palace gardens, demonstrated to Gregory that the Sun touched the vernal equinox on the 11th March by the Julian calendar and not the correct March 21, and this was an unacceptable deviation from the Nicean Council directions.*"

In 1653 the authorities extended the Basilica of San Petronio southwards, and the wall containing Danti's aperture was demolished thus rendering the meridian line useless. At this time Giovanni Domenico Cassini (1625–1712) occupied the chair of astronomy at the University of Bologna (founded in 1088, the university is the oldest in continuous occupation). He is known for his work in the fields of astronomy and engineering. Cassini discovered four satellites of the planet Saturn and noted the division of the rings of Saturn. In 1669 Cassini moved to France and helped to set up the Paris Observatory; he was the director of the observatory for the rest of his career.

His son, Jacques Cassini, took over the Paris Observatory and was elected a Fellow of the Royal Society. Jacques' son, César-François Cassini de Thury, is noted for his topographic survey of France in the 18th century.

Whilst in Bologna, Giovanni Domenico Cassini proposed a meridian line which would be 66.8 metres long, significantly longer than Danti's line. The new line would enable angular dimensions to be obtained to a greater precision than had been achieved before. Giovanni later documented his scheme in his book *La Meridiana del Tempio di S. Petronio*[5] and this contains a sketch showing how, by means of careful measurements, he was able to lay out a line between two columns (see Fig. 2).

This was a major project, and some idea of the cost is quoted in Heilbron[6] as follows:

"*The* fabbricieri *[in current Italian a Property Committee] worried about the cost and the practicability of Cassini's project. … This cost them 2,000 lire, plus 500 lire for their consultant Cassini, which made in all about 15 percent of their annual income; a sum that imperiled their souls, since they faced excommunication if they did not repay soon the large debt they had incurred to complete the nave.*"

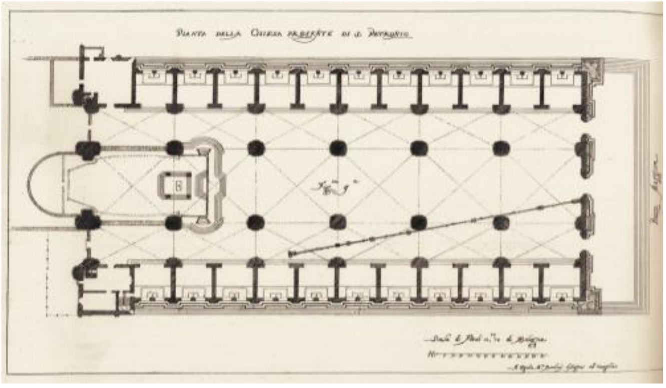

Fig. 2. Cassini's plan showing that the line could just pass between two columns. North is to the right.

In our more secular times we may be amused by the threat of excommunication but, at the time, such a sanction by the all-powerful Catholic Church was a serious matter, potentially leading to damaging social and professional life.

What we do know is that Cassini took a great deal of care to determine the point on the floor perpendicularly below the centre of the aperture (see Figs 3 and 4) in the basilica roof. He used one hundredth part of the height of the aperture as his unit of measure. The height was therefore 100 units which is equivalent to 27.07 metres. His line was to be marked by an iron strip and he took further care to ensure that this was exactly level. To do this he cut into the floor a channel of water whose surface he took as his datum height. The iron strip was placed so its height along its length matched this datum. Cassini appreciated that the line would follow the curvature of the earth and, by calculation, confirmed that this deviation from a straight line would not give rise to significant errors.

Fig. 3. The aperture in the basilica roof, seen from inside the basilica. Note the surrounding ornamentation.

At the summer solstice in 1655 Cassini invited local dignitaries to witness the transit of the sun. The solar image on the floor would then be the closest it can be to the perpendicular point. This event convincingly demonstrated that the intended line had the correct orientation and that it extended uninterrupted (missing all potentially intervening columns) to where the image would fall at the winter solstice. The line was completed after the winter solstice six months later.

Fig. 4. The location of the aperture. Note that part of a buttress has been removed to ensure that the line from the sun is not interrupted when the solar altitude is low.

The line itself has had two restorations: by Giovanni Guglielmini and Cassini in 1695, and by Eustachio Zanotti in 1776. There were also notable inspections by Federigo Guarducci in 1904 and by Giovanni Paltrinieri in 2005.

The first restoration was necessitated by a displacement of the marble slab in the roof that carried the aperture and by subsidence of slabs along the meridian line. (Bologna has a history of settlement causing the demolition of many 'towers', with two remaining: one vertical and another leaning alarmingly.) Quoting Paltrinieri:[7]

"*Not being able to remain further in Bologna, Cassini charged Guglielmini with constructing a special sextant to use in San Petronio with the help of the meridian line, with the eventual intention of determining the latitude of the basilica with precision. This instrument is now preserved in the Museum of San Petronio, and was used to align the meridian in the* <u>*direction of North*</u>*; some of the panes were removed from the large window in the facade, and with the help of a particular sight positioned on the wall it was possible to make* <u>*observations of the pole star*</u>*.*"
(My emphasis.)

Zanotti's restoration in 1776 was much more extensive than that undertaken by Guglielmini and Cassini in 1695. He replaced the iron strip by a composite bar of copper with outer strips of brass. Zanotti was not starting from scratch; he used Cassini's unit of measure and reset the aperture to its original position above the perpendicular point on the floor.

Zanotti replaced the majority of the marble slabs and, to check that the new line was level, he again used a channel of water. Rather than cutting this channel into the floor, he set up a trough of water alongside the line. Using a special gantry, he could compare the height of the line with the datum provided by the surface of the water. The general arrangement is shown in Fig. 5, which is adapted from Zanotti's own drawing.[8]

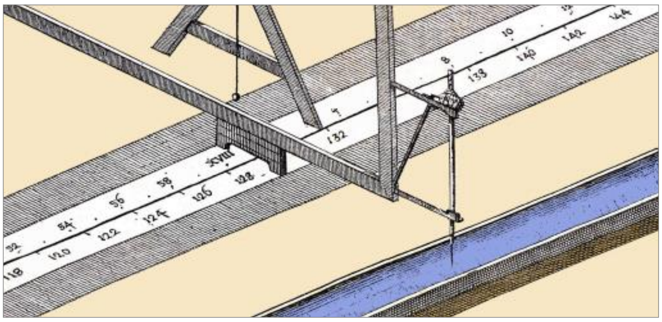

Fig. 5. An adaptation (see Acknowledgements) of Zanotti's drawing of 1779 showing part of the gantry structure that he used to compare the height of the meridian line against the reference datum provided by the surface of the water. Parts of the two scales on the line are shown.

The inspection by Guarducci in 1904 gave a good report on the condition, and Paltrinieri states that he noted that "The gnomon height still corresponds to that fixed by Zanotti…" and "The meridian line was found to be displaced towards the east by 1′ 36.6″, retarding the indication of midday by 2.5 seconds at the summer solstice." Paltrinieri's own inspection in 2005, to mark the 350th anniversary of the line, revealed that the marble slab at the winter solstice end of the line was 42 mm too low;[9] it had dropped 35 mm since the 1904 inspection.

The Scales

Zanotti's drawing in Fig. 5 shows two scales on the meridian line very much as they appear today except that the numbers on the east side of the line (the near side in Fig. 5) have now lost their tick marks. These numbers run from 38 to 250; they are offsets along the line towards the north, using the perpendicular point as the origin. The offsets are in Cassini's original unit of measure, one hundredth part of the height of the hole. This is about 270.7 mm. There were other definitions of length (well before the metre!) such as the Paris foot or, locally, the Bologna foot, but Cassini's unit was employed when he set out the original line and Zanotti used this unit too.

Each number on the west side of the line (the far side in Fig. 5) is associated with a dot and these dots survive to this day. These are the times of transit in Italian hours. In Fig. 5, the label XVIII refers to a whole number of hours and the 58, two dots to the left of this label, implicitly indicates 17 hours 58 minutes in Italian hours.

Using more familiar common hours, the time of transit is always the same, 12 hours since solar midnight, but Italian hours use sunset as the moment to mark the end of one day and the beginning of the next. To complicate matters further, there were two different definitions of sunset. The version of Italian hours best known to non-Italian diallists uses geometric sunset as the reference moment. This time scheme was known in Italy as *ore Italiane commune* or Italian hours for the locality.

Zanotti used the other version of Italian hours which was known as *ore Italiane da Campanile* or Italian hours by the bell tower. This refers to the ringing of the Angelus bell for the Ave Maria prayers that were said half an hour *after* geometrical sunset.

If the image of the sun at transit indicated that the time was precisely XVIII, observers would know that the time was 18 hours since the Angelus bell sounded and they could then check that their Italian hours clocks showed 18.

In Fig. 5, the dot associated with the label XVIII is positioned a little over 128 Cassini units from the perpendicular point and it is instructive to check that this is what should be expected…

Noting that transit is 12 hours after midnight, it is clear that, if transit is at 18 hours *ore Italiane da Campanile*, then the Angelus bell must have sounded 6 hours before midnight. Accordingly, geometric sunset must have been 6½ hours before midnight. Correspondingly, geometric sun*rise* must have been 6½ hours *after* midnight.

At the latitude of Bologna (assumed to be 44.5° in Cassini's time), when sunrise is 6½ hours after midnight the solar declination is −7.57°. The solar altitude at noon is then $90 - 44.5 - 7.57 = 37.93°$ and the associated distance from the perpendicular point is 100/tan(37.93). This is 128.32 and the label XVIII is indeed positioned just beyond 128 units.

