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CONTENTS

EDITORIAL

The December issue of the *Bulletin* always includes reports of the talks given at Newbury in September. This year's meeting provided a rich source of additional material for the Editorial team to work on. Our lead article is based on three Newbury talks, one given last year and two this. Some clever detective work is described and the outcome is a wonderfully-restored sundial by Harriet James.

On page 11, there is a group photograph of the Newbury speakers taken by our regular photographer, Mike Shaw. He placed us under the trees in strong sunlight. Readers can count how many elliptical images of the sun they can see. There is a particularly fine example on Kevin Karney's pullover. Mike further entertained us with a mathematical poem which features on page 42.

The BSS Help and Advice Service has again spawned a *Bulletin* article by Sue Manston who so splendidly runs this service. She always invites enquirers to become members and two of those she approached gave talks at Newbury: Ben Green and David Burstall. We very much hope to see more of them at Conferences and in print.

No fewer than five articles describe new (or almost new) sundials with remarkable geographical spread: Cornwall, the Netherlands, France, Italy and Scotland. The Cornish dial is another exquisite result of collaboration between Mark Lennox-Boyd and Ben Jones. The Italian contribution is an intriguing cone dial by John Arioni. His final photograph on page 36 shows two sundials which appear to bear almost no relationship one to the other and yet, on close inspection, it can be seen that they are delineated identically.

On a sad concluding note, we print an obituary to Andrew James by Joanna Migdal. Andrew died in October and will be greatly missed. He last spoke to us at Newbury in 2017 when he explained, *inter alia*, the incredibly complex workings of the Equation of Time component of the Jens Olsen clock in Copenhagen.

We wish our readers a Happy Christmas.

Frank King

RESTORATION OF A PAINTED STONE SUNDIAL NEAR PRESTATYN

JOHN DAVIS, HARRIET JAMES and KEVIN KARNEY

This article is based on presentations made by Kevin Karney at the 2018 and 2019 BSS Newbury Meetings and by John Davis at the latter meeting, plus an account from Harriet James of her practical restoration work.

Introduction: A Cautionary Tale (Kevin Karney)

This story begins, not in North Wales, but at a dinner after one of Piers Nicholson's Sundial Walks in London. I was sitting near to Professor Greg Wilkinson who said that he had an old sundial on the side of his house. It did not tell the time very well, he said. Some months later, while in North Wales, I visited the house together with Mike Shaw. We found the large, fine-looking but very faded painted stone dial with iron gnomon, shown in Fig. 1. It was an east-declining dial (approximately 5° E) mounted on a west-declining wall (3° W) and was clearly venerable. I had not brought a protractor, but up a ladder on a windy day, pencil behind one ear, notebook in one hand and yellow bendy tape measure in the other, I made linear measurements. Old photographs of the house showed that the dial was not original to the property. Mike and I thought the dial an interesting find and suggested to the owner that he contact Harriet James if he wished to have the dial restored.

Fig. 1. The Prestatyn dial in 2018.

Back home, I found that the actual measurements did not quite match up. So these were supplemented with those from a digital photograph, perspective-corrected using Photoshop. Analysis was carried out and the dial's design latitude was derived by a least-squares best fit. A reasonable fit was found – but for a latitude somewhere down in Cornwall – an unlikely 3.5° south of the actual location. It was concluded that the original delineator was incompetent.

This was quite wrong. When Harriet got the dial back to her workshop, she measured the dial properly and the analysis was repeated. This found a design declination of 7° E, and design latitude of 53.3° N, almost identical to the dial's actual location and, with a few exceptions, the hour lines were all in harmony with an average error of virtually zero degrees. So, there are lessons to be learnt if the first and second analysis are compared:

- Do not rely on measurements made with insufficient and inappropriate tools, up a ladder in inclement conditions.
- Be very cautious using perspective-corrected digital photographs: it is easy to convert perspective distortions to rectilinearity, but one must also ensure that squares are converted to squares rather than rectangles…

Harriet James Picks up the Story:

After much discussion with Kevin and the Wilkinsons, the owners of the dial, I took a train to North Wales for a closer look. I went up a ladder and tapped the stone all over to see whether it was sound. It was a fine-grained piece of sandstone of unknown origin. There was some delamination on the edges but otherwise it was in good condition. The original iron gnomon was securely fixed to the stone with lead plugs. There was no evidence of carving or scoring into the stone.

In some places the paint had weathered away leaving bare stone and clear 'ghost' outlines of Roman numerals and hour lines. Elsewhere there were patches of powdery paint with several layers remaining. I took some paint samples to send to John Davis for XRF analysis. Then I wrote a condition report and restoration proposal.

Fig. 2. Top: the bottom right corner of the dial with a small patch of blue-green colour. Bottom: a numeral 'I'.

A base layer of white overlaid with several other colours could be seen with the naked eye. The topmost layer appeared to be powdery black soot suggesting that the sundial had been moved from an industrial setting to its present exposed position in sight of Snowdon. Other paint layers to be seen (Fig. 2) were a blue/green, a deep brown, an ochre yellow, a deep red and a small speck of a vermilion colour. The blue/green pigment sparkled in bright sunshine.

Paint Analysis (John Davis)

There were several questions to be answered:

- Was there anything in the paintwork that supported or disproved an 18th-century date?
- What colour was the gnomon? It could be seen that it was now painted white which is an unusual choice – metal gnomons are normally black – so was this the result of a relatively recent restoration or had it always been this colour?
- What colour was the background and what type of paint had been used? A small area in the bottom right corner appeared to have the remains of some blue-green paint (Fig. 2 top) so was it possible that this was part of the original colour-scheme?
- What colour(s) were the hour lines and numerals? They now had very little paint at all (Fig. 2 bottom).
- Was there any evidence that any part of the dial, including the circle around the gnomon base, had originally been gilded?

I was asked whether I could shed any light on these questions from a scientific investigation. As North Wales is rather a long way from my home near Ipswich and also as the dial was accessed by means of a ladder, it was impractical to perform an on-site analysis; this led to the necessity of taking samples of paint from various areas for analysis in the laboratory (also known as my spare bedroom). Two forms of analysis were available: X-ray fluorescence (XRF) for identifying the inorganic chemical elements in the paints, and inspection of specimens in cross-section under an optical microscope to observe the layering and to help identify the paint structure. Unfortunately, the exposure of the paint to weathering over many years had oxidised and dried out its binding components and so it was not possible to obtain the large flakes of paint which would have been ideal for analysis. Instead, with careful wielding of the scalpel, Harriet had managed to remove material from four areas in the form of a powder with the occasional piece having a dimension of a millimetre or two although much of it was much finer (see Fig. 3).

X-ray Fluorescence Analysis

My XRF analyser[1] has a basic spot size of 8 mm diameter with an optional small spot (at reduced sensitivity) of 3 mm. Clearly, the available samples were too small to perform a normal planar analysis on the top surface so, instead, a 'powder analysis' was performed by placing most of the sample – having reserved two or three of the largest pieces from each area for cross-section studies – packed into a small plastic holder with an 8 mm window covered by 20 µm of mylar (polyethylene terephthalate, PET; transparent to X-rays). Thus, the individual grains of paint were presented to the X-ray beam at random orientations, producing an analysis which averaged their

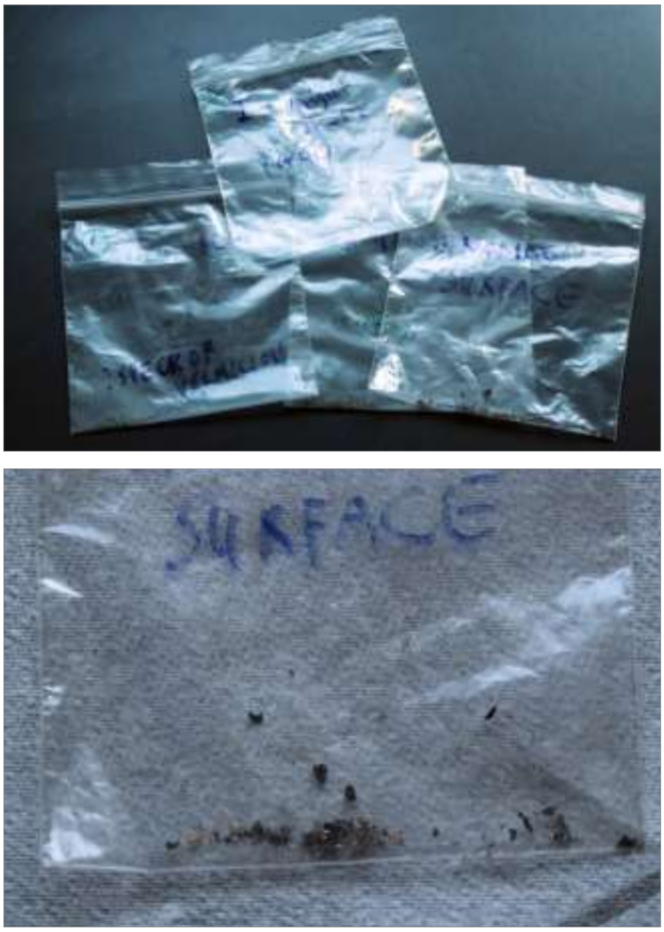

Fig. 3. *Powdery samples of paint removed for analysis from four separate areas (above) and close-up (below).*

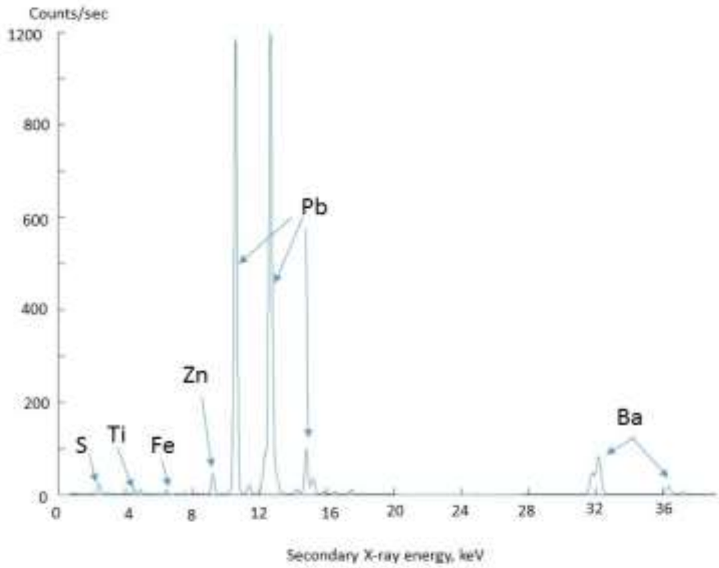

Fig. 4. XRF spectrum of the #3 paint sample from the side of the gnomon showing the full range of secondary energies.

composition rather than measuring what would have been the visible top surface of the painted area.[2] As any primer or underlayers were likely to be thicker than the top colour surface, their compositions would be disproportionately large in the results and the more interesting colour layers would be seen only as more minor components of the composition.

The analyser is carefully calibrated for metallic copper-alloy studies of sundial plates etc. where the secondary (characteristic) X-rays have energies of up to around 26 keV and the only elements present are metallic ones which give clear XRF signals. Paint pigments are usually complex molecules which contain, as well as metallic elements, lighter ones including sulphur, chlorine, carbon, oxygen and hydrogen. Of these, only sulphur and chlorine produce measurable XRF signals (and then with some difficulty) so that it is not possible to produce clearly calibrated results or to identify, for example, which copper compound is the source of a copper peak in the spectrum. Thus, although the analyser's internal algorithm still produces a table of the normalised percentage constituents of the specimen (Table 1), this needs to be treated with extreme caution as it is reporting only on the elements to which it is sensitive: the operator needs to examine the raw XRF spectra (an example is shown in Fig. 4) with some experience of the profiles likely to be produced by common pigments.

The first thing that is obvious from Table 1 and Fig. 4 is that all the specimens have a large amount of lead, Pb, in them, as might be expected from any pre-modern paint as lead could be present in both red lead ('minium', Pb_3O_4) which is a very common primer, and also in lead white, $2PbCO_3{\cdot}Pb(OH)_2$, which was a common basic pigment.

Paint Specimen			Cu	Zn	Sn	Pb	Fe	Ti	Cr	Mn	Ba	Zr	V	P	S	Si	Cl
No.	**Area**	**Description**															
#1	bottom edge	green/blue?	0.10	0.07	0	88.8	1.7	4.1	0.35	0.24	10.2	0.06	2.1	0.44	tr	2.2	tr
#2	numeral 'I'	gold?	0.25	0.09	0	64.1	23.2	6.16	0.53	0	8.4	0.12	1.6	0.65	tr	3.0	tr
#3	gnomon side	white	0.14	9.7	0.01	38.3	22.1	23.9	0.35	0.39	11.9	0.10	1.9	0.26	tr	2.0	tr
#4	gnomon root	?	0.10	–	0	80.1	5.9	3.5	0.27	0.16	8.0	0.06	1.7	0.39	tr	1.7	tr

Table 1. Normalised constituents (wt %) reported by XRF for various paint specimens. These values are indicative only and should not be regarded as quantitative. Not all elements in the specimens will produce an XRF signal. Note that the algorithm is not infallible and the signal reported as vanadium (V) is more likely to be a minor peak of barium which is present in quite large quantities. tr = trace (not quantified by the analyser).

Leaded paint was phased out in the UK from the 1960s although it was still legal until 1992: its use had been banned for most purposes in the USA in 1977.[3] Note that it is only the lead content of these compounds which is detectable by XRF. The other point to be made at this stage is that some elements which will be unfamiliar from studies of brasses are present: these will be considered in the individual samples below.

Although the analyser's X-ray tube operates at 50 keV for working on metal alloys, it is appropriate to use lower energies (typically 8 keV) and filters when looking for light elements. This is achieved by passing the primary beam through one or more filters consisting of thin metal foils – these are automatically moved into the beam by a motorised carousel during the measurement. The resulting secondary (characteristic) X-rays are very 'soft' with energies below 5 keV so their range in air is only a few millimetres and the analyser needs to be very close to the sample.[4]

Fig. 5. Potted cross-sectional paint specimen prepared for microscopy. The block is 35 mm in diameter and there are three separate paint flakes attached to the central Perspex cube.

Cross-Section Studies

The largest flakes from each area of the dial were prepared for cross-sectional viewing by first attaching them to the face of a 2 mm cube of Perspex so that they would remain upright when potted in a 35 mm diameter mould which was then partly filled with a clear, UV-curable resin. Once this had set,[5] the surface was ground down on a series of wet alumina papers starting at 600 grit and moving through multiple steps to 5000 grit. (For these relatively soft specimens, it was not necessary to progress to the final steps of polishing with a sub-micron diamond paste which would be used for metallic specimens.) A typical prepared specimen is shown in Fig. 5.

Observations were made with a low-power stereoscopic microscope at each stage through the polishing sequence. Final observations and photomicroscopy were performed with a metallurgical microscope fitted with both coaxial and angled incident illumination systems.

Results

(a) Gnomon side (sample #3). A cross section of a sample from the gnomon paint is shown in Fig. 6 and can be interpreted in conjunction with the line #3 in Table 1. At the bottom, there is a red/brown layer which is the primer for the ironwork and is likely to be red lead, mixed with an iron oxide, probably magnetite (Fe_3O_4) either from the surface of the iron or as an additional pigment. At the top, a thin brilliant white layer is almost certainly a modern paint with a titanium dioxide pigment which came into general use in the UK around 1950 and is nowadays the preferred white pigment in everything from plastic to toothpaste. It is probable that the barium signal also comes from this layer as barium sulphate ($BaSO_4$, often used for 'barium meals' before intestinal X-ray investigations) can be mixed in with the titanium dioxide to form a 'permanent white'.[6]

Between these two levels at least five layers of various shades of grey are discernible and these are likely to be a series of repaints with whatever 'white' paint was available at the time. One of these will be zinc oxide, ZnO, accounting for the large Zn peaks from this sample only.

Fig. 6. Cross-sectional micrograph of the paint from the side of the gnomon.

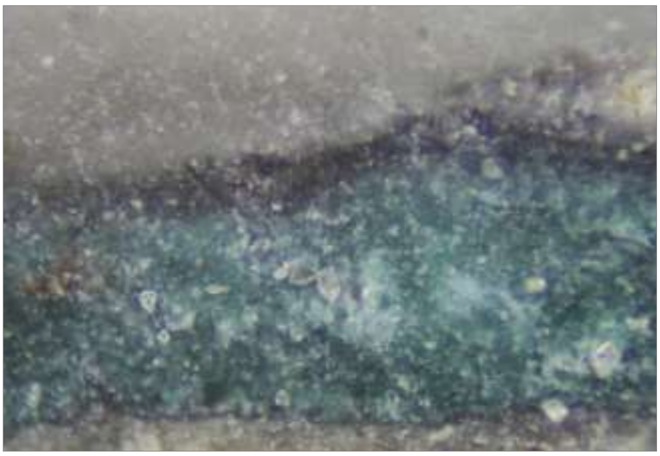

Fig. 7. Cross-section of the paint from the bottom edge of the dial plate (sample #1).

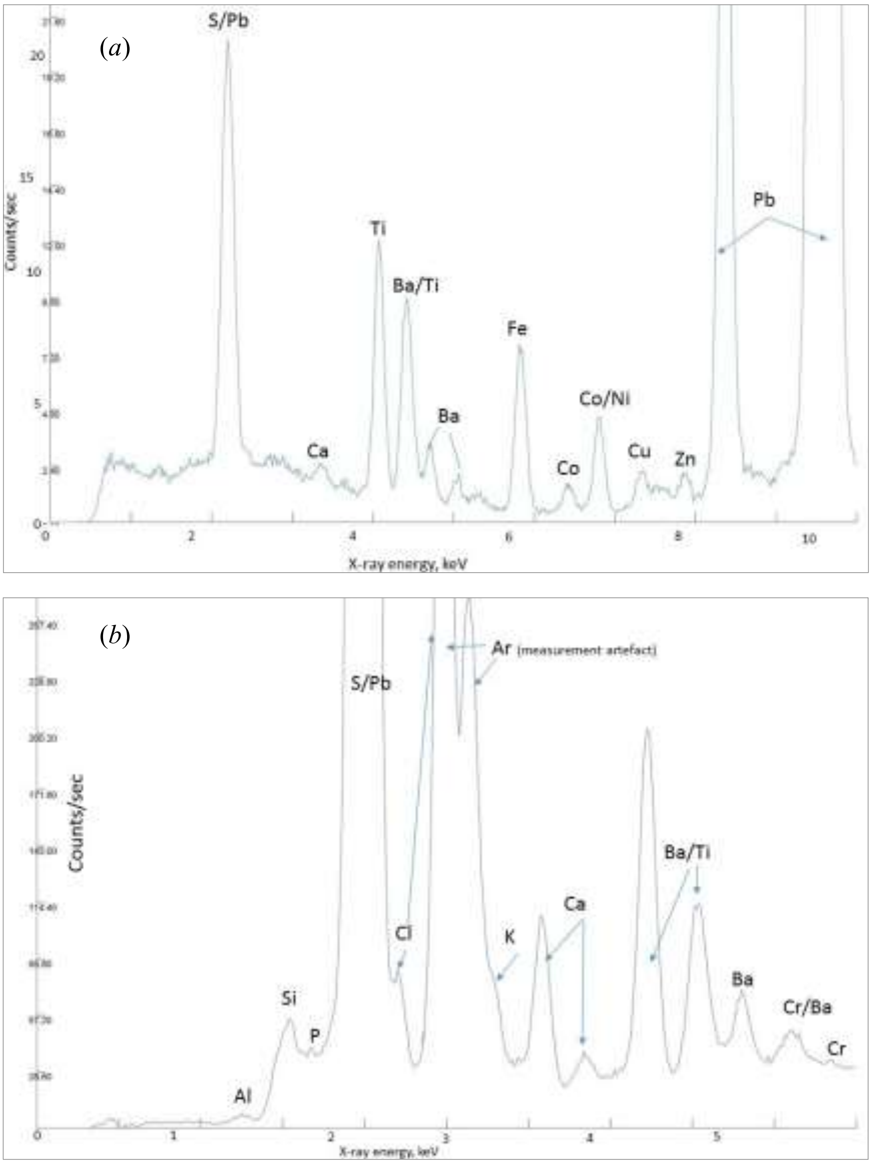

Fig. 8. XRF spectra of paint from the blue/green field area. (a) a wide range view including the large lead peaks and showing the presence of cobalt and (b) a low energy analysis showing additional light elements associated with smalt.

