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CONTENTS

EDITORIAL

Shortly after the September *Bulletin* went to press, we heard of the death of Her Majesty the Queen. She was remembered at the Newbury Meeting along with Chris Daniel and Tony Wood. The Newbury talks are reported in this issue and there are references to a handful of sundials made to commemorate three of the late Queen's Jubilees. Perhaps we shall hear of a Coronation Sundial at next year's meeting?

The lead article is by Werner Riegler who spotted that mechanical tide prediction machines can readily be adapted to calculate the Equation of Time. This article is very entertaining and is best appreciated if you set up two simple spreadsheets as suggested in the text.

Irene Brightmer presents the fruits of her almost 10 years of research on the 18th-century Welsh dial maker, Meredith Hughes, and describes his five known dials, two of which are 'geographical'.

The article in the September *Bulletin* by Peter de Clerq about a sundial in the Privy Gardens in Whitehall prompted Fred Sawyer to write a fascinating follow-up Note, and Anthony Turner to contribute a short Reader's Letter.

Sue Manston's article in the September issue about a Belgian altitude dial also prompted a follow-up article. This was co-authored by Steve Lelievre (Editor of our sister journal, the NASS *Compendium*) and Sue herself. There is a Reader's Letter by Graham Stapleton on the same topic.

Graham Stapleton's article on a Traveller's Staff describes two 18th-century printed tables that enable a traveller to estimate time using a walking stick, and he draws attention to various challenges a user would have faced.

John Davis describes a curious find by a metal detectorist that might have been a portable mass dial and Johan Wikander continues his investigation into Scandinavian sundials.

Frank King

TIDE PREDICTION MACHINES AND THE EQUATION OF TIME

W. RIEGLER

Tide prediction machines are mechanical computers that were used from the 1870s to the 1960s for calculation of the tides. This article discusses the application of this principle to the mechanical calculation of the Equation of Time for use in a heliochronometer. Since this mechanism is programmable one can take into account the slow changes of the Equation of Time and realise a heliochronometer that is in principle accurate for all time.

The Equation of Time (EoT) is the difference between the uniform civil time shown by our clocks and the time a sundial shows. The tides on the other hand signify the rise and fall of sea-water levels caused by the forces of the moon and the sun. Both are related to the movement of the heavenly bodies, but that is pretty much where the connection between the two topics seems to end. In this article it will be shown that tide prediction machines, mechanical computers for calculating and predicting the tides, can also be used for mechanically generating the EoT. Such a mechanism can then be applied in heliochronometers or mechanical clocks to implement the difference between civil time and solar time. The advantage over more traditional implementation methods like cams and gears is the fact that the mechanism is programmable and can therefore in principle be adjusted for the slow changes of the EoT.

Tides and Harmonic Analysis

The accurate prediction of the tides and tidal currents is of course of the utmost importance for navigation, scheduling at seaports and many other related areas. Many of the great physicists and mathematicians worked on the topic of explaining and predicting the tides. It was long understood that the tides were related to the moon. In the 17th century, Kepler was the first to relate the tides to the gravitation of the moon and Newton gave the first quantitative analysis based on his theory of gravitation. Also Galileo and Descartes theorised about the tides, but their ideas were erroneous. In the 18th century, Bernoulli and Laplace gave detailed mathematical accounts on the theory of tides. An important practical advancement in this endeavour was the introduction of tidal harmonic analysis by William Thomson (1824-1907), also known as Lord Kelvin. The technique was then further developed by George Darwin (1845-1912), a son of Charles Darwin.

Harmonic analysis consists of the representation of functions or signals as the superposition of basic waves. Measuring the tide at a specific location over many years one can identify different periodic components, which are used for the prediction of the tides in the future. Mathematically, the measured tides can be represented as the sum of N waves, according to Parker[1]

$$H(t) = \sum_{n=1}^{N} H_n \cos(\omega_n t - \varphi_n) \tag{1}$$

where $H(t)$ is the height of the tide (in metres) above mean sea level and t is the time (in hours) with respect to a given reference time. We have $\omega_n = 360/T_n$, with T_n being the periods (in hours) for the constituents and φ_n being the relative phases (in degrees) of the constituents at the reference time $t = 0$.

The classic calculation uses 37 of these constituents, and an example of the six largest ones is given in Table 1. The largest component, the principal lunar semidiurnal constituent M_2, evidently refers to the rotation of the earth with respect to the moon, with a period that is larger than 12 hours due to the movement of the moon by about 12° per day. The principal solar diurnal component S_2 of 12 hours refers to the rotation of the earth with respect to the sun. The periods T_n do not necessarily refer to the periods of motion but to effects like the eccentricity of the moon's

Name	H_n (metres)	T_n (hours)	φ_n (degrees)	Description
M_2	2.284	12.4206	74.1	Principal lunar semidiurnal constituent
S_2	0.811	12	96.9	Principal solar semidiurnal constituent
N_2	0.453	12.6583	51.0	Larger lunar elliptic semidiurnal constituent
K_1	0.572	23.9344	149.2	Lunar diurnal constituent
O_1	0.343	6.2103	250.1	Shallow water overtides of principal lunar constituent
K_2	0.221	11.9672	98.7	Lunisolar semidiurnal constituent

Table 1. Example of tidal constituents for Anchor Point, Cook Inlet, Alaska.[2]

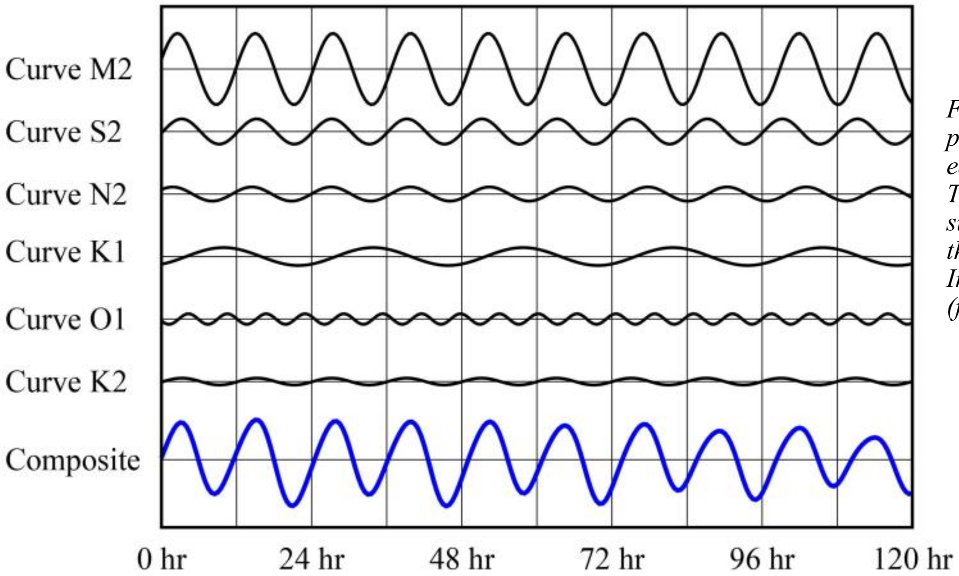


Fig. 1. The black curves are plots of the first six terms of equation(1) using the data in Table 1. The blue curve is their sum giving the height H(t) of the tide at Anchor Point, Cook Inlet, Alaska over 120 hours (five days).

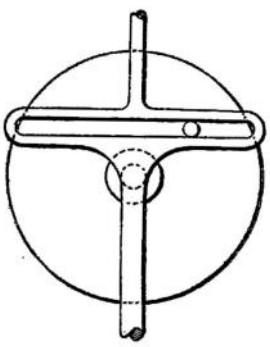
orbit, which is represented by multiples of the basic period. Fig. 1 uses the data in Table 1. It is both easy, and instructive, to reproduce these curves with a spreadsheet.

Tide Calculation Machines

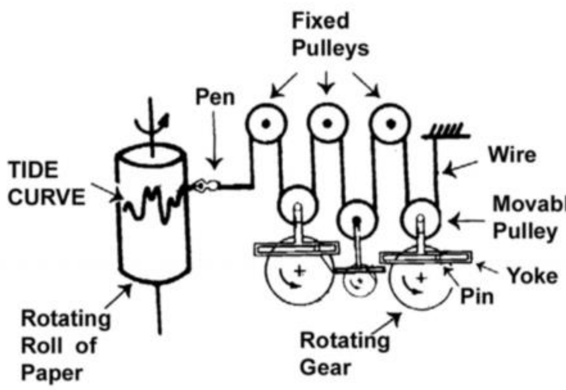
In the pre-computer era, the calculation of the sum in equation (1) was a very laborious task. Thomson came up with an ingenious way to automate tide predictions using harmonic tidal constituents. He invented a mechanical analogue tide predicting machine, a machine made up of dozens of gears and pulleys. Each tidal constituent was represented by one rotating disc with a pin that is moving up and down a pulley, as shown in Fig. 2(a). The distance of the pin from the centre of the disc represents the amplitude H_n of the sine wave, the period of rotation represents the period T_n and the relative rotation of the different discs represents the phase φ_n of the constituents. The summing of the constituents is achieved by running a wire around all the pulleys and connecting the end of the wire to a pen that records the value on a rotating paper roll, as shown in Fig. 2(b). Thomson's first tide predicting machine was built in London in 1872 and summed the contributions of the ten most important tidal constituents. Large tide calculation machines with up to 62 components were subsequently built and were in operation until the 1960s, when electronic computers took over these calculations.

An inventory and description of these large machines is given by Woodworth.[3] Many of them are now restored and displayed in museums, notably the 'Old Brass Brains' in the NOAA in Maryland (USA), the 7.5 metre long Aude & Reipert machine in the Deutsches Museum in Munich (Germany) and the Doodson–Légé and Roberts–Légé tide predicting machines in the NOC at the University of Liverpool campus. The third of these is shown in Fig. 3.

The precise time of the high tide and low tide are not easily read from the charts and there is a very elegant way of finding these maxima and minima with the tide calculation machine. The maxima and minima of equation (1) are the



(*a*)



(*b*)

Fig. 2. (a) A rotating gear with an eccentric pin produces a vertical movement, which mathematically represents the sine function.

(b) Gear and pulley system of a tide predicting machine.[2] Each gear and pulley combination represents one tidal harmonic constituent. The wire running over all the pulleys sums the motions and moves a pen on a moving roll of paper to draw the tide curve.

Fig. 3. The Roberts–Légé tide prediction machine at the NOC in Liverpool.

points where the first derivative has a value of zero. This first derivative is given by

$$\frac{dH(t)}{dt} = \sum_{n=0}^{N} -H_n\omega_n \sin(\omega_n t - \varphi_n) \qquad (2)$$

$$= \sum_{n=0}^{N} H_n\omega_n \cos(\omega_n t - \varphi_n + 90deg) \qquad (3)$$

It has the same form as equation (1) with different amplitudes and all the phases rotated by 90° and can therefore also be calculated with the tide prediction machine. The zero crossings of these curves then define high tide and low tide.

Equation of Time

An equation which gives the approximate value of EoT over a year is:

$$\tau(M) \approx A_{ecc}\sin(M) + A_{obl}\sin[2(M + \omega_0)] \qquad (4)$$

This has a superficial resemblance to equation (1) though we now have two sine functions instead of N cosine functions. The equivalent of $\omega_n t = 360 \times t/T_n$ is now:

$$M = 2\pi \times t/T$$

T is the length of a year from one perihelion to the next and t is the fraction of the year that has elapsed since the most recent perihelion. We are working in radians and, over a year, M varies from 0 to 2π and increases linearly with time. Formally, M is the Mean Anomaly.

In the argument of the second sine function, ω_0 is the equivalent of phase, the angular separation of perihelion from the vernal equinox; strictly it is the ecliptic longitude of perihelion. Currently $\omega_0 = 4.94452$ which is 283.3° expressed in radians.

Note that there is no phase offset in the argument of the first sine function, which is taken as the reference phase.

The first term on the right-hand side of equation (4) is the component of the EoT due to the eccentricity of the earth's orbit and the second term is the component which is due to the obliquity of the ecliptic. The sum of these two components is the EoT, τ, which, over a year, currently ranges from approximately −16 minutes to +14 minutes.

The coefficients of the two sine functions are:

$$A_{ecc} = 2e \times 4 \times 180/\pi$$
$$A_{obl} = -\left(\frac{\varepsilon}{2}\right)^2 \times 4 \times 180/\pi \qquad (5)$$

Here e is the eccentricity of the earth's orbit and ε is the obliquity of the ecliptic. Currently, e=0.0167 and ε=0.4091 which is 23.44° expressed in radians.

In both expressions, the factor $180/\pi$ converts radians into degrees and, noting that 1° equates to four minutes of time (from 15° equating to one hour), the factor of 4 converts degrees into minutes of time.

Using the current values of e and ε we have:

$$A_{ecc} \approx 7.6547 \text{ minutes} \quad \text{and} \quad A_{obl} \approx -9.5893 \text{ minutes} \qquad (6)$$

When t=0, M=0 and:

$$\tau(0) \approx 7.6547\sin(0) - 9.5893\sin[2(0+4.94452)] \approx 4.29$$

Note that t=0 corresponds to the moment the sun is at perihelion and, with no phase offset in the argument of the first sine function, the first term is zero (check the start value of the red curve in Fig. 4).

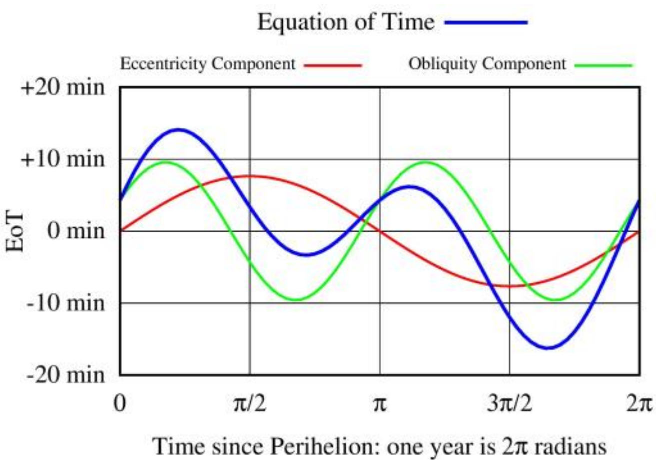


Fig. 4. Equation of Time. The values for vanishing obliquity and eccentricity are given as well.

By setting $\varepsilon = 0$ we are left with the eccentricity effect and by setting e to zero we are left with the obliquity effect. Plots of these two effects and their sum, the EoT, are shown in Fig. 4.

As with the tide example, it is both easy and instructive to reproduce these curves with a spreadsheet. One can then try some experiments and investigate, for example, just how sensitive the EoT is to changes in ω_0, the position of perihelion, and note the shape of the EoT curve when ω_0 is a multiple of 90°.

Since the orbital parameters of the earth are slowly changing with time, the EoT is also changing with time and sundials that have incorporated this correction in some form will become inaccurate. Fig. 5 shows the eccentricity of the earth's orbit, e, and the obliquity of the ecliptic, ε, for the past and future million years, together with the value of ω_0 around the present epoch.[4] The obliquity is oscillating between 22° and 24.5° with a period of around 41000 years. The eccentricity has significant variations. The present value of 0.0167 is rather small but it will continue to decrease until around the year 29300 when the eccentricity will be as low as e = 0.0027 and the earth will have an almost circular orbit around the sun. Over long periods, the eccentricity will assume values in excess of 0.05.

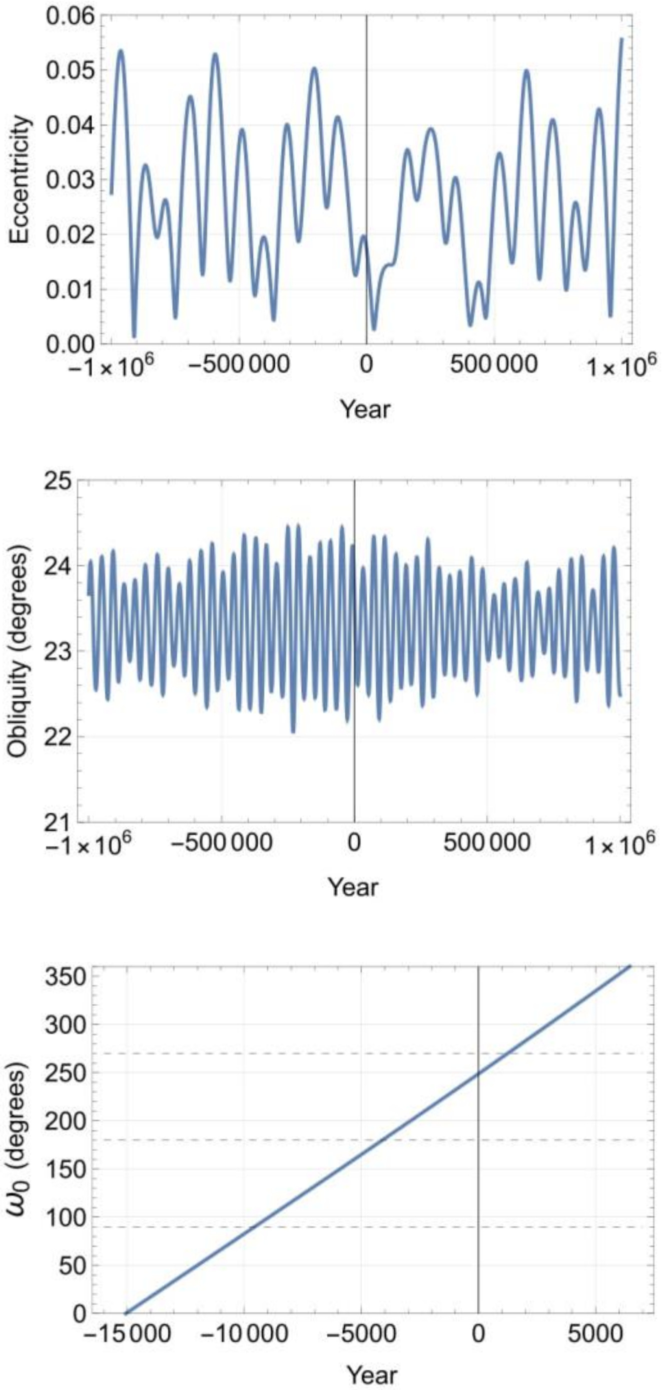


Fig. 5. Earth's obliquity and eccentricity for the past and future million years and the value of ω_0 for the present period of 21000 years.[4]

The variation of ω_0 is the superposition of two movements, the precession of the earth's axis together with the precession of the earth's perihelion. The period of the axis precession, the Platonic year, is T_{axis} ≈ 25800 years. The period of the perihelion precession is $T_{perihelion}$ ≈ 112000 years. Since the two movements are in opposite direction, the period T for a full revolution of the perihelion w.r.t. the vernal equinox is given by the relation

$$1/T = 1/T_{axis} + 1/T_{perihelion}$$

and therefore $T \approx 21000$ years.