In Cassini's time, the most important measurement to be determined from an observation of solar transit was the zenith distance (strictly, the angular offset of the sun from the zenith which is the complement of the altitude). For a given declination, the zenith distance of the sun at noon is given by:

$$\text{zenith distance} = \text{latitude} - \text{declination}$$

Accordingly, when the declination is −7.57° the zenith distance is 44.5 + 7.57 or 52.07°. The associated distance from the perpendicular point is $100 \times \tan(52.07)$, which is 128.32 units as before.

The Meridian Line and the Solar Transit

Fig. 6 shows a conventional view of the meridian line, looking south towards the aperture, and Figs 7–10 illustrate the progress of the spot of sunlight until the moment of transit on the day of my visit, 4 October 2018. The Android app, *Sol et Umbra*, gives the expected time of transit as 11:03:21 UTC or 12:03:21 local time (Central European Time). This is the time that the sun is due south but it is not quite the time to expect the solar image to cross the meridian line; recall the alignment error noted by Guarducci in 1904. The line has an angular displacement to the east of 1′ 36.6″ so the image always straddles the line a few seconds after the true moment of transit.

Fig. 6. A view south along the line with the aperture just visible in the far distance (circled). In the middle distance, protecting the line, is one of two toughened glass 'bridges'.

Simple calculation confirms Guarducci's assertion that the observed time of transit at the summer solstice is 2.5 seconds late but my visit was on 4 October when the declination was −4.42° and the image crossed the line 4.9 seconds late. The image did not straddle the line until almost 12:03:26 CET.

By calibrating my camera against a radio-controlled clock, I estimate that the photograph in Fig. 10 was taken at 12:03:23 CET which is very close.

Serious meridian line experts place a radio-controlled digital clock with a large display on the floor and video the transit. They claim to be able to judge the mid-crossing time to about half a second.

Fig. 7. The spot of sunlight 15 minutes and 27 seconds before transit.

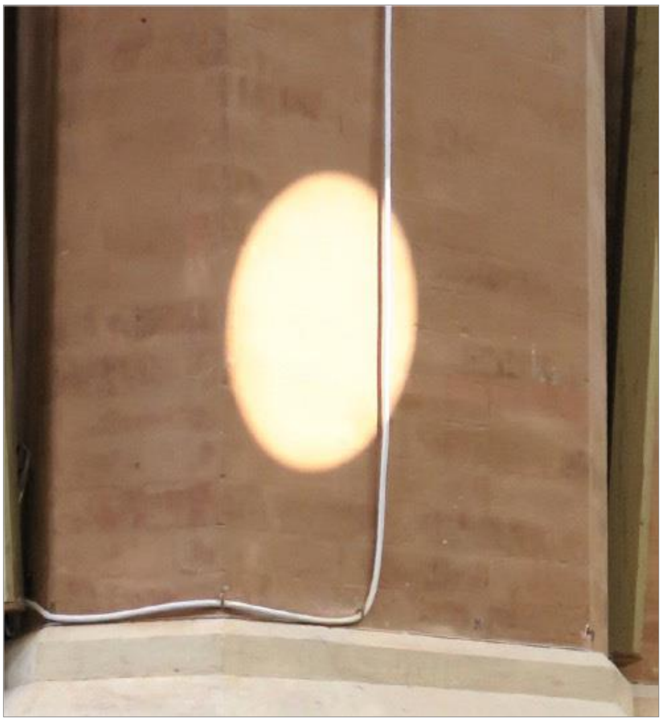

Fig. 8. 14 minutes and 41 seconds before transit.

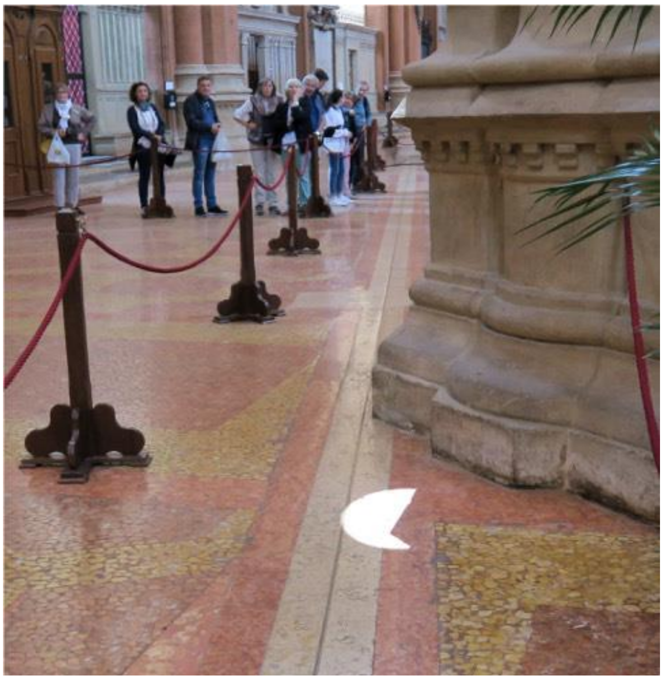

Fig. 9. 63 seconds before transit.

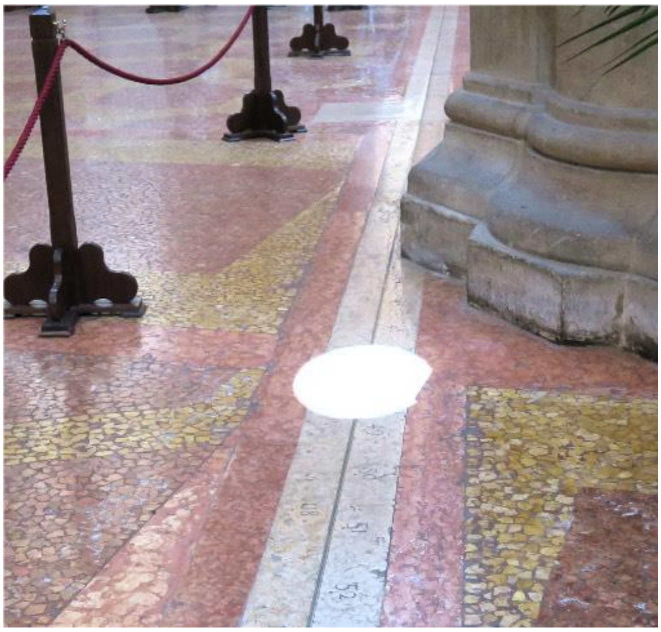

Fig. 10. False transit shortly after local solar noon.

Other Parts of the Meridian Line

Other parts of the line that I had ready access to are shown in Figs 11–14. The entry points to the first points of the twelve Signs of the Zodiac are marked on seven transverse slabs of marble. The two slabs at the extremities are for Cancer and Capricorn and each of the other five slabs is for two signs. Figs 11 and 12 show the slabs for Pisces and Scorpio, and for Aquarius and Sagittarius. Fig. 14 shows the slab for Capricorn, marking the winter solstice.

Fig. 13 shows a Latin inscription which declares that the distance from the perpendicular point to the centre of the sun's rays at the winter solstice is 1/600,000 of the Earth's circumference. Cassini used this as evidence of divine

Fig. 11. The zodiacal slab for February and October shows the signs for Pisces and Scorpio. The numbers 15 and 16 on the right-hand side of the line are both pin-pointed by dots. These refer to the times 18h 15m and 18h 16m after the Angelus bell. The numbers on the left, 146 and 148 , are units of distance from the perpendicular point and do not have any markers.

Fig. 12. The slab for January and November shows the signs for Aquarius and Sagittarius. The numbers 54 and 55 refer to the times 18h 54m and 18h 55m after the Angelus bell and 210 and 212 are distances from the perpendicular point.

intent that San Petronio should be used for the meridian line and it is instructive to investigate how good this estimate was.

First, note the pedantry in writing 'the centre of the sun's rays at the winter solstice'. This is not the same as 'the centre of the winter solstice ellipse.' The reason for the pedantry is that interpreting the image of the sun on the basilica floor is not quite as straightforward as might be expected…

Fig. 13. The plaque at the end of the line which reads: The total length of this meridian line from the vertical point to the centre of the sun's rays at the Winter Solstice is 1/600,000 of the Earth's circumference.

Fig. 14. The slab for December is engraved with an ellipse which outlines the solar image at the Winter Solstice; north is to the right. The numbers 10 and 11 refer to the times 19h10m and 19h11m after the Angelus bell and 244 to 250 are distances from the perpendicular point. The sign for Capricorn is in the upper half of the photograph, within the ellipse (although difficult to see).

The hole functions like the hole in a pin-hole camera so the image of the solar disc is inverted. If the image is projected onto a suitable board held square onto the line to the sun, the image would be circular and the ray from the centre of the solar disc would run to the centre of the image.

Given that the floor is not square on, the image on the meridian line is an ellipse but this image is not simply a linear stretching of the circular image. The uppermost point of the limb of the solar disc projects onto the south end of the major axis of the ellipse and the lowermost point of the limb projects onto the north end of the ellipse but the ray from the centre of the solar disc does *not* run to the centre of the ellipse and the horizontal diameter of the solar disc does not project onto the minor axis of the ellipse.

The centre of the hole, together with the major axis of the ellipse, form a long thin triangle. The angle bisector at the hole doubles as the ray from the centre of the solar disc and, in general, an angle bisector does not intersect the opposite side of the triangle at its mid-point. The zenith distance measured at the mid-point of the major axis will be slightly larger than the zenith distance of the centre of the solar disc.

A better procedure for measuring the zenith distance of the centre of the solar disc is to determine the zenith distances of the upper and lower limbs separately and then average the two results. Using this value you can readily determine where 'the centre of the sun's rays' falls on the ellipse.