Zinc white came into use as a pigment in the early 19th century.[7]

A discontinuous region of bright white in Fig. 6 is thought to represent titanium dioxide white from a recent repainting which has penetrated through cracks in the earlier layers, showing that the gnomon was not stripped back to bare metal each time.

(b) Field area, bottom edge (sample #1). The cross-section in Fig. 7 shows a range of colours, the thickest in the middle being responsible for the blue/green colour seen in the bottom right of the dial plate and probably the field colour of the whole dial. This thick layer lies between two whitish ones with thin black lines at the interfaces. These thin lines are thought to be the carbon-based ‘dirt’ which had accumulated on the surface before each repaint: they are likely to include various sulphates as a consequence of the ‘acid rain’ produced by burning sulphurous coal as well as the carbon-based soot particulates. The current location of the dial is a relatively rural one with clean, coastal, air so it is possible the dial was originally in the Liverpool area which is not far away and has a similar latitude.

What is the composition of the blue layer? One strong clue is that the layer can be seen to contain numerous small crystal-like grains which points to the use of smalt, a traditional blue pigment used as it was much cheaper than the alternatives, especially those based on *lapis lazuli*. It is these small ‘crystals’ that account for Harriet’s observation of its ‘sparkly’ appearance in the sunshine. Smalt is made from a crushed potash (K) glass with the relatively complex formula

$$SiO_2\,(65\%) + K_2O\,(15\%) + Al_2O_3\,(5\%) + CoO\,(10\%)$$

where it is the cobalt (Co) that actually provides the colour, though it should not be confused with the artificial pigments cerulean blue and cobalt blue which were developed in the 19th century and have a more intense colour.[8] Cobalt glass was known to the Romans and its use in pigments for oil painting in Europe was mainly between the 15th and 18th centuries.[9] In addition, the elements iron, nickel, arsenic and bismuth are sometimes detected in smalt as a result of their presence in the cobalt ore used in the preparation of the glass.[10]

Smalt is a fairly strong blue when first applied but it degrades and changes colour to be more green or even brown over time.[11] It can be seen from the chemical formula that it contains only a small percentage of cobalt which is not quantified by the XRF analyser's internal algorithm in Table 1. However, if we look at the spectrum shown in Fig. 8(a), the presence of small cobalt peaks can be clearly seen. Looking in more detail at the low energy region in Fig. 8(b), we can observe the peaks for silicon (Si), potassium (K) and aluminium (Al) expected for smalt, together with a larger peak for sulphur (S), probably associated with the thin soot layers containing sulphates.[12] It was also just possible to detect one of the higher-order bismuth peaks at 13.023 keV as a shoulder on the side of an equivalent but much larger lead peak at 12.61 keV. Several other elements are also seen but their sources have not been identified, though it is possible that the copper is associated with pigments deriving from the copper-containing minerals azurite (blue) and malachite (greenish, and seen in the patina on brass sundials), both common before the introduction of artificial pigments. Studies of smalt in Flemish panel paintings can provide useful comparisons of the variety of constituents found in smalt of the 16th century.[13]

(*c*) *Numeral 'I' (sample #2).* It had been suggested that the numerals of the dial had been gilded so it was important to search for any evidence. Although gold (Au) itself is easy to detect by XRF, gold leaf is incredibly thin (of the order of 0.1 μm) even if it has not been weathered off, so finding it in a mixed powder would be extremely difficult. Thus, the absence of any XRF Au signal was not unexpected. Also, the thickness is less than the wavelength of light so it would not be seen in cross-section with an optical microscope. The cross-sectional view in Fig. 9 shows that the top colour layer is a yellowish-gold which could well be the backing varnish which was typically mixed with yellow-red pigments to allow for any 'misses' in the gold. The XRF shows a high level of iron (Fe) which is present in both the natural pigment yellow ochre (as FeO(OH)) and in the red ferric oxide. Although this is not proof of gilding, it is a good indication that it could have been present.

Fig. 9. Cross-section of the paint from the numeral 'I' (sample #2).

(*d*) *Gnomon root area (sample #4).* This specimen again shows multiple layers of greyish-white separated by thin black layers together with a yellowish surface but there is no smalt layer in this area.

Conclusions from the Paint Analysis

Overall, the results suggest that the original colour scheme was a blue background with gilded numerals and that the gnomon has been white for an extended period, through several repaints (it could, of course have originally been a different colour which was stripped before the white layers started). With the exception of the most recent repaint of the gnomon using a modern paint, all the other colours are entirely consistent with pigments which would have been available in the 18th century. Harriet's on-site inspection of the dial had shown a few small specks of a bright red, perhaps vermilion (HgS).[14] This would certainly have been possible (vermilion, from the mineral cinnabar, has been found as the infill of the engraving in a 15th-century ivory dial[15]) but no sign of the mercury required was found in any of the analyses and the sulphur peaks are explained from other origins so it is possible that the red colour was actually red lead.

In addition to the primary constituents discussed above, several other elements were observed in the spectra but have not been discussed, such as manganese (Mn) which is a minor component of umber, another common early pigment. The characteristic of XRF being able to detect only elements and not compounds has certainly been a limitation in the study (further analyses using Fourier Transform Infra-red Spectroscopy (FTIR) and Raman spectroscopy could give insights into the actual compounds but were not available[16]) but despite this some useful, practical results have been obtained from unpromising samples.

Harriet Continues:

Following John's XRF analysis of the paint samples and some research into smalt, I concluded that the original dial was likely to have been painted with a single background colour of smalt blue (with a white undercoat), and that the delineation and numerals had been gilded.

Although no gold had been detected in the XRF analysis this did not prove the absence of gilding. It was common for gold leaf to be underpainted with a layer of red (this was supposed to make the gold look richer), topped with a layer of yellow size (varnish) onto which gold leaf was applied. Small patches of red and yellow were particularly prominent on the strokes of the Roman numerals which convinced me that they had been gilded.

With the help of Mark Rawlins, stonemason, I removed the sundial to my workshop. There I measured the hour angles and gnomon angle and sent them to Kevin for analysis. It became clear that the dial had been correctly delineated for a wall of a different orientation but that it could be restored and canted out to function at its present location.

The edges of the stone were filled and repaired. Old layers of paint were sanded back by hand and several thin layers of a blue signwriting paint were applied with a roller. This was the nearest modern pigment that I could find to smalt blue. The thin layers ensured that the pigment soaked deep into the stone and would not peel off in its exposed position near the sea. On top of the blue I repainted the numerals and hour lines with an orange-yellow undercoat of oil-based signwriting paint, then applied gold size and 24 ct double thick gold leaf on top of that.

The rust was cleaned off the gnomon and it was repainted with a metal primer and an undercoat, then gilded. It was quite corroded at the tip but I thought it should be retained as its upper edge would still cast a reasonably straight shadow.

Reinstallation of the dial was tricky because Mark and I had to lift the heavy stone onto the wall without scratching the gold leaf or damaging the paint (Fig. 10). We had to cant the dial out on a new stone support and cap it to stop water running down the back. We were constrained by the delicate carved stone heads which were set into the wall either side of the dial.

We needed sunny weather to check that the dial was telling the correct time when canted out from the wall. Even

Fig. 10. Stonemason Mark Rawlins working on the reinstallation of the dial. Note the capping on the dial, now canted-out to the east.

Fig. 11. The completed restoration.

though it was summer and we were blessed with a heat wave, we were working against time to make the five-hour drive to Prestatyn and get the dial in place before the sun went behind the tall Corsican pines in the garden, hoping all the time that the weather would not change.

All went to plan: the completed restoration is seen in Fig. 11. The owners of the dial were wonderful hosts, cooked us delicious meals and took us to the beach to watch the sun sink into the sea towards Anglesey. We were all up early the next morning to watch the sun come onto the dial and to check its accuracy.

ACKNOWLEDGEMENTS

We are grateful to Professor and Mrs Wilkinson for commissioning the dial restoration and for their hospitality to both Harriet and the Karneys, and to Mark Rawlins for his help in re-installing it.

REFERENCES and NOTES

1. A Thermo-Scientific Niton XL3t GOLDD+ instrument with a 50 keV primary beam and a Silicon Drift Detector operated at – 25°C with an approximately 180 eV energy resolution (FWHM). Most analyses were performed with a 90 second dwell time.
2. For painted surfaces with multiple layers, it is possible to get a measure of the individual layers by creating a 'wedge' of varying thickness, down to the underlying substrate. See, for example, Susanne Kahn and Hanne Moltubakk Kempton: 'The use of handheld XRF for pigment analysis in complex paint structures', presented at *Technart*, Catania, Italy (2015). DOI 10.13140/RG.2.1.1678.3444.
3. *https://en.wikipedia.org/wiki/Lead_paint#Regulation*
4. Improved results can be obtained by purging the normal atmosphere with helium but this was not available at the time; it is planned for any future investigations.
5. The UV-curable resin sets in under 30 seconds when a UV torch is shone on it. The reaction is exothermic so it is necessary to progress in layers less than 2 mm thick to avoid overheating and outgassing.
6. *https://en.wikipedia.org/wiki/Barium_sulfate#Pigment*

7. *http://www.webexhibits.org/pigments/indiv/history/zincwhite.html*
8. *http://www.webexhibits.org/pigments/indiv/overview/coblue.html*. The 'Pigments through the Ages' website at *http://www.webexhibits.org/pigments/* is an excellent source of information on the topic.
9. *http://www.webexhibits.org/pigments/indiv/history/smalt.html*
10. Marika Spring, Catherine Higgitt & David Saunders: 'Investigation of pigment-medium interaction processes in oil paint containing degraded smalt', *National Gallery Technical Bulletin*, 26, 56-70 (2005).
11. *ibid*. The degradation of the smalt in a number of 16th-century paintings is examined mainly by the use of FTIR. See especially p.63.
12. Note, though, that the primary K_α peak for sulphur is closely overlapped by the minor M_α line for lead so that it is very difficult to deconvolve the extended asymmetrical peak seen in the spectrum quantitatively. The spectrum also shows peaks for the gas argon (Ar) which are the result of its presence at approximately 1% in the atmosphere which exists in the gap of around 3 mm between the sample and the detector.
13. Anabelle Kriznar, Maria del Valme Munoz, Fuensanta de la Paz, Miguel Angel Respaldiza & Mercedes Vega: 'Non-destructive XRF analysis of selected Flemish panel paintings in the Fine Arts Museum of Seville', *Journal of the Institute of Conservation*, 1-16, July 2014. DOI: 10.1080/19455224.2014.915224
14. R.J. Gettens, R.L. Feller & W.T. Chase: 'Vermilion and Cinnabar' Ch. 7, p.159 of N. Eastaugh, *Pigment Compendium: a dictionary and optical microscopy of historical pigments* (2013).
15. R. Schewe and J. Davis: 'Time on a tablet: early ivory sundials incorporating wax writing tablets', *Early Science and Medicine*, 24, 213-247 (2019).
16. For more details of this topic see, for example, Madeleine Hours: *Conservation and Scientific Analysis of Painting*, Van Nostrand Reinhold, New York (1977). The extensive literature on analysing fine art painting can often provide useful information for studies of painted sundials. See for example the many papers presented at Art2008, 9th International Conference on NDT of Art, Jerusalem, May 2008, downloadable at *https://www.ndt.net/search/docs.php3?showForm=off&MainSource=65&Country=-1&KeywordID=128*

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DIZZY'S DIAL

GRAHAM STAPLETON

Among the collection at Hughenden Manor, Buckinghamshire,[1] the country home of Benjamin Disraeli (British Liberal politician, active 1837–80),[2] there is a small – some 4¼″ in diameter – sundial of strange appearance with, apparently, a peculiar history (Fig. 1).

Fig. 1. The sundial presented to Disraeli (image by permission of the National Trust).

On the dial plate there are two inscriptions. Inside the chapter ring is "P.M. XI 1st August. 1862" with the XI displaced from the chapter ring on a solitary hour line (apart from the pair properly denoting noon). The other, behind the gnomon, reads: "To the Rt. Honble. B. Disraeli. M.P. From Philip Lybbe Powys. M.P." On the silver band that forms part of the ebony base is a third inscription: "Horam Disraeli Loquente Numeravi Serenissimam Tacente Haud Numerabo Alteram."[3]

The Latin proved too hard for Google Translate, and so I asked John Foad about this dial. As it happened, he had looked at it a few years ago, and conferred with other members about its characteristics. In his notes copied to me, Jill Wilson suggested that "the motto could be a bit of an amusing concoction from some of the standard ones of that time". The consensus then was that it might be rendered as: "An hour of Disraeli speaking I consider serene; nor do I think any different when he is silent."

However, the glaring issue is that the gnomon is pointing the wrong way and, as John Davis noted, "quite unusual with its extreme shift of the origin to the south – not made by a mathematical instrument maker, I suspect, though quite competent. I hope they didn't think that fitting the gnomon backwards would allow it to show times at night! My guess would be that Powys was trying to curry favour with the Great Man."

Not having been able to see and measure the dial, I have had to work to approximations, but the layout of the hours in the chapter ring does appear to be substantially correct. An interesting effect of displacing the gnomon is that the hours 9–12–3 become almost evenly spread. This is at the expense of the hours adjoining the 6–6 line, which become densely packed and less precisely readable. The whole dial has the appearance of having been routinely manufactured but customised for an occasion. That it is capable of functioning, but has no means of setting it correctly, suggests to me that it was sold as a desk ornament or paperweight. To date, I have not found another example that might confirm this.

All of this raises questions, in particular the significance of the date, and the connection between the two men. The date – 1 August 1862 – might seem the simplest. On this day, the Wycombe Railway opened its northward extension, passing within a mile of Hughenden;[4] however, there is no indication that either man attended this opening, or had any involvement with the line. The most plausible and complete explanation so far for the inscriptions comes from a study of Hansard.[5]

It was the practice of the time for Parliament to convene in the late afternoon and continue through the night; this particular session terminated at 4.15 am on 2 October. One of Disraeli's notable Parliamentary speeches, on the State of the Parties, was given in that day's session and John Foad notes that the total session comprised 32303 recorded words, with two thirds of the spoken time having been spent by the time Disraeli started. "It is possible therefore that the 'P.M.' refers to 11 pm on 1 August, despite being marked at the 11 am hour line." This symbolic reversal of the hours could be plausibly reinforced by the reversed gnomon.

What the motivation was for this presentation is not so easily envisaged. In contrast to Disraeli's extensive political career, Philip Lybbe Powys barely registers in Hansard;[6] there are no recorded speeches, though assumedly he "always voted at my party's call". Since long speeches were commonplace in that era, if the dial is a reference to the speech (in which there are no references to dials), it was either an expensive and complicated satire, or a signal of approval from a political opponent. Personally, I cannot see any cause for currying favour: aside from political difference, having lost his position as Chancellor of the Exchequer in 1859, Disraeli led an ineffectual opposition and was not to return to his former position until 1866.

As no hint lay with Disraeli, I hoped that Powys's biography might shed some light. It starts unremarkably enough with education at Eton and Oxford, qualifying as a barrister, becoming a magistrate, marriage and children. However, research by the Powys family shows that 1861–2 were troubled years. To start with, the Powys children took legal action against their parents and others.[7] Then in October 1862, Philip Powys brought ridicule upon himself by becoming involved in a scuffle outside a public house (for which he was fined £10) and complaining in *The Times* newspaper about bullying at Eton College.[8]

Somewhere also around this time he left his wife and, without obtaining a divorce, started another family with one Fanny Worth, eventually settling in the outskirts of Brighton.[9] All these taken together, we get a picture of a troubled man making unwise gestures. Assuming that he did not personally know Disraeli, was he casting about for help? Did he envisage an early return to power and advantage by changing political allegiance? For that matter, did he have similar dials made for other leading politicians? I have to conclude that all of these matters are most likely lost to history.

Finally, I need to return to the dial itself. It did not stay at Hughenden, because it was presented to the National Trust by the Disraeli Society in 1947. Whether Disraeli presented it to an admirer, or it was disposed as part of his estate, is as impossible to say as how many hands it has passed through since its making. Its condition did, however, prompt me to a wider thought about the condition in which it has come down to us.

I notice that it is very highly polished – the reflection in the gnomon particularly shows this – and that in the crevices there is a good deal of white residue tinted green. From experience, I recognise these as signs of repeated polishing over a long span, and unconsidered polishing at that. If an item has been incautiously handled in one respect, then the possibility of other mishandling also opens. It might provide an alternative explanation for the reversed gnomon. Was it taken apart and carelessly reassembled? Did it need repair, or did someone hope that the base contained a hidden compartment? Short of dismantling it (which the National Trust is highly unlikely to consider) the possibilities remain unknown. We must wonder about this dial and make of it what we will.

ACKNOWLEDGEMENTS

My thanks to John Foad for the sharing of his notes and permission to quote them.

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Newbury 2019 – The Speakers

Left to right: David Brown, Doug Bateman, Kevin Karney, Patrick Arnold, David Burstall, John Davis, Louise Smail, John Foad, Ian Butson, Martins Gills, Ben Green, Frank King (photo: Mike Shaw). See pages 39-44 for a report on the day.