In Fig. 5 we see the value of ω_0 for the present period. The perihelion coincided with the vernal equinox (ω_0 = 0°) in the year −15 060, with the summer solstice (ω_0 = 90°) in the year −9563, with the autumn equinox (ω_0 = 180°) in −4102, with the winter solstice (ω_0 = 270°) in the year 1246, and it will again pass the vernal equinox in the year 6446.

Fig. 6 shows the change of the EoT over time. In 200 years the difference is around 1 minute and in 5000 years the difference is 20 minutes. The change over this period comes primarily from the variation of ω_0.

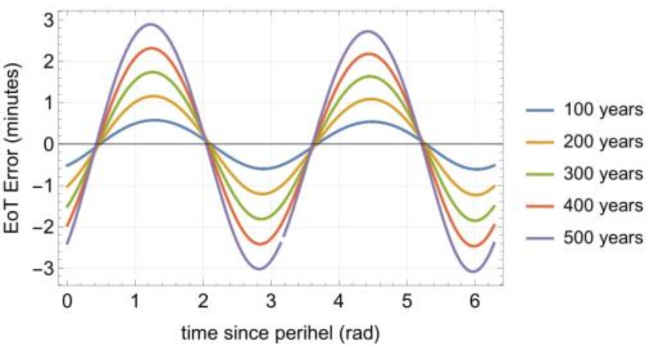


Fig. 6. Variation of the EoT. In 100 years, the EoT changes by about 30 seconds, in 200 years by about 1 minute and in 500 years by 3 minutes. In 5000 years the difference is 20 minutes.

Equation (4) uses two sine waves to give an approximation of the EoT. Various ways of implementing these sine waves with gears have been reported.[5] The method of Deskovich[6] allows the adjustment of ω_0 and, in principle, also the adjustment of A_{ecc} and A_{obl}. This method can approximate the EoT to around 30 second accuracy for the present orbital parameters and to about 1 minute for the entire ranges of the parameters displayed in Fig. 5.

Since the obliquity changes only between 22° and 24.5°, A_{obl} ranges only between 8.5 and 10.5 minutes within the past and future million years. By contrast, since the eccentricity varies from 0.0014 to 0.054 over this period, A_{ecc} ranges between 0.6 and 23.4 minutes. The maximum value of the EoT in this period is therefore around 34 minutes.

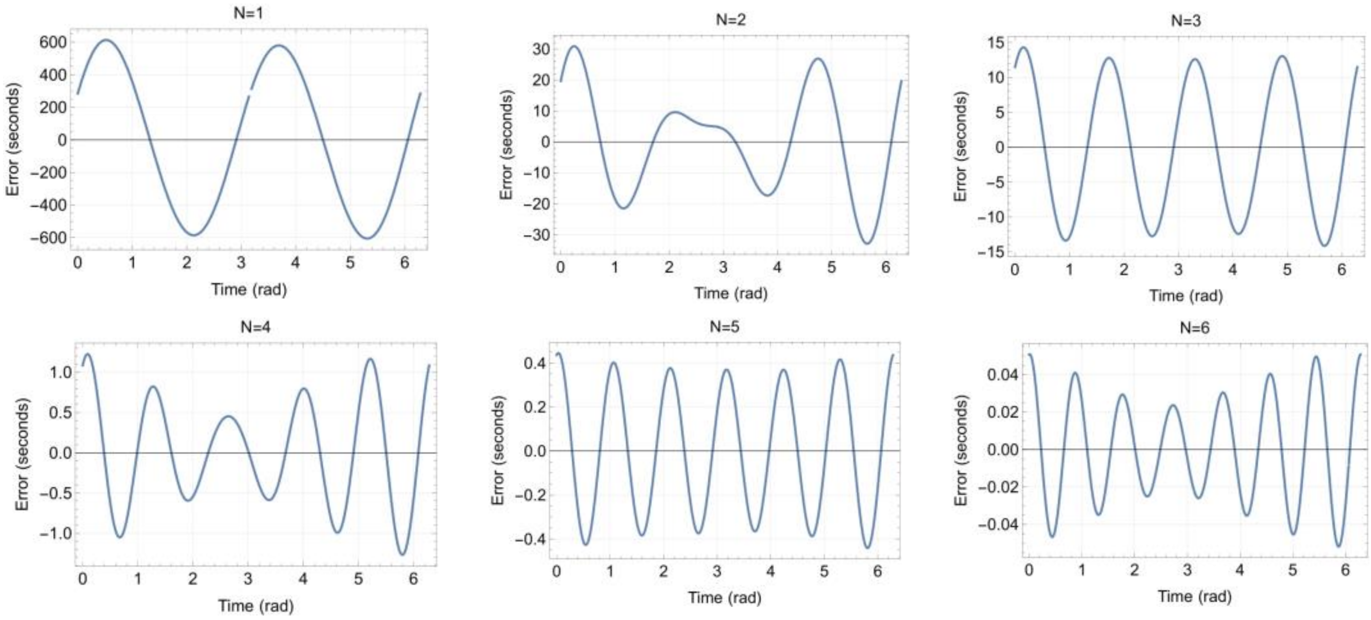


Fig. 7. EoT error when approximating the EoT with different numbers of sine waves. Using four components (N = 4) we can approximate the present EoT to around 1 second precision.

Harmonic Analysis of the Equation of Time

Using Fourier analysis, any periodic function with a period T can be approximated to arbitrary precision by the sum of sine waves:

$$f(t) = \frac{A_0}{2} + \sum_{n=1}^{N} A_n \sin(\omega_n t - \varphi_n) \qquad N \to \infty \qquad (7)$$

Here $\omega_n = 2\pi n/T$ and the amplitudes A_n and phases φ_n are calculated according to equations (15) and (16) from the Appendix, and by using more and more sine waves, the function $f(t)$ can be approximated to arbitrary precision.

We use this method for the EoT and define the period T=2π representing the tropical year, so we have t running from 0 to 2π. The amplitudes and phases (for N=6) for the present EoT are then as shown in Table 2. Fig. 7 shows the accuracy of this approximation when using different numbers of waves. We see that with two components we can approximate the present EoT to a precision of 30 seconds and with four components to a precision of about 1 second. For the entire range of parameters in Fig. 5, four components can approximate the EoT to better than 4 seconds.

n	A_n (mins)	φ_n (degrees)
0	0.0018	
1	7.36	104.0
2	9.92	89.3
3	0.32	103.2
4	0.22	89.3
5	0.014	102.7
6	0.0066	89.8

Table 2. Amplitudes and phases for equation (7) as currently applicable.

Realisation in a Heliochronometer

We can now use the principle of the tide calculation machine to calculate the EoT by adding up the first four components described above. The ‘frequencies’ ω_n of the four components are $2\pi n/T$ with n = 1, 2, 3, 4, so we need four wheels that are representing these frequencies. Fig. 8 shows the set of gear wheels that produces these frequencies from one turn of the centre gear wheel, which represents one year. An adjustable pin on each of these wheels produces a linear sinusoidal motion of the pulleys that is summed by the wire that connects all of them. The end of the wire will then represent the EoT and it can be used to display the EoT, to move the hour lines of a

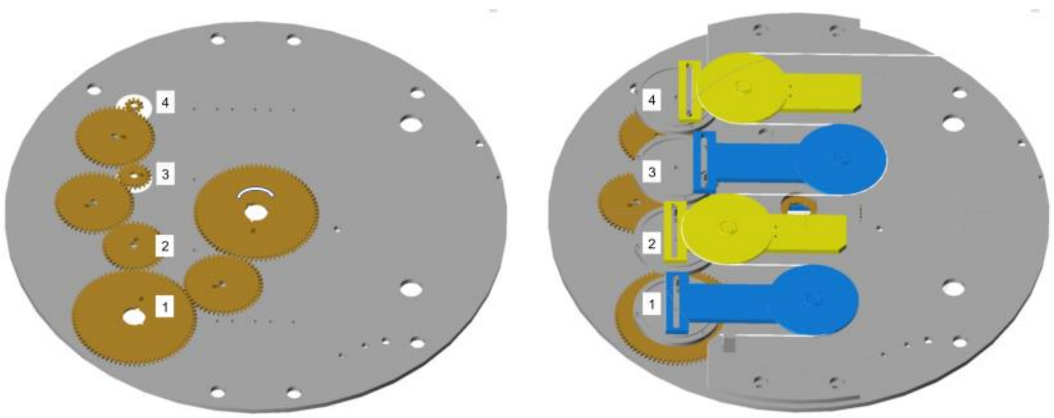


Fig. 8. Left: One turn of the centre gear wheel will turn gear wheels 1, 2, 3 and 4 one, two, three and four times respectively.

Right: Each numbered wheel produces a linear sinusoidal motion through an adjustable pin on the wheel, and the wire running around all the pulleys will sum the components.

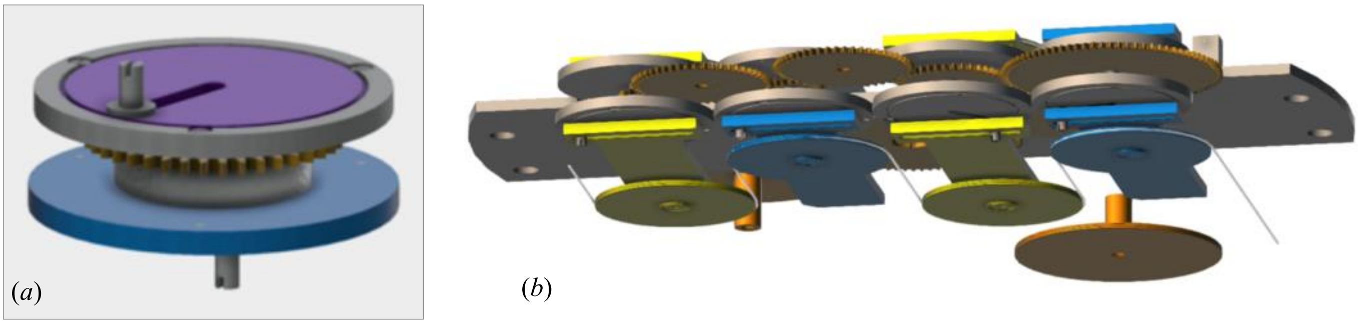


Fig. 9. (a) The amplitude of the individual components is adjusted by a radial displacement of a pin; the phase is adjusted by a rotation of the pin. (b) Using the same mechanism on the reverse side one can use the four components to calculate the solar declination.

sundial, or it can be connected to other gears in a mechanical clock.

Fig. 9(a) shows the mechanism to adjust the radial and angular position of the pin. Fig. 9(b) shows that, on the reverse side of the mechanism, another set of components can be installed, which implements equation (13) in the Appendix to calculate the solar declination, δ. With four components one can represent the solar declination to an accuracy of 0.2 arcminutes throughout the year. The mechanism can therefore be used to mechanically provide a high precision analemma.

Conclusion

In our digital era there is an increasing interest in real world objects and machines. Many mechanical tide calculation machines have been restored in recent years and are now displayed in museums. It is therefore interesting to revive these machines for the application in sundials, where they can be used to mechanically 'predict' the Equation of Time and the solar declination for a given day with high accuracy.

I would like to thank Kevin Karney for many interesting discussions, and Frank King for many important suggestions for this article. I would also like to thank the BSS for the kind invitation to their Conference at York in April 2022.

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Appendix

Equation of Time

The exact expressions for the equation of time $\tau(M)$ and the solar declination $\delta(M)$ are

$$\tau(M) = \arctan[\cos\varepsilon \tan\lambda(M)] - \big(M - (2\pi - \omega_0)\big) + 2\pi \mathrm{Floor}\left(\frac{\lambda(M)+\pi}{2\pi}\right) \quad (8)$$

$$\delta(M) = \arcsin[\sin\varepsilon \sin\lambda(M)]$$

where $0 < M < 2\pi$ and $M = 0$ is the perihelion. We have used the following expressions:

$$\lambda(M) = \nu(M) - (2\pi - \omega_0) \quad (9)$$

$$\nu(M) = 2\arctan\left(\sqrt{\frac{1+e}{1-e}} \tan\frac{E(M)}{2}\right) + 2\pi \mathrm{Floor}\left(\frac{E(M)+\pi}{2\pi}\right) \quad (10)$$

$$M = E(M) - e\sin E(M) \quad (11)$$

Two iterations of Newton's method for solving equation (11) give

$$E(M) = M + \frac{e\sin M}{1 - e\cos M} + \cdots \quad (12)$$

We have defined

$$
\begin{aligned}
M &= \frac{2\pi}{T}t \quad \text{Mean anomaly}\\
T &= \text{Tropical year}\\
t &= \text{Time since perihelion}\\
e &= \text{Eccentricity of the orbit}\\
\varepsilon &= \text{Obliquity of the ecliptic}\\
\lambda &= \text{Ecliptic longitude of the sun}\\
\omega_0 &= \text{Ecliptic longitude of the perihelion}\\
v &= \text{True anomaly}\\
E &= \text{Eccentric anomaly}
\end{aligned}
$$

Expanding $\tau(M)$ and $\delta(M)$ in a Taylor series to first order in e and to second order in ε, we find

$$\delta(M) \approx \varepsilon \sin(M + \omega_0) \quad (13)$$

$$\tau(M) \approx A_{ecc}\sin(M) + A_{obl}\sin[2(M+\omega_0)] \quad \text{with} \quad A_{ecc} = 2e \times 4 \times 180/\pi \quad A_{obl} = -\left(\frac{\varepsilon}{2}\right)^2 \times 4 \times 180/\pi \quad (14)$$

All angles τ, δ, M, ω_0, ε are units of radians and to convert δ to degrees we have to multiply by $180/\pi$ and to convert τ to minutes we have to multiply by $4 \times 180/\pi$.

Fourier Coefficients

$$A_n = \sqrt{(a_n^2 + b_n^2)} \qquad \varphi_n = \arctan\frac{b_n}{a_n} \quad (15)$$

$$a_n = \frac{2}{T}\int_0^T f(t)\cos(\omega_n t)dt \qquad b_n = \frac{2}{T}\int_0^T f(t)\sin(\omega_n t)dt \qquad \omega_n = \frac{2\pi}{T}n \quad (16)$$

NEWBURY ONE-DAY MEETING

17 September 2022

The 2022 Newbury Meeting was held on a day with clear skies and bright sunshine, and once again, David Pawley's organisation was excellent. As always, it was good to see old friends and excellent too to be joined by a new member. Wendy greeted arrivals with a choice of tea, coffee and a variety of soft drinks, as well as biscuits and savouries. Peter Ransom again served as Master of Ceremonies and arrived early to set up his newly-acquired data projector.

Morning

Prior to the meeting, Peter reminded our Chairman, Frank King, that since last year the Society had lost two distinguished members: Chris Daniel and Tony Wood. This Meeting was of course held barely a week after the death of Her Majesty the Queen and it was felt appropriate to open our proceedings with a minute's

silence. Peter then invited Frank to give the first talk…

Frank King: *The French Republican calendar – Designed with sundials in mind?*

Frank reminded everyone that Sue Manston had given an excellent introduction to the French Republican Calendar last year. At the time it was available only as an Italian language edition; it is now available in English with the new year, year 231, beginning on the day of the Autumnal Equinox, Friday 23 September in Gregorian Calendar terms. Frank explained that the 12 French Republican months closely aligned with the 12 astronomical months, Aries, Taurus and so on. It is difficult to represent Gregorian months on a sundial at all elegantly; showing the astronomical months is much easier.

The French Republican Calendar's treatment of leap years has considerable merit. The year always begins on the day of the Autumnal Equinox (as observed in Paris) and the 12 months of 30 days each are followed by either five days or six days of holiday, whichever is necessary to ensure that the following year begins on the day of the next Autumnal Equinox. With the Gregorian Calendar, the Autumnal Equinox can fall on any one of four dates. By

chance, year 230 was a year that ended with six days of holiday and, by astonishing coincidence, the first of these extra days was the day we were meeting, 17 September.

Frank still has a few copies of the year 231 calendar left. Anyone interested can get in touch with him via *chairman@sundialsoc.org.uk*

Gerard Sheldon: Kings Langley Human Sundial

Gerard Sheldon, a local resident of Kings Langley village, talked about the recent creation of a human (analemmatic) sundial on Kings Langley Common (Fig. 1).

The sundial is 7 metres wide and is located close to a secondary and primary school. The sundial's plate mentions four contributors: Kings Langley Parish Council, Hertfordshire County Council, Kings Langley Carnival, and Geoffrey Osborne Ltd. Kings Langley is northwest of London. It used to have a royal palace and has the tomb of Edmund of Langley, 1st Duke of York, in a local church.

Gerard is an amateur astronomer and has a Ph.D. in physics. In 2010, he was a volunteer speaker on astronomy at a local school. He wanted to do something astronomical during the school day, and so he got the pupils to make a very simple equatorial sundial, using a straw, a protractor, a pencil and a piece of paper. This sparked Gerard's interest, and he visited many sundials in central London.

In September 2016, the Parish Council were consulting the public on how to improve the village. Gerard and his wife suggested the idea of a human sundial to two councillors, Alan Johnson and Mark Rogers. Gerard explained how one works at a Parish Council meeting, and they decided to support the creation of one in Kings Langley.

In October 2016, Gerard invited David Brown, designer and maker of sundials, and two councillors to a meeting at his house. David showed us a schematic diagram of a sundial and explained that someone needed to build the base. Geoffrey Osborne Ltd, who were working on the nearby motorway, volunteered to do this.

There were delays in installing the sundial. Planning permission was required, and then Covid happened. In 2021, it was installed, and the Chair of the Parish Council cut the ribbon at the grand opening ceremony. Gerard was interviewed on Astro Radio and wrote an article about the sundial in *Popular Astronomy* Magazine.

Peter Ransom: The Wonder Box Sundial

Peter introduced his talk by saying, "I live in the world of wonder. I wonder where my keys are. I wonder what day it is. I wonder who that is. I wonder why I came into this room".

The Wonder Box Sundial (Fig. 2) was one of the items distributed with *The Children's Encyclopedia* when it was published in parts between 1905 and 1910. It has a detachable gnomon, so it could lie flat and be kept in the Wonder Box. It is made of tin plate, with the printed part being 5 inches square. It is accurately delineated for 52°, the angle of the gnomon. The envelope it came with gives instructions on how to set it up, by aligning the shadow with the time on a watch, so doesn't take into account the longitude, or Equation of Time.

David Brown: Recent Sundialling Adventures

David Brown described some of his sundial activities from the past year, with dials ranging from 17th century Somerset to 21st century New York.

St Laurence Church at East Harptree, about 10 miles south of Bristol, is

Fig. 1. Kings Langley Human Sundial.

Fig. 2. The Wonder Box Sundial.

Fig. 3a. The sundial high on the wall of East Harptree church.

Fig. 3b. Close-up of the sundial.

Fig. 4. Analemmatic sundial at Minehead.

undergoing extensive repairs and refurbishment. Scaffolding to the top of its 1633 tower allowed access to a sundial carved into the stonework at the top easterly edge of its direct south facing wall. He was asked by the architectural conservators to examine the sundial with a view to its restoration. Considering its age, it was in good condition but very difficult to read from ground level (Figs 3a and b). The ferrous metal gnomon, held in place with lead plugs, was slightly bent but appeared to have the correct geometry. The form of the numerals seemed compatible with their age. Measurement from photographs and by measuring tape on two separate visits suggested that delineation was suspect. A third visit to take a wax rubbing on layout paper confirmed discrepancies in the delineation. Nevertheless, painting the dial face white with black lines and numerals was advised, but how the conservators have completed the restoration remains to be seen.