Paltrinieri gives the distances from the perpendicular point to the two ends of the major axis of the winter solstice ellipse as engraved in 1656 as 65.882 metres and 67.711 metres.[10] In Cassini units these distances are 243.377 and 250.134. [Note: these values are derived using Paltrinieri's scaling factor of 0.270699 and differ slightly from the values as published.]

The zenith distances of the upper and lower limbs are $\tan^{-1}(2.43377)$ and $\tan^{-1}(2.50134)$ and the average of the two angles is 67.936°. This is the zenith distance of the centre of the sun's rays and corresponds to a point on the floor at a distance of 246.716 from the perpendicular point.

Note well: 246.716 marks 'the centre of the sun's rays'.

Note that the distance to the mid-point of the ellipse is the average of 243.377 and 250.134 which is 246.756. This is 0.04 units *further* from the perpendicular point, or nearly 11 mm.

The distance 246.716 units is a candidate value for what Cassini believed to be 1/600,000 of the circumference of the Earth. The current estimate of the equatorial circumference is 40,075 km and if this is divided by 600 and then scaled, we obtain 246.738 units. Cassini's value is just 0.022 units (6 mm) shorter.

This seems too good to be true and there are several uncertainties. We cannot be sure that Zanotti placed the new winter solstice slab in precisely the right position and, even if he did, we cannot be sure that it hasn't moved slightly. There is also no good reason for relating Cassini's line to the equatorial circumference. The meridian line is a short section of a polar circumference of the Earth and the polar circumference is 40,008 km; 1/600,000 of this equates to 246.325 units. Cassini's value is 0.391 units (106 mm) longer.

The Aperture

An external view of the aperture is shown in Fig. 4. Both Paltrinieri and Heilbron refer to Casssini's choice of aperture as being in the horizontal plane and having a diameter of 1/1000 of its height above the floor.

The great meridian lines in Italy are referred to as *meridiane a camera oscura*. They function as camera obscuras which demand hole diameters very much smaller than the distance to the floor. If the hole is too big you do not get an image of the sun; instead the patch of light that you see on the floor has the same shape as the outline of the hole itself. This latter is what you typically see when using an aperture nodus on an ordinary sundial.

The huge advantage of having an image rather than an outline of the hole is that the penumbral region does not increase with distance from the hole. Provided the hole is horizontal, the width of the fuzzy region round the image exactly matches the diameter of the hole no matter where the image falls on the line.

Up to a point, the smaller the hole the better, but if it is too small there will be insufficient light to see the image. Clearly, reducing the amount of ambient light will improve the contrast which is why the arrangement is not generally practical for outdoor sundials.

Choosing the hole diameter as 1/1000 of the height seems to have been a good compromise and it was adopted as a rule of thumb by others who laid out meridian lines.

Conclusion

The great height of the aperture gives rise to large projected elliptical images of the sun, varying from 292 mm (minor axis) at the summer solstice to 708 mm (minor axis) at the winter solstice. Using his instrument, Cassini was able to measure the change in diameter of the solar disc over the year as the Earth orbited closer to and further away from the Sun. These observations enabled him to compare the measured diameter against the expected diameter from a circular orbit. He concluded that the changes in size were consistent with Johannes Kepler's 1609 heliocentric theory, where the Earth was moving around the Sun in an elliptical orbit. This was in contrast to the Ptolemaic system where the Sun orbited the Earth in a circular orbit. Another function of the line was to determine the timings of equinoxes, both to assist the revision of the calendar and for the determination of Easter. He also showed that there was a detectable atmospheric refraction. Finally, Heilbron[11] records "Reviewing the record of observations since 1655, Zanotti estimated that the length of the tropical year was 365d 5h 48m 47.0s. The heliometer of San Petronio eventually produced the result for which Danti had built the first *meridiana* there, to an accuracy beyond his wildest imaginings." The mean length of the tropical year for 2000 is 365d 5h 48m 45.19s.

ACKNOWLEDGEMENTS

Frank King for explaining the Italian Hours scale adjacent to the west side of the meridian line.

Tom Boyd for permitting the use of Fig. 5 that appears on his website *www.flat-earth-academy.com*. He in turn is grateful to Nigel Phillips,[12] a rare books seller, for allowing him to photograph the drawing in the book by Eustachio Zanotti.[13]

This book contains two folding plates that are printed from the same copperplates used in Cassini's book of 1695, but the second plate, which at almost 6 feet long must be one of the largest in a scientific book, has an additional strip along the bottom illustrating Zanotti's new brass meridian. The rarity and importance of this book is reflected in the price of £3,200.

REFERENCES

1. Giovanni Paltrinieri: 'The Meridian of the Basilica of San Petronio in Bologna', Part I, *BSS Bulletin* 94.2, 32-36 (June 1994).
2. Giovanni Paltrinieri: 'The Meridian of the Basilica of San Petronio in Bologna', Part II, *BSS Bulletin*, 94.3, 18-21 (October 1994).
3. J.L. Heilbron: *The Sun in the Church* (1999), Harvard University Press, Cambridge, Massachusetts, and London, England.
4. Girolamo Fantoni: 'The Gregorian Reformation of the Calendar', *BSS Bulletin*, 94.3, 29-31 (October 1994).
5. Giovanni Domenico Cassini: *La Meridiana del Tempio di San Petronio*, Bologna (1665), p.77.
6. Ref. 3, p.89.
7. Ref. 1, 94.2, 36.
8. Eustachio Zanotti: *La Meridiana del Tempio di San Petronio Rinnovata l'anno MDCCLXXVI*, Università di Bologna, Instituto delle Scienze (1779), p.158.
9. *http://www.basilicadisanpetronio.org/the-sundial-of-s-t-petronios-basilica/* specifically section 4. Structural Verification of the Sundial: 1904-2005.
10. Ref. 2, 94.3, 18.
11. Ref. 3, p.138.
12. See *http://nigelphillips.com*
13. See ref. 8.

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Holiday Picture

Pitié-Salpêtrière Hospital, Paris

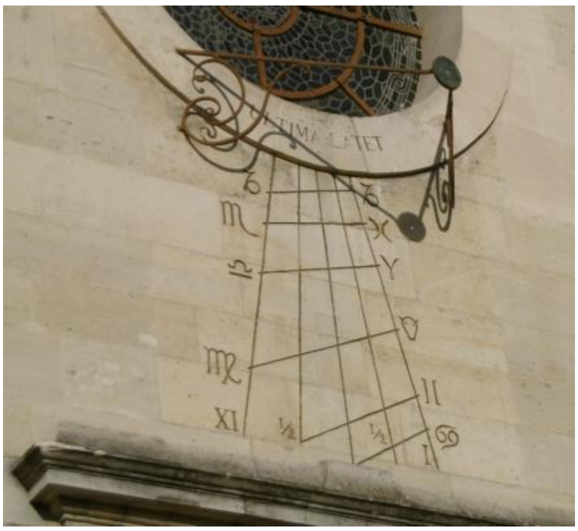


Photo: Catherine Slater.

This vertical meridian dial on the chapel gives the solar time of noon ±1 hour (with half-hours) as well as short sections of the declination lines.

ANTON SCHMITZ

Photo courtesy of Ursula Schmitz.

In September 1944 a young 19-year-old German soldier was captured at Cap Gris Nez. It was my very dear friend Anton Schmitz (1925–2019), Bildhauermeister. After the cessation of World War II hostilities, Anton, then a prisoner of war in Somerset, England, returned to Germany to a situation of no work. Anton's father knew a mason nearby in Bonn and asked him to take Anton on as an apprentice stone mason. Anton became an extremely gifted mason and sculptor, crafting over the years some of the finest sundials and monuments to be found anywhere in Europe. One of his masterly works is the 4-metre high sculpture of a miner at the entrance to the Hasli-Berg hydro power station facility near Innertkirchen, Switzerland, completed in 1958. Another is the restoration of the large decorative frieze on the Kornhaus in Rorschach, Lake Constance, Switzerland in the early 1950s.

Members of the BSS will remember Doug Bateman's article in the June 2015 *Bulletin*, in which he illustrated many examples of Anton's work, with particular emphasis on the sundials.[1] One of Anton's specialities was the design and making of spherical dials. In 2011, the largest one he ever made was unveiled at the entrance to the Eifel National Park, Germany (*see picture*). It was carved from a piece of the local volcanic rock. His skills were much in demand and he was often called in to refurbish sundials such as the magnificent Graf von Spee dial at Ahrenthal, Germany.[2]

Anton sculpted numerous subjects and loved sculpting wildlife: one of his most popular productions was Koala bears! In his last year he was working on a set of 'giant' copies of the Lewis chessmen. His production of sundials was outstanding, every conceivable type from book dials to cross dials. I think Anton was probably the most prolific stone sundial maker ever. Much of his sundial work is illustrated in the three-volume book set *Sonnenuhren* by H. Schumacher, Callwey (1973).

Anton and Veronica at the unveiling of the sundial at the Eifel National Park. Photo: Ursula Schmitz.

Few know that besides his masonry skills, Anton was also a gifted and prolific artist specialising in watercolours.

Anton was a great Anglophile and relished being a member of the BSS. He is survived by his dear wife Veronica and daughters Ursula and Annegret.

One of Anton's Lewis chessmen 2018, with numerous sundials in his workshop yard. Photo: Anton Schmitz.

The world has lost a great sculptor and artist but above all a lovely kind and generous man. We shall all miss him.

REFERENCES

1. Douglas Bateman: 'Anton Schmitz—Bildhauermeister', *BSS Bulletin*, 27(ii), 22–27 (June 2015).
2. Ref. 1, p.26 (Fig. 17).