THE VOSS OBELISK ‘TIME FOR EVERMORE’

MARK LENNOX-BOYD and BEN JONES

Earlier this year I (MLB) completed the installation of this sundial which stands as an eye-catcher in the view from a recently constructed contemporary house in Cornwall. The house is built on a circular arc at two levels as shown in Fig. 1. You arrive by car at the higher level and immediately see garden steps to the lower level, and as you descend them you see the sundial. It is located at the centre of the arc and on the centre line of the steps. The position of the dial is shown in red (much exaggerated in size). Few people get the chance to make a dial in such a splendid position and I warmly thank my sister-in-law and brother who commissioned it. The dial is formed by an obelisk of equilateral triangular cross section, with one vertex pointing south.

My original hope was to use Burlington slate for the whole construction but that idea proved very expensive and so the compromise was made to have a combination of granite and slate which match well together. There are two blocks of ‘Portuguese Grey’ granite, each about one metre in height, the top one with a tetrahedral cap, and a block of Burlington ‘Broughton Moor Light Green’ slate 40 cm in height. All three have a honed finish and sit on a turntable of stainless steel on a concrete base which is disguised by a Cornish bank faced with loose stones of local slate. Such banks are a major feature in the surrounding area. In all, the Obelisk stands nearly 300 cm from ground level (Fig. 2).

Fig. 2. Overall view of the Obelisk.

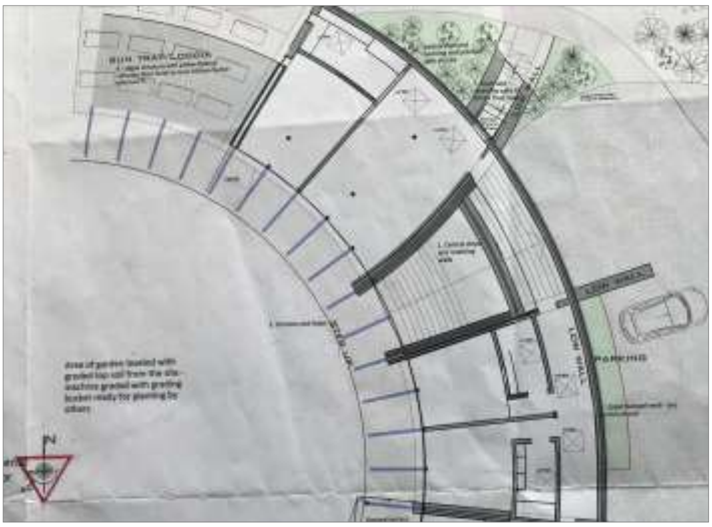

Fig. 1. Position of the Obelisk.

It is clear that the two dials (Figs 3 and 4) are declining 60°, one to the east and one to the west, and are also reclining, in fact 1.30° from the vertical. The third face (Fig. 5) which faces north is decorated with a sun symbol and a table of corrections, much simplified. The dials are calibrated for Greenwich Apparent Time, and so adjusted for longitude.

The Granite and Slate

A section (S–S) of the granite and slate is shown in Fig. 6. A and C with D each in one block are of Portuguese granite, cut in Portugal, and equilateral in horizontal cross-section. The top of A is shown in section but the three edges are each 40 cm long, which of course cannot be shown on this plan. B is 40 cm high and cut by Burlington. Needless to say, I was worried about the accuracy of the cutting, with two companies in two different countries at

Fig. 3. West-declining face.

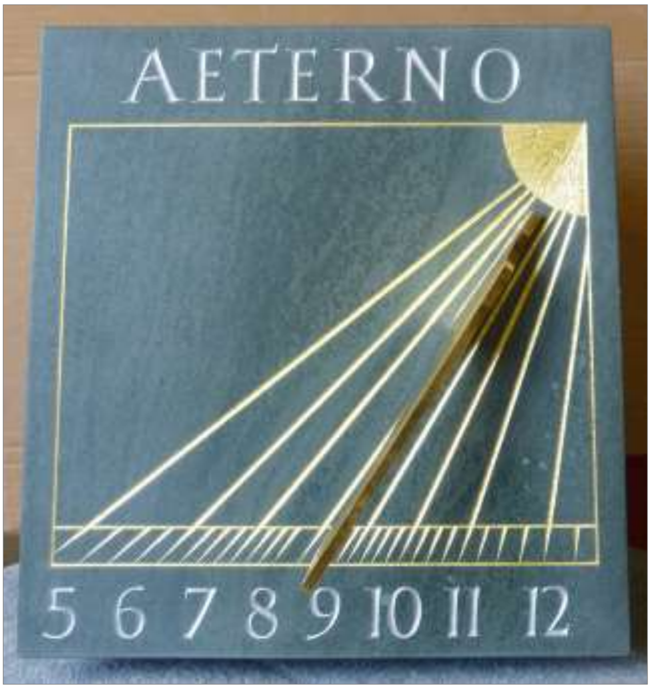

Fig. 4. East-declining face.

Fig. 5. North face.

work. If the slate B had been larger than A and C where they joined, even by as little 2 mm, it would have looked bad. So I decided to make the slate B very slightly smaller. The sides were specified to the quarries as: top of A 40 × 40 × 40 cm, bottom of B 39.4 × 39.4 × 39.4 cm, that is, 6 mm shorter. A similar reduction was made for the top of B in relation to the bottom of C. In the event both quarries worked to an accuracy of 1 mm and the slate is therefore inset very slightly from the granites. All three main pieces were drilled top and bottom with centre holes of 22 mm diameter and three other holes of 12 mm diameter to take rods of 20 mm and 10 mm with epoxy. All holes were to a depth of 100 mm.

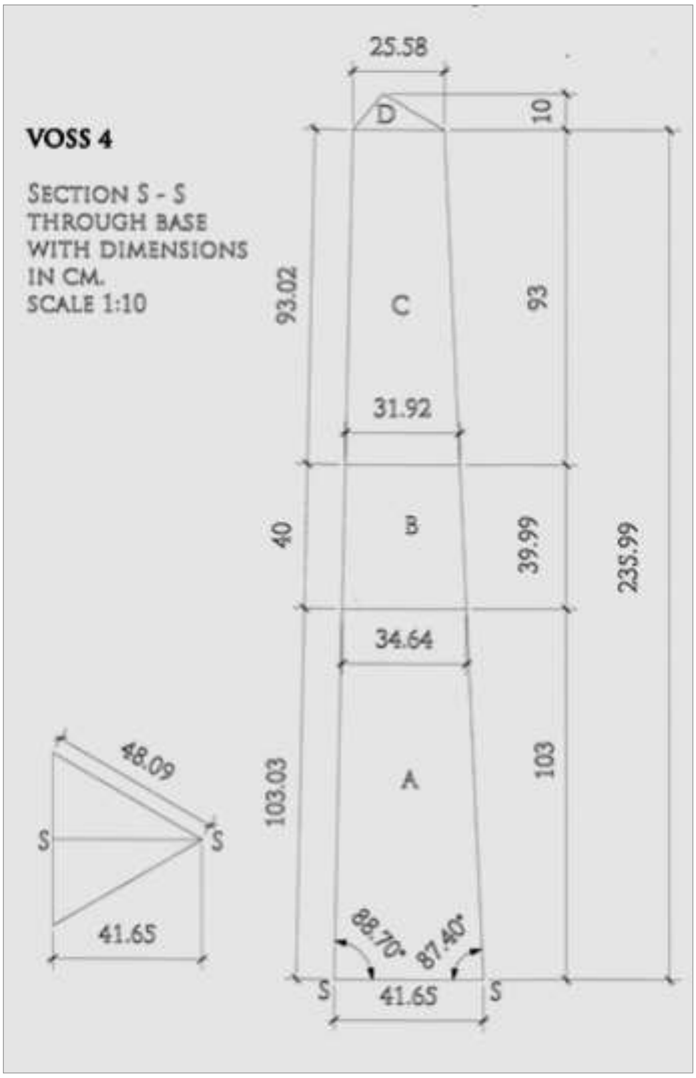

Fig. 6. Section of the Obelisk.

Fig. 7. Foundation and turntable.

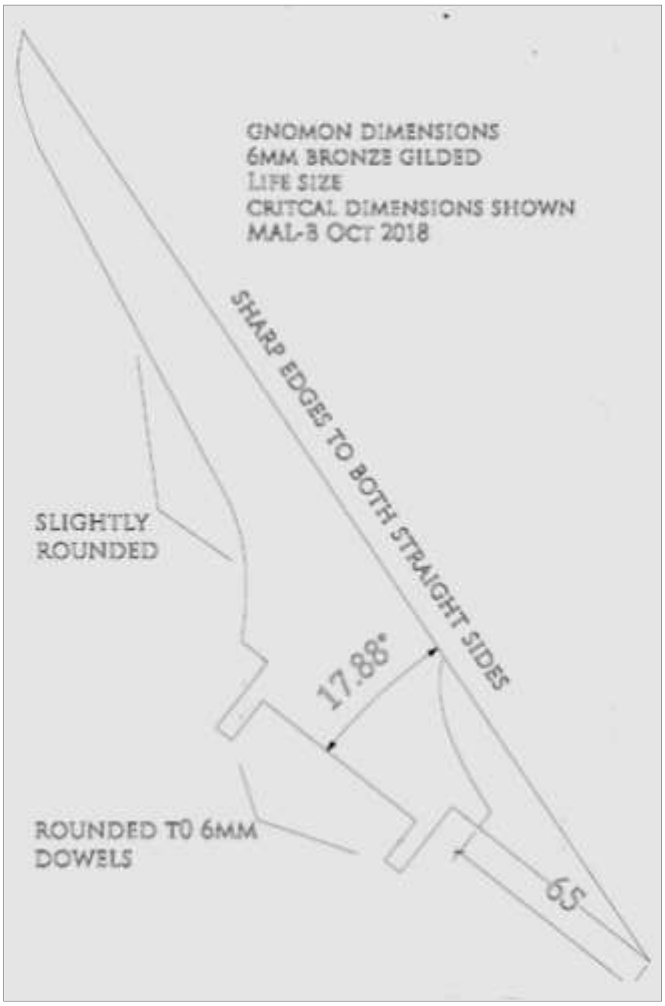

Fig. 8. Gnomon.

The Base and Metal Work

I want my dials to be as accurate as is possible, and on a project like this it is easy to erect an obelisk with an inaccuracy of at least half a degree in direction which would be very noticeable. Look at Fig. 7, which shows the concrete foundation and the turntable. The concrete rises to about 40 cm high from ground level and is an irregular hexagon in shape. It was cast aligned with the orange cord which had been put in position precisely north–south by an engineer. It is important to have very strong foundations for a pillar, liable to subsidence, and, given the location, wind of gale force, and so there is a much larger block of concrete supporting the hexagon, 100 × 100 × 50 cm deep, as advised by the engineer.

The two stainless steel plates can be seen. The lower one has six levelling bolts (each with two nuts and two washers) on extending tabs with a fixed central bolt which penetrates the top plate. The tops of three locking bolts can just be seen penetrating slots on the lower plate. The base of granite A fitted the top plate precisely. Visible also are three 'L' shaped (actually 91.3° not 90°) brackets which were later used to tie the bottom of A to the foundation. There were three more brackets (not shown). I have used turntables for two earlier dials, the Buscot obelisk and the Tetrahedron cairn, both described in the *Bulletin*.[1,2,3]

The design for the two gnomons is shown in Fig. 8. The slanting edge has the calculated angle of 17.88° but does not reach the plane of the dial faces as is usual. Instead, it is truncated with a curve that reaches down to a ridge on the dial face which ends 65 mm from the point where the hour lines would, if extended, converge on the dial face. This is to allow a view of the sun symbol unrestricted by the gnomon. As you can see the quadrants are carved with a ripple and gilded.

Erection and Orientation

The weight of the massive three pieces was initially a worry but I was reassured that the combined weights of A and B of 350 kg would not be so great as to prevent the turntable from functioning because of friction between the two plates. The plate assembly was levelled and a dab of cement locked each of the six bolts to the concrete. Lifting ropes were fixed to the bucket of a digger and A was easily lowered into its place with a dab of epoxy on the protruding central rod before it was manhandled into its precise position on the top plate (Fig. 9). The four stainless steel connecting rods were then epoxied into A, and B was lowered onto A with epoxy smeared on the four rods and on the surfaces. On a sunny day the builder Tony Elliot tapped the granite until it was correctly orientated measuring from the meridian string line set out using GPS by the engineer. He also had the sun to check by. The top plate was then locked to the bottom one. Concrete was then inserted into a simple shutter round the plates so that A sits wholly on concrete and the two plates. The six brackets were then

Fig. 9. Lowering block A onto the base plates.

fixed with bolts, nuts, washers and epoxy into holes previously drilled in A (by the Portuguese quarry) and also fixed similarly in holes drilled in the concrete. Finally, C with D was lowered with straps tethered to it and to the JCB, with epoxy on the joining rods and joints.

The Design and Suppliers

Ben Jones engraved the three faces to my design, developed from the Shadows software package, as usual beautifully with his lettering and numerals and gilding. One of the features of a pair of dials declining as in this design is that it is possible to engrave all the hour times along a horizontal row at the base. In any south-facing vertical dial it is necessary to have some of the hour times placed vertically on the left and right sides of the main area. Had it been necessary to place hour times to right and left it would have been essential to make the slate much wider and the whole design would have appeared clumsy. I may be accused of fudging because the figure 8 on the west face should be on the right vertical but I find putting it at the base acceptable. As the Chairman has pointed out there is a period of about four hours when the sun shines on both dials. The east face could have been delineated until well past 12:15 and the west face much earlier than 12:15 but once again I did not want numerals on the left or right sides. I also find my layout pleasing as well as somewhat different from the norm. The north face has corrections on the appropriate dates for all maxima and minima in equation-of-time values, as well as several intermediate dates. This provides sufficient information to tell clock time to within a minute, mostly by interpolation between two values.

The granite was supplied by the Lantoom quarry in Liskeard who ordered it from their supplier in Portugal, and the slate by Burlington. Both firms must be congratulated for having the material cut to an accuracy of 1 mm, and the holes drilled with precision. Will at Lantoom took immense trouble with the Portuguese quarry, and Burlington was highly reliable as usual. My friend John Huddlestone of Lancaster made the bronze gnomons and the stainless steel turntable and other metalwork. The obelisk was built by Tony Elliot, a local builder, who did a fine job. The foundation and turntable are disguised by the Cornish bank, which was built later without my supervision. I had intended it to slope at a lesser gradient and so wider at the base and faced with horizontal rather than vertical slabs, but I hope it will look better when covered with moss and other vegetation. A Latin scholar friend translated my invented motto into Latin.

Everyone involved worked with great care and to great precision without error, including, thank God, myself. I hope the result looks relaxed, but as I look at my thick file of printed emails and 15 different plans I recall that the process of design was hard work and enjoyable but not relaxing. An immense attention to detail was shown by everyone involved, especially Ben Jones who now adds his comments about other practical difficulties.

Ben Jones Writes:

This was a very nice job for me to work on. Mark did all the designing, calculating and dealing with the clients, Tony Elliot the builder did all the fixing and, best of all, a surveyor using GPS marked out a very precise meridian line by which to orientate the dial.

Setting up a dial is often the unhappiest part of the job especially when relying on sunshine to orientate the dial. Clouds get in the way and rain and overcast skies show no respect for deadlines. And so it was on a rainy overcast day earlier this year that a sundial maker, a builder and a surveyor gathered to work out a method by which the builder could set up and correctly align Mark's obelisk sundial.

First the surveyor, using GPS, marked out the meridian line running through the site where the obelisk would stand. To do this two batter boards were set up (north and south) as far from the dial site as possible. On their cross bars (like small goal posts) the surveyor marked the points precisely north and south from the centre of the site. A string line stretched between these points would lie exactly on the local meridian. This line would allow the builder to position and orientate the base plate on which the obelisk would stand (Fig. 7).

Once the first granite block was in place the original string line could not be used as it would have had to run through the granite block, so marks for a second line, parallel to the first, were also made. From the second string line the builder could check the granite's orientation. In theory it should be fine if carefully positioned on the correctly orientated stainless steel base but the base might shift, even slightly, when the granite was being stood on it.

There are of course a number of norths: magnetic, grid as well as true north. If you have any doubts about your surveyor's reliability, asking for all three should help you establish the correct north.

One feature that struck all of us working on the dial, which stands in the centre of the semi-circle of the house, was the echo that the house created. If we spoke when standing next to the dial, there was an echo. But if we stood even just a few feet away from the dial, the echo would be gone.

Slate is a dense and heavy material which means that while the dial block was not large it was too heavy for me to lift reliably. At the same time, it was also too small for two people to pick up easily and carry without bashing heads and standing on toes. My answer was to use an engine hoist to lift the slate up onto the banker (workbench) and then use wooden rollers and a 'miller' to turn it over. By securing the dial block to a small wooden pallet, two or more people had ample room to get a firm hand hold, lift and carry it. A miller is a disk or some small piece of wood placed centrally under the block upon which even very large and heavy blocks can be spun round quite easily.

The gnomons were fitted into slots in the dial faces. The slots were made with hammer and chisel, followed by careful drilling and then using a Dremel engraving tool with a coarse tile cutter bit.

The chisel is used to create a shallow slot. A chisel can only go so deep before the back of the tool makes damaging contact with the delicate top edge of the slot.

A drill with a sharp drill bit is then used to remove a lot of material in the centre of the slot. It is a rough tool and would easily 'lift' the surface of the slate if it were used directly into the slate. The chiselled slot protects the delicate top edge by keeping all the drilling well down, ¼″+, below the surface.

The Dremel tool is slow and dusty but will gently straighten up the sides of the slot.

The job is easier and less stressful if a gnomon has a plate to cover a ragged slot. But even slim plates would have spoilt the look of this dial.

Positioning the gnomons was slightly tricky because they are cut short and do not actually touch the surface of the slate where the centres of the dial were marked. To position the gnomons I first set a dial face up so it was horizontal. Using heavy set squares, the gnomon was positioned over the sub-style lines. Then the gnomon was tapped back and forth until a straight edge on the gnomon's style edge touched the dial's centre points. Having the dial centres off the dial face would have called for some very precise measuring and a lot of faffing about. Gnomons can be fixed into their slots with either sloppy neat cement or polyester or epoxy resin.

All incising was carried out with conventional tungsten tipped chisels and a mallet. For the gilding I used Kolner Rapid Size. This is yellow and is workable from 15 minutes to 8 hours from application. This length of working time seems reliable and makes gilding very easy. Most of the gold sizes I have used in the past rarely become workable near the times they are sold for: 1, 8, 12 or 24 hours. This has usually made gilding a frustrating and time-consuming business.

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3. These two, as well as La Meridiana and other of my designs, are described on my website *www.romevilla.co.uk*

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Lunchtime at Newbury 2019

Photos by Martins Gills. *See pages 39-44 for a report on the day.*

CORD SUNDIAL IN ’s-GRAVELAND

PETER de GROOT

This article was first published in *Zon & Tijd* 2019.2; English translation by Mary Keane.