Fig. 5. Kilkenny limestone dodecahedron.

In late May, with the late Queen Elizabeth's Platinum Jubilee very much in mind, David decided that the analemmatic sundial that he had installed in 2002 on the promenade at Minehead to mark her Golden Jubilee needed some cleaning-up. Adverse weather and shortage of time limited the extent of the operation, but with the help of his wife and a grandson, enough cleaning and repainting was done to make the effort worthwhile (Fig. 4).

A former teaching colleague from Kingswood School in Bath was about to retire in August and move to Cornwall, so David offered to remove and clean up a dial he had been commissioned to make several years previously as a 50th birthday gift. The dial is in the form of a dodecahedron fashioned from Kilkenny limestone. Apart from two sundials and an EoT correction curve, other faces are inscribed with emblems representing the many interests and activities of the owner and his wife (Fig. 5). The dial now graces the garden of their new home near Truro.

Fig. 6. Wedding anniversary super-ellipse.

Bob Gaffey, who organises the USA alumni of St Edmund Hall, Oxford, himself a former student, now a retired lawyer, lives in a residential area of New York. He had been inspired by the two sundials that David had made for the College to want one himself. The dial was to include features relating to the dial over the south porch of the college library, formerly the church of St Peter-in-the-East. After much discussion and tuition on how to take measurements to determine the declination of the wall and how to fix the dial to the wall, the dial took the form of a slate super-ellipse approximately 1 metre tall, with a brass gnomon and disc nodus, supported by a hidden stainless steel corbel. Some months after the request had been made the completed dial was duly delivered just in time for the wedding anniversary of Bob and his wife Debra (Fig. 6).

Sue Manston: Sundials at Etwall Almshouses

Sue Manston spoke about two sundials erected on the chimney stacks of the Sir John Port Almshouses in Etwall, near Derby. An old postcard, circa 1900, showed two sundials, one facing southeast and the other facing southwest. A later postcard, circa 1950, showed the sundials were no longer present.

One of the almshouses' Trustees contacted the BSS Help and Advice Service in 2018, asking for the name of someone who could make replacement

Fig. 7. The replacement sundials at Etwall Almshouses. Photo courtesy of Smith of Derby.

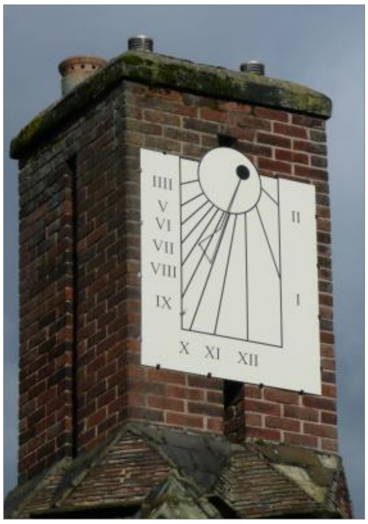


Fig. 8. Close-up of the southeast-facing dial. Photo: Joyce Newton.

dials; four sundial makers were suggested. All went quiet until October 2019 when the Trustee contacted Sue to say the project had been awarded to a local clockmaker, Smith of Derby. The almshouses, built in 1681, are Grade II* listed and listed building consent for the sundials had to be obtained.

At the end of March 2022 the Trustee

got in touch again to say the job was going ahead and the two dials had to be finished and erected by 2 June, in time for a grand opening ceremony to coincide with the Queen's Platinum Jubilee. The design of the dials had already been agreed between the Trustee and Smith of Derby; they were to be made from powder-coated aluminium. With less than nine weeks to go, someone was needed to do the delineation quickly. Sue agreed to help and to prepare the necessary drawings. A local firm of surveyors was asked to find the declination of the chimneys and, in spite of asking for angles from True North, the values provided related to the National Grid, so the necessary adjustments had to be made.

Two days before the opening ceremony the dials were erected, then taken down again as they were not correct. Sue's drawings had not been followed; one of Smith's drawings even had the gnomons upside down! They agreed it was their mistake and made two new dials which were erected in mid-September (Figs 7 and 8).

This talk was followed by a short AGM and a discussion (see page 13) and then lunch.

Afternoon

Peter Ransom: The Hythe Undial

A buoy-like structure on the jetty at Hythe (Fig. 9) is described on a plaque as a polar sundial, and the text reads "The tip of the gnomen [*sic*] shadow indicates British Summer Time". However, there is no indication of any lines indicating the time! The developer's sketch shows that lines were planned. However, Peter said that on recent visits he had seen no sign of any lines. Having been past the structure for many years, he is now aware of its sundial potential, and hopes to find out more soon.

Fig. 9. The Hythe 'polar sundial' overlooking Southampton Water.

David Hawker: Faversham Noon Mark Sundial

David Hawker explained how, in 2017 and 2018, at the request of Chris Daniel, he investigated and corrected an anomaly in the Faversham Guildhall Noon Mark dial. The dial had been designed by Chris in 2012 to celebrate the Queen's Diamond Jubilee and David confirmed that the gnomon produces a sun spot that shines perfectly on the dial's meridian line at local noon. However, the solstice and equinox lines marked on the dial were put into doubt when a photograph taken by a

member of the public was received by the Council showing the sun spot way below the dial's summer solstice line on 21 June.

With information on the location of

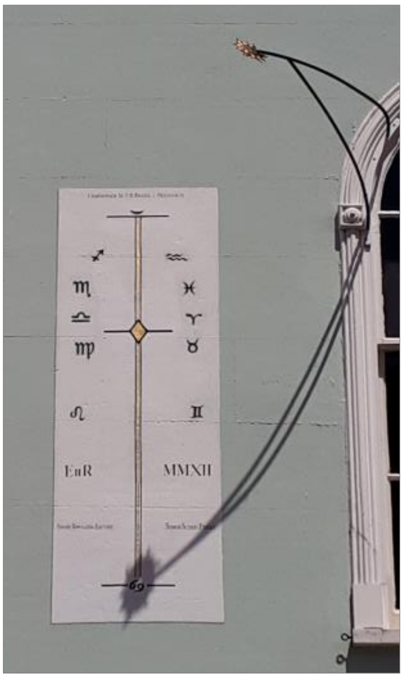


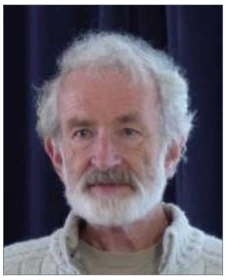
Fig. 10. Faversham Noon Mark, Summer Solstice 21 June 2018. Photo: Clive Sherwood.

the gnomon given by Chris Daniel, David made his own calculations for the positions of the solstices and equinox. These were compared with measurements from a template retrieved from the archives of the local Council that had been made by Chris for the original painter to follow. The calculated solstice and equinox lines were found to be different from the template.

In May 2018 scaffolding was erected and David marked out the revised solstice and equinox lines. The new markings were then painted in by Clive Sherwood, a local letter carver and sign writer. Fig. 10 confirms the revised summer solstice line.

Chris Lusby Taylor: CLT in London

Chris Lusby Taylor gave an account of his trip to London on the day before the meeting. He had been asked by Piers Nicholson to give talks at two sundials that were featuring in the annual Open House Festival (see *https://open-city.org.uk/open-house-festival*) which is a two-week festival during which interesting properties open their doors and invite the public to be shown around, for free. Or, in the case of sundials, to have the dial explained to them. Chris had spent the morning at the new Fleet Street Heritage vertical east-facing sundial, visible from the street, and the afternoon at the Tylers and Bricklayers polar dial on the Embankment near the Millennium Bridge that Piers had designed for the millennium. He reported that many visitors had not previously known they were there and all were impressed at how accurate a sundial is once you apply the Equation of Time and take BST into account. Chris pointed out to them that, of the three large clocks visible along Fleet Street, two are stopped and the third is many hours out. So a sundial is far more reliable.



At the end of his shift Chris had walked to Buckingham Palace and Green Park where he had been hugely impressed and deeply moved by the floral tributes to HM the Queen who had died the previous week.

Fig. 11. SS Persia memorial sundial at Buckler's Hard.

Geoff Parsons: SS Persia Sundial

Geoff described a relatively recent sundial that he had seen when visiting the Maritime Museum at Buckler's Hard, Beaulieu. The museum and surrounding buildings are located in the New Forest and were at the centre of the 18th century ship-building industry. The sundial is a declining vertical dial that commemorates the sinking of the P&O Line ship SS *Persia* by a German U-Boat on 30 December 1915. It was commissioned by the Montagu family, and was designed and made by Harriet James. It is a relatively simple but elegant design with a depiction of the ship, hour lines, and a description of the sinking. Edward, 3rd Baron Montagu, built the Beaulieu motor museum nearby in memory of his father John, 2nd Baron, who survived the sinking. Eleanor Thornton, John's secretary and mistress, did not survive the sinking, and is reputed to be the model for the Spirit of Ecstasy car mascot used on Rolls-Royce motor cars. The sundial was unveiled on the 100th anniversary of the sinking with wreaths laid at the sundial by representatives from P&O, members of the Montagu family, and families connected to the sinking.

Kevin Karney: A Gnomonist's Lament

Kevin Karney was lucky enough to acquire a modern multi-function LoRaWAN® (Long Range Wide Area Network) weather station (Decentlab DL-ATM41). This measures every conceivable meteorological parameter, including solar radiation in watts per sq m with a claimed resolution of 1 W/sq m. With a pair of standard C-sized batteries, this will, for about a month, broadcast its output to a LoRaWAN® base station. This can be up to 10 km away. The base station passes the signal via a domestic router to the Cloud. From this, measurements can be downloaded.

By trial and error, it was found that solar radiation of above ca. 180 W/sq m was strength enough to produce a shadow usable on a sundial.

Over June to mid-September, during a beautiful summer, solar radiation was measured every 2.5 min near a pleasant south-facing wall, which was – unfortunately – eclipsed for much of the day by surrounding trees.

A somewhat facetious measurement – the Gnomonic Utility – was defined, giving the percentage of the day between 8 am and 6 pm (the period of time when a civilised person might wish to read a sundial) when a useful shadow could be produced on a sundial.

For the wall in question, the Gnomic Utility was a meagre 9%; the idea of a sundial on that wall was abandoned.

Note 1: LoRaWAN® is the technology that will be used for remote monitoring of the 'Internet of Things'.

Note 2: Changing the Gnomonic Utility's time constraint to the period from dawn to dusk produces a useful measurement.

Finally, there was a vote of thanks to everyone involved in making this another most successful and enjoyable day, in particular to David Pawley and Wendy for their hard work, and to Peter Ransom for acting as MC.

Notes by the speakers
Group and Speaker photos by Mike Shaw
Photos from the talks by the speakers, unless otherwise indicated

MINUTES OF THE 32nd BSS ANNUAL GENERAL MEETING

Newbury, 17 September 2022

The AGM was chaired by Frank King (Chairman) with Jackie Jones and Ben Jones in attendance.

1. Receive 2021 accounts and trustees' report

The 2021 accounts and trustees' report were circulated to all members in the June 2022 *Bulletin*. As no comments had been received by the trustees, they were taken as read.

2. Election of charity trustees

Bill Visick retired by rotation from the office of elected charity trustee. Bill was willing to continue to serve and offered himself for re-election.

Bill Visick was elected to the office of elected charity trustee.

Ben Jones, a nominated trustee since June 2022, resigned and offered himself for election.

Ben Jones was elected to the office of elected charity trustee.

3. Appoint examiner for 2022 accounts

Counterculture LLP were (re)appointed to examine the 2022 accounts.

4. AOB

Prior to the meeting, Piers Nicholson had suggested that the matter of the size of our membership might be aired. After consultation with the Chairman, it was agreed that this topic might best be discussed informally after the end of the meeting. No other business was raised.

The Trustees
1 October 2022

Discussion – Membership, Conferences and Volunteers

Piers Nicholson had asked about the decline in the number of members. Happily, in each of the past two years (and Covid notwithstanding), the number of new members joining has exceeded the number leaving. We now have approximately 250 members who are not Libraries or other similar bodies. A matter of greater concern is that very few of the recent joiners attend our conferences or Newbury meetings. This means that we do not get to know them and that, in turn, means that we cannot identify potential trustees or volunteers. Two obvious questions arise:

How do we entice newer members to our Conferences and Newbury Meetings?

In what other ways might we get to know our newer members?

There was a wide diversity of views on the conferences. For some, ease of car parking was essential; for others, proximity to a mainline railway station was important. Some liked the present format of two nights in some conference venue, many talks, a half-day outing and a conference dinner; others thought that more one-day meetings might be better. There was more agreement that if we do continue with our traditional conference format, we might make it clearer that attending as a day delegate could significantly reduce the costs; it is often quite easy to find cheaper accommodation not too far away.

Peter Ransom noted that traditional conferences were going out of fashion and Zoom meetings were taking their place. In this context, Martins Gills proposed that there should be a Zoom meeting approximately six weeks after each issue of the *Bulletin* is published; those signing in could make comments on and ask questions about any of the articles in the latest issue. The Latvian Sundial Society was already doing this with some success. It would certainly be a way of identifying enthusiastic members who had not otherwise come to our attention. Clearly someone has to host these meetings and there were no immediate volunteers.

Later in the day, Michael Faraday offered his services as a 'Zoom Master'; he can provide the technical service but would need someone else to act as host and guide the questioning. Anyone interested in this is asked to get in touch with *chairman@sundialsoc.org.uk*

The Trustees
1 October 2022

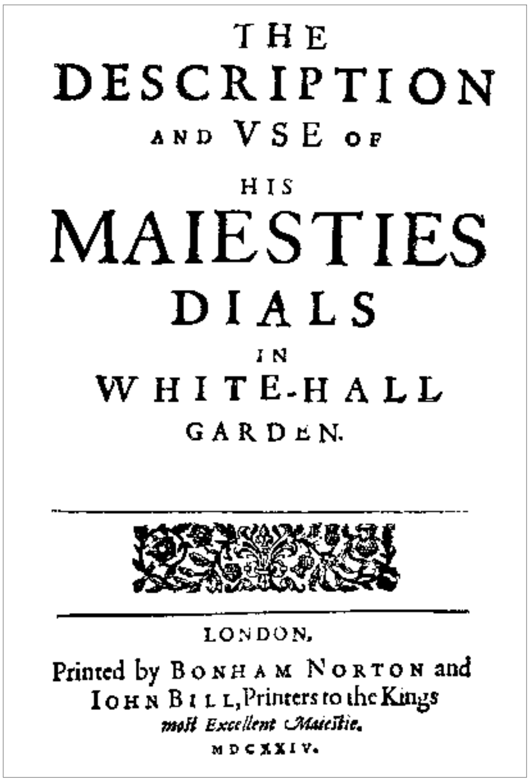
NOTE ON ANOTHER VANISHED DIAL IN THE PRIVY GARDEN, WHITEHALL

FRED SAWYER

I enjoyed reading Peter de Clercq's 'Note on the vanished dial in the Privy Garden, Whitehall' in the September 2022 *Bulletin*.[1] I was not previously aware of Zacharias Conrad von Uffenbach's travel journal and his mention of seeing in 1710 the "great sundial of which a special description in quarto has been printed" in the open space that was once the King's Privy Garden.

However, I believe that note also provides an opportunity to remind fellow diallists that there was more than one dial in the King's Privy Garden. No doubt the most famous today is the short-lived pyramid dial by Francis Hall (Line) pictured in Peter de Clercq's note and offered as possibly the dial referred to by Uffenbach. A brief description and history of this dial is given in the following excerpt from the *Survey of London*.[2]

> *A[n]…elaborate dial was set up in the Privy Garden on 24th July, 1669. This was of pyramidal form, with a series of iron branches projecting at intervals and supporting glass bowls, which showed the time according to various methods. The inventor (the "Reverend Father Francis Hall, otherwise Line, of the Society of Jesus, Professor of Mathematicks") wrote a detailed account of the dial, which was printed, with illustrations, in 1673…. Glass entered very largely into the composition of the dial, which was therefore liable to damage by frost. It was, nevertheless, left exposed to the inclemency of the weather, and the natural result followed. Towards the middle of the winter Father Hall "receaved a letter from a friend at London, wherein he told me that the Diall, for want of a cover (which according to his Majestyes gracious order, should have been set over it in the winter) was much endomaged by the snow lying long frozen upon it, and that, unlesse a cover were provided (of which he saw little hope), another or two such tempestuous winters would utterly deface it."*
>
> *In 1675 the dial met with further mishap. In a letter dated 26th June in that year it is recorded that "My Lord Rochester in a frolick after a rant did yesterday beat doune the dyill which stood in the midle of the Privie [Gard]ing, which was esteemed the rarest in Europ. I doe not know if … it is by the fall beat in peeces."*
>
> *The incident seems to have marked the end of the dial, for it does not appear in the view of 1695–8. Vertue doubtfully suggests that some of the remains were afterwards at Buckingham House, and Walcott records that "about 1710 Mr. William Allingham, mathematician in Canon Row, demanded £500 to repair this dial, but his offer was refused." It has not been possible to confirm this statement, which more likely refers to the great sun-dial.*


THE
DESCRIPTION
AND VSE OF
HIS
MAIESTIES
DIALS
IN
WHITE-HALL
GARDEN.

LONDON,
Printed by BONHAM NORTON and IOHN BILL, Printers to the Kings most Excellent Maiestie.
MDCXXIV.

Fig. 1. Title page of Edmund Gunter's 1624 book.

Uffenbach suggests that the dial he saw was of stone, but the only stone in the Grand Pyramidical dial was the pedestal; the dial itself was a fragile but very expensive construction of iron and glass. An evening of drunken revelry destroyed the dial and its remains either disappeared or (doubtfully) may have been moved to the gardens of Buckingham House (now Palace).

As the above excerpt points out, an offer in 1710 – the year of Uffenbach's visit – to repair a dial in the Privy Garden more likely referred to the Great Horizontal Sundial which had graced the garden in one incarnation or another since at least 1584. This dial was indeed of stone – 80 cubic feet of stone, styles and painted hour lines:

> *The Privy Garden…. The earliest description undoubtedly applying to the 'great garden' is that given in 1584 by Von Wedel: "… In the middle of the garden is a nice fountain with a remarkable sun-dial, showing the time in thirty different ways." …*

This is no doubt the one referred to in the following entry of 1621–2: "Nicholas Stone, mason, for takeinge downe the greate Sune Diall in the privy garden at Whitehall, makinge there a newe Diall of Portland stone answerable to the same in all poyntes, settinge in and fasteninge all the Gnomons there." The new dial was a copy of the old one so far as the main structure was concerned (save in the particular kind of stone used, see below), but seems to have differed in other respects. What may be called the scientific portion of the apparatus was devised by Edmund Gunter, the most famous mathematician of his time. In 1624 Gunter, by "the speciall direction of the Prince his Highnesse" (afterwards Charles I), published a description from which the following extracts have been taken:

"The stone whereon the Dials are described, is of the same length, bredth, and depth, with that which stood in the same place before. That, was of Cane stone, and of many pieces: this, all of one intire stone from Purbecke Quarrie. The base of it is a square of somewhat more than foure foot and a halfe; the height three foote and ¾ and so unwrought contained about 80 feete, or five Tonne of Stone …

"There be five Dialls described on the upper part: foure on the foure Corners; and one in the middle, which is the chiefest of all, the great Horizontall Concave …

"The Margent of this Horizontall Concave containeth foure Circles: whereof, the Uttermost is the Circle of the xij Moneths, conteining the severall dayes, the Dominicall letters, and the standing Festivails: The Holy dayes, in Redde; The Garter dayes in Blue, and the common Saints dayes in Blacke …

"The second Circle is of the twelve Signes: Aries, Taurus, etc …

"The third Circle is a standing Compasse, divided into thirty two points … whereby you may see upon what point the Sunne beareth, and how the winde bloweth.