Martin Jenkins

Sundial Exhibition in Wrocław, Poland

20 March 2019 until 2020

On the March equinox this year a new exhibition of many historic sundials opened in Wrocław. It is in the Mathematical Tower which is part of the main building of Wrocław University . The Tower, built over the period 1728–37, is some 42 metres tall and gives magnificent views of the Old Town and islands on the Odra River. It is visited annually by around 60,000 tourists.[1]

The sundial exhibition will remain open for at least a year. It is on the 5th floor of the Tower, on the site of a former astronomical observatory that was run by Johann Gottfried Galle in the mid 19th century and which houses a major Silesian gnomonic monument – a meridian line constructed in 1791 by Anton Jungnitz.

A collection of 87 excellent sundials has been assembled by Maciej Lose, well known to *Bulletin* readers for a number of articles on previously unknown sundials by English makers of the 17th and 18th centuries.[2] The makers represented include well-known names such as John Rowley, Samuel Saunders, John Coggs, Thomas Heath and Benjamin Cole II. Unusual finds include a horizontal dial made by Thomas Wright for a location in Jamaica and an unrecorded double horizontal dial attributed to John Allen – only the second known by this apprentice to the great Elias Allen. This is probably the best collection of quality English horizontal dials to be found anywhere in the world! The opening ceremony even appeared as a news item on the local television, with Maciej extolling the virtues of John Rowley.[3]

Some of the very smart display cases with thematically-grouped dials and with QR-links to the full catalogue descriptions.

More of the display cabinets, with the low-latitude Wright dial in the centre and Johann Gottfried Galle lurking in the alcove on the left.

A horizontal dial attributed to the workshop of William Deane.

An extremely rare double horizontal dial by John Allen – only one other example (in Medway Museum) is known by this maker.

Other dial types and countries of origin are also represented, including an example of Dent's dipleidoscope, French precision heliochronometers and a selection of ring dials, diptychs, equatorials and more. An online catalogue[4] is available which not only gives photographs of all the exhibits but describes them very perceptively. If you can possibly get to this exhibition, I urge you to do so.

REFERENCES

1. *https://visitwroclaw.eu/en/place/mathematical-tower*
2. See, for example, M. Lose: 'An unrecorded Silesian Sundial by John Rowley', *BSS Bull*., 22(iii) 40-45.
3. See *https://wroclaw.tvp.pl/41798194/18032019-1830*, starting around 18 minutes into the broadcast.
4. *http://mbd.muzeum.uni.wroc.pl/kolekcje-uniwersyteckie/zegary-sloneczne*

John Davis

MINUTES OF THE 30th BSS ANNUAL GENERAL MEETING

Bath, 27 April 2019

The AGM was chaired by Frank King (Chairman) with Chris Williams (Secretary) and Graham Stapleton (Treasurer) in attendance.

1. Minutes of 2018 AGM

The minutes of the 29th AGM, held at Norwich on 21 April 2018, were published in the June 2018 *Bulletin.* As no comments had been received by the Secretary, they were taken as read.

2. Receive 2018 annual statement of accounts and the 2018–19 trustees' annual report

Both documents were circulated to all members in the March 2019 *Bulletin.* No comments were received before, or made at, the AGM. The Chairman confirmed that both the accounts and the trustees' report had been received by the membership.

3. Election of charity trustees

David Brown and Bill Visick retired by rotation.

David has decided not to continue to serve as a trustee. The Chairman, to acclamation from the floor, thanked David for his long and distinguished service. Bill was willing to continue to serve and offered himself for re-election.

Bill Visick was elected to the office of charity trustee.

The Chairman took the opportunity to thank all volunteers, in whatever capacity, for their contribution to the Society's activities.

4. Note new examiner for 2019 annual statement of accounts

It was noted that the trustees have appointed Counterculture LLP.

5. AOB

No other business was raised.

Secretary
2 May 2019

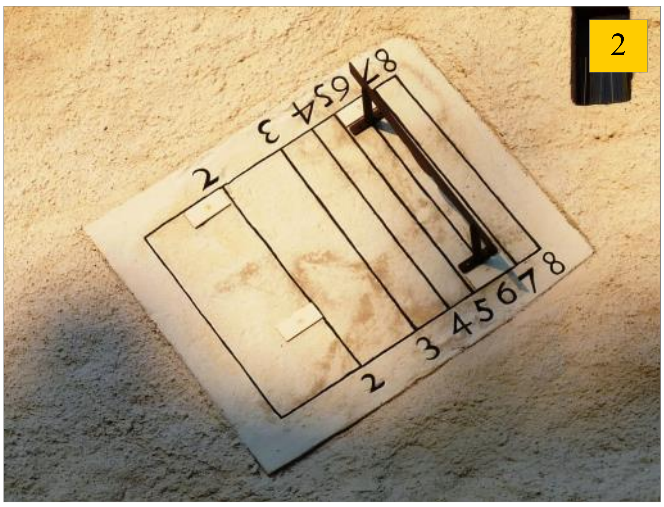
NEWLY REPORTED DIALS, 2018

JOHN FOAD

There were fewer new entries to the Register in 2018 than in recent years, and half of these were 21st-century dials. Is the record of good older dials at last nearing completion? The long list of dials still to be recorded, compiled by Graham Stapleton and Ian Maddocks, makes it seem unlikely. Please go to *https://bit.ly/2aXDLq5* and see whether there are any you could track down. It will be interesting to see what delights 2019 may bring! The examples here, from 2018, show the older dials first.

1 and 2. You may remember seeing these two dials on page 25 of the March 2019 *Bulletin*. They are located high on a Scottish Town House, now a museum. They date from 1686 and were restored in 2011. SRN 8056 and 8088, Dunbar, Lothian, EH42 1ER. Open.

1

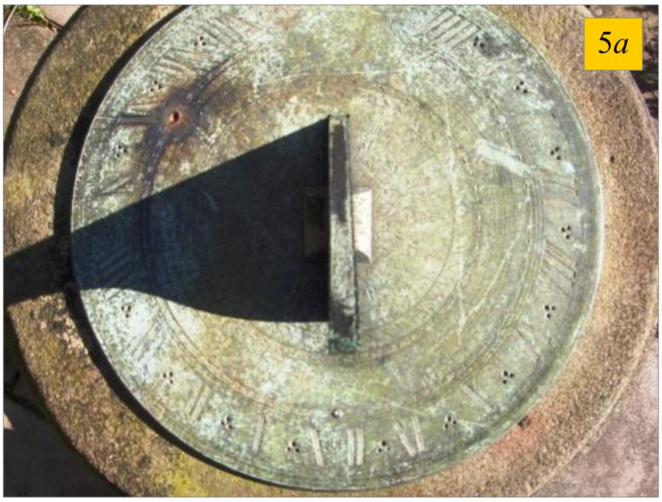


2

3. This direct east dial is also one of a pair, the other being SRN 5795, which was recorded 15 years ago. The pair are mounted at first floor level on the south and east corners of a street house. Mrs Gatty recorded the motto across the top and the foot of this one as "Omnem crede diem tibi diluxisse supremam" (Think every dawn of day to be thy last), but it was almost illegible even in Mrs Gatty's day. The date 1719 is clear towards the base of the interior dial area, and there are other inscriptions just above the date. SRN 8076, Crail, Fife, KY10 3TQ. Visible.

3

4


5a


5b

4. This square stone dial plate was described by John Wilson in his article on page 33 of the September 2018 *Bulletin*. It is mounted flush into a south west brick gable wall, and the furniture appears to be in dark blue paint. The Meeting House was founded in 1701, and the dial was installed in 1780. SRN 8077, Friends' Meeting House, Brant Broughton, Lincolnshire, LN5 0SH. Restricted.

5. This 18th-century George Adams dial has been moved within living memory from its original location in the stable block of a North Wales country house, where it would have been used to regulate the stable clock. It now stands in the flower garden, on a decorative stone baluster. Heavy green patina makes it difficult to read the engraving, but the signature is legible, and a compass rose and an EoT ring can still be seen. SRN 8065, Wrexham, Clwyd. Private.

6. Another fine 18th-century dial is this one by Heath and Wing, which came to our notice following a query to the Help and Advice Service. SRN 8066, Amport, Hampshire, Private.

7. This interesting dial also came to light through Help and Advice. It is inscribed "Erected 1821" and is signed


6a


6b

"Fecerunt W & S Jones, 30 Holborn, London", the only time I have seen the plural form in use! It is mounted high on the eastern end of the south wall of the nave. SRN 8084, St Martin's Church, Firbeck, South Yorkshire, S81 8JY. Open.


7


8

9*a*


9*b*

8. A simple dial signed "Dollond, London", which puts it at the 18th or early 19th century. It is situated in the 'Eight-bed' or American Garden. SRN 8072, Pentillie Castle, Saltash, Cornwall, PL12 6QD. Private.

9. Another Dollond dial surmounts the cube in this example. All four dial faces of the cube have lost their gnomons, and very little of the delineation remains. However, below the four faces, reading counter-clockwise from the delineated south face (currently oriented to the north!), are clearly inscribed the words SOLE, SPLENDIDIUS, QUAERE, NECASTI. Please see Martin Jenkins' article on pages 22 to 25 of the March 2019 *Bulletin* for more details. SRN 8078, Sundial House, Tipton St John, Devon, EX10 0AQ. Private.

10. This elaborately carved slate dial was mounted on the south wall of a loggia of the castle when it was built in 1698. It may have been brought in by Lady Elizabeth Coryton from Newton Ferrers, but the date it was made is unknown. It carries the date 1693, possibly in reference to the founding of Pentillie Castle about that time. The symbol for noon may be a *marigold proper*, which is the Coryton crest. SRN 8074. Pentillie Castle, Saltash, Cornwall, PL12 6QD. Private.