The Gooi en Vechtstreek observatory, ’s-Graveland, Netherlands organises solar viewing afternoons on the first Sunday of the month during the summer. Visitors have the opportunity to view the sun through the telescopes (fitted with a sun filter). Sometimes sunspots or a prominence are visible; most of the time the sun is visible as a bright orange. We felt that we should have more to offer to children.

I therefore suggested an interactive sundial for the observatory – a sundial by which children are expected actively to read the time. One possibility is an analemmatic sundial. It has its time scale on the ground. The child, acting as shadow caster (gnomon), can read the time by standing at a certain point, depending on the month of the year.

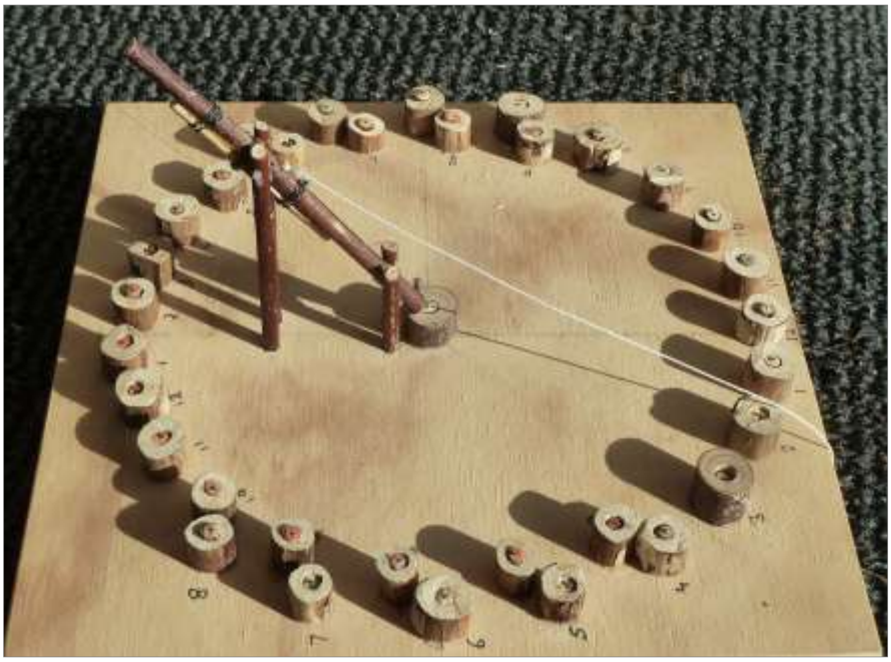

Fig. 1. Scale model of the combination sundial; the right side is south facing. The black hour points of the cord sundial form a large circular arc on the right side. The red hour points of the horizontal sundial lie on a slightly smaller arc to the left.

Another type of sundial, a cord or shadow plane sundial, can be found at Keelven near Someren. The cord sundial caught my attention. A cord is attached to a pole and the visitor walks with the cord tightly stretched along the hour scale until the shadow of the cord falls on a particular point (as discussed below).

To solve the eternal problem of whether the sundial should give solar time or summer time (daylight saving time), I wanted to combine the cord sundial with an ordinary horizontal sundial. The cord sundial would indicate local apparent time and the horizontal sundial would give an approximate indication of Central European Summer Time, or zonal apparent time plus one. In the case of the Netherlands, that means the local apparent time at 30 degrees east.

Figure 1 shows a model of the planned sundial. The cord is attached to the polar style of the horizontal sundial.

Calculations

How can the calculations for this sundial be done? One possibility is to do them graphically on paper. However, in the case of a large sundial 10 metres in diameter, it is difficult to transfer accurately a drawing on to such a large design. One has to design it in the field.

Two years ago I wanted to make a sundial with a diameter of 10 metres. However, after I had made the model I decided to change the diameter to 7 metres. On the day before the digging was due to begin I wondered whether the dimensions were not too big. I laid two slats (each 2.7 metres) in the living room with two buckets placed upside down at each end (the weather was wet and then these things happen indoors!). I felt that these dimensions were big enough.

With the help of a custom-made Excel program, I calculated the sundials with diameters of 6.5, 6, 5.5 and 5 metres. The following day I laid the slats on the ground with a tree trunk log at the end. I felt that a diameter of 5.5 metres was large enough and that it was a manageable size. I had an area as big as a football pitch but I found that this size of 5.5 metres was suitable and viable for this terrain. To ensure that the two hour-point arcs would not collide I moved that of the horizontal sundial 50 cm inwards so that its diameter was 4.5 metres.

In the Excel program the coordinates of the hour points were calculated. These coordinates are easier to plot in the field.

Solar time	X-axis	Y-axis
05:00	2.60	0.89
06:00	2.75	0.00
07:00	2.60	-0.89
08:00	2.22	-1.63
09:00	1.70	-2.16
10:00	1.14	-2.50
11:00	0.57	-2.69
12:00	0.00	-2.75
13:00	-0.57	-2.69
14:00	-1.14	-2.50
15:00	-1.70	-2.16
16:00	-2.22	-1.63
17:00	-2.60	-0.89
18:00	-2.75	0.00
19:00	-2.60	0.89
20:00	-2.22	1.63

X-axis	Y-axis	Summer time
-1.94	-1.15	06:00
-2.20	-0.49	07:00
-2.24	0.25	08:00
-2.04	0.94	09:00
-1.68	1.49	10:00
-1.24	1.88	11:00
-0.78	2.11	12:00
-0.31	2.23	13:00
0.15	2.24	14:00
0.62	2.16	15:00
1.09	1.97	16:00
1.54	1.64	17:00
1.94	1.15	18:00
2.20	0.49	19:00
2.24	-0.25	20:00
2.04	-0.94	21:00

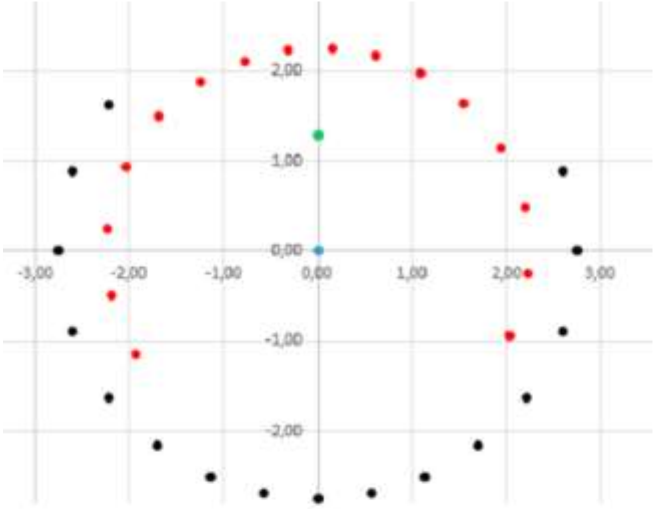

Fig. 2. Work list (above) and diagram from the computer program for positioning the hour points in the ground. The beam from the cord sundial (black points) is 2.75 metres and from the horizontal sundial (red points) 2.25 metres.

Length of the Polar Style

I wanted to ensure that the shadow of the polar style would fall on the hour points at the summer solstice. How long would the polar style need to be? The horizontal sundial has a radius of 2.25 metres. The calculation is based on Fig. 3.

P is the length of the polar style; g, the gnomon height, is the height of the top above ground level.

The latitude is $\phi = 52°$.

The maximum solar altitude on this latitude and at the maximum declination $\delta_{max} = 23.5°$ is:

$$h_{max} = 90° - \phi + \delta_{max} = 61.5°.$$

We want a + b to be at least 2.25 metres.

In this situation: a = g / tan(52°) = 0.781 g
and b = g / tan(61.5°) = 0.543 g.

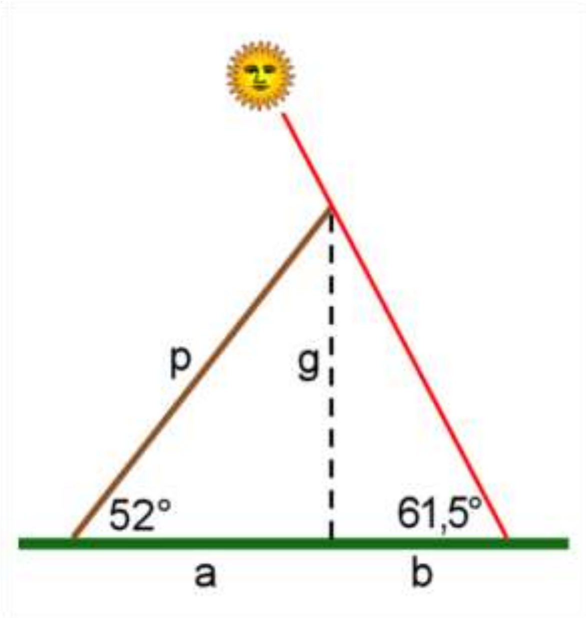

Fig. 3. Diagram (model) for the calculation of the length of the polar style. The brown line is the polar style. The right side is north facing.

Fig. 4. Determining the north–south line.

Thus a + b = 1.324 g = 2.25 metres,
from which follows: g = 1.70 metres,
and p = g / sin(52°) = 1.269 g = 2.16 metres.

The Implementation

On 20 January 2019, the logs were positioned for the hour points. A condition imposed by *Natuurmonumenten* (Dutch Society for Natural Conservation) for the placement of the sundial was that no kinds of *preserved* timber should be

Fig. 5. The trench being dug for the placement of the hour-point markers.

Fig. 6. The square has been placed and the hour-point markers made from logs are being placed.

Fig. 7. Construction of the base of the polar style: a line drawn from the centre of the top of the polar style extends to the centre of the coach bolt that has been hammered into the section of trunk.

used. We therefore chose wood from the *Robinia Pseudoacacia* which is very sustainable. It is difficult, however, to obtain long straight sections of *Robinia* trunks.

Determining the North–South Line

Firstly the north–south line needed to be determined. In 's-Graveland the sun rose at 8:37 CET (Central European Time) and set at 17:04. These two times (8:37 and 17:04) added together equals 25:41, divided by 2 equals 12 hours and 50.5 minutes. At that time the sun is exactly at its highest point in the south. I drove a pole vertically into the ground and at 12:50 I positioned poles along the shadow line which marked the north–south line (Fig. 4).

Now a start could be made with making the holes for the supports for the polar style and with the digging of a trench. In this trench the logs, which form the hour points, could be placed in position. In the first instance I also wanted to dig holes for the logs; however, it was much easier to dig a trench (Fig. 5). The logs can easily be aligned in this way.

A square, made from timber slats, was placed around the trench. The square was orientated on the north–south line and had the polar style as its midpoint. This whole area was levelled using a laser spirit level, the baseline being approximately 30 cm above ground level. With the assistance of this square and two *cross lines*, the coordinates for the hour points were positioned and each log was placed exactly on its designated position (Fig. 6).

Subsequently the polar style was placed at an angle of 52° to the north. For the polar style I used not a *Robinia* pole but a straight-planed pole from Douglas Fir wood (Fig. 7).

The Hour Numerals

I had intended to cut the Roman hour numerals out of Perspex with a laser cutter. While this produces lovely numerals, Perspex is too brittle. The next idea was to make the numbers using a 3D printer. This would also produce nice numerals but the printer thread is biodegradable and therefore not suitable for use outdoors. In the end I made vinyl numerals glued onto an aluminum plate.

The final appearance of the sundial is shown in Fig. 8.

How is a Cord Sundial Used?

One of the intended uses of the sundial was for educational purposes. A sundial is a clock which derives its time from the position of the sun in the sky. When the sun is at its highest point it is 12 o'clock. Reading the time with a cord sundial is done by standing outside the circle, stretching the cord tightly, moving to the left or right until the shadow line falls exactly on the metal point of the central post. The shadow falling on one of the hour markers of the larger circle indicates the time (Fig. 9).

The cord sundial gives local solar time. At 12 o'clock local solar time the red cord is neatly in line with the polar style, the middle of the central post and the 12 o'clock marker. The horizontal sundial gives CEST (Central European

Fig. 8. The completed combination of a cord sundial (with its hour points in the foreground) and a horizontal sundial, with the supported polar style.

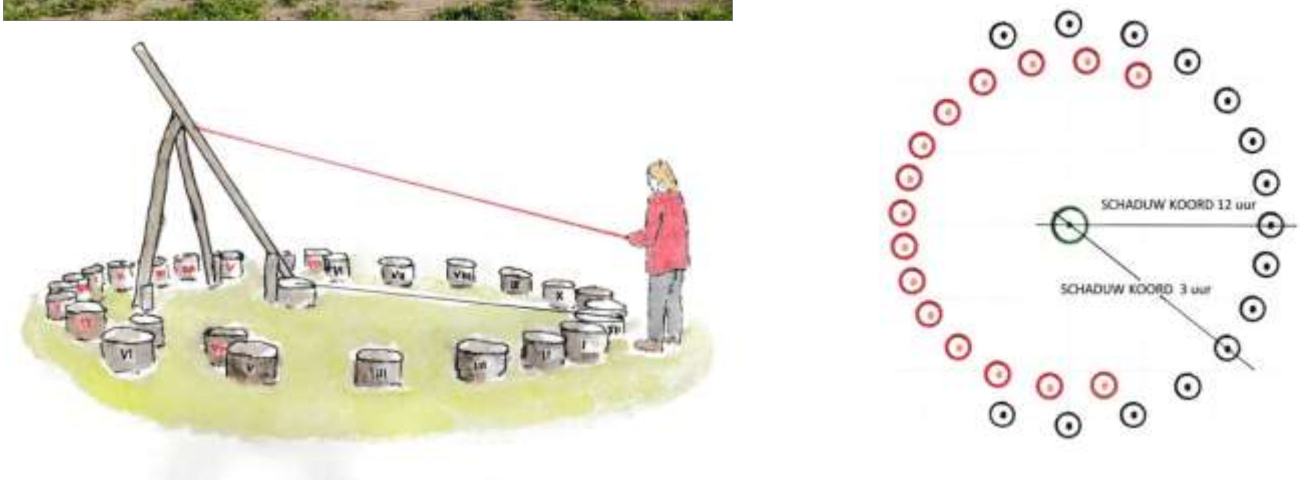

Fig. 9. Using the cord sundial. The shadow of the cord must fall on the centre of the base point of the polar style. The right side is south facing.

Fig. 10. The sundial at 12 o'clock solar time. The shadow of the cord falls on the middle of the polar style and, on the bottom right hand side of the photo, over the grey metal point on the 12 o'clock marker. The shadow of the polar style can be seen behind it, between the poles with red numerals, approximately two thirds of the distance between 1 and 2 pm. This is 1:40 pm (daylight saving time).

Summer time), except for the Equation of Time. The time scale on this circle is corrected for 5° E and for daylight saving time and is 1 hour and 40 minutes ahead of solar time (Fig. 10).

The Precision of the Time-telling/Reading of the Cord Sundial

The cord creates a thin shadow line and the solar time can be read accurately on the large circle with the white hour points. Because the shadow plane is slanted (except at 12 o'clock solar time), the height at which the time is read affects the accuracy of the time reading. The time determination has to take place at the level of the top of the hour markers. This is easy to do at the whole hours. However, in Fig. 11 the shadow falls on the ground between two markers, 30 cm below the base level. The time can be accurately read only by placing, for example, a stick on top of the two hour points.

Fig. 12. From left to right: the mast for the weather station, the double sundial, and the Observatory Gooi en Vechtstreek.

The Horizontal Sundial

The northerly circle with the red hour numerals is the time scale for the horizontal sundial. The time on this dial face cannot accurately be read because the polar style is quite thick. In the morning, therefore, while reading the time, one should use the left edge of the shadow line, at around 12 noon you need to use the middle of the shadow line and in the afternoon you use the right edge.

Another factor affecting the accuracy is that the EoT has been ignored. However, in the summer (from the beginning of April until mid-September) the EoT amounts to 6 minutes at most, which is hardly significant in light of the broad shadow.

In Conclusion

The result is a fine sundial which fits in well in its surroundings (Fig. 12). The volunteers at the observatory receive many questions about it. A scale model of the sundial can be found in the visitor centre, with an explanation of how to use it to tell the time. There is also an information panel beside the sundial itself. In addition, the volunteers give information about the sundial during solar viewing afternoons.

Fig. 11. Between the whole hours, the time can be accurately read by using a reed stick.

Sundial commissioned by: The Royal Dutch Meteorology and Astronomy Association, Gooi en Vechtstreek.

Design and construction: Peter de Groot

Calculations: Many thanks to the anonymous calculator for his Excel program

Location: Visitor centre Natuurmonumenten ’s-Graveland and observatory Gooi en Vechtstreek

Coördinates: 52° 15′ 3.9″ N, 5° 07′ 30.2″ E

Sponsors: Rabobank Gooi en Vechtstreek in Hilversum,
Natuurmonumenten ’s-Graveland
De Nederlandse Zonnewijzerkring

Fig. 13. Peter explains how to use the cord sundial to a young visitor. Photo: Astrid van der Werff.

Peter de Groot worked as a hand therapist in an Academic Hospital. After retirement he became enthusiastic about sundials after following a course about them (thirteen digital lessons given by De Zonnewijzerkring Nederland). He is now the treasurer of De Zonnewijzerkring. He is a volunteer in the Observatory of ’s-Graveland and enjoys explaining the sundial near the observatory on sun-watching afternoons in the summer (Fig. 13). He can be contacted at *peter.degroot@hccnet.nl*

AN INSTRUMENT FOR DIALLISTS?

SUE MANSTON

A very interesting and unusual enquiry arrived in the BSS Help and Advice Service inbox in September. David Boles has been collecting scientific instruments for many years, but the purpose of one particular instrument is a puzzle; he wondered whether it was used for measuring the angle of a sundial gnomon and also for checking a sundial's orientation.

The brass instrument comprises a compass and an inclinometer with a spirit level and scale (Fig. 1). The inclinometer is used to find the angle of a slope from the horizontal, measured on the scale from 0 to 90 degrees. The reverse of the scale is inscribed "T. Mason Dublin" (Fig. 2).

The very attractive compass (Fig. 3) has two sets of scales: 0–360 degrees and four lots of 0–90 degrees. The compass is designed to be easily removed, and a brass arm locks the compass needle up against the glass for safe transport. The endstone in the centre of the compass appears to be agate.

The instrument, which probably dates to the 19th century, is 16 cm long and has its original mahogany box (Fig. 4).

Fig. 1. The instrument, showing spirit level, scale and compass (photo courtesy of David Boles).

Fig. 2. Inscription "T. Mason Dublin" on the reverse of the scale (photo courtesy of David Boles).

Fig. 3. The compass (photo courtesy of David Boles).

The purpose of the inclinometer is clear, but it is the addition of the compass which is the enigma. So a little bit of research has produced the following suggestions for use.