"The fourth and innermost Circle containeth another description of the dayes of each moneth, fitted to the concave …

"The Concave is twentie inches deepe, and fourtie inches over: and being halfe round resembleth that halfe of the heavens which may be seene.

"The one part, which is drawen upon the white ground, resembleth so much of the heavens, as is contained between The Tropiques. As, there, the Sunne hath all varietie of motion, so heere, the point of the Style, all variety of shadow. The other part, which is on the Blue ground, is that part of the heaven, where the Sunne never commeth.

"The Style belonging to the Concave is xx inches long, and about xiij inches broad at the foot. The one edge which is upright, is the Axis of the Horizon, and with his shadow sheweth the Azimuth."

In 1632–3 further references occur to Gunter's dial: "Thomas Decritz, Painter, for painting, guilding and oyling the greate Dyall in the privy Garden and fower little dialls there"; "John Marr, Mathematician, for his paines and invention in making the greate Stone Dyall in the privy Garden at Whitehall"; "Elias Allen for taking of the horrizon of the greate Dyall in the privy Garden and making xx new screwpins to fasten it againe."

In March, 1665–6, William Marre received payment of £200 for "making the dial in the King's privy Garden at Whitehall."

There can be little doubt that 'the Sun Dial' marked in the plan of 1670 was in the main the same structure as erected in 1622. We meet it again in 1688 when William Marre applied for payment for "new lineating the Dyall in the Privy Garden." He mentioned that the work done was similar to that when he 'made' the dial "in the late King's time," so that 'making' need not mean more than 'new lineating.' [N.B. This payment may well be the source of Andrew Somerville's probably incorrect suggestion, cited by Peter de Clercq, that the pyramid dial was restored in 1688. Correct date – wrong dial.]

The dial survived the Fire of 1698 but had disappeared before 1741….

So, I suggest that the great stone dial encountered in 1710 by Zacharias Conrad von Uffenbach in the Privy Garden environs was more likely the remains or the descendant of Gunter's sundial, with lines having been recalculated and repainted a number of times since 1621 but still in a lamentable state of disrepair.

Gunter's complete 1624 text was reprinted (in Modern English) by Charles Aked in the June and October 1992 issues of the *BSS Bulletin*.[3] In his comments, Charles said that Gunter's dial was "demolished in 1697 as a result of damage and decay." However, the notes in the *Survey of London* observe that the dial survived the 1698 fire. An offer was made by William Allingham in 1710 to repair the dial (which one?). And, of course, we now know that Z.C. von Uffenbach visited a stone dial in the Privy Garden, also in 1710.

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2. Montagu H. Cox and Philip Norman ed. 'Whitehall Palace: Buildings', in *Survey of London: Volume 13, St Margaret, Westminster, Part II: Whitehall I* (London, 1930), pp. 41-115. *British History Online http://www.british-history.ac.uk/survey-london/vol13/pt2/pp41-115*. All excerpts in this note are from this source.
3. Charles K.Aked: 'His Majesty's dials in Whitehall Garden', *BSS Bulletin*, 92.2, 30-35 (June 1992) and *BSS Bulletin*, 92.3, 31-36 (October 1992).

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‘MEREDITH HUGHES OF BALA’ AND HIS FIVE KNOWN SUNDIALS

IRENE BRIGHTMER

Nearly a decade ago I began to track down dials made by Meredith Hughes. His 1761 dial in the churchyard at Conwy has been known for many years and is in the BSS Fixed Dial Register (SRN 3262). It was visited in 2001 on the BSS Sundial Safari, when members noted that it was “badly pitted”. Although they recognised that it was by Meredith Hughes, they reported little else.[1] Since I began my search four others by Hughes have emerged in North Wales, all signed and dated and spanning the decade from 1758 to 1768. Two were made for the gardens of country houses, and as well as the one in Conwy two others were made for rural churchyards. It is hoped that other examples may yet turn up with a further search of churchyards and country house gardens in North Wales.

Fig. 3. Churchyard dial by Meredith Hughes, 1766, originally in Caerhun. Now lost. Photo: Colin Brown.

Fig. 1. SRN 7490. Garden dial by Meredith Hughes, 1758, now near Ruthin.

Fig. 2. Detail of the Ruthin dial showing signature and date.

Dials by Meredith Hughes

Three of the dials are ‘plain’ dials. The earliest is dated 1758, and is now in a private garden near Ruthin (SRN 7490; Figs 1 and 2). It was formerly in the garden at Penloyn near Llanrwst[2] and may well have been commissioned for this location. It has been moved from there through inheritance arrangements, and the present owner purchased it a decade ago from its previous owner in Bolton, Lancashire.

The Ruthin dial strongly resembles the 1766 Meredith Hughes dial originally in the churchyard of St Mary’s in Caerhun, Caernarfonshire (Fig. 3). In the signature of both, the M for Meredith runs into the H for Hughes and there is a date. This image of the original Caerhun dial dates back to the 1980s and suggests that it had undergone some restoration, or perhaps the image was enhanced digitally.[3] Its present whereabouts are unknown; the pillar in the churchyard at Caerhun now supports a modern, mass-produced cast dial (SRN 2333) which was reported to the BSS in 1994.

The third ‘plain’ dial by Hughes sits on a simple stone pedestal in the churchyard of St Bridget’s at Carrog near Corwen (Figs 4 and 5). Only two-thirds of the original dial plate survives (SRN 7871), but happily it includes the inscription*: Meredith Hughes fecit 1768,* making it the latest of his five known dials.

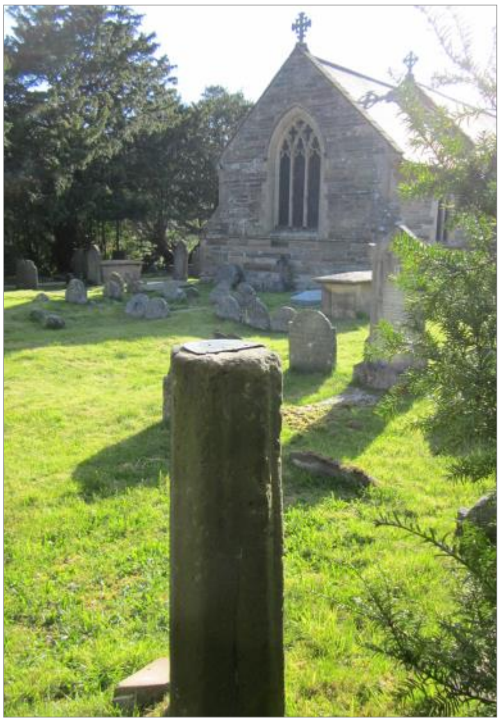

Fig. 4. SRN 7871 Churchyard dial by Meredith Hughes, 1768, in Carrog, near Corwen.

Fig. 5. Detail of the Carrog dial showing surviving part of dial plate with signature and date.

The other two Hughes dials are more elaborate, with further dial furniture, and are very different from one another. Both incorporate the Equation of Time and one is also a 'geographical' dial. One is the dial in the old walled town of Conwy, already mentioned (SRN 3262). It is in the churchyard of St Mary and All Saints and was originally reported to the BSS in 1996. By then it was already too badly weathered for the inscription to be read (Figs 6 and 7). However, Norman Tucker (1894–1972), the North Wales historian, saw it in 1960 and was able to decipher the details which recorded the commissioning of the dial, the date, maker, latitude and motto:

Erected
by the Corporation
of
Conway
Robert Wynne, Jnr Esq. Alderman
Hugh Williams and John Nuttal, Bailiffs,
1761
Meredith Hughes, Fecit Lat 53 20
Disce bene vivere et mori.

(The motto translates as: 'Learn to live and die well'.[4])

These details were also recorded more than a century ago by Bezant Lowe[5] but in addition he reported that the dial is delineated with single minutes, a compass rose, an Equation of Time, and that the time in Conwy is 15 minutes behind Greenwich.

The second complex dial is in the garden of a large country house near Denbigh and is signed: *Meredith Hughes de Bala fecit 1767* (Figs 8–11). It is the only dial identifying Hughes with Bala (SRN 7580). Also

Fig. 6. SRN 3262. Churchyard dial by Meredith Hughes, 1761, in Conwy.

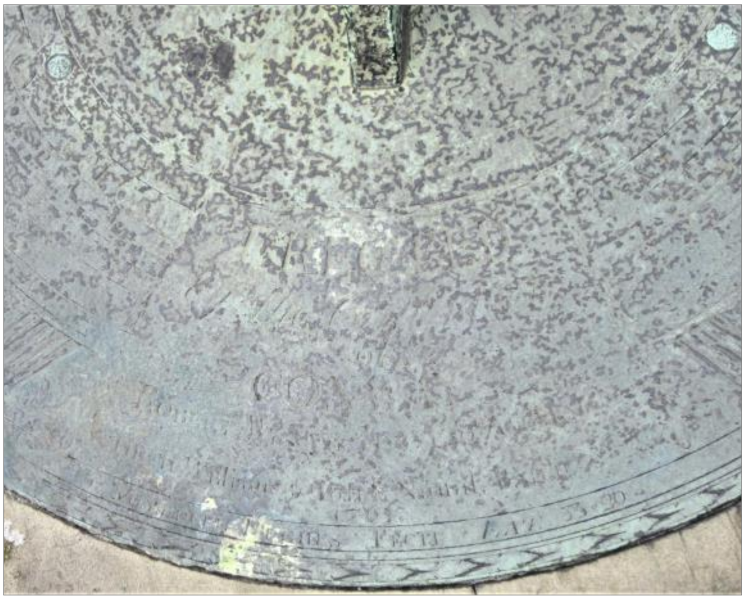

Fig. 7. Detail of the Conwy dial showing severe pitting of dial plate, but it is just possible to decipher signature, date and latitude.

Fig. 8. SRN 7580. Garden dial by Meredith Hughes, 1767, now in a country house garden north of Denbigh. Photo: Jim Maxwell.

Fig. 9. Detail of the 1767 dial, showing the motto and signature.

Fig. 10. Detail of the chapter ring of 1767 dial, with one of the place names: YAS DE AMBER.

inscribed are the latitude of 53d 14m, and a motto: *Ex hoc momento pendet aeternitas,* which translates as: 'On this moment hangs eternity'[6] (Fig. 9).

This is a geographical dial and incorporates 32 names of places around the world positioned in the chapter ring between the hour numerals, which are inward-facing (Figs 10 and 11). The place names are located on the dial to show when noon occurs at that place. New York, for example, is inscribed at about 5 pm on the dial, indicating the time in Wales when it is noon in America. Like other details on the dial, some of these place names are now difficult to read after over two hundred and fifty years of weathering. Moreover, some places have changed their name and are difficult to identify today (see Table 1) especially as the longitudes of far-off places were not known accurately in the eighteenth century.

Inside the chapter ring is an Equation of Time scale, this time facing outwards and arranged anticlockwise. The outer ring specifies WATCH FASTER/WATCH SLOWER. Then there are the EoT minutes (perhaps subdivided?) followed by the individual days numbered in 10s and finally the months (abbreviated).

After a double-circle divider, there is the first part of a unique feature. The main dial has a narrow scale whose details have not yet been deciphered. The values are read against those on an outer circle of a moveable annulus which rotates on top of the main dial plate (or at least did – it is now immoveable), with the aid of two small knobs. Inside the annulus is located by a fixed disc which carries the gnomon and is engraved with a 16-point compass rose. The annulus carries a set of four outward-facing concentric scales, none of whose details have been fully interpreted. Working inwards, the outer ring has a numerical scale. The next ring is slightly broader and carries some script which seems to include the words "Number of days…". Further round, the word "Eclipse…" is visible. The third ring seems to bear the names of the zodiac and the fourth is

Place Name On Dial	Place Name Now	Longitude	Calc Time (h:min)	Dial Time (h:min)
				XII
CALAIS	Calais	1° 56′	11:38	11:42
GENOA	Genoa	8° 57′	11:10	11:15
				XI
C PASSERO	C Passero (Sicily)	15° 10′	10:45	10:44
VENICE	Venice	12° 21′	10:57	10:15
				X
NICOSIA	Nicosia, Cyprus	33° 22′	09:33	09:40
ALEPPO	Aleppo, Syria	37° 10′	09:17	09:12
				IX
TAURIS	Tabriz, NW Iran	46° 17′	08:41	08:43
YAS DE AMBER	Amber Island, Mauritius	57° 05′	07:58	08:16
				VIII
DIGO ROYT	?	*64° 30′*	07:42	07:42
TATA	Thatta, Sindh, Pakistan	67° 55′	07:14	07:16
				VII
CALICUT	Calicut, Kerala, Malaya	75° 46′	06:43	06:45
BACCA	?	*87° 30′*	06:10	06:10
				VI
ANDAMAN	Andaman Is, Indian Ocean	92° 30′	05:36	05:40
PEGU	Bago, Burma	96° 29′	05:20	05:10
				V
BANSAC	Banten, Java	106° 15′	04:41	04:40
CANTON	Canton, China	113° 10′	04:13	04:16
				IV

Place Name On Dial	Place Name Now	Longitude	Calc Time (h:min)	Dial Time (h:min)
				XII
DUBLIN	Dublin	6° 20′	12:11	12:10
C BAJADOR	C Bojador, W Africa	14° 30′	12:44	12:45
				I
ST MICH TEST	Sao Miguel Island, Azores	25° 30′	01:28	01:15
EORTS	Flores, Azores	31° 12′	01:51	01:50
				II
FATR TORT	Fortaleza, N E Brazil	38° 32′	02:20	02:15
C ERTO	C Frio, Rio de Janeiro	42° 01′	02:34	02:45
				III
C JOHN	C St John, Newfoundland	55° 30′	03:28	03:15
ANTEGONE	Antigua, Caribbean	61° 48′	03:53	03:50
				IV
C COD	Cape Cod, Mass, USA	70° 10′	04:27	04:18
NEW YORK	New York	74° 00′	04:42	04:50
				V
PANAMA	Panama	85° 40′	05:31	05:15
ESCONDIDO	Escondido, Nicaragua	87° 05′	05:34	05:50
				VI
NEW ORLEANS	New Orleans	90° 04′	05:46	06:10
NACANNE	?	*103° 50′*	06:55	06:55
				VII
COMPOSTELLA	Compostella, Nayarit, Mexi-co	104° 53′	06:46	07:10
S THOMAS	?	*117° 30′*	07:50	07:50
				VIII

Table 1. The geographical place names on the Meredith Hughes dial of 1767.
The shaded columns show the Place Names and their corresponding time positions on the dial: these indicate the time at Segroit when it is noon at the named Place.
The 'Calc Time' is the time difference between Segroit and the named Place: it is calculated from the Longitude, less 14 minutes for Segroit's position 3.5 degrees west of Greenwich. Ideally the last two columns would agree.
A 'Longitude' in italics is calculated from the Dial Time for unidentified locations.
Compiled by John Foad.

Fig. 11. Detail of the 1767 dial, showing the monogram and "SEGROIT" in the noon gap.

again numerical, and seemingly reads up to 30° for each sign, i.e., it is showing the sun's celestial longitude.

(Another geographical dial with a rotating disc has been described in the *BSS Bulletin*.[7] But the plate of the Norfolk dial (SRN 7369) had a different function from that of the Hughes dial and was connected with the reading of noon time at places around the world.)

Around the 'toe' of the gnomon (the centres of delineation) there is a small, partly damaged, triangular segment on top of the central disc: it may be engraved with the datum mark for the inner scale of the annulus. Altogether, this set of scales is most intriguing and probably unique – hopefully one day it will be properly explained.

The gnomon itself is pierced and nicely cast and features a small foot along its base to provide extra stability, a feature which is sometimes found on Irish dials of the period.

In the noon gap is "SEGROIT" (Fig. 11), indicating the place for which the dial would have been made. This is an old name for Segrwyd, a country estate a mile or so south of Denbigh and only three or four miles from the dial's present location. The dial may well have been in its present country house garden for as long as two hundred years. The late owner who first showed me the dial and allowed me to record and photograph it knew that the dial had come from elsewhere long before his lifetime, but he did not know from where, and could not account for the move.

On the dial plate there is also a decorative monogram (Fig. 11) which incorporates an intertwined double initial 'M', providing a clue to the owner of Segrwyd when the dial was made. Segrwyd was originally given by Henry VII to Robert Dolben and it remained with the Dolben family until 1709 when the male line died out with John Dolben. His daughter Jane married John Mostyn, from when Segrwyd remained with a branch of the ancient Mostyn family until the late nineteenth century.

A subsequent John Mostyn of Segrwyd married Anna Maria Maredydd and it is likely that the dial was commissioned in 1767 by them. The inscribed double 'M' combines the initials of their respective family names: Mostyn and Maredydd. It is possible that the date on the dial commemorates their marriage. Their son, John Maredydd Mostyn, was born in 1775.

How, when and why the dial came to its present home needs further research into the links between the Mostyn family of Segrwyd and the earlier occupants/owners of the dial's present location, but I have discovered nothing so far to explain the dial coming here so long ago.

(Confusingly, the recent council listing details for the house, which is Grade II*, suggests that the 1767 date on the sundial may refer to the date of a major re-ordering of the house in the 1760s. We know that the house was indeed altered, but later than this, by John Maredydd Mostyn and his wife Cecelia after their marriage. Therefore the listing note reveals an incomplete reading of the dial, through ignoring the inscribed name of the place 'Segroit' for which the dial was originally made.)

Meredith Hughes

Meredith Hughes appears in the archives numerous times. We have no record of his birthdate, but he died in 1796.[8] He appears to have been a man of many parts and was variously identified as a gentleman, chief steward and land surveyor. There are references to him living in Bala: *.....he keeps the shop next to the Inn. He is an excellent surveyor, somewhat of a philosopher and a very decent and intelligent man.*[9] To these we can now add 'sundial maker'.

In 1782 Meredith Hughes was the chief steward to Robert Watkin Wynne (c.1754–1806).[10] Wynne was a North Wales landowner and politician, and cousin of Sir Watkin Williams Wynne of Wynnstay, the Fifth Baronet. Robert Watkin Wynne's two estates were Garthmeilo in Corwen, Merionethshire, and Plas Newydd in Denbighshire. He was MP for Denbighshire 1789–96, and then became High Sherriff of Merionethshire in 1798–99.