11. This cast metal dial is a standard pattern, but unusual and better than the average. A similar dial (SRN 6906) can be seen on a Roman Catholic church in Nottingham. SRN 8068, Eastgrove Cottage Garden Nursery, Shrawley, Hereford and Worcester, WR6 6LQ. Restricted.

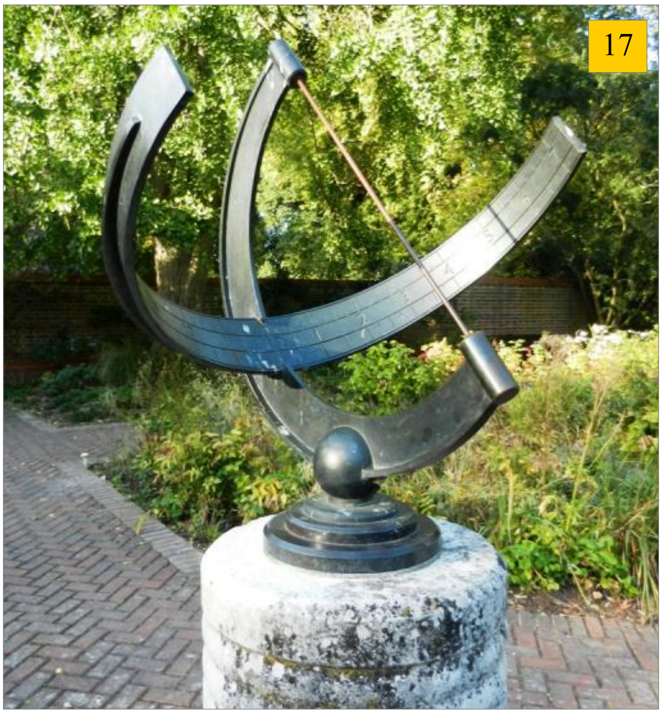
12. This hemicyclium was designed to be held indoors with moveable lighting to illustrate its operation, but it has now been painted with a weatherproof coating and is located in the dementia-friendly garden of the museum. It is inscribed RATAE, the Roman name of Leicester. It was designed by Allan Mills and sculpted from Clipsham oolitic limestone by Rattee & Kett of Cambridge. SRN 8067, Abbey Pumping Station Museum, Leicester, LE4 5PX. Restricted.

10

13. A striking large-scale horizontal by Ben Jones, celebrating the Queen's Diamond Jubilee. Ben described its manufacture at the 2015 Conference (see pages 41–42 of the June 2015 *Bulletin*). The gnomon consists of six vertical strips of stainless steel. The dial plate is gravel, with hour markers carved on granite blocks which came from the farm buildings that now lie at the bottom of the reservoir. The hour lines are in brick. SRN 8077, Roadford Lake Reservoir, Lifton, Devon, PL16 0RL. Restricted.

14. A third find at Pentillie Castle, and another large ground-level horizontal! The dial was made by the owner of the estate, Mr Ted Coryton. It is laid out in a semi-circle, in the lawn in front of the castle. The gnomon is wooden, with a dragon design on the east side, and its base is a granite block from an old sluice found on the estate. Unmarked granite slabs indicate the hours from 6 am to 6 pm, using longer slabs for 6, 9, 12, 3 and 6. SRN 8073, Pentillie Castle, Saltash, Cornwall, PL12 6QD. Private.

15. This dial by David Brown is made of Welsh blue-black slate with a brass gnomon. The perimeter is inscribed "God Almighty first Planted a Garden / And indeed it is the Purest of Humane Pleasures / It is the Greatest Refreshment / to the Spirits of Man", from Francis Bacon's Essay 'Of Gardens'. For more detail see the September



2017 *Bulletin*, page 16. SRN 8087, Wells, Somerset, BA5 1RQ. Private.

16. Another slate dial by David Brown is this one on an Oxford college library, formerly the church of St Peter in the East. It featured in David's talk at Newbury last year, as noted in the December 2018 *Bulletin*, page 51. Access to the dial is restricted to College opening hours, but it is just possible to see the dial through the garden gates next to the college entrance. There are two date curves, commemorating St Peter's Day and the Granting of the Hall's Charter in 1957. The design was based on that of a dial shown in an old engraving of the church, with the date 1777 clearly visible on the face. SRN 8083, St Edmund Hall, Oxford, OX1 4AR. Restricted.

17. Finally, a good example of a simple bow-string equatorial, date and designer unknown. It stands in the Old English Garden, which was refurbished in 2012, and may date from then. It appears to be aligned (almost) with regard to the directions of the paths, rather than north–south. SRN 8075, Battersea Park, Wandsworth, SW11 4PA. Restricted.

registrar@sundialsoc.org.uk

On the Steps of the Pump Room, Bath

During this year's Conference in Bath, there were two outings, and two group photographs. This one is from the Sunday morning visit to the Pump Room, and was taken by Doug Bateman. See page 42 for the previous day's photograph.

A TEA PLANTATION SUNDIAL IN MUNNAR, KERALA STATE, INDIA

MARTIN JENKINS

In January 2019 my wife Janet and I visited the states of Kerala and Tamil Nadu in southern India. While in Munnar, a small town in Kerala, we decided to visit the Kanan Devan Hills Tea Plantation museum (Fig. 1).

At the entrance to the museum, in the little garden, there is a brass polar sundial mounted on a stone capital atop a stone plinth (Fig. 2). From our travels in the past throughout various parts of India, sundials are scarce to say the least. Coming across this one more than made our day. The museum is very interesting and chronicles the history and development of the tea estates and includes many industrial relics of a bygone era as well as a demonstration tea production line and of course a 'tea shop' where every conceivable type of tea can be purchased. However, no information about the dial was available, just a sign next to it stating that it was a 'sundial'.

Fig. 1. Entrance to the Kanan Devan Hills Tea Plantation museum.

A Brief History of the Kanan Devan Hills Plantation

The first European to visit these hills was the Duke of Wellington in 1790. It was nearly 30 years later that Lieutenants Ward and Connor of the Madras Army, seconded to the Great Trigonometric Survey, located the mountain peaks of the High Range and, in particular, the Aneimudi and the Chokanad mountains. In 1877, Henry Gribble Turner and A.W. Turner came to India for game hunting, reached the mountains by a pass called the Bodimettu and guided by the local hill men, the Mudhuvans, eventually reached the summit of the

Fig. 2. The dial and its 'information' plaque!

Aneimudi and saw the grandeur of these hills with commercial advantage formulating in their minds. Before their expedition ended, they obtained a 'Concession' of approximately 227 sq. miles from the Poonjar Raja of Anjanad. Smallholders then began to purchase plots of these lands and planted a variety of crops ranging from cinchona to coffee and sisal to tea, and eventually these planters formed themselves into the North Travancore Land Planting and Agricultural Society Limited in 1879.

In 1895, Sir John Muir, Baronet of Deanston, Scotland bought over the deeds of the Concession for further development and in 1897, Finlay Muir & Co. of Glasgow formed the Kanan Devan Hills Produce Co. Ltd, its two subsidiaries being the Anglo-American Direct Tea Trading Company and the Amalgamated Tea Estates Company. These two companies became interested in the development and cultivation of tea, rather than other crops.

Fig. 3. The dial on its octagonal capital.

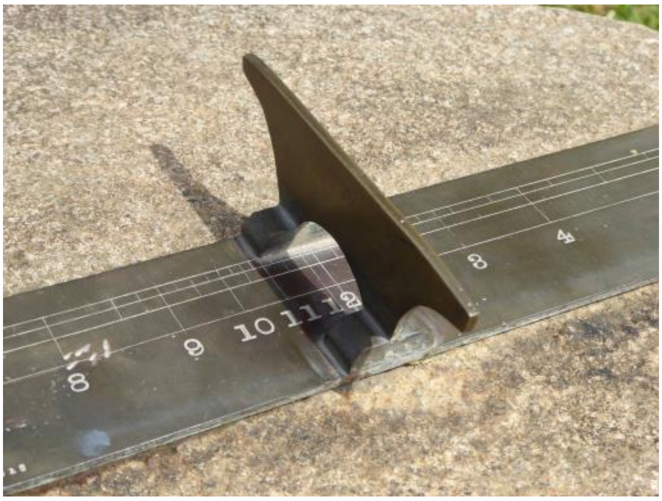


Fig. 4. Gnomon and scale markings.

Thus in 1900 the Concession area became the Kanan Devan Hills Tea Plantation Company Limited, of which Finlay Muir & Co. of Glasgow held a large interest, and the area started to develop very rapidly along more commercial lines, the main crop becoming tea. In 1976 the Finlay Group of Companies entered into an agreement with the Tata family of India, forming the company Tata-Finlay Limited, which in 1983 was fully acquired by the Tata Group, giving rise to one of the biggest tea companies in India with more than 30 tea estates.[1]

The Sundial

The sundial is in excellent condition; however, the 'engraved' information on it illustrates how easily one can come to the wrong conclusions if more authoritative information is not readily to hand at the time! The dial plate is approximately 400 mm long by 80 mm wide by 5 mm thick (Fig. 3). The gnomon is of a robust design and still in perfect condition.

The plate is engraved with hour lines, half hour lines, and quarter hour lines. Interestingly the gnomon width is taken care of by the noon gap in the scale markings (Fig. 4). This suggests to me that whoever designed and delineated the dial was conversant with sundial design. In addition, the words; ART INDUSTRIAL SCHOOL, NAZARETH, 1913 are stamped into the dial plate (Fig. 5). This is where assumptions can play havoc with study!