1. Measuring the angle of the gnomon on a sundial and checking the orientation of a dial (Fig. 5). This seems unlikely as no such instrument has been described before.
2. Finding the reclination and declination of a slope for siting a sundial. Reclining/declining sundials are very rare so it would be strange to see an instrument made specifically for this purpose. It would only work on a reclining surface and not on a proclining surface. Also, the instrument measures the angle from the horizontal, whereas diallists usually work with the angle from the vertical.
3. Adjusting the position of a sundial so it will work at a different latitude. A wedge can be used to tilt a sundial which has been designed for another latitude. Fix the instrument to the gnomon, set the scale to the latitude of the dial's new site, then tilt the dial plate until the spirit level is horizontal.
4. Inclinometers are often associated with gunnery (to get the muzzle of a cannon at the right elevation) so the addition of a compass could conceivably allow pointing at a target you cannot actually see. But military instruments are not usually finished so finely.
5. It could be used for surveying – finding the angle of a slope and the direction of some far-off reference point.
6. It might be used by geologists for measuring the strike (direction) and dip (slope) of rock strata.

Fig. 4. The instrument and its mahogany box (photo courtesy of David Boles).

Fig. 5. Checking the angle of a gnomon (photo courtesy of David Boles).

T. Mason Dublin

Seacome Mason was born in 1745 and trained as an optician. In 1780 he established Thomas H. Mason and Sons in Dublin. In the early days the company was known as a supplier of optical and mathematical instruments, including equipment for science and surveying. Sale items included telescopes, glasses, microscopes, concave and opera glasses, and celestial and terrestial globes of all sizes.[1]

Seacome had nine children, including Thomas (1781–1837) and Jonathan (1784–1849). The partnership of Thomas and Jonathan Mason took over from their father and continued to use his premises at 8 Arran Quay. In 1813 they moved the business to 11 Essex Bridge.

There are several known sundials signed "Mason", including a large bronze dial in the Armagh Museum and portable dials (including a mechanical equinoctial dial) in the National Museum in Dublin. It is difficult to differentiate between members of this family as many items were simply signed "Mason" with no initial. However, an equatorial and a 'circular', signed I (or J for Jonathan) Mason and giving the address as Essex Bridge, Dublin, have appeared in sales.[2]

Thomas's grandson, also called Thomas (1840–1912) was involved in the business as well.[3] Whilst it seems very likely that David's instrument is by one of these Thomas Masons, it is uncertain which one. The company is still in business today, managed by the seventh and eighth generations of the Mason family.[4]

Conclusion

It is very unlikely that this instrument was designed for use in dialling. There are, however, several ways in which a diallist could make use of such a device. Surveying or construction seem possible uses, but my preferred option is the geological tool. If anyone reading this has any better ideas, please let me know.

ACKNOWLEDGEMENTS

Grateful thanks go to John Davis, Frank King, David Boles and Stan Mason, Chairman of Mason Technology.

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A HELICAL EQUINOCTIAL DIAL

MIKE COWHAM

Our recent trip to France, close to the autumn equinox of 2019, took us to some interesting parts and allowed us to study some of their fine sundials. The one that particularly interested my wife Val and me was this helical equinoctial dial (Fig. 1). It is positioned close to the church in the village of Fouzilhon in Hérault, about 15 km north of Béziers. It is not a common design of dial and was not really familiar to me, so I needed to investigate its features. Unfortunately, when we arrived in the morning, the dial was still shaded by some trees that were fairly close. We therefore decided to return later, in mid-afternoon, but this was just a little too late as another tree was keeping most of the sun off the dial! However, a few spots of light got through its leaves, owing to a gentle breeze, and let us see how the dial would actually function.

Fig. 1. Helical equinoctial dial in Fouzilhon.

Fig. 2. Information plate just in front of the dial.[1]

This dial is quite new, being made by Pierre Verine in 2015 (Fig. 2). It is relatively large, standing at least two metres high. It is made from Vosges granite, the helical chapter ring being made in three pieces joined together.

The dial gnomon is of a slightly smaller diameter at its centre with a helical slot allowing a short line of sunlight to fall on the dial's main hour scale (Figs 3 and 4). It is seen in Fig. 4, here crossing the equinoctial line. The split gnomon appears to be made from two separate pieces of stone which are joined together at the top and bottom

Fig. 3. Gnomon detail showing the spiral cut allowing a thin 'slit' of sunlight to fall on the hour scale.

(Fig. 5). Some other helical sundials have been described in the *Bulletin*,[2] but this feature of the dial, to my knowledge, has not been seen before. It was obviously quite difficult to make and would also have been quite expensive.

Fig. 4. 'Slit' of sunlight as seen on the hour scale.

Fig. 5. The dial viewed from the top end of its gnomon.

The hour scale itself is engraved on the inside of the helical chapter ring. It is also divided with lines to show the zodiac signs (Fig. 6). In this figure the lower joint of the granite, a 'Z' shape, can be seen crossing the scales.

Close to the dial is a notice showing the Equation of Time so that visitors can check the time shown against their watches compared with Greenwich time. The text therefore describes how to add differences due to longitude of 12 minutes, 56 seconds as well as one hour for Winter and two hours for Summer time, to agree with their French time.

Fig. 6. The morning end of the hour scale.

REFERENCES and NOTE

1. The inscription translates into English as SUNDIAL / made by / Pierre VERINE / "The tranquility of Caen" / Member of the Guild of Stonemasons / Inaugurated on 3 October 2015 / Lydie COUDERC, mayor.
2. See, for example: Allan Mills: 'Helical sundials', *BSS Bulletin* 92.2, 21-3 (June 1992); Tony Wood: 'The Singleton dial', *BSS Bulletin* 25(i), 23 (March 2013); Barrie Singleton: 'The Singleton "Druid" helical dials', *BSS Bulletin* 25(iv), 50-51 (December 2013).

mandvcowham@gmail.com

IN THE FOOTSTEPS OF THOMAS ROSS

Part 29: Some Midlothian Sundials

DENNIS COWAN

In volume 5 of *The Castellated and Domestic Architecture of Scotland*,[1] Thomas Ross mentions a number of sundials in Midlothian, but this article will concern itself with only five of them.

The first three are at Oxenfoord Castle or Oxenford as Ross misnames it. He says:

"*There are three dials at Oxenford Castle. The first stands in the centre of the garden; it is a plain circular horizontal dial, with a marble dial-plate. The second stands in the old churchyard adjoining the castle; it is a square horizontal dial, and has also a marble dial-plate, which, in addition to the figures, has the name JAMES ANDERSON cut on it.*"

Oxenfoord Castle was originally built by the Macgill family and was a typical Scottish tower house. It passed through marriage to the Dalrymple family and in 1780 the famous architect Robert Adam was commissioned to incorporate the tower house into a new building; it was remodelled again in 1842.

Still owned by the Dalrymple family, it was used as a school for more than 60 years, but since 1993 has reverted to being a private house, also being used as an up-market wedding venue.

Unfortunately, Ross does not provide sketches of the first two sundials, but the one currently in the centre of the garden (Fig. 1) is obviously neither of the two mentioned, as it is a much-weathered octagonal stone sundial whereas the two Ross sundials are both marble, and circular and square respectively.

Fig. 1. The octagonal stone sundial at Oxenfoord not seen by Ross.

Fig. 2. The one remaining marble sundial at Oxenfoord, complete with dinosaurs.

Fig. 3. The Oxenfoord marble sundial on its baluster shaft.

However, a sundial in the front garden of one of the estate houses does appear to be the first one mentioned by Ross, as it fits his description of a circular marble sundial. As can be seen from Fig. 2, it must be an old one as it comes complete with several dinosaurs! It sits on a stone baluster shaft (Fig. 3) and has a broken gnomon. There are Roman numerals from 4 am to 8 pm read from the inside and there is a 15-minute scale with three dots on the half hour mark. It also has a noon gap.

Despite checking the churchyard and a thorough search elsewhere, I was unable to locate the other marble sundial. The gardener (who alerted me to the above sundial) was not aware of it either.

Fig. 4. Ross's sketch of the Oxenfoord cube sundial.

Fig. 5. Oxenfoord's cube sundial today near to the wall of the castle.

Ross goes on to say:

"*The third dial, of an extremely simple design, is the one shown by* [Fig. 4]. *On each face of the square pedestal there is cut a bear evidently the crest of the Macgills of Cousland, from which place this dial was brought. There are three dials on the block above. The dimensions of the dial are height of base (which is modern), 13½ inches; the pedestal, 17½ inches high by 15¼ inches wide; dial, 9 inches high by 8¾ inches wide; total height, 3 feet 10 inches.*"

This third sundial is still at Oxenfoord, but is located next to one of the walls of the castle (Fig. 5) and is not orientated correctly. As Ross says, it has three dials on the east, south and west faces and there are Arabic numerals throughout. It is in a poor condition and has lost its ball finial. All the sheet metal gnomons survive, although the one on the west face has partly rusted away (Fig. 6).

Fig. 6. The south and west faces of the Oxenfoord cube sundial.

Near to this sundial is a type 2 Pilkington and Gibbs Heliochronometer (serial number 730) with Arabic numerals (Fig. 7). According to the gardener, it was all seized up, which I confirmed, and was inhabited by a large swarm of wasps, which I decided not to confirm!

Fig. 7. The Oxenfoord Pilkington and Gibbs heliochronometer.

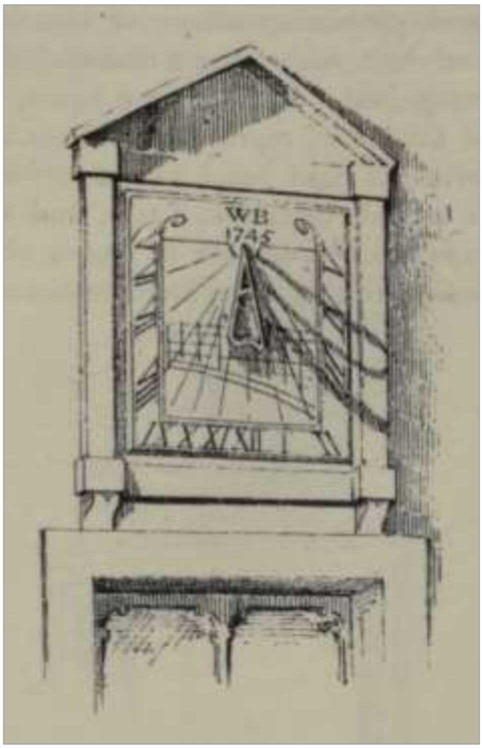

Fig. 8. Ross's sketch of the Dalkeith sundial.

Fig. 9. The Dalkeith sundial today with its fire insurance plaque above (inset).

Moving on, there was not too much to go on with the next sundial other than it was in Lugton, a district of Dalkeith, and the fact that it overlooked the river Esk, if indeed it still existed. Luckily, however, I found it almost straight away. Ross said:

"*There is a dial here, placed over one of the second floor windows of a house overlooking the Esk* [Fig. 8]. *It is a metal plate, and contains the initials W.B., and the date 1745. The panel with the pediment enclosing the plate are of stone, and date from early in this century.*"

The sundial today is just as Ross described it, except that he did not mention the fire insurance plaque above it with the number 2466 under shaking hands, which appears to be that of the Hand in Hand Fire & Life Insurance Society (Fig. 9). These were used in the 18th and 19th centuries as a guide to the insurance company's fire brigade, so would have been present in Ross's day and possibly from 1745 as dated on the dial. However, Ross suggests that the pediment and presumably the fire insurance plaque are early 19th century. The top part of the pediment appears to be lower today than it was in Ross's sketch, but there may be inaccuracies in the sketch.

Fig. 10. The Dalkeith sundial showing its position above the first floor window of the tower.

Fig. 11. The plaque above the Dalkeith sundial showing the date of 1853.

The vertical sundial itself has Roman numerals from 5 am to 5 pm with a quarter-hour scale, and faces a few degrees east of south. The gnomon with a nodus notch is complete and the declination lines are still just legible.

Ross said that it sat above a second-floor window, but there has never been a second floor on this house. The sundial sits above the first-floor window (Fig. 10). There is, however, a separate plaque above the sundial, again with the initials WB, but with the date of 1853 (Fig. 11). A conversation with the home owner confirmed that the turret on which the sundial is mounted was added in 1853, so that is not the sundial's original position. It is not known whether the sundial came from another building or whether it was simply moved to the turret in 1853. It would have been there where Ross saw it, but I cannot give an explanation of why he got its position wrong.

Next, Ross talked about the sundial at Mid Calder House and he said:

"*This dial* [Fig. 12] *is placed in the garden of Mid-Calder House. At some unknown period it got broken and was in danger of being lost, when Lord Torphichen had it repaired and placed on a new shaft and base. It has the constant features, and, in addition, a central portion, consisting of a narrow octagonal band, which is cut away beneath, and is then splayed out from the octagon to the square with sloping and perpendicular dials. The dialstone is 27 inches high, and the width across the horns of the book part is 13⅛ inches. The whole height as it now stands is 35½ inches, but it was doubtless higher in its original state.* [Fig. 13] *shows a side and back view of the dial.*"

Although Ross recorded this sundial at Mid Calder House (which was in Midlothian in Ross's day but is now in West Lothian), it was missing for a number of years. Apparently the 13th Lord Torphichen became somewhat unpredictable in his old age, and in the 1960s when he sold off part of the estate for a housing development, the sundial went missing. This was some seventy years or more after it was first feared that it might get lost!

Fig. 12. Ross's sketch of the Mid-Calder lectern sundial, now at Culzean Castle.

Fig. 13. Sketch showing the side and back of the Mid-Calder (Culzean) sundial.

It later transpired that it was in the possession of the County Council, although how they got hold of it is not known, and in 1971 they presented it to the National Trust for Scotland. The Trust eventually placed it in the walled garden at Culzean Castle in Ayrshire, one of the largest walled gardens in Scotland, where it remains to this day. However, it now stands on a square shaft and base rather than the octagonal ones when it was seen by Ross (Fig. 14).

Fig. 14. The Culzean Castle lectern sundial in the walled garden.

Fig. 15. View showing the north faces and the star on top of the Culzean Castle sundial.

Fig. 16. View showing the hemi-cylinder and south faces of the Culzean Castle sundial.

This sundial is one of the lectern type of which there are only around twenty-eight complete examples still existing in Scotland, and so it is a very important item. Lectern sundials come with or without a star on top and this one includes a star with dials in each of the angles and also on top (Fig. 15). The south face features the usual hemi-cylinder as well as several direct south-facing dials (Fig. 16).

Fig. 17. East, south-east and south faces of the Culzean Castle sundial.

Fig. 18. West, south-west and south faces of the Culzean Castle sundial.

It is basically octagonal in shape and there are dials throughout on the eight compass points including inclining, reclining, cup-hollows and heart-shaped dials (Figs 17 and 18).

The dial is in quite good condition with Arabic numerals throughout, although lichen is starting to encroach. Although I wasn't able to count them accurately, there are around forty dials with the vast majority of the gnomons complete, although they are replacements. It was last restored in 1984 by George Higgs, one of the very early members of the British Sundial Society.

The National Trust for Scotland are currently (June 2019) redesigning the whole of the walled garden, but it is planned that this sundial will continue to be the main focal point in the new layout.

REFERENCE

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ANDREW JAMES, FRSA HonMBHI

(5 June 1954 – 24 October 2019)

It is with the greatest sadness that we include the following obituary, much of which is adapted from the biography that Andrew wrote himself, when he was elected Master of the Worshipful Company of Clockmakers. Andrew was one of the wisest, calmest and deeply good men we were lucky to know. Everyone felt the greatest respect and awe at his knowledge, and his generosity in sharing it with patience and clarity.

Andrew at the 2017 Newbury Meeting (photo: Mike Shaw).

Born in Somerset, Andrew learnt from his father, before he went to school, that skilled hands could, with simple tools, transform raw materials into useful and beautiful objects. When he was nine his elder brother showed him how it was possible to dismantle and, more surprisingly, reassemble a watch, and thus his fascination with horology began.

After studying both Natural Sciences and Computer Science at Cambridge, he joined the Computing Development Department at the Central Electricity Generating Board and was soon given the task of creating software for a revolutionary new meter – the precursor of today's smart meters. He later spent 25 years as chief scientist for a meter manufacturer.

While never his career, horology always remained his true passion and from 2000 to 2016 he chaired the Wessex Branch of the British Horological Institute. In September 2018, the branch bestowed upon him the honorary title of Branch President. He was recorded in the Antiquarian Horological Society journal as a new member in September 1968 and his major contribution was the creation of the indexes for quite a few years, and these enjoyed the attention to detail for which everyone knew him.

Andrew combined a love of calligraphy and carved lettering with a strong interest in sundials. He produced a number of very finely carved slate sundials and had a particular interest in the technicalities of the Equation of Time. He became a member of the British Sundial Society in 1993.

Classical music had been another life-long interest of Andrew's and he sang bass in a considerable number of choirs and enjoyed taking part in some memorable performances of great compositions in wonderful venues around the country and abroad. Other interests included art, keyboard music, the countryside, cooking and wine. He was an enthusiastic student of blacksmithing, engraving, silversmithing, and painting in oil and watercolour.

He married Phyllida on 12 September 2009 and he was wonderfully aware of how lucky he was to have found such a gloriously supportive, loving and caring wife. Andrew, with Phyllida as his consort, became Master of the Worshipful Company of Clockmakers in January 2018. Halfway through his year he was diagnosed with spinal and lung cancer. Andrew showed a resilience to his illness which inspired all of us and he met the pain with courage and determination. Andrew continued as part of the team of Wardens to the end and 'attended' the meetings by phone. The loudspeaker phone was in the middle of the table and it certainly led to harmonious and measured meetings. His knowledge of horological matters was immense, on both technical and historical fronts. He will be very much missed.

Joanna A. Migdal

A SUNDIAL DELINEATED INSIDE A CONE

JOHN ARIONI

Abstract: Sunlight shining into a cone through a slit projects a strip of light onto the internal surface. From the position of the strip, one can tell the time. Quite separately, an aperture nodus projects a spot of light whose position indicates the solar declination.

In a location at latitude φ, a right circular cone with an opening angle φ rests on a horizontal surface along one of its generating lines (generators) which is aligned north–south (Fig. 1). The generator opposite (*GEN* in Fig. 1) will be parallel to the polar axis.

The cone is empty and has a slit of appropriate width centred on the generator *GEN*. Sunlight shining through the slit projects a strip of light onto the internal surface of the cone; this strip of light falls on a line that runs from the vertex to some point on the circumference of the base of the cone. The position of the point on the circumference depends on the time of day.

Given that the slit is polar oriented, it serves as a regular gnomon except that it produces a strip of light instead of a line shadow.

In analysing such a dial, it is convenient to consider the development (opening-up) of the cone as shown in Fig. 2. The development takes the form of a sector of a circle of radius *GEN* and angle AVB = θ = 2π.sin(φ/2) radians.

Construction of the Hour Lines

To draw the hour lines, we first recall that they extend from the vertex of the cone to the circumference of the base. Accordingly, for each hour line, we need to locate the point where it meets the circumference.