There are records of Meredith Hughes working for several North Wales landowners as a land surveyor. Bangor University Archives hold a volume of maps of the Wern estate of William Wynne (1745–96) in Merionethshire and Caernarfonshire, drawn by Hughes in 1773.[11] The catalogue comments: *The maps, generally, are neat enough and the names of fields are especially valuable,* and also states that Hughes was working as a surveyor from 1761 to 1779. This period overlaps with and extends beyond the decade of his known sundial-making period.

Maps drawn by Meredith Hughes from 1774 and 1775 for other North Wales estates were reportedly donated to the National Library of Wales in the 1970s. They include land in Gyffylliog parish and a map of the Bachymbyd estate in Llanynys parish, both in Denbighshire.[12] Anglesey

Archives hold a map of the Cemaes Estate in 1772, also drawn by Hughes.[13]

Meredith Hughes is included in the Index of British Mathematicians as a 'land surveyor' and his dates are given as 'after 1740 and before 1770'. It does not mention his other mathematical activities.[14]

Meredith Hughes's name occurs in numerous archival references to routine legal cases and other matters connected with his responsibilities as Wynne's chief steward.

We also discover that Meredith Hughes was an experimental scientist. The Hon. Daines Barrington FRS (1727–1800), lawyer, antiquary and naturalist, with professional connections in North Wales, wrote a letter to the Royal Society giving an account of experiments which Hughes conducted in the Arenig Mountains near Bala, demonstrating that rainfall increases with altitude.[15]

There are also references to Hughes working out a method for measuring the altitude of mountains using a barometer, again in the Arenig Mountains. This is mentioned by the eighteenth century North Wales traveller and naturalist, Thomas Pennant, who described Hughes as: … *the ingenious Mr Meredith Hughes of Bala ...* [16]

Conclusion

Clearly Meredith Hughes was not the usual eighteenth century diallist, who may have been making dials alongside clock-making. He was a gentleman with a scientific mind and seems to have moved easily among the aristocracy of North Wales. So how did he go about making these five dials?

Our attention was originally drawn to the complex garden dial near Denbigh by the late Colin Brown who wrote the book about the clockmakers of Llanrwst (see Note 2). During his research Brown looked for sundials which may have been made by those clockmakers, but drew a complete blank. His conclusion was that a clockmaker would make sundials only if there were an engraver in the workshop. Brown deduced that the Llanrwst clockmakers were not themselves skilled engravers, and that until about 1790 their clock dials were engraved elsewhere, mostly in Lancashire.[17]

In my correspondence with Colin Brown he stated that he believed that the dials signed by Meredith Hughes were designed by him but made in Lancashire, like the clocks of Llanrwst. Some other North Wales dials from the same period as the Hughes dials have been examined by BSS members, including the 1775 Bryngola dial, where it is believed that the making was also out-sourced to engravers in Lancashire.[18]

This study has shown that the sophistication, especially of the Conwy and Denbigh dials, displays the mathematical knowledge, understanding and competence of Meredith Hughes as a diallist, even though he may not have been the engraver. It is tantalising to think that there may be more dials out there which provide further evidence of his dialling skills.

ACKNOWLEDGEMENTS

I am immensely grateful to John Davis (BSS Editor) and John Foad (BSS Registrar) for their huge help in deciphering and interpreting these dials, especially the complex dial dated 1767 located near Denbigh (SRN 7580).

The late Colin Brown played an important part in the early stages of this study. The private owners of SRN 7490 (now in a garden near Ruthin) and SRN 7580 near Denbigh were both very helpful in allowing me to record and photograph their dials. Dr Shaun Evans of Bangor University kindly assisted by alerting me to some of the archival references to Meredith Hughes. Many thanks to Jim Maxwell for some of the images.

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2. Colin and Mary Brown: *The Clockmakers of Llanrwst*, Bridge Books, Wrexham (1993), pp. 181-2.
3. I am grateful to the late Colin Brown for the illustration.
4. A. Gatty, H.K.F. Eden and E. Lloyd, *The Book of Sun-Dials,* George Bell and Son, London (1900), p.241. Entry number 220 refers to the Conwy dial and gives its date of 1761 and the commissioning details, as cited above. No examples are given of the use of this motto elsewhere.
5. W. Bezant Lowe, *The Heart of Northern Wales,* Vol. 1, published by the author, Llanfairfechan (1912), p.303.
6. Gatty, Note 4, p.255. Four other uses of this motto on sundials in Britain are given, but the Hughes dial is not included.
7. Ian Butson: 'An Unusual Geographical Sundial', *BSS Bulletin,* 25(i), 37-39 (March 2013).
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THE BELGIAN ALTITUDE DIAL: A HEVELIUS DIAL

STEVE LELIEVRE and SUE MANSTON

In an article[1] in the September 2022 *Bulletin*, Sue Manston described a small, undated Belgian altitude dial and offered a couple of suggestions as to how it might be properly oriented in use. Two responses were received: a letter from Graham Stapleton (see page 40) and an email from Steve Lelievre. Both suggested that the dial should be held with the long edges horizontal, and that the string with a bead on the end was a plumb bob to ensure the dial was held level. There needs to be some sort of alidade or pinhole in the 'sunrise' curve which would cast a beam of sunlight onto the correct hour marker once the dial is turned edge-on to the sun.

More specifically, Steve suggested that the dial is a form of Hevelius dial, perhaps imperfectly implemented. Hevelius dials are very rare — only about 20 are known — and to find a wooden one would be exceptional. Another extremely unusual attribute of the Belgian dial (Fig. 1) is a declination scale calibrated not by degrees of solar declination or by months, but by the hour of sunrise (a table on the back gives the time of sunrise for various dates throughout the year).

The Hevelius dial is a type of altitude dial; it is latitude dependent and consists of a circular declination scale with a bulge for the hour scale, and a pinhole on a moveable arm which can be set to the declination.

This type of dial is named after astronomer Johannes Hevelius (1611–87) from Danzig in the Polish–Lithuanian Commonwealth (now Gdansk, Poland). Unfortunately, Hevelius's own dial, dating from 1638, was lost during the Second World War and is now known only from photographs.[2]

Fig. 1. The front side of the Belgian dial (contrast altered to enhance detail). The reverse has a table showing the time of sunrise for various dates throughout the year. Scanned image courtesy of François Juge.

When Sue Manston informed the owner of the Belgian dial, François Juge, that it could possibly be a Hevelius dial, he sent photographs of another item in his collection — a Hevelius dial dated 1616 (Figs 2 and 3). This was quite a surprise as it indicates that the design actually precedes Johannes Hevelius's item.

Fig. 2. Front view of Hevelius dial with declination scale on the left and hour scale on the right. Photo courtesy of François Juge.

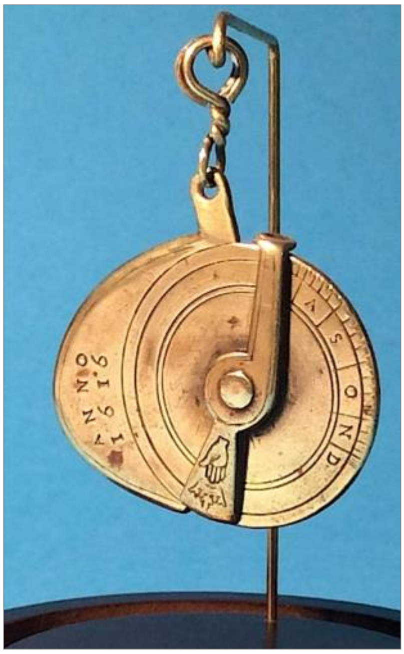

Fig. 3. Reverse of Hevelius dial showing rotating arm with pinhole, dated 1616. Photo courtesy of François Juge.

Jan Roelas van Vries of Amsterdam made Hevelius dials in the mid-17th century, two of which survive. A description of his construction method[3] is:

- Decide the radius and centre of the circle that provides an arc for the declination scale. Draw the circle at the upper left of a piece of paper.
- Decide the position of the noon hour mark; it should be marked at approximately the same level (height on the page) as the bottom of the circle, but slightly to the right.
- From the noon mark, draw a line upwards to the left at an angle equalling the co-latitude, so that the line runs fully across the circle. The equinox position of the declination scale occurs where this line intersects the circle for the second time (left side of circle). Repeat for the co-latitude ± 23.44° to get the solstice positions on the scale. Continue the process by marking scale positions for other dates/declinations of interest.
- With the declination scale complete, start to add the hour marks. This requires a table of solar altitudes on the solstices and equinox. For each hour, draw lines starting from the equinox and the two solstice positions, sloping down at the applicable angles until they reach the right side of the paper. The three lines will not quite converge, instead forming a triangle. Use the incentre as the hour point (Fig. 4).

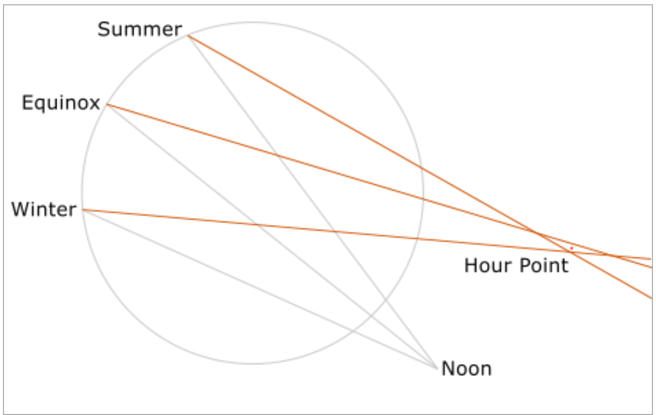

Fig. 4. Placement of hour marks by the method used by Jan Roelas van Vries.

Note that during the winter months the sun is below the horizon for some of the hours being marked, but there was no explanation of how to proceed when this happens. One could continue to use the winter solstice as a starting point for the lowest of the three lines, even though the sun is below the horizon, or one could use only the remaining two lines, plotting the hour point at their intersection. Other constructions are possible. For example, the option adopted by Steve Lelievre for his on-line Hevelius Dial generator (*https://gnomoni.ca/hevelius*) always uses three lines but if, for the hour being plotted, the sun is below the horizon on the winter solstice, the program substitutes the declination that produces sunrise at the chosen hour. In the following

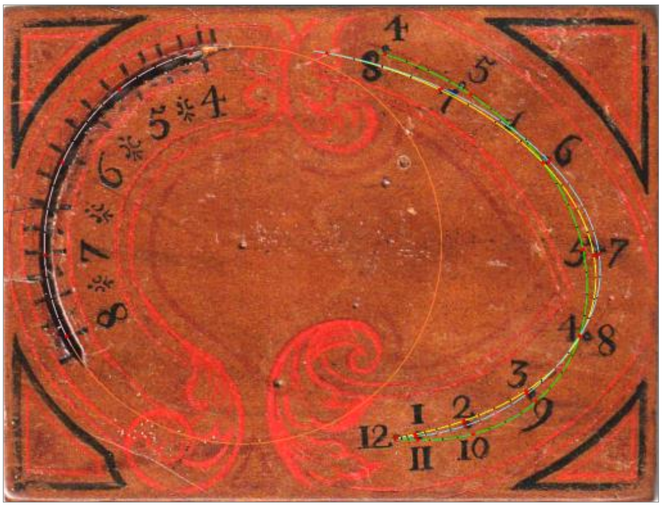

Fig. 5. The Belgian dial with superimposed construction circle, declination scale, and hour curves. The pale blue hour curve is generated by Steve Lelievre's program, which places hour points at the centre of a triangle made by altitude lines emanating from the declination scale's summer solstice position, the 'lower position' (see main text), and a position halfway between the two. The yellow curve was generated by using the intersection of the lines from the summer solstice and the 'lower position'; the green line used the summer solstice and equinox positions. Background image courtesy of François Juge.

discussion, we will use 'lower position' to refer to whichever declination is selected according to this rule.

To assess possible methods used to calculate the Belgian dial, we obtained a digital image of it and superimposed hour marks calculated using various combinations of starting points for the construction lines. Using a digital scanner, rather than a camera photograph, helped ensure that the image was not skewed or subject to perspective distortion.

The yellow curve of Fig. 5 uses only the summer solstice position and the lower position, so each hour point is simply the intersection of two lines. The pale blue curve is generated by the online program. This curve would be harder to construct manually because it always uses three lines to determine each hour point; the lines do not meet at a single point so the maker would end up using the resulting small triangle to guess the best position.

Between noon and ±6h, both the pale blue and the yellow lines stay close to the hour points seen on the dial, but neither matches the dial particularly well between ±6h and ±8h. On the other hand, the green line is a worse match between noon and ±6h but performs better than the other cases between ±6h and ±8h. It is based on the equinox and summer solstice positions.

In short, the dial could have been calculated in a number of different ways, perhaps even a hybrid method that takes different starting points depending on the part of the hour curve being plotted. That is, one could use the yellow (or perhaps the pale blue) curve until ±6h and then switch to the green curve. Doing so gives the best match of all the combinations we investigated but, given the lack of clues, a non-hybrid method is equally likely. Another reason we will never know for sure is because, as we are about to discuss, the hour curve as drawn does not conform well to the theoretical shape, however calculated.

It is all very well to find a reasonable match for the positions of the hour points, but the dial also has an hour curve connecting its hour points. As mentioned in Sue Manston's article in the September 2022 *Bulletin*, this hour curve is clearly made up of two circular arcs. We see in Fig. 6 that between the 5 am/7 pm point and the 4 am/8 pm point, even our hybrid yellow–green hour curve is not a good match for the dial's hour curve (emphasised in black and drawn from centres A and B).

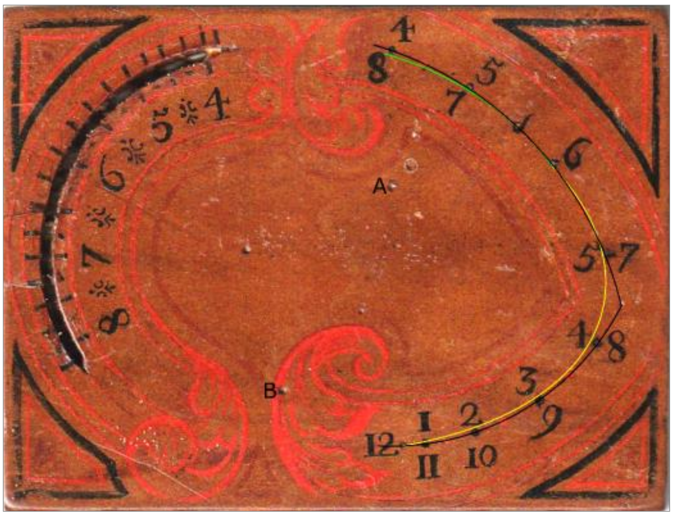

Fig. 6. A candidate hour curve based on calculation (yellow–green) alongside the actual hour curve seen on the Belgian dial (black). Background image courtesy of François Juge.

It seems that the bulbous shape of a calculated hour curve was discarded for some reason, with a geometrically simpler version replacing it – even though doing so reduces the accuracy of a type of dial that already has some intrinsic inaccuracy owing to the design. Quite how the centres A and B were chosen is unclear. Steve has done some analysis but his findings are inconclusive (he would welcome correspondence about it).

We speculate that an original, more precise, layout may have been simplified so that multiple copies of the dial could be made using only a ruler, compasses (for drawing the sunrise and hour curves) and a protractor (for placing marks according to a prepared list of angles). A simple painted wooden dial produced this way would have been easy to make at low cost.

Conclusions

We believe that the dial is of the Hevelius type, possibly a unique example — the only wooden one, and the only one using the time of sunrise as a proxy for solar declination. There are some deliberate simplifications and small errors in the way the dial is laid out. The table on the reverse, which gives the time of sunrise on various dates, has several significant errors and only gives sunrise time to the nearest quarter of an hour. We conclude that the dial is probably the work of a provincial maker, perhaps following a template, rather than an expert diallist.

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Holiday Picture: Delft

This misaligned dial is in the garden of the Klaeuwshofje, a courtyard of almshouses in Delft, dating from 1605 and founded by Dirck and Elizabeth Uyttenhage, owners of a brewery called 'de Klaeuw'.

Photo courtesy of Jenny Tyte

THE TRAVELLER'S STAFF: A CONTINUITY OF TIME-TELLING

GRAHAM STAPLETON

Casting about the Internet in Google Books for dialling material that could be written about, I found a number of antique books and pamphlets that had been digitised in the interests of wider access. One such find was *The Newest Young Man's Companion* of 1773,[1] which offers within its pages a variety of information for the aspiring but impecunious, including '*a table shewing the hour of the day by a walking-stick divided into ten parts*.' The table (Fig. 1) is easily recognisable as being of solar altitudes for pairs of hours before and after noon, converted to shadow lengths and running between the summer and winter solstices. The accompanying text (Fig. 2) describes how once having marked a "rule or walking-stick of any length […] into ten equal parts", by measuring the length of the upright stick's shadow and finding the nearest comparable value in the table, the hour is known.

[344]

A TABLE ſhewing the hour of the day by any ſtick, or walking-ſtick, divided into ten parts.

Before Noon.				12	11	10	9	8	7	6	5
After Noon.					1	2	3	4	5	6	7
J	11	11	I	5b	6	7b	9c	13b	19a	3 b	57a
	1	12		5b	6	7b	10	13c	19b	30	59
	21	2		5c	6b	7c	10	14	20a	32	65a
M	11	13	I	6a	6c	8a	10c	14c	21b	35	78b
	40	23		7	7b	9	11b	16	23	40	108
A	20	2		7c	8a	10	12c	17b	26b	48	196
	9	13	A	8c	9a	11	14	19b	30a	62a	
	30	23		10	10b	12a	21	22a	30b	92a	
M	20	2		11a	12	14	18	26	46	182	
	10	13	S	13	13c	16	21	31a	62c		
	28	23		15	16	18c	24c	39	17a		
F	18	3		17b	18b	22	29c	51	210		
	8	13	O	20b	21c	26	36	70			
	29	23		24	25b	31	46	110			
I	19	2		28	29c	37	59	208			
	9	11	N	32	4b	44	76	829			
	30	21		36	39	51	97				
D	21	1		29	42b	56b	117				
	11	11	D	40	43c	59	126				

Fig. 1. Table of dates and shadow lengths according to the hour (The Newest Young Man's Companion, 1773).

The Uſe of this Table.

TAKE a rule, or a walking-ſtick of any length, and with the compaſſes, or otherwiſe, divide it into ten equal parts, by nine notches therein, or ſmall braſs nails.

To know the Hour of the Day.

Set the ſtick upright, on ſome plain level ground (the ſun ſhining on the ſtaff, and mark where the ſhadow of the ſtick ends, then meaſure the length of the ſhadow, if the ſhadow was one ſtick's length and a half, that is fifteen parts.

E X A M P L E.

Suppoſe that on the 22d day of February, I found the length of the ſhadow of my ſtaff, two ſticks length and two parts, that is twenty two parts in all.