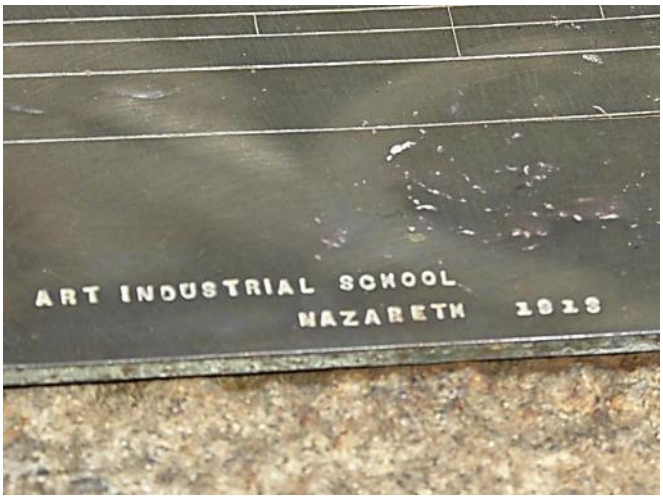


Fig. 5. Art Industrial School stamping in the dial plate.

My initial thoughts, until we got back to the UK, were:

- Nazareth in 1913 was in Palestine; the state of Israel did not yet exist.
- What was the connection between Nazareth, Palestine, and a tea plantation in Munnar?
- What was significant about 1913?
- What was the Art Industrial School and what was its connection with the tea plantation?
- Who commissioned the dial and why?
- Who designed the dial?

Art Industrial School, Nazareth

A search on the Internet for Art Industrial School, Nazareth, showed that Nazareth was not the famous one in the Middle East but was a small town in Tamil Nadu State, the other side of India approximately 200 km south east of Munnar in Kerala. The town was named by early Christian missionaries in memory of the city of Nazareth, Palestine, where Jesus Christ spent his early days. In the centre of Nazareth town, Tamil Nadu, there is St John's Cathedral, a church over 100 years old. It transpires that this school has a very interesting history.

In 1877, there was a severe famine in the Tinnevelly District of Tamil Nadu. Thousands of people died, and consequently, there were a large number of destitute orphan children who were left without their parents. To provide food and shelter for these orphans, an orphanage was started by the missionary the Revd Arthur Margoschis in 1878. Arthur Margoschis (1852–1908) was born in Leamington, Warwickshire. As a result of his connection with St John's Church (cathedral) the orphanage was named St John's Orphanage. The Revd Arthur Margoschis was supported by the Society for the Propagation of the Gospel (Dursley Branch) and the Indian Famine Orphan Fund. The aim of the orphanage was not only to teach children how to read, write, and do arithmetic but also to teach each child some industrial skill so that when they left the orphanage they could earn a livelihood. In 1900, the orphanage was renamed and became the Art Industrial School, offering technical training in 18 trades to 283 children. These trade skills included carving, carpentry, masonry, metalworking, spinning, weaving, dyeing, lace making, embroidery, stitch-craft and such other skills relevant to self-employment. The Revd Arthur Margoschis died on 27 April 1908; he had given 31 years of service at Nazareth. He is buried inside St John's Church. After his death the missionary Revd C.W. Weston took charge of the Art Industrial School, his wife taking charge of the Nazareth hospital. The couple returned to Britain in 1913. I have been unable to find any more information about them, but the date 1913 may be relevant to the sundial's history. Today the Art Industrial School is known as the Industrial Training Institute and continues its training philosophy offering modern training courses such as Fitter, Turner, Tool & Die Maker, Tailoring, Fitting and Blacksmithy, Carpentry and Cabinet Making, Data Entry Operator, Web Designing and Visual programming.[2]

Associated with St John's Church (cathedral), in the same diocese, is St Paul's Church in the district of Meignanapuram. In the St Paul's Church Centenary Festival Magazine of 1985 it is stated that:

"*In 1913, a granite Sundial made by this school was placed in the Tea Museum at Munnar. It is still functioning in good condition and best example for its quality.*"[3]

Dial Location

The dial was made in Nazareth, Tamil Nadu, Latitude N 8° 33′, E 77° 58′. However, Munnar, where it is located, is N 10° 5′, E 77° 3′. The dial being of the polar type can be set for any latitude. As near as I can determine from Fig. 6, the angle of the granite capital has been carved to 10°, appropriate for Munnar. Unfortunately, the dial is no longer set up correctly, although the whole plinth and capital have been tilted and contrived to read the approximately correct time.

Unsolved Mysteries

This dial certainly has an interesting background. To date I have still not been able to discover who commissioned it and why.

What was the link between the Art Industrial School and the Kanan Devan Hills Plantation? Could a connection have arisen from staff being recruited from the skilled trained workforce graduating from the Art Industrial School?

Was there some link between the Revd C.W. Weston and his wife, and the plantation, given that the date on the dial and the date of their return to Britain is the same, i.e. 1913?

Was there a connection somewhere relating to the First World War being on the horizon and people returning home?

Fig. 6. View showing the carved angle of the granite capital.

As this is a polar dial and thus location independent, did the school make more of these dials and if so, where are they?

If any members of the BSS can add to the information about this dial, then please do let us know.

Finally, don't travel; it only results in more dialling mysteries!

REFERENCES

1. History of the Kanan Devan Hills Tea Plantation, *www.kdhptea.com/our-history,* accessed February 2019.
2. History of the Art Industrial School, Nazareth, Tamil Nadu *https://en.wikipedia.org/wiki/Art_Industrial_School* accessed February 2019.
3. T. Yesudasan: *The Business Line,* 30.04.2004; *St Paul's Church – Centenary Festival Magazine, Meignanapuram, 29.1.1985* (J. Stella: *Women's Education in Tirunelveli District from 1800 to 1947,* PhD Thesis, (iv), p.107 (2014)), *http://shodhganga.inflibnet.ac.in/jspui/bitstream/10603/184294/8/front%20page.pdf*

For a portrait and CV of the author, see *Bulletin* 27(i), March 2015. He can be contacted at *sundialduo@gmail.com*

BSS 30th ANNIVERSARY CONFERENCE

Bath, 26–28 April 2019

Bailbrook House, a fine Grade II*-listed building on the London Road, Bath, and now a 4-star hotel, was an imposing but most comfortable venue for the 30th anniversary Conference held in April 2019. At the top of a long and steep drive, the hotel is set in most attractive grounds, and boasts beautiful views across the valley.

Bailbrook House.

A special Bath-themed programme had been assembled by the Conference Team of Chris & Liz Williams, Doug Bateman and Bill Visick, augmented this year by David Brown as the local expert. Kevin Karney assisted as 'projectionist', in place of Bill, who was unable to attend.

Friday 26 April

Registration was accompanied by tea (with the hotel's version of Sally Lunn cakes, a Bath speciality) and later, in honour of this special anniversary, a barbecue had been arranged; unfortunately, Storm 'Hannah' made it impossible to hold this outside, but we need not have worried as we were very well accommodated in the Cloisters Restaurant, where the plentiful food was most efficiently served buffet-style.

After the barbecue, we re-assembled in the spacious Brunel Suite, where BSS Chairman Frank King formally opened the 2019 Conference, and then Chris Williams, as Master of Ceremonies, introduced the first speaker…

David Brown: *An Overview of the Tours Around Bath and Bath Sundials*

"Bath is the finest place on earth, for you may enjoy its society and its walks without effort or fatigue."

David welcomed the delegates with this apt quotation from 18th-century writer James Boswell. Our transport was to be by coaches rather than by either sedan chair or Bath chair, but hopefully there would be little effort or fatigue on our walks. Former residents of Bath include Horatio Nelson, I.K. Brunel, Charles Dickens and William and Caroline Herschel – just a few of the eighty-or-so famous people whose presence is recorded on plaques around the city.

Not far from Nelson's plaque is Parade Gardens where Frank King would be unveiling a BSS Commemorative plaque recording our 30th anniversary conference. This was placed next to a recently restored armillary sphere in Parade Gardens. David illustrated some of the sundials we were due to see as well as those we could not because they were on private land hidden behind trees or buildings near to our Saturday tour route. In the case of Bath Abbey, Mrs Gatty's reported number of thirteen scratch dials on its walls has now become zero owing, presumably, to extensive cleaning of the surfaces and lack of appreciation of what they were.

Part of the display of photographs, one per year from the first 30 years of the BSS, assembled by David Hawker.

A 1675 etching by Johnson (in the Bath archives) showed us what bathing in the warm waters of Bath might have been like, but on close inspection also showed a vertical sundial. Another etching (Gilmore, 1692) gave more (gnomonically suspect) details of the dial as well as a hint of another.

David ended his introductory presentation with a speculative flight of fancy. There is an area of Bath known as Seven Dials, where once stood a tavern of the same name, at a meeting of seven small roads. With the Seven Dials near Covent Garden in London in mind, would it not be possible to construct a similar edifice in Bath, with not only seven sundials at its summit but also, as befits a city with Roman origins, a supporting column carved in the manner of the Trajan column but giving an account of the history of Bath? The idea has yet to take root amongst the City elders.

Julian Lush: *The Mnajdra Temple in Malta and Solar Alignments*

Julian described the Mnajdra megalithic temple complex in southern Malta, and argued that it could claim to be the earliest structure known for marking with precision, and venerating, the cycle of the sun. This will be described in detail in a future article in the *Bulletin*.

Piers Nicholson: *A Fleet Street Dial*

For more than two centuries, the term 'Fleet Street' has been synonymous with the newspaper industry in Britain. Now, all the newspapers which used to be published in the neighbourhood of Fleet Street have moved to other locations, leaving little trace of their passing. Fortunately, there is a large blank wall on the corner of Bouverie Street and Fleet Street, which has had nothing on it for

sixty years or more. It is ideally suited to have a sundial, and, because the wall faces a few degrees north of East, the hour lines on the sundial will be nearly parallel, so that it would be possible to fit the mastheads of five or six of the newspapers that used to be published nearby.