Fig. 3 shows a much-enlarged version of the cone touching the Earth's surface at latitude φ. The slit, which serves as a style, meets the base of the cone at point E. It is clear from the figure that the plane of the base is parallel to a vertical direct south-facing plane sundial at latitude (φ/2). The broken line drawn through point P shows the position of this hypothetical vertical dial with a style at E′.

We can mark out the hour lines of a vertical direct south-facing dial using standard methods and the result is shown in Fig. 4(a), where the dial plate is circular and has the same diameter as the base of the cone. The hour lines in Fig. 4(a) assume that the cone dial is at latitude 44° 10′ N (so the hypothetical vertical dial is at 22° 05′ N). The hour lines shown allow for a longitude offset of 9° 53′ from the relevant reference meridian.

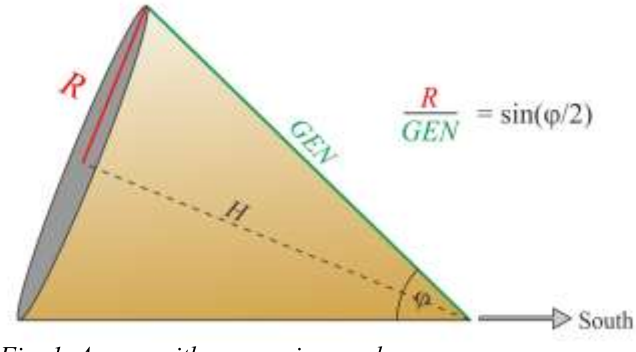

Fig. 1. A cone with an opening angle φ.

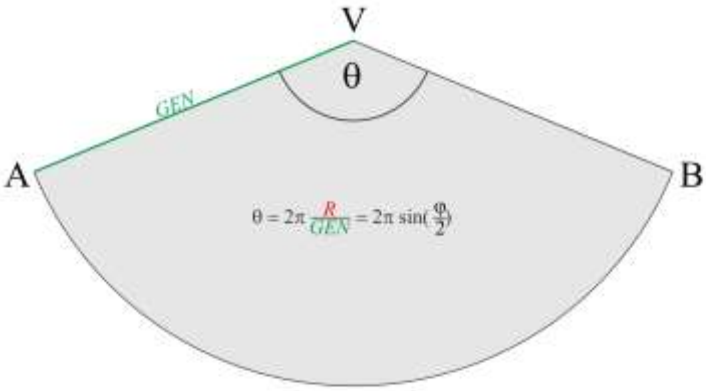

Fig. 2. The development of the cone on the plane.

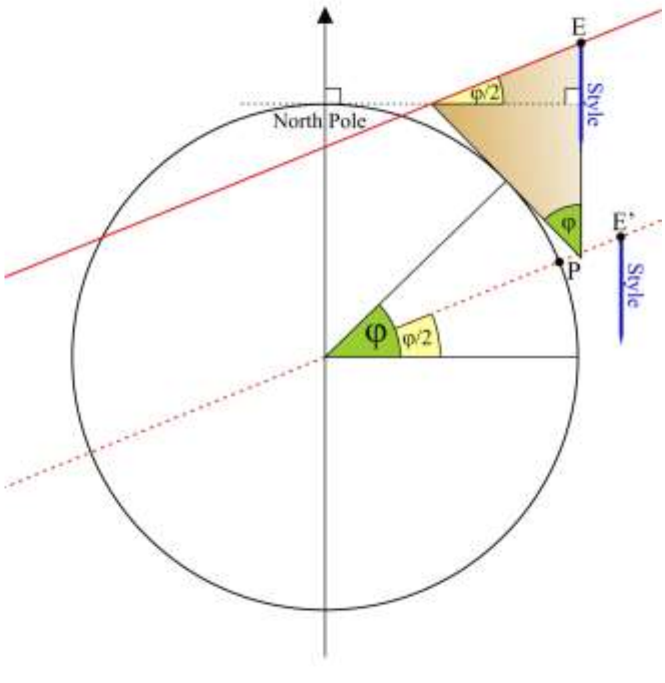

Fig. 3. The cone lying at latitude φ.

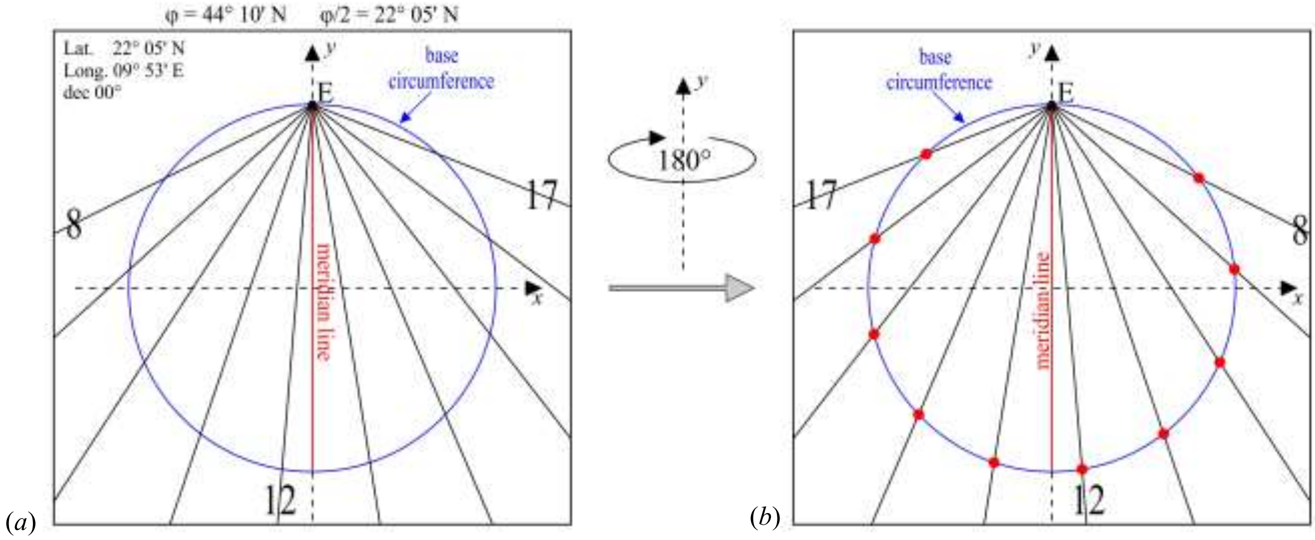

Fig. 4. (*a*) *Hour lines on a vertical direct south-facing sundial at latitude φ/2 marked out on a circle whose diameter matches that of the base of the cone.* (*b*) *The mirror image.*

Note that the south face of the base of the cone is the internal surface and it is more convenient to use the equivalent lines on the outer (north) surface of the base. These lines are those of the mirror image of Fig. 4(a) and are shown in Fig. 4(b).

We still have to transfer the positions of the points where the hour lines intersect the circumference of the base of the cone to the arc AB in Fig. 2.

Here we note Fig. 5(a) where the 10 o'clock hour line (shown in Fig. 4(b)) is used as an example. The angular offset of the point where this hour line meets the circumference from the point diametrically opposite E is shown as $\alpha(10)$. By the angle-at-the-centre theorem, this angle is twice the angular offset of the 10 o'clock hour line from the diameter which goes through E.

We know from Fig. 2 that the entire circumference (angle 2π radians) of the base translates into the angle $2\pi.\sin(\varphi/2)$, so an angle $\alpha(10)$ translates into an angle $\beta(10)$ where:

$$\beta(10) = \alpha(10).\sin(\varphi/2)$$

Construction of the Declination Curves for the Calendar

In a traditional plane sundial, the seven canonical calendar curves, or constant-declination curves, are hyperbolas; in the case of the cone they are closed curves which resemble ellipses (the equinoctial curve really is an ellipse). In this section, we shall omit most mathematical detail and just quote the formulae required to draw the curves.

For a given solar declination δ, we can describe the position of any point on the curve by two coordinates: VA, the distance from the vertex V, and ω, a running variable which is an angle that ranges from 0 to 2π.

VA is given by:

$$VA = L/[\cos(\rho)+\sin(\rho)*\tan(\delta)]$$

Here, L is the distance of the aperture nodus from the vertex of the cone and ρ is an angle given by:

$$\rho = 2*\arcsin[\sin(\delta/2)*\sin(\omega/2)]$$

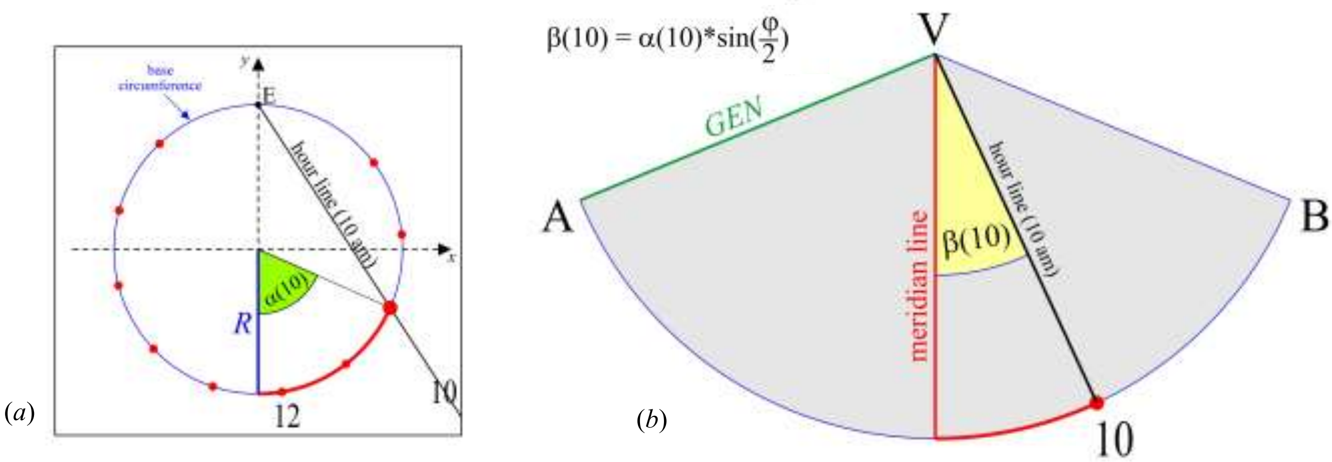

Fig. 5. Laying out the hour lines in the development of the cone.

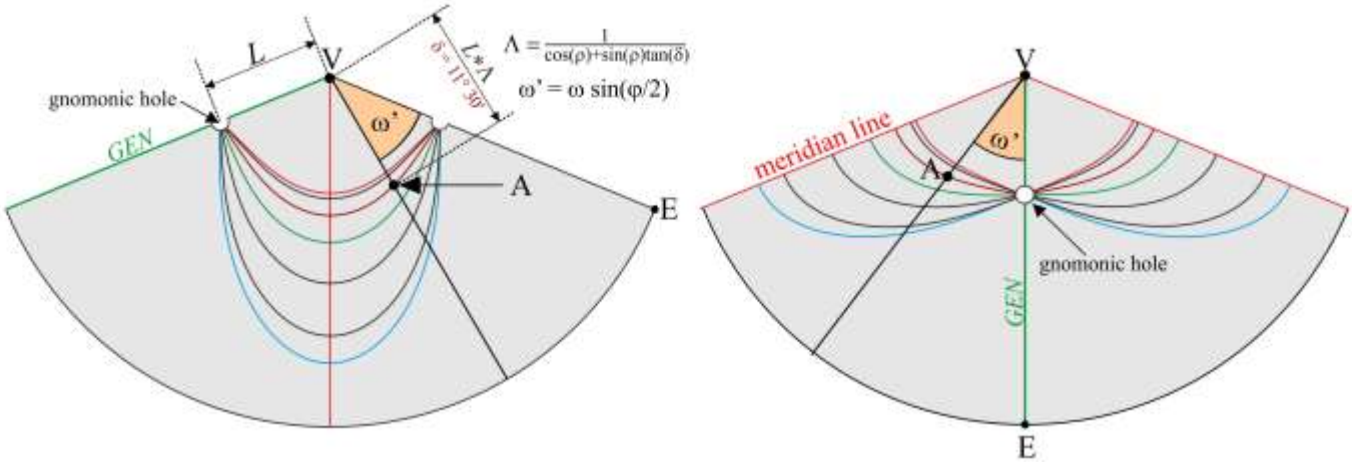

Fig. 6. The calendar curves. left: when the cone is opened with a cut along the generator GEN, right: when the cut is made along the generator opposite GEN.

Fig. 6 shows the development of the calendar curves. The example point A is on the constant-declination curve associated with solar declination δ = 11° 30′ (the cusps of the Zodiac signs of Taurus and Virgo) and has polar coordinates (VA,ω′), where ω′ = ω.sin(φ/2). Note that the angle ω is shown in Fig. 7.

The identifier Λ, shown in Fig. 6, is the ratio VA/*L*. Using Λ serves to simplify the discussion and to make the tables more readable. Note that, at an equinox, when δ = 0, the ratio Λ = 1/cos(ρ).

An associated ratio, ε, expressed in terms of ω and τ is shown in Fig. 7. This describes the ellipse that is obtained by cutting a cone with an inclined plane. In the figure, the angle of inclination is shown as τ, the angle made by the plane to an outward normal of the generator VE.

In the special case τ=0, the ratio ε reduces to 1/cos(ρ), thereby confirming that the constant-declination curve inside the cone at an equinox is an ellipse.

$$\varepsilon = \frac{1}{\cos(\rho) + \sin^2(\omega/2)\sin(\varphi)\tan(\tau)}$$

$$\rho = 2\arcsin[\sin(\omega/2)\sin(\varphi/2)]$$

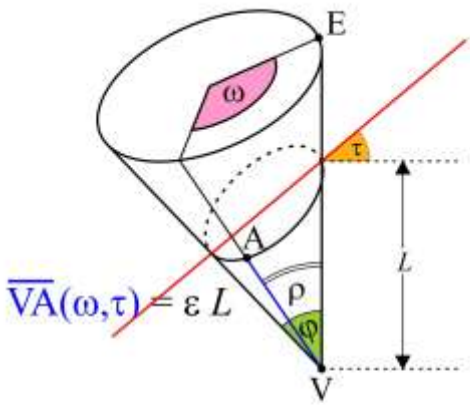

Fig. 7. The rule that describes an ellipse.

A Cone with an Opening Angle φ′ that differs from the Local Latitude φ

In the foregoing description, the opening angle of the cone matched the local latitude. At sufficiently high latitudes, the opening angle may appear inelegantly large. From experience and personal taste, the ideal opening angle of the cone ranges from 32° to 36°. If, for example, the designer is happiest with an opening angle of 32° then it is perfectly possible to use this angle; simply prop the entire cone up so that its uppermost generator is polar oriented.

More generally, if the local latitude is φ and the required opening angle is φ′, then the cone must be propped up at an angle (φ −φ′) as shown in Fig. 8.

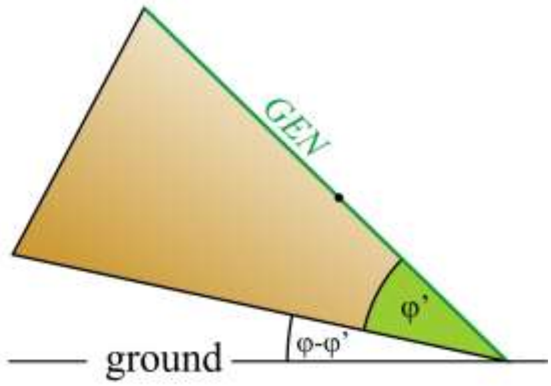

Fig. 8. Tilting a narrow-angle cone so that the uppermost generator GEN is polar oriented.

Using the example opening angle of 32°, the prop-up angle required is (φ−32°).

Figs 9 and 10 show two photographs of a model sundial made for testing. The front panel ensures that the cone is correctly propped up.

Does that Sound like a Magic Trick?

Consider the cones A and A′ on the left of Fig. 11. They are identically oriented with respect to the sun so their hour lines and declination curves are also identical.

Fig. 9. A model of the cone dial.

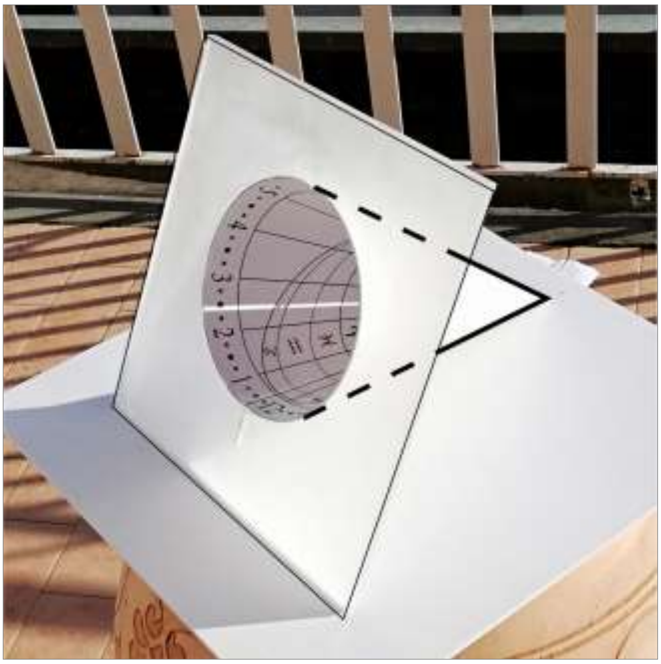

Fig. 10. The square panel that props up the cone dial.

Now consider cones A′ and B′ in the centre of Fig. 11. The broken lines (blue and red) represent the sun's rays at the two solstices and it can be seen that what in cone A′ is the summer solstice line will, in cone B′, be the winter solstice line, and vice versa. Similarly, the remaining declination lines will be exchanged two by two, except for the equinoctial line, which is the same in both dials. With simple arguments, it is also possible to show that the hour lines in cone B′ are the mirror image of the hour lines of cone A′.

Finally, consider the cones B and B′ on the right of Fig. 11. These cones are identically orientated with respect to the sun but, on a small scale, it is challenging to see the internal surface of cone B. If the cone is made from semi-transparent material, then the lines and the strip of light can be seen from outside the cone. One can, of course, mark out the outside surface and, in the development of such a cone, the markings will be the mirror image of the markings on the development of the internal surface,

To set up cone B, you take cone B′ and cut it with a plane inclined at an angle τ with respect to the normal to the generator *GEN* noting that τ must be equal to the colatitude of φ, that is τ= 90°−*φ*.

The drawing on the left of Fig. 12 shows the development of cone B; the blue curve (shown as a broken line) is the development of the ellipse at the base of the cone. This ellipse is determined using the formula in Fig. 7 by setting τ= (90°−φ) and setting φ′=32° using the ε(ω,τ) rule.