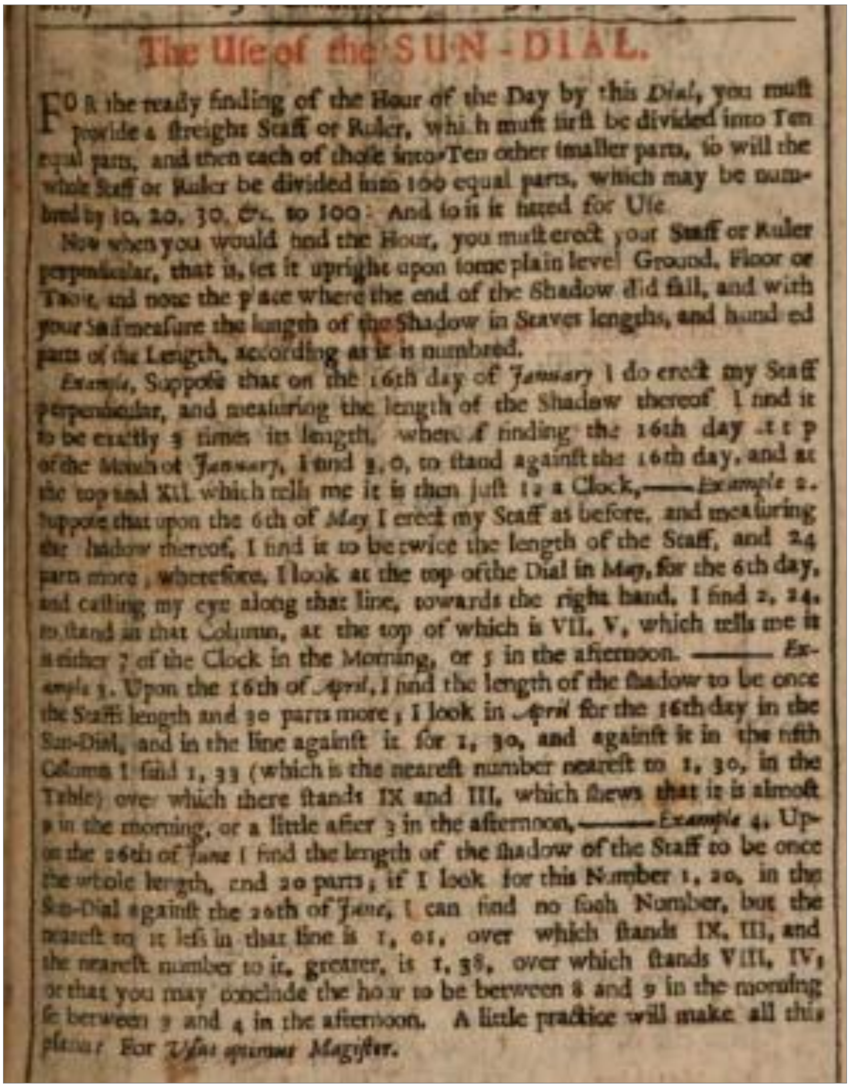
Firſt, I look into the table for February, or F. the 22d day, but I take the neareſt, that is the 18.

Secondly, Having found the neareſt day of the month, as 18, from thence I draw my finger along the line towards my right hand to find the neareſt number to the 22 part of my ſtick's ſhadow, and I find 22. Then I caſt my eye above this 22 to the top of the table, and I find 10 and 2, ſo that it is either 10 o'clock in the morning, or 2 in the afternoon.

Note, That 19 a in the top-line ſtands for 19 parts, and the a for a quarter of a part. And b ſignifies half a part. And c three quarters of a part.

Fig. 2. Instructions for preparing a stick and use of the table (The Newest Young Man's Companion, 1773).

As diallists, we immediately recognise that this is an unsophisticated approach. One table will not provide good results for the whole of England, still less by measuring in tenths of a stick's length, even if a few quarters, halves and three-quarters of a 'part' are admitted. What came as a surprise however was the right-hand double column of dates: With 11 December and 11 June given as solstice dates, and 10 March/13 September given as the equinoxes, this table is clearly for the Julian calendar, over twenty years out of date at the time of publication.



The Use of the SUN-DIAL.

FOR the ready finding of the Hour of the Day by this *Dial*, you must provide a streight Staff or Ruler, which must first be divided into Ten equal parts, and then each of those into Ten other smaller parts, so will the whole Staff or Ruler be divided into 100 equal parts, which may be numbred by 10, 20, 30, *&c.* to 100: And so is it fitted for Use.

Now when you would find the Hour, you must erect your Staff or Ruler perpendicular, that is, set it upright upon some plain level Ground, Floor or Table, and note the place where the end of the Shadow did fall, and with your Staff measure the length of the Shadow in Staves lengths, and hundred parts of the Length, according as it is numbred.

Example, Suppose that on the 16th day of *January* I do erect my Staff perpendicular, and measuring the length of the Shadow thereof I find it to be exactly 3 times its length, where finding the 16th day at top of the Month of *January*, I find 3, 0, to stand against the 16th day, and at the top stand XII which tells me it is then just 12 a Clock,——*Example* 2. Suppose that upon the 6th of *May* I erect my Staff as before, and measuring the shadow thereof, I find it to be twice the length of the Staff, and 24 parts more; wherefore, I look at the top of the Dial in *May*, for the 6th day, and casting my eye along that line, towards the right hand, I find 2, 24, to stand in that Column, at the top of which is VII, V, which tells me it is either 7 of the Clock in the Morning, or 5 in the afternoon. ——*Example* 3. Upon the 16th of *April*, I find the length of the shadow to be once the Staffs length and 30 parts more; I look in *April* for the 16th day in the Sun-Dial, and in the line against it for 1, 30, and against it in the fifth Column I find 1, 33 (which is the nearest number nearest to 1, 30, in the Table) over which there stands IX and III, which shews that it is almost 9 in the morning, or a little after 3 in the afternoon,——*Example* 4. Upon the 26th of *June* I find the length of the shadow of the Staff to be once the whole length, and 20 parts; if I look for this Number 1, 20, in the Sun-Dial against the 26th of *June*, I can find no such Number, but the nearest to it less in that line is 1, 01, over which stands IX, III, and the nearest number to it, greater, is 1, 38, over which stands VIII, IV, so that you may conclude the hour to be between 8 and 9 in the morning & between 3 and 4 in the afternoon. A little practice will make all this plain; For *Usus optimus Magister*.

Fig. 3. Instructions for marking a stick and examples of its use (The English Chapman's and Traveller's Almanack, 1710).

The other dates provide a further disappointment and suggest that the results would always have been very approximate. The dates are given at ten-day intervals, but checking with a contemporary source,[2] it can be seen that the apparent pairs of dates – which might be expected to have matching solar declinations – vary by 20-40 minutes of arc. Clearly for the intended reader, overall simplicity was a greater consideration than accuracy.

This said, it seemed worth establishing the latitude of the table. Reverse-calculating the altitude figures for the equinoxes and solstices suggested a value around 52.4°. The most obvious candidate for this is the city of Coventry (whose modern value is 52° 24′ 29″ N),[3] which is very nearly at the geographic centre of England[4] and a fair median for the market towns of central England.

Searching further, I came across *The English Chapman's and Traveller's Almanack*,[5] which was published over a span of years. This pamphlet is older than the *Companion* and intended for a lower class of person. The term 'chapman' is now obsolete, but may be understood as pedlar or hawker, an itinerant seller of small, cheap goods. Amongst other information the *Almanack* gives are: the post-roads, lists of fairs and markets, arithmetical tables, a sun-dial, the rising and setting of the sun and moon and length of days.

This takes a similar, but more thorough, approach to the 'sun-dial' (Fig. 3), supposing the stick to be divided with one hundred 'parts', and giving figures for every fifth day of the month (Fig. 4). The shadow-lengths for the hours are given in staff-lengths and their hundredths, rather than just total hundredths. Once again, reversing the altitude figures suggested a centring upon Coventry. All of the foregoing suggests that for at least a section of the population in eighteenth-century England, time-finding from the sun's altitude remained a practical and possibly essential method. Walking from town to town, a pedlar would probably be out of range of even a church clock's chimes for long parts of the day, but would need to know how much daylight remained.

Such traveller's staffs as made by itinerants would have been improvised and subject to heavy wear, so it is not surprising that apparently no examples of this rougher form of divided staff remain. The possibility of a surviving staff of more sophisticated manufacture led me to trawl the collections database of the National Trust.[6] My study of the more than 1050 canes and sticks was necessarily cursory, but found nothing. I was however guided to Chris Daniel's 'Sundial Page' for a possible example.[7] Originating in the Groningen province of the Netherlands, this antique walking stick has a scale marked by small brass nails that shows every sign of having been 100 units before the stick was shortened. However, ambiguity in the date of the stick and because the scale is almost exactly one metre, positive identification as a traveller's staff was not possible.

The next question that occurred to me was where the compilers of these pamphlets obtained their figures. Given their cheap nature, I suggest that they were copied from one of the numerous popular astronomy books available in the eighteenth century, such as that of Thomas Todd.[8] In the case of the *Companion,* the figures were blatantly lifted from an earlier work, and in all probability so were those of the *Almanack*. The process of copying (which would inevitably introduce mistakes), plus the number of older books with calendrical and astronomical tables that were produced since the advent of printing, makes it impossible to trace the origins of any particular set of figures.

Among the much earlier forerunners for these tables are the *Kalendarium* of both Nicholas of Lynn and John Somer, both of the late fourteenth century, but available in a

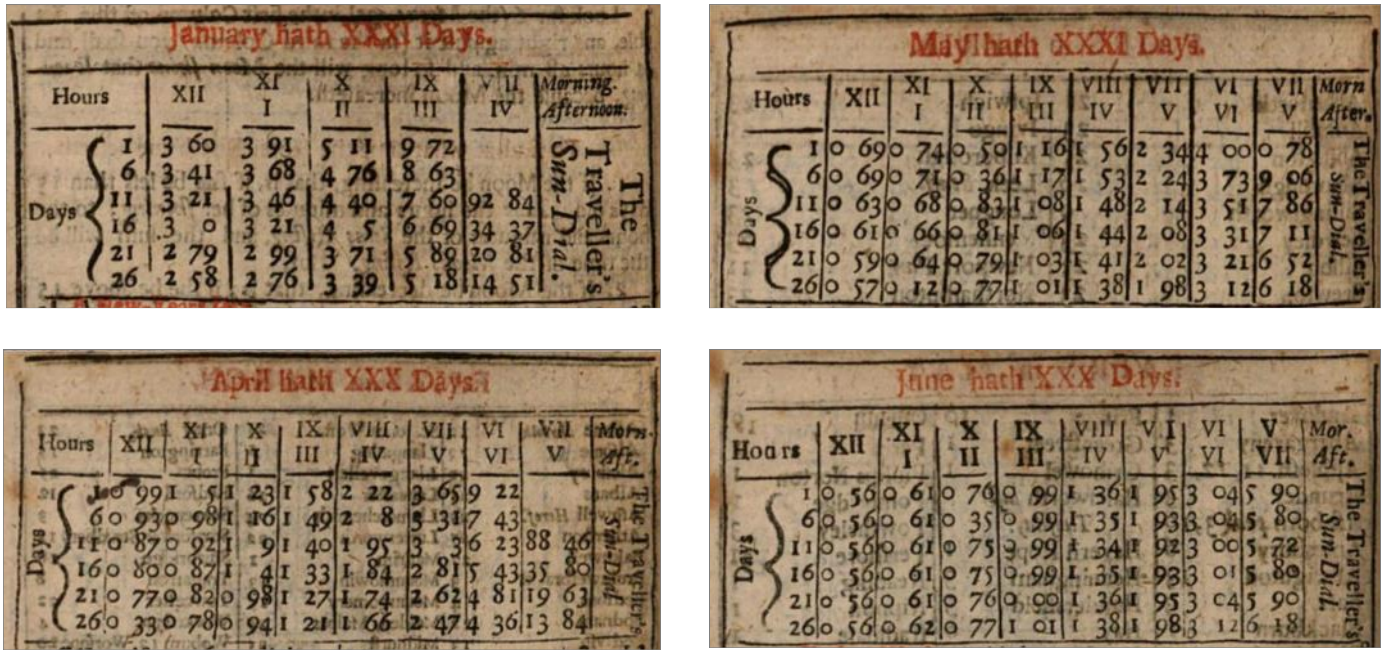


Fig. 4. Table of shadow lengths for the months of January, May, April and June (The English Chapman's and Traveller's Almanack, 1710).

modern publication.[9] Nicholas of Lynn (now King's Lynn, Norfolk), a Carmelite friar based in Oxford – possibly associated with Merton College's School of Astronomy – composed his *Kalendarium* in 1386, intending its values to be correct until 1462. Each month has several pages of figures, but the ones of interest here are of solar altitudes.

Each of these pages is headed "The altitudes of the Sun and the lengths of the shadows of any man six feet high in hours of equal distance from Noon and from Midnight at latitude 51 degrees 50 minutes." Across the top of the columns are whole hours in pairs from noon, with the most hours in June and fewest in January. The dates of the month run down the side of the page. For each hour, the solar altitude is given in degrees and minutes, and the 'man's shadow' in feet and their sixtieths ('pedes' and 'partes'). Besides being a probable source for other publications, there are at least three places in Geoffrey Chaucer's *Canterbury Tales* where values from this *Kalendarium* are used.

The furthest I go back in time before reaching the Classical world is an eleventh-century manuscript known as the Tiberius Horologium. Members with access to the NASS *Compendium* can read Bob Kellogg's descriptions,[10] otherwise the manuscript can be seen on the British Library website.[11] A fresh translation of this – and transcription of some others – is given in the appendices of BSS Monograph 14.[12] This list of shadow lengths (in 'feet' and 'heels') appears to have been compiled for a monastery somewhere near the latitude of 53°, somewhat further north than Coventry, but still just about central England.

Time telling by solar altitude has a long history, helped by it being inexpensive and easy to understand. However, even in the eighteenth century it cannot always have been easy to find sufficient level, uncluttered ground, and that has not improved since. This is one reason for the ubiquity of the polar gnomon dial we enjoy.

ACKNOWLEDGEMENTS

My thanks to John Davis for his advice and sources of information.

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11. British Library: *https://www.bl.uk/manuscripts/Viewer.aspx?ref=cotton_ms_tiberius_a_iii_f179r*
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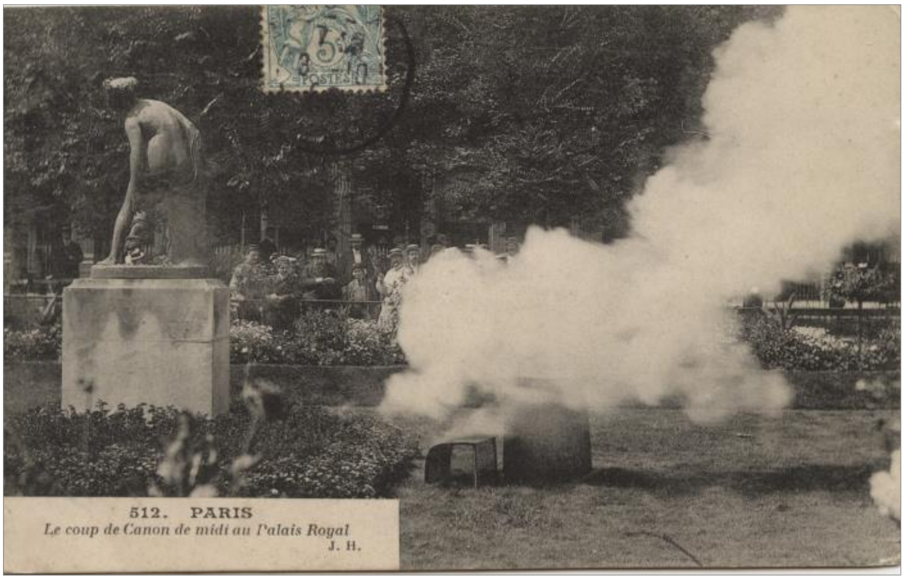
Postcard Potpourri 61 – Paris

Peter Ransom

You cannot see the sundial on this card, just the smoke left after the noon cannon was fired! The stamp on this card was issued between 1900 and 1903, so that gives an approximate date, as the year on the postmark is not clear.



Le Petit Canon (The Little Cannon) is positioned on a stone pedestal and was produced by Monsieur Rousseau. He was a watch and clockmaker who had a shop in the Galerie de Beaujolais, within the grounds of the Palais Royal, since 1786. The Little Cannon was made of bronze and placed on the Meridian Line of Paris in 1796 and fired every day at noon, so that the people nearby could ensure their own watches were accurate.

In 1799 it was moved to a flowerbed in the gardens of the Palais Royal and continued to fire at noon until either 1911 or 1914 (sources differ on the date). In 1990 it was restored and started firing again until it was stolen in 1998. However, an exact replica was made and installed in 2002, which is featured in the picture on theleft.

Since 2010 this has been fired every Wednesday at noon.

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The Equation of Time in your Phone's Calendar

Andrew Hodgson

Every year, the British Sundial Society's *Bulletin* kindly includes a handy card tabulating the Solar Declination and Equation of Time at 12:00 GMT for each day in the following year.

However, when encountering sundials on walks, we rarely have this with us to help us check their accuracy. I have sometimes resorted to pulling up a website such as *www.ppowers.com/EoT.htm on* my phone. But then it occurred to me that I could put a weekly set of events in my Google Calendar – that way I see them every time I look at my calendar on my phone or my laptop, so I am conscious of the changing values on an ongoing basis and I do not forget to hold a small celebration on the special days when the EoT crosses zero and sundials near London nearly tell the 'right' time!