The project will be expensive to realise since the sundial must be made out of very durable materials, and will require scaffolding, and possibly footpath closures. The City authorities have said that they support the project in principle. It is planned to approach some major national newspapers to ask for financial support (though the industry is currently experiencing tough conditions with declining advertising revenues). It is hoped that other major local employers (particularly financial institutions, legal and accounting firms) will be willing to make contributions. The website will have facilities for individual contributions. We will be asking public bodies such as the Heritage Lottery Fund to contribute to the cost of the project, but members were urged to add their names, without obligation, to the list of supporters at *www.fleetstreetheritagesundial.uk/*

Saturday 27 April

As usual, the formal proceedings of the first full day of the Conference began with the AGM (the minutes are on page 29) and this was followed by the morning's presentations.

Secretary Chris Williams, Chairman Frank King and Treasurer Graham Stapleton.

Frank King: *Bath: Holy City, Holey City*

Bath is famous for its fine Bath stone buildings, and Bath Abbey (*Holy City*) was cited as an example. Frank noted that, in the vicinity of Bath and not far below the surface, there are numerous voids and cavities in the form of worked-out stone quarries (*Holey City*). Frank drew our attention to the Greek inscription on the north front of the Pump Room and its English translation "Water is Best". He suggested that this might be a good motto for a sundial commissioned by a Temperance Society. Frank noted that the line along the ridge tiles of the Royal Crescent seems to be a semi super ellipse. He left it as an exercise to investigate whether the 18th century architect could really have drawn a super ellipse and then showed us a modern sundial which is framed by a super ellipse.

Frank told us about Box Tunnel which was designed by I.K. Brunel and which might be considered the best-known hole left behind by the extraction of Bath stone. We were reminded of the claim that the sun shines through this tunnel on Brunel's birthday, 9 April. Could this be true? Frank outlined his analysis and showed that the sun could shine through on 6 or 7 April but never on 9 April. Frank then made the observation that "Whereas it is perfectly possible for a railway tunnel to be absolutely straight, it was not possible for a canal tunnel to be absolutely straight." The surface of any stretch of still water follows the curvature of the Earth and this was something that Cassini pondered when he was setting out his meridian line in Bologna. He dug a mini-canal and used the surface of the water as his height datum. The line was nearly 70 metres long and Cassini wondered whether the slight curvature in the line would give rise to observational errors. By calculation, it is easy to show that there is indeed a problem but that, even in the extreme case of the winter solstice, the error is insignificant. As a final example,

Box Tunnel, west portal.

Frank showed us a newish building at Pembroke College, Cambridge which is faced with Bath stone and he explained that he had found this an excellent stone to work with when marking out the sundial on the south face.

Kevin Karney: *How to Set Clocks, and Tompion's Contribution to that Science*

Thomas Tompion – father of English Clockmaking – came to London as a skilled maker of iron church clocks and was thus was able to join the clockmakers' guild, without having to be apprenticed. He was a highly skilled craftsman through which he gained both a commission and the friendship of the Royal Society's experimenter, Robert Hooke. Tompion was able to make a quadrant for Hooke of such quality that his skills became known to members of the Royal Society. As such, he was funded to make the first two clocks for Flamsteed's new Greenwich Observatory. When Huygens visited London with his balance-spring watch, claiming it to be his invention, Hooke was incensed since he claimed that distinction. Hooke therefore commissioned Tompion to make a balance-spring watch to his design. This watch was presented to King Charles II who was pleased with it. Thus with patronage from members of Royalty and the Royal Society, Tompion's fame was launched. By his death, his workshop at Dial and Three Crowns in Fleet Street produced some 650 clocks and 5000 numbered watches. Tompion produced a number of Equation clocks, including that in the Bath Pump Room, together with a number of sundials to accompany his clocks.

Horologically, this period was one of huge change. With the introduction of the 'royal' pendulum (beating seconds) and the anchor escapement, clocks could at last be produced where the difference between 'true time' (that is, God's/solar/ apparent time) and 'equal time' (that is, mean time) was at last easily perceptible. Over some 150 years, clocks gradually gained ascendancy over sundials – the latter being reduced from their role of prime time indicators to merely setters of clocks. Things moved from (a) how to adjust one's clocks to

Tompion clock face (photo courtesy of the Pump Room, Bath).

give true time to (b) how to correct solar time to set one's clock to mean time. This was the age of Equation Clocks and Equation Tables. This age came to an end when accurate clocks became widespread and finally the telegraph allowed time signals to be broadcast.

Equation correction of clocks began with simple printed EoT tables together with clocks where the minute ring was manually adjusted according to such tables. Variable-length pendulum clocks were attempted to give direct reading of solar time but these (with modern eyes) were doomed to failure. The introduction of the kidney cam, which mechanically encoded the Equation of Time, allowed the EoT to be displayed on the clock. The invention of the kidney cam equation clock was claimed by Thomas Tompion but also by Joseph Williamson. Commonly (and on Tompion's Pump Room clock), the correction was shown as a separate dial face. On the highest quality clocks (including Tompion's two clocks made for William III and for Queen Anne's husband), an additional rotating minute ring was added concentric with and outside the static mean-time minute ring. The final significant technical change in Equation clocks began when differential gears were used to add the kidney-produced EoT to the pendulum's mean time to give the clock a second true-time minute hand concentric with the mean-time hand.

Equation clocks and watches subsequently have become the domain of astronomical clocks and of 'complications' to watches and clocks made for the significantly wealthy. Gnomonists, however, will be happy that the huge 10,000 years Clock of the Long Now being built inside a mountain in Texas will be corrected by the EoT encoded onto a cam, the correction being triggered by the sun's transit.

Doug Bateman: *The Meridian Line in the Basilica of San Petronio, Bologna, and Dials in Parma*

The combination of dials and clock in Parma is outstanding, and the photographs revealed the quality of a recent restoration. Of particular interest was the noon dial with an analemma, and what appeared to be a date scale but in fact is a scale of degrees of solar longitude, 0 to 30, within each sign of the zodiac. The Basilica is famous for its meridian line, almost endlessly shown on YouTube. Doug's photograph showed the line in the nave as it is today, with barriers to protect it from the tourists. Photographs were shown of the progress of the spot of sunlight until the transit across the line, and at the right time! Despite the emphasis on sundials, somehow a photograph of a Ferrari car crept in... The subjects have been featured in the March 2019[1] and current[2] issues of the *Bulletin*.

Johan Wikander: *Two Mass Dials, St Milburga's Church, Wixford, Warwickshire*

The church is dedicated to St Milburga, a Saxon princess and saint, and is situated a few miles outside Stratford-upon-Avon. A chapel was built in 1400 on the south wall of the church by Thomas de Crewe, a member of the nobility. His very nice tomb is in the chapel. There are 13 mass dials carved. Drawings of two of the most interesting ones were shown. The first and more recent one of the two in the talk is a bit damaged, and has Arabic numerals for the 7th and 8th hours, and

Roman numerals for hours IX, X and XI according to the French system of counting the hours. A circle and radial lines for the hours are carved.

The second one has a carved circle, a central hole for a gnomon and dot numerals for the 6th hour at midday according to the Babylonian system of counting the hours. However, this mass dial has no radial carved line for the hours. This particular mass dial must be the older one, and carved at the same time as the chapel was built in 1400. The talk argued that originally the hours, each 15 degrees at that time, most probably had been painted. However, this painting has disappeared through the centuries. This dial was compared with a mass dial from Utstein Monastery, west coast of Norway at 59 degrees North. The circles are very well carved, however no radial lines are carved. Most probably the hours, sectors of 15 degrees and also some numerals, were originally painted on the soapstone.

As St Milburga's Church is situated a few miles outside Stratford-upon-Avon, the talk argued that most probably the young William Shakespeare would have seen these interesting mass dials. Perhaps the painting on the older one still could be seen then?

Woody Sullivan: *William Herschel – astronomer and musician*

Woody Sullivan gave a talk on aspects of William Herschel's (1738-1822) career in music and astronomy. Herschel lived in Bath from 1766 to 1782, mostly as a successful musician, but in the mid-1770s he began to get serious about astronomy, which led to the discovery in his back garden in March 1781 of the distant planet Uranus – the first planet not known since prehistoric times! He soon gained the patronage of George III, completely dropped his musical career, moved to Slough to be near Windsor Castle, and in the following three decades established himself as one of the greatest astronomers of all time. He built telescopes of unheard-of size and quality and used them to study the size and structure of our Milky Way galaxy, the nature of star clusters and mysterious, fuzzy 'nebulae' (some now known to be galaxies), double stars revolving around each other, comets, and the moons of Jupiter, Saturn and Uranus. He was greatly aided in all his observations by his sister Caroline (1750–1848). His theoretical ideas were also groundbreaking, in particular that the Universe was millions of years old and vast in extent, and that it was possible to study the slow 'maturation' of, say, a star cluster by observing many such clusters in different life stages, and then reasoning how one changed into the other over very long times.

Fred Sawyer: *Dialling Scale Nostalgia*

Fred related the story of how he came to find a folder labelled with his name in the private papers of the late sundial author Albert Waugh. This discovery led to a trip to the UCONN (University of Connecticut) archives to examine the folder which included correspondence, copies of some of Fred's early articles, and a manuscript copy of his proof of dialling scales by trigonometry. Fred's talk presented this proof, which he had created and subsequently lost while in graduate school. Fred then addressed the need to generalize the proof to show that there are an infinite number of configurations of the scales that will allow for the layout of sundials. Finally, he used this generalization to produce his differential dialling scales which include tick marks for every ½ degree of latitude instead of the crowded arrangement found in traditional scales. Fred distributed printed copies of the differential scales as well as a half dozen laser-etched wooden scales.