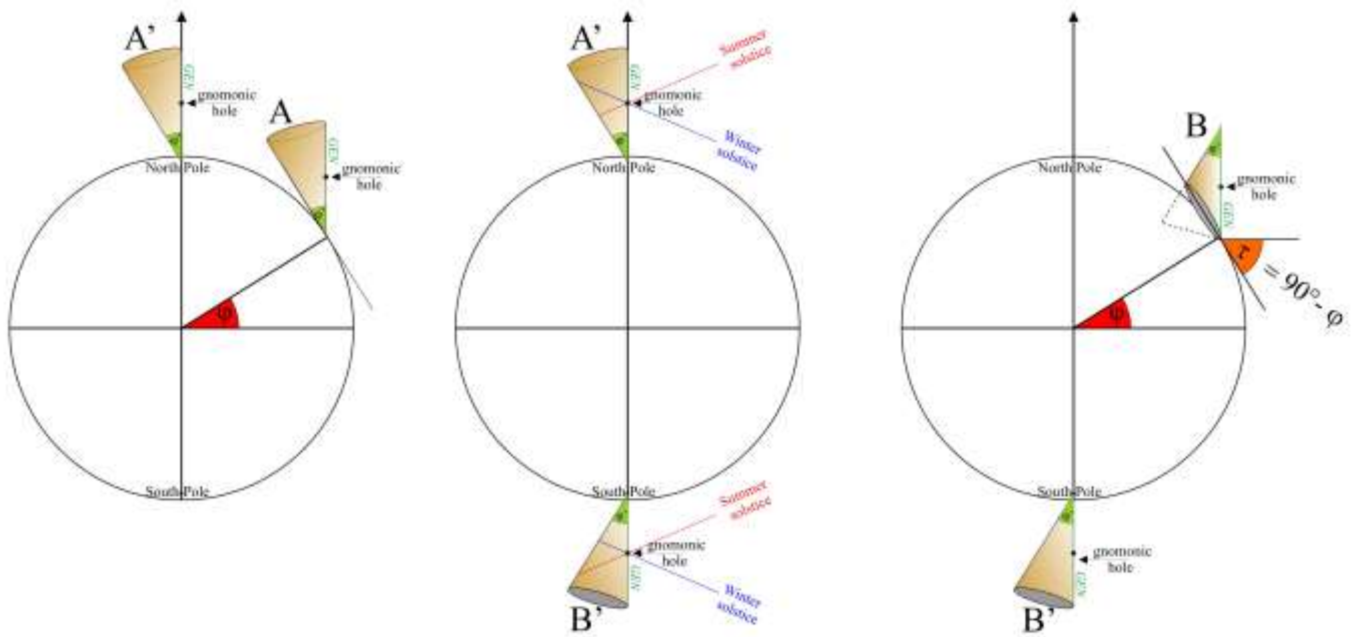

Fig. 11. Comparison of cones: at the north pole or the south pole and at latitude φ.

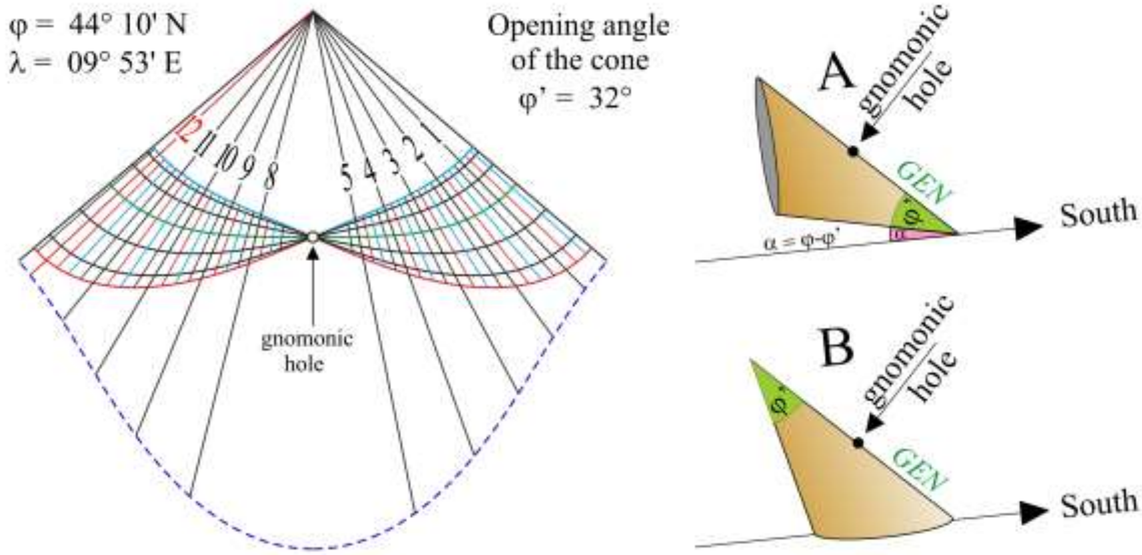

Fig. 12. Drawing used for two different sundials: wrapped up one way in A and the other way in B.

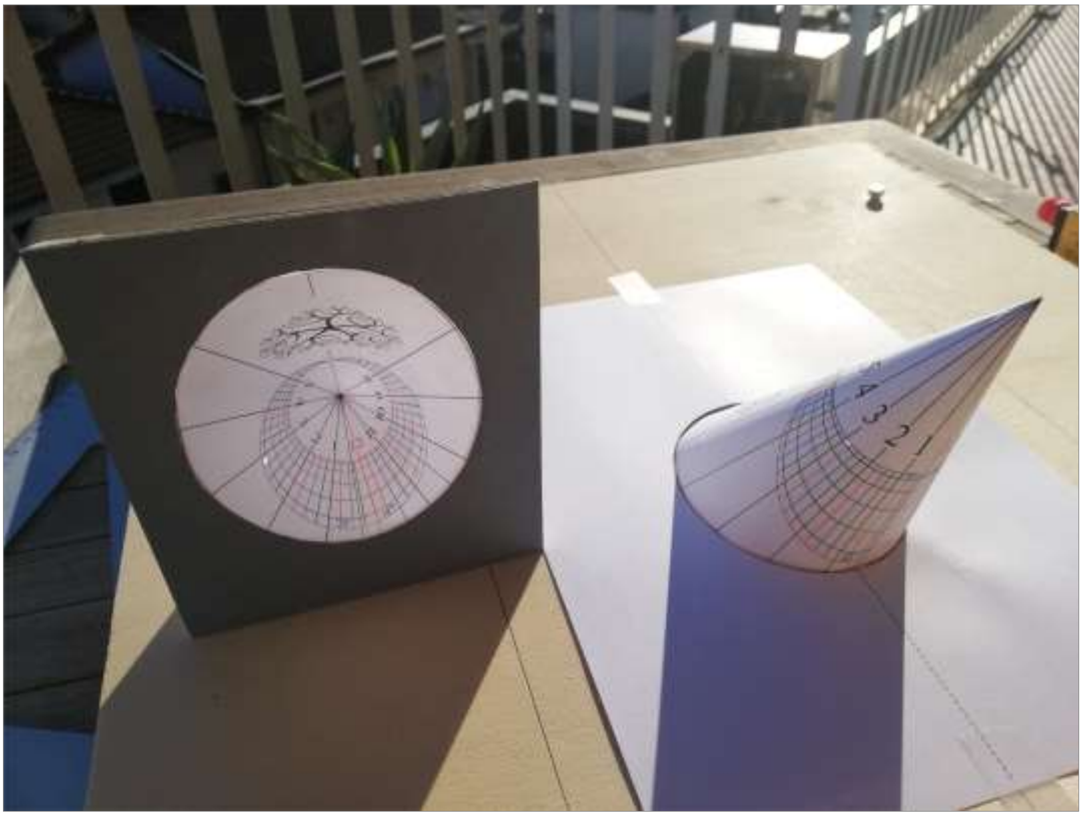

Fig. 13. Two paper sundials side by side. Each has an aperture nodus but no slit.

The cone, made with semi-transparent material, can be wrapped up in two ways as shown in Fig. 13. When wrapped up as a cone whose inside surface is used, the observer can read the time and declination directly. When wrapped up so the markings are on the outside surface, the observer, from the outside, can read the time and declination from the projections of the silt and aperture onto the inside surface. Now here is the magic…

By changing the direction of wrap, we get two dials with wildly differing appearance and features and yet they have the same markings! When the markings are on the inside surface we obtain cone A, the dial with which we started!

The photograph in Fig. 13 was taken on 31 December 2018. The small bright spot in the dial on the right is the projection of the aperture onto the internal surface; it is seen through semi-transparent paper. We are just 10 days away from the winter solstice and in both dials the bright spot is close to the winter solstice curve.

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A longer version of this article, in Italian, was first published in *Orologi Solari*, 18, 8-17 (April 2019).

MARKING TIME WITH OAK LEAVES

ALASTAIR HUNTER

Time defines our very existence. These are the opening words in the illustrated brochure for 'Marking Time', an exhibition of sculpture by Tim Chalk held in autumn last year in Edinburgh. Tim's work features sundials in endless imaginative forms and is well known to the BSS.[1] My wife Sheila and I were delighted to acquire the beautiful oak leaf sundial from the exhibition for our own home (Fig. 1), and we invited Tim to come and see where it was installed. He brought his signature stamp and fixed it on the back of the sculpture, which was unsigned before (Fig. 2).

The sculpted oak leaves are wonderful. They are life-size etched into glass and cast in relief in plaster and they throw their own shadows in sunshine. Delicately like in a woodland glade the rays of the sun appear to filter through the leaves. These rays are the hour lines of morning and afternoon on the dial. The base is solid oak.

Of course there is not only sundial art here: there is science as well. The time is shown by the shadow of a single oak bud, which acts as a nodus, and the dial faces south for solar time.

Fig. 1. Sundial sculpture with oak leaves. The dial is delineated with hour lines from 6 am to 6 pm marked in Roman numerals. It is overlaid with an artistic design of sculpted oak leaves. The gnomon is provided by the glass plate in front of the dial. This carries a nodus, which is the single bud at the end of an oak twig.

Fig. 2. Tim Chalk signature stamp. This is cast in the same plaster material as the dial and bonded to the back.

But this sundial in sunshine is too lovely to be anchored down. It has its own place on a sunny shelf indoors. You can turn the dial and watch it as the shadows drift while the sun moves round. Time and existence seem to float on a breeze like an oak leaf.

REFERENCE

1. Tim Chalk: 'Painting with light: A sculptor's take on sundialling', *BSS Bulletin* 26(ii), 22-27 (June 2014).

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MORE ON THE STANDARD TIME OF SUNRISE AND SUNSET

KEVIN KARNEY

Alastair Hunter's 'A Study of the Shortest Day' *BSS Bulletin* 31(ii), 1719 (June 2019) has already produced two further comments,[1,2] but I thought the subject needed to be expanded to cover all latitudes in a systematic manner.

Thus for latitudes between the Arctic and Antarctic in 0.1° steps and for each day of the year, the time of sunrise and sunset was found. I used the simple definition of sunrise and sunset – i.e. when the centre of the sun has zero altitude, without making any allowance for atmospheric refraction. I used a two-step iteration. The first step used the declination and Equation of Time at noon to give a first estimation of sunrise and sunset. For the second step, the declination and EoT were recalculated using the Sunrise/ Sunset times from the first step.

$$\mathrm{SunRise}_0/\mathrm{Set}_0^{\mathrm{hrs}} = 12^{\mathrm{hrs}} \mp \left\{ \frac{\cos^{-1}\left(-\tan(\phi)\times\tan(\delta_{\mathrm{noon}})\right)}{15} \right\}^{\mathrm{hrs}} + \frac{\mathrm{EoT}_{\mathrm{noon}}^{\mathrm{mins}}}{60}$$

$$\mathrm{SunRise}_1/\mathrm{Set}_1^{\mathrm{hrs}} = 12^{\mathrm{hrs}} \mp \left\{ \frac{\cos^{-1}\left(-\tan(\phi)\times\tan(\delta_0)\right)}{15} \right\}^{\mathrm{hrs}} + \frac{\mathrm{EoT}_0^{\mathrm{mins}}}{60}$$

where ϕ is the latitude and δ is the solar declination.

A third iteration proved unnecessary.

For each of the 366-day latitude series, the maximum and minimum points were found, representing the day of earliest/latest sunrise/sunset.

Sunrise in Solar Time

For solar times, the EoT terms above were set to zero. Fig. 1 shows the results in Solar Time.

As one might expect,

- everything is symmetrical about the solstices and equinoxes,
- sunrise is at 6 am all year on the equator,
- sunrise is at 6 am at all latitudes at the equinoxes,
- sunrise is at midnight or midday on the Arctic and Antarctic circles at the solstices,
- the earliest and latest sunrise for all latitudes occurs at the solstices, as shown by the maxima and minima of the curves.

Sunrise in Standard Time

Fig. 2 shows the results for Standard time. The picture changes dramatically. The symmetrical curves of solar time are perturbed by the EoT. Now the blue stepped curve indicates the maxima of each latitude curve (or latest sunrise) and the magenta stepped curve indicates the minima (or earliest sunrise).

Things to note:

- On the Arctic and Antarctic circles, the daily change in solar-time sunrise is so great (12 hours in half a year = nearly 4 mins/day), that the effect of EoT is virtually nil.

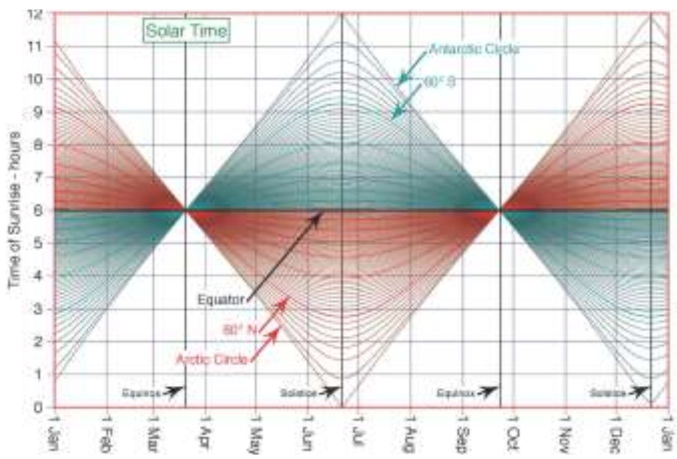

*Fig. 1. Sunrise in Solar Time. Nota bene: the fact that the winter solstice Arctic (and Antarctic) curves do not exactly end at 0 and 12 hours is a computational aberration since the calculated maximum solar declination does not **exactly** equal 90° – Latitude(Arctic Circle)°*

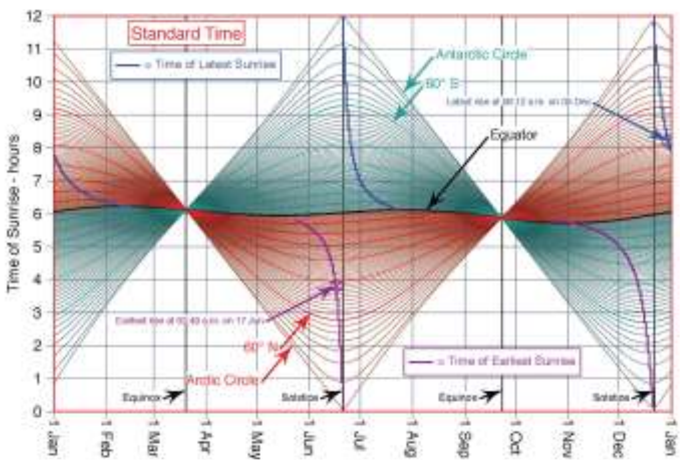

Fig. 2. Sunrise in Standard Time. The marked example is Greenwich at 51.5° North. Calculations for the Greenwich meridian, assuming no atmospheric refraction.

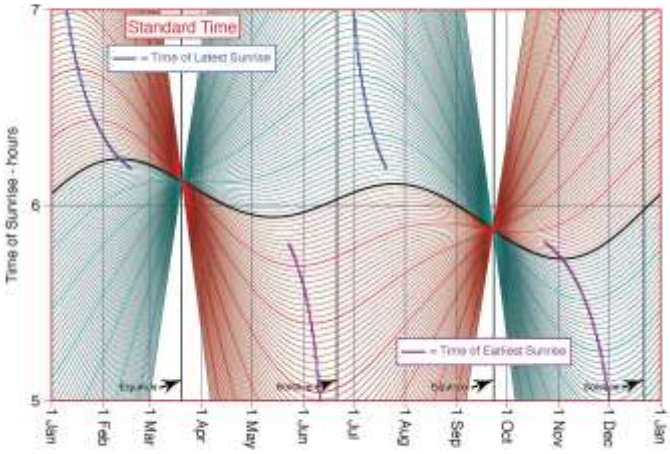

Fig. 3. Sunrise in Standard Time around the Equator showing the familiar EoT curve. Calculations for the Greenwich meridian, assuming no atmospheric refraction.

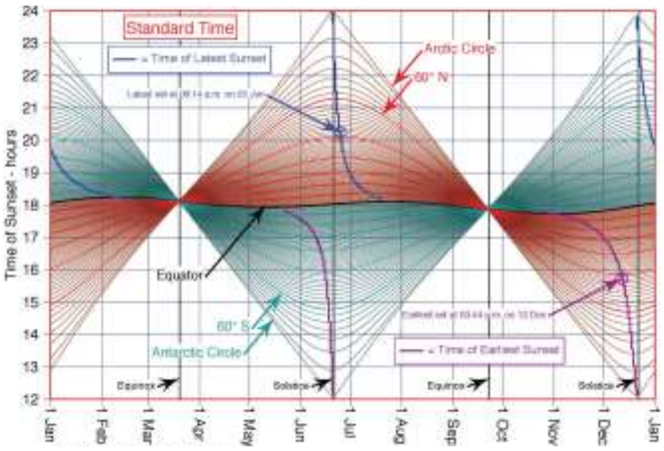

Fig. 4. Sunset in Standard Time. Calculations for the Greenwich meridian, assuming no atmospheric refraction.

- At Greenwich (the indicated latitude), the latest sunrise is on 30 December, while in Hawaii (20° North), the latest sunrise is halfway through January.
- On the Equator, the earliest sunrise is around 1 November and the latest 10 February, a span of more than 3 months!
- On the Equator, *solar-time* sunrise is always at 6.00 am, so that *standard-time* sunrise is 6.00 plus the EoT. This is shown in Fig. 3 – which is the same as Fig. 2 but with the latitude scale amplified – here one clearly sees the familiar EoT curve.
- The blue and magenta lines are stepped along the *x*-axis by 1-day increments, since one is calculating the day (not part of day) on which a maximum or minimum occurs.

These may seem counter-intuitive! But one is seeing the annually changing nature of the EoT intersecting with the latitudinally changing nature of solar-time sunrise and sunsets.

Sunset in Standard Time

For completeness' sake, Fig. 4 shows the results for Standard time sunset rather than sunrise. The picture is essentially the same.