Initially, I spent an hour or so manually creating a year's worth of weekly events in my calendar, but recently I decided to spend several more hours writing software to create them programmatically instead. My Python program calculates the EoT value for each noon, and creates a calendar entry at noon

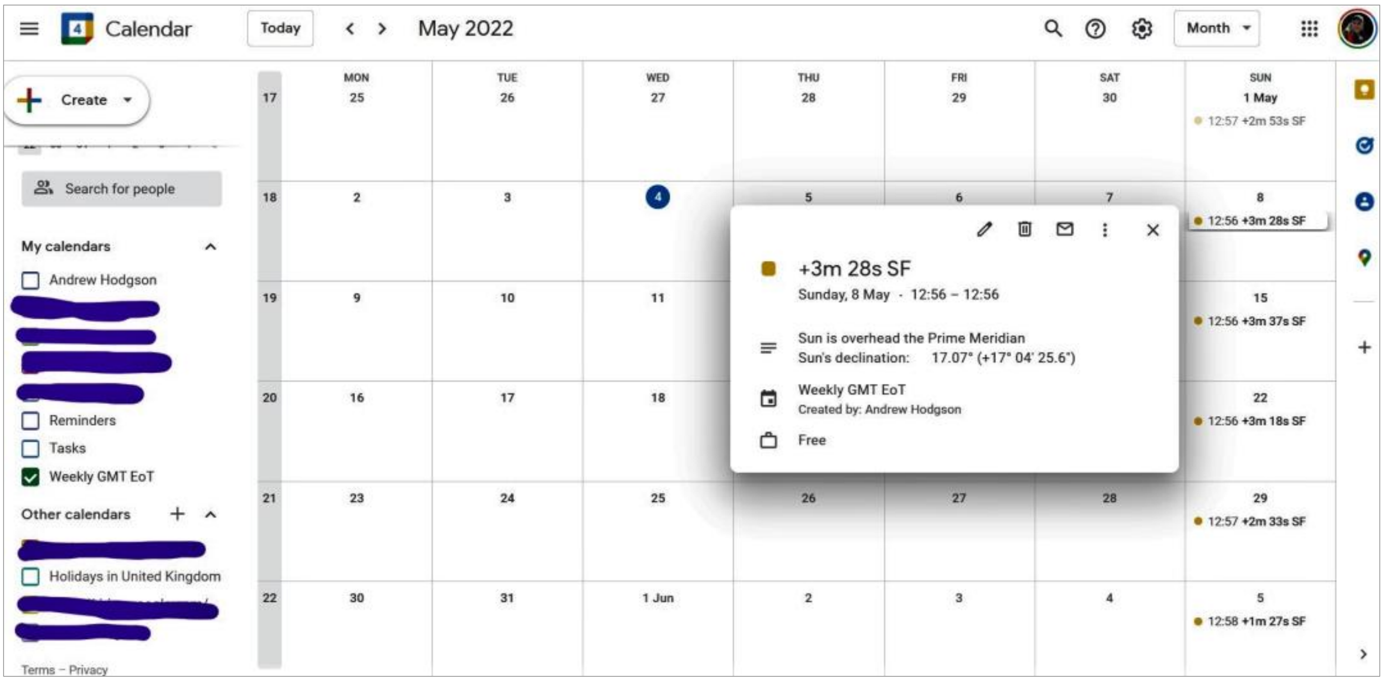

Fig. 1. The weekly events, in a monthly view on a laptop.

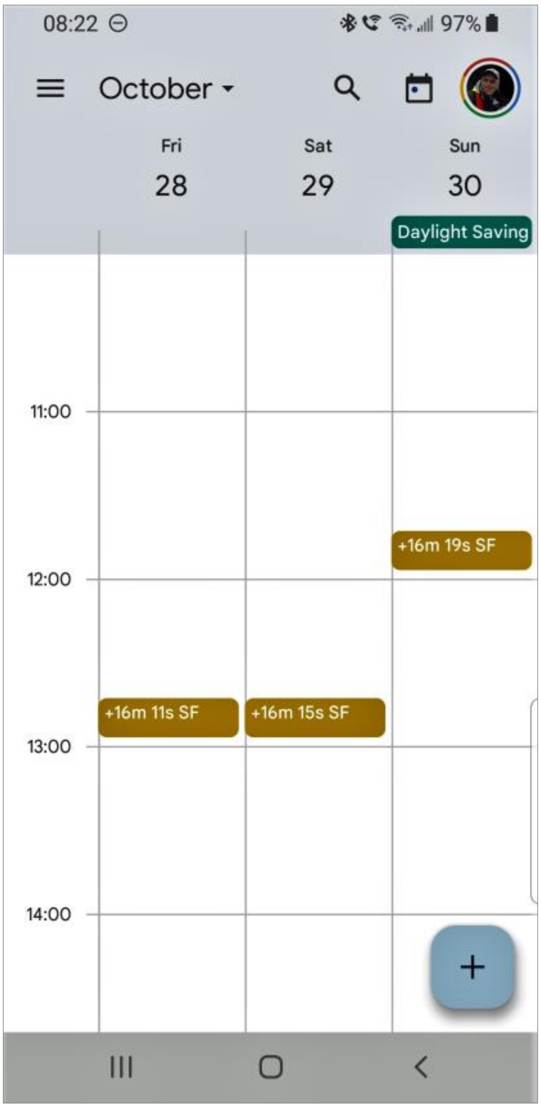

Fig. 2. The daily events on an Android phone, around the hour change.

less the EoT, i.e., at the clock time at which the sun crosses the Greenwich meridian. It does this for the 26 Sundays either side of any given date (e.g. 1 July 2023 to give all the Sundays in 2023), and then uses the Google Calendar web APIs to insert new events at these times (and delete old events now outside the window of interest), so my Google Calendar shows a year of weekly EoT events (see Fig. 1). The event's time is set to the crossing of the meridian, rather than 12:00 GMT to give a visual Sun Slow/Sun Fast indication.

For calculating the EoT, I used a Python library called Skyfield (*rhodesmill.org/skyfield*): "*Skyfield computes positions for the stars, planets, and satellites in orbit around the Earth. Its results should agree with the positions generated by the United States Naval Observatory and their Astronomical Almanac to within 0.0005 arcseconds (half a 'mas' or milliarcsecond)*." It also compensates for the travel time of light, light bending due to gravity, and the aberration of light produced by the observer's own motion through space(!).

For EoT I have adopted the sign convention given in Wikipedia (*en.wikipedia.org/wiki/Equation_of_time*) – EoT is shown as positive when the sundial is fast ('SF'), negative when slow ('SS'). Note that this is the opposite of the convention used in the table provided with the *Bulletin*.

You can subscribe to this public calendar 'Weekly GMT EoT' from your Google calendar or from your iPhone or iPad calendar by following the instructions here: *sites.google.com/view/ah-sundials/EoT-Calendar/help*, which also includes more details and a link to a daily version 'Daily GMT EoT' (see Fig. 2), but you may feel this makes rather too much clutter in your calendar.

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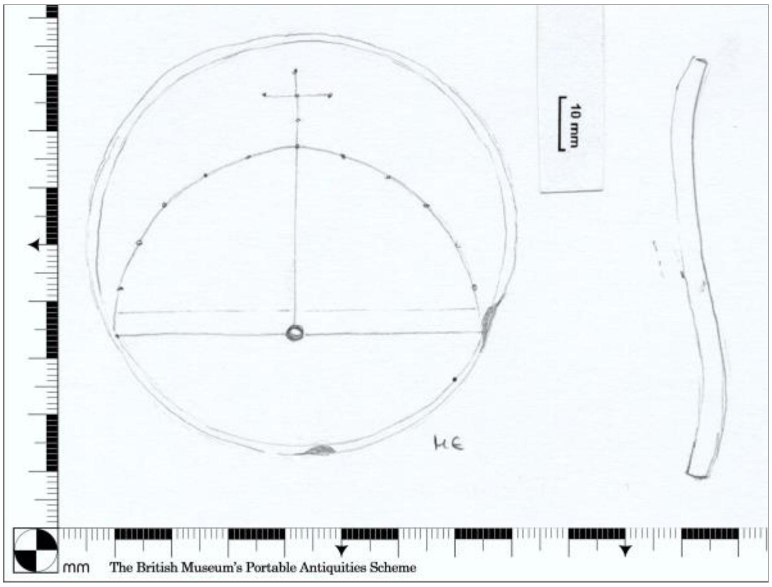
A PORTABLE MASS DIAL?

JOHN DAVIS

Lead sundials are relatively rare, probably because the metal is so easily recyclable.[1] A few small examples have been found by metal detectorists and they usually take the form of rather poorly delineated horizontal dials showing equal hours and sometimes with a cast-in integral gnomon. The find shown here is unusual, perhaps unique, in that it appears to be designed for a rod gnomon and to show unequal hours.



The dial was found in July 2000 at a site near Epworth, North Lincolnshire, but it has only recently been recorded on the database of the British Museum's Portable Antiquity Scheme (with reference number NLM-C293AA). It was not photographed at the time and it is now proving difficult to contact the finder but we do have the benefit of an accurate drawing made by the trained archaeological illustrator Marina Elwes. This shows it to be a disc 78 mm in diameter and a nominal eighth of an inch thick with, critically, a semicircle of 11 engraved spots with an equi-angular 15° spacing around a central hole and with a cross above the central mark. If the drawing is imagined rotated by 180° and placed against a south-facing wall and with a small rod perpendicular to the plane in the central hole to act as a gnomon, then the similarity to a 'mass' dial is unmistakable. The divisions, though, are not into the quarters (and eighths) to be expected for the canonical hours of the masses but into the unequal hours, with the First hour beginning at sunrise and counting to the Sixth hour at noon and then to the Eleventh hour at sunset.

The disc could equally well be imagined as a horizontal unequal-hour dial with a vertical gnomon but this would require alignment to the meridian and there is no sign of a magnetic compass – they were rare until the middle of the 15th century and by then equal hours were in general use. It might be argued that the device could show equal hours, at least for the summer half of the year, if it was regarded as an equinoctial sundial with the disc propped up to an angle equal to the co-latitude.[2] There is very little evidence that such dials existed before the Early Modern period and the problem of alignment to the meridian still exists.

It is altogether an intriguing find and shows that there is still much to discover about early sundials.

Acknowledgements are due to Kevin Leahy and Martin Foreman (PAS) for assistance and to North Lincolnshire Museum for use of the image.

REFERENCE AND NOTE

1. For two examples, see Peter Blaxandall: 'A Lead Domestic Windowsill Dial', *BSS Bull*., 21(ii), 34-40 (June 2009) and John Davis: 'An Excavated Lead Sundial', *BSS Bull*., 24(iv), 18-20 (Dec. 2012).
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READERS' LETTERS (1)

Whitehall Dial

I have just read Peter de Clercq's article 'A Note on the Vanished Dial in the Privy Garden, Whitehall' in the last *BSS Bulletin* (34(iii), pp. 36-7, September 2022), and have a suggestion for *Areis* and *Stylis*. Uffenbach could have been adopting *Area* in its transferred sense of an open space around something, normally a house or court, but also a playing field, the bed in which flowers grow, a threshing floor or even the halo around the Sun or Moon. So it could here refer to the dial ground carrying the hour lines. I would then take *Stylis* to be the gnomons.

Why should Uffenbach say "A*reis* or holes"? Probably because many of the dials on the Whitehall monument were concave, scaphe type, dials. Others were polyhedral dials which would have more than one gnomon, so this would explain 18 *Areis* and 25 *Stylis*.

Anthony Turner

THREE SCANDINAVIAN SUNDIALS

JOHAN A. WIKANDER

Only six vertical mass dials are known about in Norway at present. One of them is unfinished, and another one was covered a long time ago when the church was rebuilt, so cannot be seen today. After the Reformation in the early 16th century, churches were successively whitewashed. Obviously, several mass dials are hidden under the white chalk and we know nothing about them so far. We have in Norway today 28 wooden 'stave' churches of post and lintel construction, but no mass dials have been found to date. At the end of the Middle Ages we had about 750 stave churches, but nothing is known about their mass dials.

Only one of these six mass dials can be closely dated. This particular dial is analysed in the next section.

The Tingvoll Church Mass Dial, Norway

The chancel is the oldest part of the church; the building started about 1170. There is a very nice runic stone inside on the wall, saying that the owner of the church was named *Gunnar*.[1]

The upper parts of the walls of the nave were built ca. 1200. The mass dial was then projected as a part of the south wall. The mass dial is carved on a slab of marble built as a part of the wall, about 5.5 metres above ground level (Figs 1 and 2). The mass dial was reworked about 1660–70. Hour lines and Roman numerals VI – XII – VI were then carved and painted black. The black paint has not so far been analysed. Local white marble is also used in other places in the church, as cornerstones, around windows, portals etc.

Fig. 1. South wall of the nave of Tingvoll church (62° 55′ N, 8° 11′ E). We see the mass dial to the right of the window, bottom corner. The mass dial is about 5.5 metres above ground level. A man in the bottom right corner is stretching his arms up towards the eaves. This indicates that the mass dial is installed high up on the wall. Photo: Norwegian Directory for Cultural Heritage, Oslo, 1966.

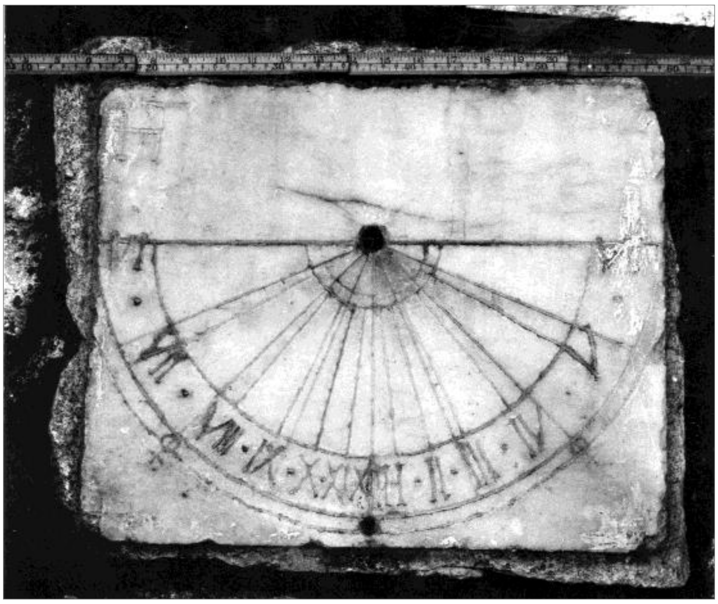

Fig. 2. The mass dial, south wall of the nave. The mass dial was reworked about 1660–70. Hour lines and Roman numerals VI – XII – VI were added and painted black. However, the original mass dial and its symbols are visible. Photo: Norwegian Directory for Cultural Heritage, Oslo, 1966.

I have identified all the hour lines, symbols and Roman numerals and made an exact drawing of the mass dial at scale 1 : 1, using transparent plastic. Four hours on a ladder against the wall in very bright sunlight was sufficient to do this. We start our analysis of the mass dial, made ca. 1200 when the nave was built (Fig. 3). The original horizontal gnomon, perpendicular to the wall, was lost a long time ago.

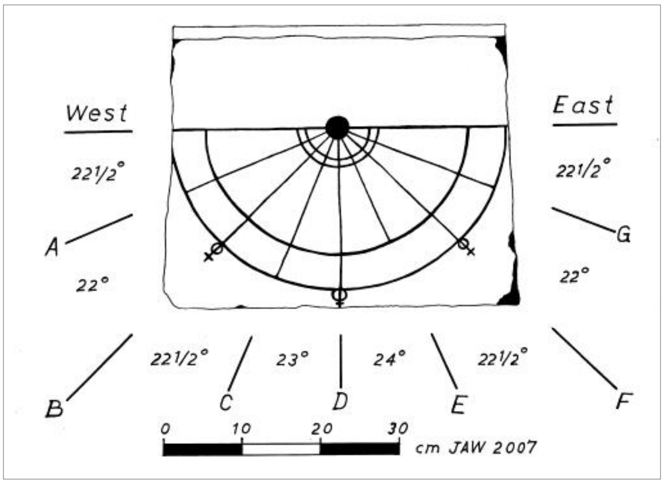

Fig. 3. The Tingvoll mass dial, made ca. 1200 when the nave was built.

The mass dial is carved according to the octaval hours, showing half of an octaval hour. This hour is 45 degrees on a sundial, and one half is 22½ degrees. The mass dial is very accurately carved. The octaval hours are:[2]

West–A: This is the last half of the octaval hour *morginn* or *rismál.* The Anglo-Saxon name is *Morgan;* the early morning. The Old Norwegian and Anglo-Saxon languages are related.

A–C: This is the octaval hour *dagmál.* The Anglo-Saxon name is *Daeg-mael,* also related to the old Norwegian language.

C–E: This is the octaval hour *hádegi*. This means "when the sun is highest in the sky".

E–G: This is octaval hour *undorn* or *eykt.* Undorn means in old Norwegian "intervening time", and undorn was also the name of a meal.

G–East: This is the first half of the octaval hour *aptann*. The Anglo-Saxon name is *Mid-aften,* also related to old Norwegian.[3]

Symbols used

The hour lines B, D and F are marked with symbols – a circle and a cross. These hour lines identify the middle of octaval hours. However, they also identify respectively the end of the 3rd, 6th and 9th unequal hours. One unequal hour on a mass dial is 15 degrees. A multiple of 15 degrees, approximately, from "West" towards "East" also identifies the three hour lines B, D and F. These unequal hours are canonical hours, times for service and prayer in the church in the Middle Ages.

Crosses are well known as symbols used on mass dials. However, I have never before seen this particular symbol, a circle and a cross. I wrote a letter to the Vatican Library, *Biblioteca Apostolica*, and asked if this particular symbol was known. This symbol is not known as a Christian symbol in the Vatican.[4]

The reworked Tingvoll sundial ca. 1660–70

Hans Nielssøn Tausan (1626–97) was a priest from 1650 to 1697. He was a learned man and was well known for his library. He was interested in astronomy and the common understanding is that this sundial was probably reworked by him. The canonical hours were not important so late; this is then an ordinary equal-hours sundial, not a mass dial (Fig. 4).[5]

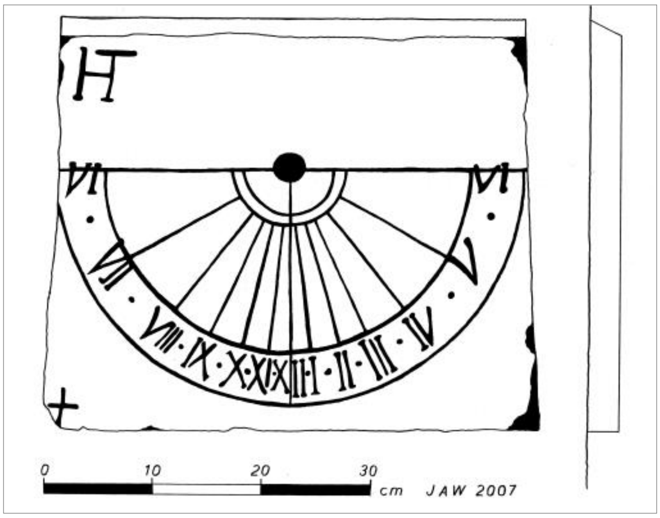

Fig. 4. The Tingvoll sundial made ca. 1660–70, the reworked mass dial.

A monogram is carved in the upper left corner. It is usually explained as the initials of the priest Hans Tausan. This interpretation is questionable, and I will explain why:

He wrote his name "Hans Nielssøn Tausan", and in his signet his name is also spelled HANS NIELSSØN TAVSAN. The common abbreviation in the 17th century would be "HNST" or "HNSST".

The left upright of the "H" is also carved wider and more marked than the right one. Thus "I H T" is more likely as the interpretation of the monogram. A small Greek cross is carved in the left corner below. This cross is obviously linked directly to the monogram above. This carving, the monogram and the cross were most likely made by a priest. This small cross was not noticed earlier by anyone. The mass dial is 5.5 metres above ground level and rather difficult to inspect.

Carved 'graffiti'

Notice in Fig. 2 that an arc of a circle is unprofessionally carved underneath the mass dial, crossing the symbols carved at the end of the hour lines B, D and F. This was most likely done after the Reformation, 1536 in Norway. The canonical hours and the service and prayers then used in the church were abolished. The three symbols were luckily not completely destroyed.