Saturday afternoon

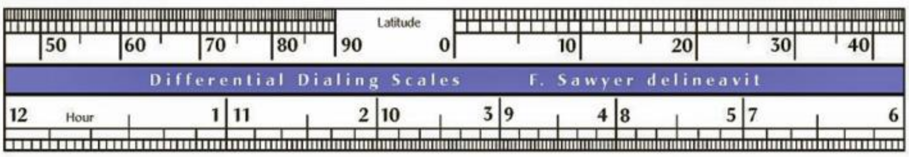
The afternoon's tour, the first of two, began with a walk down the fairly long and, in places, steep hotel drive to our transport. David Brown had considered hiring an open-top bus for this outing, but in view of the fact that Storm Hannah was still making itself felt, it was just as well that he had opted for a London Routemaster bus instead. The most agreeable driver and conductor seemed to enjoy the trip as much as we did, and were happy to answer questions about some of the features we passed. Thoughtfully, they had made a BSS sign for the route panel; they would have changed the number (50) to a more appropriate '30' but that was not available, and the picture of a cake appeared instead. The first stop was near the Empire Hotel, where we descended to the Parade Gardens with its armillary dial, to watch Chairman Frank King unveiling the plaque which explains that the dial had been restored to commemorate the 30th anniversary of the founding of the BSS.

Saturday afternoon's transport, complete with a 'BRITISH SUNDIAL SOCIETY' sign and a birthday cake.

Then it was back to the bus and a tour of some of Bath's handsome streets on our way to the beautiful arboretum in the Royal Victoria Gardens, where we saw a cross dial (SRN 7809) on a column, tucked away amongst the shrubbery.

Next it was back on the bus again for a view of the Royal Crescent, and the ascent of Lansdown Road to Kingswood School. David had provided a most informative sheet with some fascinating facts about the history of the school which had originally been founded in 1748 by John Wesley, in the Kingswood district of Bristol. There was much to see around the grounds, including several dials, all of different types. On the east side of the terrace there was a Pilkington and Gibbs heliochronometer, no.184, dated 1908. The detailed handout quoted the long inscription on this dial, but it was left to the reader to decode the Latin. On the east side there was a horizontal slate dial by David Brown, dated 2019 and replacing SRN 1962 (which had also been made by David).

Kingswood School is built on sloping ground, and the set of steps here



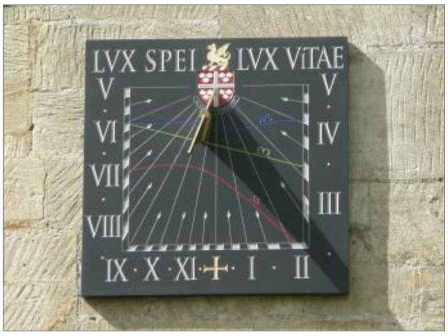
Sawyer's differential dialling scales.

Upper deck passengers.

Ceremonial unveiling by the Chairman …

… of the commemorative plaque.

David Brown and the refurbished armillary dial.



Four dials at Kingswood School.

Cross dial in Royal Victoria Gardens.

provided the opportunity for the first group photograph of the Conference.

At a higher level there was another handsome slate dial by David, this time a vertical one, with a shorter Latin motto. Yet more Latin was to be seen on a plaque on a wall adjacent to the fourth dial: an analemmatic. Both these last two were recent replacements for earlier dials.

As for translations of the Latin, all will be revealed in the September 2019 *Bulletin*.

After seeing more of the sights, we were given an welcome cup of tea in the Dining Hall of 1852, where David pointed out some more features of interest, including the pulpit which was in the original school and from which John Wesley himself had preached.

As usual on the Saturday evening, there was the Gala Dinner, made special this year with the addition of anniversary cakes made and beautifully decorated by Pauline and Michael Faraday.

On the terrace steps at Kingswood School. Photo: Mike Shaw.

The display of cakes made and decorated by Pauline and Michael Faraday.

The Chairman cuts the cake.

Tea in the Dining Hall, Kingswood School.

At the Tompion clock.

Sunday 28 April

Another treat this year was a second outing, this time on a conventional coach that was able to negotiate the steep drive to the hotel. After an early start we went to the Pump Room by way of the Sally Lunn Eating House and the Bath Bun Tea Shoppe, and an unsuccessful hunt for scratch dials on the Abbey walls. Before going into the Pump Room we assembled on the steps outside for another group photograph (see page 34). Inside, the main attraction was the Tompion Equation clock, and, just outside one of the windows, a sundial that may also be by Tompion and which a nearby plaque explains was placed here after being lost for more than a century. We were then taken through part of the Roman Bath complex from where we could see an external view of the sundial on its pedestal.

Next it was a fascinating visit to the Herschel Museum of Astronomy, part of the house where William and Caroline Herschel had lived, and from whose garden the planet Uranus was first observed. Of particular interest was the mirror polishing machine in the workshop, as well as globes, planetaria and telescopes (including a model of the forty-foot version).

Then it was back to the Brunel Suite for coffee and cake, and the final presentations of the Conference.

Fred Sawyer: *Ancient Portable Sundial Design*

Inspired by an exhibition of ancient sundials at the Institute for the Study of the Ancient World at New York University, Fred discussed and showed photos of the six various types of the 25 known extant portable sundials from Antiquity. He focused on the unique 3rd century sundial (Type V) found in Philippi, Greece and demonstrated how it relies on an interesting equation that is easy to implement and closely approximates the correct seasonal hour. Fred indicated that this equation may well have worked for ancient Egyptian dials 3500 years ago, was clearly the justification for the Pros Pan Klima (Type VI) portable sundial of which there are 13 extant examples, and is equivalent to the equation underlying several Arabic dials and quadrants from the 8th to the 18th century. Fred introduced his own

The Pump Room sundial.

Model of the 40-foot telescope.

Garden of the Herschels' House.

A third century dial from Philippi, Greece.

Woody's forearm sundial.

version of a simple sundial based on this same equation and showed that it is easily constructible and has several features in common with the six classical varieties.

Woody Sullivan: *Three New Sundials in San Diego (California), Bellingham (Washington State), and on My Forearm*

Woody Sullivan spoke on three recent dial projects from the US West Coast. The first (from 2017) is a large wall sundial on a new dormitory complex of the University of California at San Diego (near the Mexican border). The second, which was designed and painted by Gretchen Leggitt after an international competition, was installed in 2018 on a wall in the city of Bellingham, Washington State, close to the Canadian border. Sasch Stevens was the diallist who shepherded the project through all stages. Finally, Woody proudly displayed on his forearm the latest in wearable technology – the world's first *working* sundial tattoo. The tattoo pattern works in conjunction with a custom stainless-steel bracelet holding a 20-mm long gnomon and a small circular bubble level. It is an altitude dial – he slides the gnomon according to the date, moves his arm until the sun's shadow is aligned with the length of the dial, levels his arm, and reads the time to an accuracy of ~15-20 minutes. Small arrows within the pattern also make it into a compass, indicating the direction of South. Finally, the dial pattern contains two sets of hour lines (blue and red), one for Seattle at 48° N latitude, the other for Miami at 26° North. No matter where he is in the Continental US, he can read the time by interpolating for his actual latitude.

The Andrew Somerville Memorial Lecture

Michael Davis: *Adelard of Bath*

Adelard of Bath was a noted snappy dresser and Michael Davis, taking the role of Adelard himself, made his entrance wearing a green cloak fashioned from English broadcloth with, underneath, an elaborately embroidered tunic.

Adelard lived from approximately 1080 to 1160 and has come to be known as England's First Scientist. He was born in Bath and eventually died in Bath. He had a privileged upbringing and travelled widely in his youth. Adelard was educated both in Bath and in the Cathedral School in Tours where he studied the Trivium and the Quadrivium.

Adelard appreciated that there was much to be gained from studying with Arab scholars and he spent seven years in the Middle East before returning to Bath with a wealth of knowledge that was almost unknown in Christian Europe. He translated a number of important works from Arabic into Latin and wrote original works too. He is particularly well known for translating Euclid's 13 Elements of Geometry and this led *inter alia* to advances in architecture. His original works include *De regule Abaci*, on the operation of the Abacus, and *De opere Astrolapsus*, on the working of the Astrolabe. His writing also extended to a general review of Astronomy. Adelard served as a tutor to the young Prince Henry who was later to become Henry II.

Adelard worked for the Exchequer and was a member of Henry I's Court. Intriguingly, as a member of this Court he was once excused from a Murder Fine in West Wiltshire. Henry I had brought in a law that applied whenever a Norman was murdered by an Englishman. The local Hundred were required to identify the culprit and, failing that, they had to pay a fine.

Astonishingly, most if not all Adelard's writing survives, on parchment, in archives and libraries. Adelard can be regarded as a Renaissance man 300 years ahead of his time. He appreciated that the Christian Church in his day was wary of too much knowledge and that Arab scholars were not impeded by this malign influence.

A particularly important biography, *Adelard of Bath: The First English Scientist*, has been written by Louise Cochrane. A review by Tina Stiefel of London University, notes that the book is 'an absorbing study and should be read by all who are interested in the history of science.'

Following lunch, delegates dispersed, with many thanks to the Team for a highly successful Conference.

REFERENCES

1. Douglas Bateman: 'Sundials in Parma, Italy', *BSS Bulletin* 31(i), 35-38 (March, 2019).
2. See pages 20-26.

Notes by the speakers
Speaker photos by Mike Shaw
Other photos by Frank King, Mike Shaw and Christine Northeast

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