REFERENCES

1. Fiona Vincent: 'The shortest day revisited', *BSS Bulletin* 31(iii), 20-21 (June 2019).
2. Kevin Karney: 'More on the shortest day' (Reader's Letter), *BSS Bulletin* 31(iii), 33 (June 2019).

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NEWBURY ONE-DAY MEETING

21 September 2019

On a lovely sunny day, BSS members and friends met at Sutton Hall, Stockcross near Newbury for the annual one-day meeting. As always, the event was splendidly organised by David Pawley, and Wendy cheerfully kept us supplied with plentiful tea, coffee, biscuits and other nibbles.

Morning

This year, Kevin Karney was our Master of Ceremonies, and he began by welcoming everyone and, in particular, those attending the Newbury Meeting for the first time.

David Brown: *Time Flies*

David Brown opened his 'Time Flies' talk with a photo of a Portland stone hemicyclium dial he had made about twenty years ago on which two flies were resting (Fig. 1) which gave him the excuse to talk about some of his sundial projects (time files) during the last twelve months. It being the centenary year of the signing of the First World War armistice at Versailles, he had put on display a sundial which had been made to commemorate that occasion (Fig. 2). Other projects included the restoration of a horizontal slate dial, the completion of a large vertical dial in Oxford for St Edmund Hall library (shown in the December 2018 *Bulletin*, 30(iv),

Fig. 1. Portland stone hemicyclium with flies (DMB).

Fig. 2. Versailles treaty (1919) commemoration sundial (DMB).

Fig. 3. Analemmatic sundial at St Augustine's Priory School, Ealing (DMB).

Fig. 4. The Queen's Golden Jubilee sundial at Minehead, Somerset with added blue surround and LED lights (DMB).

p.51), an analemmatic sundial at East Stour, North Dorset which acts as a war memorial, and another at St Augustine's Priory School, Ealing (Fig. 3). Details were shown of the background work associated with two dials visited during the recent annual Conference at Bath: the vertical slate dial at Kingswood School and the armillary sphere in Parade Gardens, both of which were illustrated in the June 2019 *Bulletin*. David also drew attention to two events recently with which the Society had been marginally involved: the annual gatherings organised by the Classics Centre at Cheney School, Oxford and the Clockmakers' Company stall at the Livery Schools Link in London. Hundreds (literally) of (mostly young) people were able to take away small easy-to-make cardboard sundials. Hopefully this will add to the Society membership in the long term but it will certainly have added to the general appreciation and understanding of sundials. Finally, he was surprised to discover that an addition that had been made to his analemmatic sundial on the promenade at Minehead when he visited it recently – a ring of blue glass chips set into concrete had been added to its perimeter and, within that, nine small solar-powered LED lights had been randomly placed (Fig. 4). The blue ring brightened the day-time appearance of the dial and the lights at night were an attractive feature, but neither had any effect on the time-telling properties of the sundial which commemorates the Queen's Golden Jubilee in 2002.

Kevin Karney: *Catching Dawn*

Kevin Karney described an unusual project into which he had been drawn in relation to Burning Man 2019 in the Black Rock Desert, Nevada (*https://burningman.org/event/brc/*). Each year, the event has many artistic exhibits. This year, one of these, from a French artist, was a huge staired form, through which one could catch the sun at the moment of dawn (Fig. 5). The festival lasts for some eight days. The questions asked were on which day of the festival should the structure be aligned to catch the sun (the last day was chosen) and more importantly – in the absence of trained surveyors – how could the structure be aligned? Methods with GPS and compasses were possible. But the chosen procedure was to use a flagged azimuth line

created by catching the moment of first gleam of the dawn sun on the horizon on some day before the installation of the structure, and thereafter to step the line around radially to match its target azimuth. The NASA/JPL Horizons program was used to provide the time of the first dawn gleam on all days before and during the festival.

Fig. 5. Catching Dawn (KK).

Frank King: *Heliodrome Projections – Sundials by Another Name*

Frank King explained that the word 'heliodrome' has been attributed to Athanasius Kircher, a 17th century German scholar who lived in Rome. More recently, an Italian diallist, Gianluca Belgrado, living in the 'heel' of Italy, has taken a long-exposure photograph showing the diurnal arc of the sun on (almost) a daily basis from the winter solstice of 2018 to the summer solstice of 2019. Frank suggested that Athanasius

Kircher would have described the result as depicting the heliodrome. The photograph used a cylindrical projection of the sky which exaggerates the heights of the higher altitudes and has a field of view of just 80 degrees either side of straight ahead.

Frank introduced a conical projection which has a much greater field of view and in which both hour angle and declination are represented linearly. All this is at the cost of introducing a distorted horizon. Using this projection, Frank demonstrated that it could show the whole of the summer solstice arc at a latitude of 52 degrees north. The region of celestial real estate between this and the winter solstice arc is the heliodrome. This is the region of sky that diallists are constrained to use when designing sundials.

The heliodrome can be marked out with constant declination lines and hour lines (of any kind). Projections of the

heliodrome onto a plane (or even irregular surfaces) are what we see on dial plates. Frank showed gnomonic projections of the heliodrome that gave rise to regular horizontal sundials that depict common hours, Babylonian hours and Italian hours, and to an ancient Greek hemicyclium which shows unequal hours. He concluded by showing a stereographic projection of the heliodrome that he has developed into a simple cardboard sundial which can be cheaply mass-produced.

Ben Green: *An Early French Heliochronometer*

Ben Green showed his newly-acquired French heliochronometer (Fig. 6). He explained that Paul Flechet had patented his design in Paris in 1862; it was described as a precision sundial that could be used at any latitude.

The instrument first has to be set up by aligning the base to true North–South and then tilting the plane of the dial plate to match the local latitude. Resting against the northernmost part of the chapter ring there is a short Vernier scale whose position can be adjusted so that the user can take into account the local longitude offset from the relevant reference meridian.

Fig. 6. Heliochronometer designed by Paul Flechet (BG).

The chapter ring rotates and, attached to this ring, are two sights: the foresight has a pin-hole which serves as an aperture nodus and the backsight has a labelled analemma engraved on it.

In operation, the chapter ring is swivelled until the spot of light from the nodus falls on the point of the analemma which corresponds to the date of the observation. Standard time can then be read by means of the Vernier.

Several instrument makers marketed the device under their own names. This custom, common at the time, was followed by several quality clockmakers including Molteni and Benevolo. An American scientific journal of 1878 gave instructions for reading time with a precision of 30 seconds. Ben noted that he had not achieved quite this degree of precision. He was assured that 30 seconds was rather an optimistic target but he might be able to improve precision by deliberately setting the chapter ring a little ahead of the proper time and waiting for the spot of light to fall on the analemma.

John Davis: *Restoration of a Sundial near Prestatyn*

Kevin Karney and John Davis made separate presentations on the restoration of the stone sundial near Prestatyn that Kevin introduced at last year's meeting and which has now been restored by Harriet James. A full report of this project by the three authors is on pages 2-9 of this issue.

The next item on the programme was shown as …

Mike Shaw: *Group Photo + Jokes*

… and everyone went out into the garden for the group photograph shown above (and a second one of the speakers: see page 11). Mike Shaw then provided some mathematical entertainment (Fig. 7).

After this, there was a long lunch break with plenty of time to look at the exhibits inside the hall and outside in the sunshine (see page 16).

Afternoon

Doug Bateman: *Proposed Netherlands Sundial Safari 2020*

Doug Bateman described his plans for a Sundial Safari that he was hoping to arrange to Utrecht in 2020. He discussed possible routes and showed pictures of some of the dials that might be seen, including those in the Zuylenburg Collection (see the September 2019 *Bulletin*). There was some discussion of possible difficulties likely to be encountered in obtaining insurance.

David Burstall: *Octagonal Equatorial Glass Sundial*

David Burstall showed and described a glass sundial that he had made. The glass face is 430 mm across, each side being 178 mm in length. The glass is 10 mm thick with an 8 mm hole at its centre to take the gnomon. The sundial measures 45 cm × 45 cm × 30 cm overall, and weighs 8 kg. The 24-hour clock face is etched on the underside only. Hour numbers are etched anticlockwise and backwards. The etching includes a

Fig. 7. Mike Shaw and his arithmetical verse:

A dozen, a gross and a score
Plus three times the square root of four
Divided by seven
Plus five times eleven
Equals nine squared plus nothing at all

Photo: Ian Butson

50 mm-wide ring to show up the gnomon's shadow. The upper face is left plain and the whole glass face is toughened. The dial is mounted in a robust stainless steel frame. The glass is bonded under a 25 mm protective stainless steel rim. A 70 mm gnomon protrudes through the central hole both above and below the glass face so that a shadow is cast whatever the sun's declination. This sundial is designed to lie in the equatorial plane at the latitude of 50° N, but the supporting legs will vary in length for other latitudes. The sundial must be sited on a horizontal mount facing due north. The shadow from the upper gnomon will be cast on the 50 mm etched ring when the sun is north of the equator and from the lower gnomon when the sun is south of the equator. The time will be local solar mean time. To read the time, the dial must be viewed from the upper face. Being constructed of glass permits viewing all the year round from the upper side. Furthermore, as all the etching is on the underside, it is protected from weathering. Maintenance will be simple: an occasional wipe down of the upper surface after rain.

John Foad: *The Fixed Dial Register – a New Release*

John Foad described the proposed issue of the Fixed Dial Register for public sale. It will be in PDF format, on DVD or memory stick, and will be filed in the Legal Deposit Libraries with an ISBN. Private dials will be excluded, as will the location of the more vulnerable dials which are classified as Open, Visible or Restricted. The format will be similar to that on the DVD of the entire Register that is available to members, but with up to four photographs shown per dial, and with location data made more suitable for copying and pasting directly to mapping apps. The Public Register will contain about 4,500 dials.

Patrick Arnold: *A Pipe, an Egyptian and a Folding Dial plus Stonehenge Revisited*

Pipe dial: This is a portable vertical dial (Fig. 8). A piece of 49mm PVC pipe was hung by a thread. A slot was cut on one side and a notch was cut opposite the slot. On a piece of paper 13 columns were drawn. They were for the months of the year and were lettered JAN to JUN, then a blank column, then JUL to DEC. Hour lines were added. The piece of paper was then pasted to the pipe so the blank column covered the slot. In use the dial is hung from the hand and turned so the sunlight passes through the notch to fall on the slot. The time is found by tracing the light round to the appropriate month.

Egyptian portable (Fig. 9): A lively debate centred round this dial. The instrument consists of a horizontal bar which has a small block at one end set at right angles to the horizontal bar. With the aid of a small plumb bob the dial can be held level and turned so that the block acting as a gnomon allows a shadow to fall on the horizontal bar. The surviving examples of this ancient dial have different scales. The copy presented at the meeting was marked on the bar to show the shadow length at the summer and winter solstices. Patrick was of the opinion that measuring the shadow by palms (four fingers) and fingers would be a practical method of agreeing the time. For example, a merchant could say that he would meet a client in the afternoon of the fifth day after the full moon when the shadow on the bar was one palm and two fingers long.

Folding dial: This could be classified as a horizontal dial. It consists of a rectangle of silk on which are marked 12 columns, one for each month and the hour lines. The shadow is provided by a matchbox

which is also the container for the piece of silk. In use the rectangle is laid on a level surface and the matchbox is positioned at the head of the appropriate column. The time is found where the shadow falls on the appropriate hour line.

Stonehenge Revisited: Patrick then advanced the theory that Stonehenge was constructed as a solar temple/ observatory in stages between 2350 and 1359 BC. He showed that from a centre point a circular ditch was laid out and the soil was heaped to form a wall about shoulder high. This wall acted as an

Fig. 8. Pipe dial (PA).

Fig. 9. Copy of an Egyptian portable dial (PA).

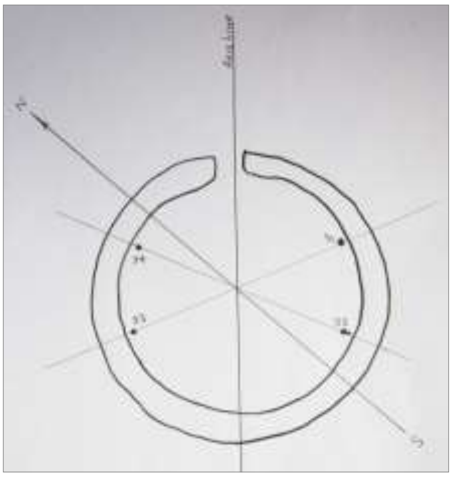

Fig. 10. Stonehenge 2350-1900 BC (PA).

artificial horizon. Within the wall, on separate mounds, stones were placed to mark the sunrise and sunset at the Summer and Winter solstices (Fig. 10). The other stones were erected symmetrically about an axis line. The whole theory that Stonehenge was a solar temple/observatory depends on the acceptance that the difference between True North of today is some 50° of arc. This means there must have been a major astronomical event that changed the position of the terrestrial poles. Patrick cited Dr Immanuel Velikovosky, who, in *Worlds in Collision* (1950), listed many pieces of evidence from ancient literature, geology, fossil remains and archaeological sites to show the realignment of the Earth's axis took place about 2795 years ago, after which Stonehenge was redundant.

Louise Smail: *The Old Parsonage (Glass) Sundial Restoration*

Over three years ago a project started at the Old Parsonage Didsbury to reinstate a stained glass sundial window in what had been the library (Fig. 11). The Old Parsonage is a Grade II listed building, parts of which date back to the 17th century, with major alterations in the 1830s/40s. Its most eminent owner was Fletcher Moss, who lived there from 1864 to 1919; he was the author of several local history books, a Justice of the Peace, Alderman and philanthropist. He bequeathed the house, gardens and the land to Manchester Corporation. The house was part of Manchester City Art Gallery until the 1980s. It then became offices and in 2011 the Manchester City Council closed the building because of financial constraints. The Didsbury Civic Society took over the building after a considerable fundraising process for renovation and it is now run as a community hub by a separate charity, the Didsbury Parsonage Trust.

The money for reinstating the window was raised through public donations and fund raising; the remainder came from a National Heritage Lottery grant. There are very few images of the original stained glass window, but working from what we had, some members of the BSS and John Carmichael, a sundiallist in

Fig. 11. An impression of what the Old Parsonage sundial window should look like.

North America, were able to provide the design works and the necessary calculations.

In August this year, having raised enough funds, the present window was removed by Pendle Stained Glass who will be restoring the seven window panes and recreating the stained glass sundial along with the innovative, magnetic gnomon that John Carmichael designed. The dial will also have a picture of a bee rather than a fly, as the worker bee is the symbol of Manchester. It is expected that the restored window will be installed in mid to late December this year and a formal opening ceremony will take place in Spring 2020. Part of the work also involves the installation of a camera so that during daylight hours people can log on to the Old Parsonage website and be able to view the sundial in real time. For more information visit *www.didsburyparsonagetrust.org.uk*

Martins Gills: *Hours to Sunset and Some Other New Sundials*

In this talk Martins gave an overview of his new sundials unveiled during last 12 months, all located in Latvia. The first one is in Kandava,made in the shape of an open book, and devoted to Kārlis Mīlenbahs, the main contributor to the dictionary of the Latvian language which was published in the early 20th century. This is an equatorial sundial with a dial

Figs 11 and 12. Sundials at Kandava (above) and Rundale (below) (MG).

plate in a form of arc depicting both local time and the standard summer time. Made from stainless steel, the sundial is made to survive visitors trying to climb or sit on it (Fig. 11).

The next one is a small horizontal sundial located on the terrace of a private astronomical observatory 'Lielzeltini'. The key distinguishing element of this sundial is the glass gnomon. The stylus part is made of steel. One interesting feature is that the glass displays the correct configuration of stars in the constellation of Orion; the perfect time for comparing the art work with the original is during the early months of the year.

And, finally, the most recent is a set of two sundials made as stainless steel lines on a cylindrical concrete wall for the amphitheatre in Rundale (Fig. 12). One of the sundials shows local time, the other – hours to sunset. The latter created the biggest challenge for Martins of how to calculate it owing to the curved surface of the wall. The solution was found through 3D modelling. After the installation, several tests were made, showing the sundial's accuracy within 10 minutes. Both sundials are connected with a specific decorative pattern of stainless-steel lines throughout the whole 27 metre long wall. As of 2019, this is the only 'hours to sunset' sundial in the Baltic region.

Martins Gills: *An Update on the Sundials Atlas Website*

At the 2018 Newbury meeting, Martins gave an overview about the largest online database of sundials – the Sundial Atlas (SA; can be accessed via web address *sundialatlas.net*). The website has been developed by Italian diallist Fabio Savian, and there are plans to transfer its further maintenance to a non-profit educational organization. The key issue in 2018 was the absence of any links between the SA and the online BSS register published at Society's website. Thus, the same sundial can be described in both databases, but the user would have no clue whether and under which ID to look in the other database.

Since 2019, SA has a new feature – for any UK sundial it is now possible to add the BSS register identifier (SRN). As of September 2019, 528 out of 2521 British sundials listed in SA had references to the BSS register. Thus, visitors to SA can look for more detailed information on the BSS website.

What is now missing, said Martins, is the reverse link – the link from BSS register to the SA. He suggested that it would be mutually beneficial for everyone if in the BSS Register there were an additional data field in which one would start adding the unique IDs of SA. Also, it would be highly advisable to compare the data of individual sundials between the two registers.

Kevin Karney: *A New Way to Display the Equation of Time*

Following a tip-off from Fred Sawyer, Kevin described a novel, entirely friction-free, method of displaying the Equation of Time on a high-quality, multi-'complications' watch. The Greubel Forsey watch has a graph-like shape of the EoT integral to the watch's rotating month indicator. The graph is read off an unsigned minutes scale. But the shape is edged in red when the EoT is positive, and blue when negative (Fig. 13).

Fig. 13. Gruebel Forsey watch (KK).

Ian Butson: *Rose Ornamentation on Sundials*

Having seen the article in the September 2019 issue of the *Bulletin*, by Sue Manston (*BSS Bull.*, 31(iii), pp. 15-19) concerning the sundial made by Thomas Hart, Ian was interested to see that this sundial included rose-petal ornamentation, as well as the half-hour points marked by three punch marks. The maker's name and date of 1775 were also shown on the dial plate.

Only a few dials with these particular features had been encountered by Ian during the period that he had been recording sundials, and none of them carried a maker's name, or date. Seeing this article suggested to him that it might be possible to establish the maker's name and the dates of those dials that he had previously signed.

Fig. 14. Dial at Shalstone House, Buckinghamshire (IRB).

Images of the un-named dials inscribed with these features from a number of locations were shown (Fig. 14), with the request for information from any members who had knowledge of any others with similar markings that could possibly establish the maker and a likely date.

Finally, Kevin Karney proposed a vote of thanks to David Pawley and his helpers for another highly successful Newbury Meeting.

Notes by the speakers
Group photo by Mike Shaw