The Falsterbo sundial ca. 1500, Sweden

Falsterbo is a small city on the extreme south-west tip of Sweden, 55° 24′ N, 12° 49′ E. In the Middle Ages this part of Sweden, *Skåne*, belonged to Denmark. An incomplete portable sundial (Figs 5 and 6) was found during excavations in the ruins of Falsterbohus Castle. The conclusion was that the sundial is from the late Middle Ages, so ca. 1500 is a rather good estimate.[6]

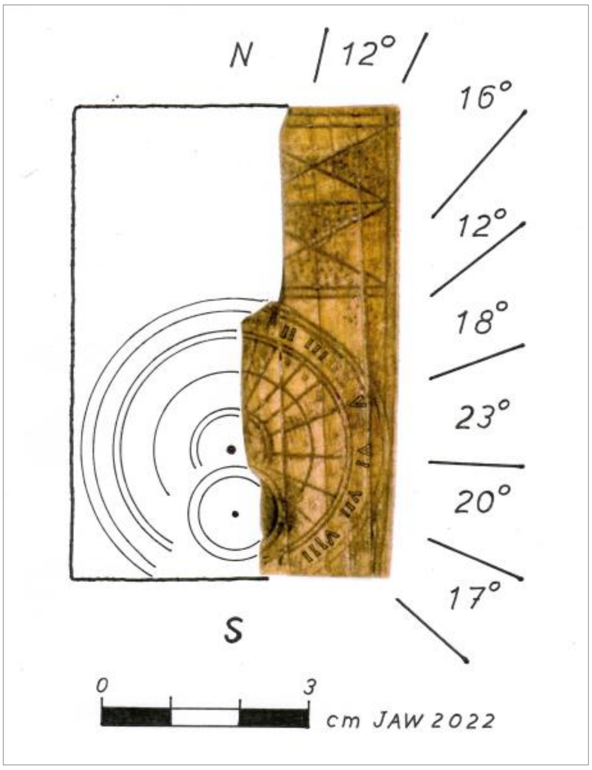

Fig. 5. The main part of the ivory Falsterbo horizontal sundial with compass made ca. 1500, showing modern equal hours.

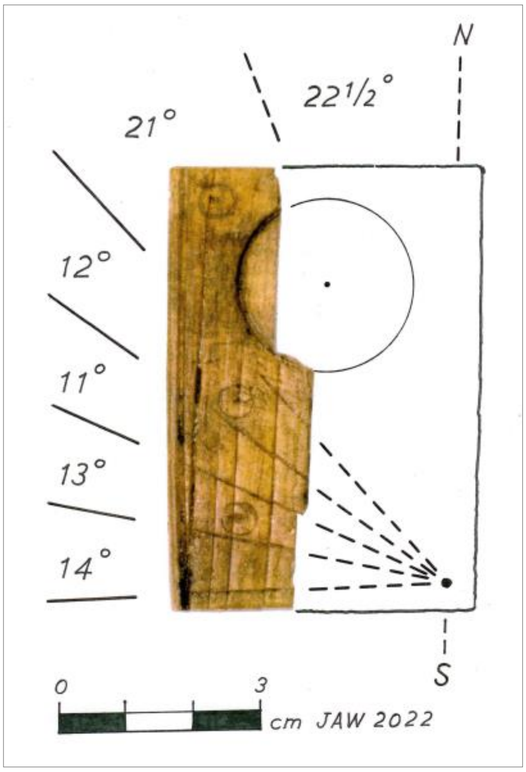

Fig. 6. The main part of the ivory Falsterbo horizontal sundial with compass made ca. 1500, showing quarters of the octaval hours.

Only a part of the sundial was found, but there was sufficient to estimate the original size as 7.0 cm × 4.5 cm. The sundial is made of ivory, three or four pieces stuck together. The part found is also sufficient to make a partial reconstruction of the original sundial. We now describe its main part (Fig. 5).

The compass is rather small, ca. 1.1 cm in diameter. The needle was protected by glass: small pieces are still visible at the edge. No details of the compass rose or the radial compass lines remain. The sundial is a type made of ivory that might well be the precursor of the well-known diptych dial made from ivory or wood.[7]

The sundial is carved on a single panel. At the edge of the top, there is no mark or rests of a second hinged vertical panel. The gnomon was polar-pointing; however, this was not found by the excavations. Thus we do not know for which latitude the sundial was originally designed. The polar-pointing gnomon could occasionally be removed.

The hour lines show modern equal hours. However, they do not seem to be quite exactly carved, for the angles vary too much (Fig. 5). The decorative features, crosses and large rectangles, are known on a few other sundials. One specimen is today in The British Museum, an ivory Nuremberg diptych dial dated around 1485–95.[7]

We are now informed about the main part and turn it over (Fig. 6). This second sundial is made according to the octaval hour system. The vertical gnomon has been kept separately and put into a vertical drilled hole, in the right corner below. This lower part of the sundial is the thickest one, 0.4 cm. The upper part of the sundial is only 0.2 cm thick. Ivory was rather expensive and only sufficient ivory has been used to make the sundial. The compass needle has also been kept separately. However, this second compass has not been protected by glass.

The hours shown are quarters of an octaval hour, one quarter 11¼ degrees exactly. We notice that these quarters are more accurately carved than the modern equal hours carved on the main part of the sundial (Fig. 5). The two quarters 14 and 13 degrees represent the last half of the octaval hour *morginn*.

The two next quarters, 11 and 12 degrees, are more accurately carved and represent the first half of the octaval hour *dagmál*. However, the correct spelling as late as ca. 1500 of these two octaval hours in this southern part of Scandinavia is so far not known. This sundial (Fig. 6) covers only 90 degrees. We also notice that no symbols are shown for the octaval hours.

The Vardøhus Sundial, Norway

Vardøhus fort, 70° 22′ N, 31° E, was built ca. 1300 to protect Norway against Russian tribes and rebuilt ca. 1470. An interesting sundial is preserved from this fort. It is made of very dark soapstone, most probably dating from very late in the 16th century or in the 17th century (Fig. 7). The octaval hours are used and divided into quarters round the horizon. This high latitude has of course midnight sun in summer. No symbols are shown to identify the octaval hours. However, the sundial is made as an octagon, each side corresponding to an octaval hour.

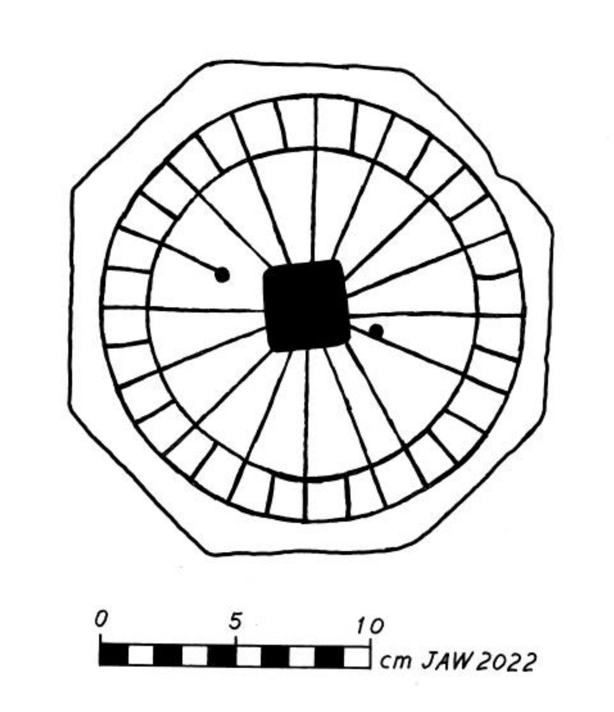

Fig. 7. The Vardøhus horizontal sundial made of very dark soapstone, showing the octaval hours.

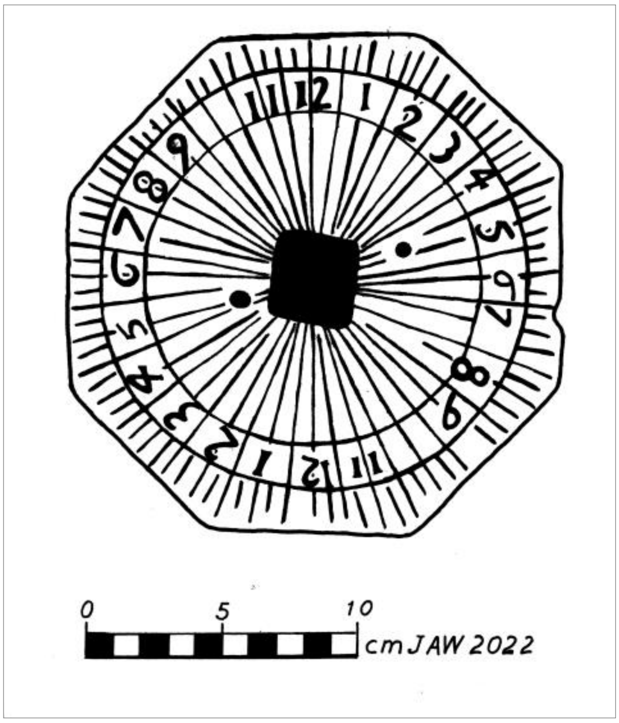

Fig. 8. The Vardøhus horizontal sundial made of very dark soapstone, showing the unequal hours. The octaval hours are identified by the octagon. Noon is in the middle of a side in the octagon; this is correct.

We turn the soapstone over (Fig. 8). This particular second sundial shows unequal hours, sectors 14–16½ degrees. The most distinct Arabic numerals are carved in the north semicircle. Noon is in the middle of the octaval hour, in the middle of a side in the octagon. This is of course quite correct. The unequal hours are corresponding correctly to the octaval hours. Both octaval hours and unequal hours were used in Scandinavia. We understand this also from the Falsterbo sundial.

ACKNOWLEDGEMENTS

I got very good photographs of the Falsterbo sundial, Figs 5 and 6, from Helena Rosengren, Statens Historiska Museer, Stockholm. I also got very good photographs of the sundial made of rather dark and 'difficult' soapstone, Figs 7 and 8, from Adnan Icagic, Tromsø Museum. I thank them very much for this help. I also thank John Davis for informing me of the article,[8] and Christine Northeast for brushing up my Scandinavian English to a more modern language.

REFERENCES and NOTES

I examined the Tingvoll Church mass dial in 2007, and my plan was then to write an article. However, I hoped to find another comparable sundial and then write the article. This search was rather difficult and at last I have succeeded. I have so far in 2010 written briefly about the Tingvoll mass dial ca. 1200, my article 'Norwegian medieval sundials', in Mario Arnaldi: *Tempus et Regula. Orologi Solari Medievali Italiani: le Origini, la Storia*, Vol. 1, Ravenna (2010), p.310, Fig. 7.11.

Kjartan Prøven Huglid has also written about the mass dial in: 'Del 4. Kirkekunst og Inventar', pp. 239–82, the book 2006, note 1 below. This chapter deals with the rich sculptures and furniture in the church, and then the mass dial too.

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6. Sten Lundwall: 'Solur, (old Swedish: *timastokker*)', *KLNM* (see note 3 above), Vol. 16 (1971), pp. 426–7. This is an article about sundials, and the Falsterbo sundial is mentioned. The Falsterbo sundial is today in Statens Historiska Museum, Stockholm, Item nr. 17948:233.
7. The British Museum, Diptych-Dial, Nuremberg, 1485-1495, inv. no. 1877,0521.23, online at *https://www.britishmuseum.org/collection/object/H_1877-0521-23*
8. Roland Schewe and John Davis: 'Time on a Tablet: Early Ivory Sundials Incorporating Wax Writing Tablets', *Early Science and Medicine* 24 (2019), 1–35, see especially Fig. 10, page 21.

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DIAL DABBLING DOWN UNDER

DAVID BROWN

Together with other members of my family, I paid a three-week visit to Hobart, Tasmania over Christmas and New Year 2021-2. Covid restrictions were tight, and a week of quarantine was necessary. The southern hemisphere summer solstice weather was perfect, and I avoided being gnomonically idle by tracking and marking over a few hours the shadow of the highest point of a convenient road signpost which was visible from the house. The sights of the noon shadow being cast to the south and the shadow moving anticlockwise were unsettling, but the accumulated marks did enable me to establish the direction of north to my own satisfaction.

After a week of isolation and Covidly-distanced outdoor conversations with our hosts (who had kindly moved into their campervan for the duration to let us use their house), Christmas celebrations could be held normally. Christmas morning brunch on the beach was a new experience and collecting shells from the beach offered an interesting diversion, leading to an unexpectedly pleasant surprise of which more will be revealed later…

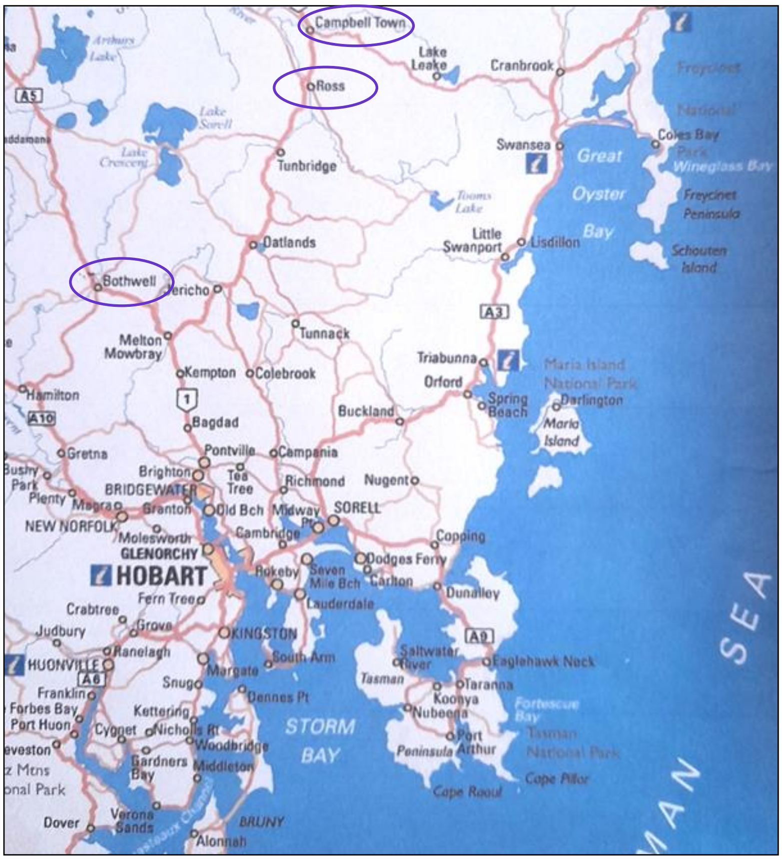

Fig. 1. SE Tasmania. The distance shown north to south is approximately 100 miles, and the capital, Hobart, is at 42° 52′ S, 147° 20′ E. Blue ellipses indicate places visited on the day trip out of Hobart.

Fig. 2. The horizontal sundial in a field at Beaufront, Ross, Tasmania, with a carved eagle and its prey.

The last week of 2021 was filled with an exploration of the Hobart harbour area and watching smart yachts arrive at the end of the Sydney–Hobart yacht race, but more particularly, with an opportunity to go on a sundial safari driven by my son-in-law. Tasmania has only about a dozen public sundials, many of which are close to Hobart.

A 150-mile round-trip in one day at the tail-end of December was started early one morning with a long hop north towards Campbell Town (Fig. 1). A 9 am coffee break was taken in Ross and a conversation had with a cheery shop-owner who pointed us in the direction of a well-appointed single-storey mansion at Beaufront just outside town. On arrival, and after several loud knocks, the owner's son, acting as caretaker, was eventually aroused. He sleepily directed us towards a field where amongst long grass there stood a rather dilapidated sundial, albeit showing approximately the right local time (Fig. 2). It sat on top of a square pillar with one face carved in the shape

Fig. 3. The 'Transit of Venus' sundial by Tony Sprent (2004) at Campbell Town, Tasmania. The user sits on the tractor seat and turns the plough disc to face the sun. (See Ref. 1 for full details and close-up photos.)

of a large eagle clutching its prey. This odd feature was later found to link with another sundial described below.

Next was Campbell Town about 10 miles further north. Standing in a recreation ground is the 'Transit of Venus' commemorative sundial created by Anthony (Tony) Sprent in 2004 (Fig. 3) and described in detail by Christine Northeast in the March 2020 *Bulletin*.[1] It was made from pieces of farm machinery collected locally. The stunning assembly of miscellaneous mechanical parts worked perfectly and was gnomonically correct.

Fig. 4. The war memorial with sundials at Bothwell, Tasmania.

A long drive south passing The Melton Mowbray Hotel (!) took us to Bothwell. The War memorial there is a very solid-looking Art Deco construction with a large direct vertical cast bronze dial atop each of its four faces (Fig. 4). A cast bronze Equation of Time plaque gave the time correction. With the armed forces casualties all listed on the lower parts of the faces, it is very clearly a much-respected memorial and immaculately maintained.[2]

Then further south back to Hobart after a snack lunch where we tracked down a lonesome dial in the Princes Park (Fig. 5). The dial and pillar seemed to be robustly made of bronze, showing hours, half-hours and quarter-hours in rings of increasing diameter with small Roman numerals at the periphery. The gnomon was larger than it needed to be, and its root over-stepped the 6 am/pm line. The latitude is shown, but it is not clear what the origins of the dial were.

Fig. 5. The horizontal sundial in Princes Park, Hobart, Tasmania.

A short drive to The University of Tasmania (UTAS) campus took us to an unusual sundial which was found to be totally in the shade of a large tree, bringing two disappointed and weary travellers to the end of their safari. However, a further visit to this dial on New Year's Eve a few days later and at an earlier time of day gave us a better chance to explore its features (Fig. 6). A plaque attached to its stone base told us that Tony Sprent had again been heavily involved in its design and construction in 1993. A hand-sized domed cap at its lower end was marked in minutes and could be rotated to turn the whole double-arched frame until a spot of sunlight shone through a small circular aperture in the upper arch on to the lower one

Fig. 6. The sundial at the University of Tasmania, Hobart.

Fig. 7. Checking the accuracy of the sundial at the University of Tasmania, Hobart. The spot of sunlight cast on the day's date on an analemma can be seen in the shadow, top right.

where an analemma was engraved (Fig. 7). The cap was turned until the spot of sunlight was exactly over 31 December as judged against the clearly-marked daily dots and named months. The correct clock time in hours was shown on a circular scale aligned with the lower end of the axis with an indicator for summer-time included. The minutes were read off the graduated cap. The smoothly-running faultless mechanism had the same superb feel to it as Sprent's dial seen earlier at Campbell Town.

A visit on another day to The Royal Tasmanian Botanical Gardens brought us to a splendid robust sundial made by

Fig. 8. Horizontal sundial by Sundials Australia in the Royal Tasmanian Botanical Gardens, Hobart.

Sundials Australia (Fig. 8). A quick muscular adjustment to the top stone of the pillar to re-align it with its base meant that the dial could then show the correct solar time. Five minutes later we noticed a young girl and her sister sitting on top of the sundial having used the pillar as a climbing frame, so for the sake of sundial and personal safety a few polite but firm words were said to the indifferent mother who sheepishly took the girls to a different picnic spot.

A casual glance through a nearby padlocked gateway revealed what must surely be another sundial (Fig. 9). The

Fig. 9. The horizontal sundial discovered in the grounds of The Garden Superintendent's House, at the Royal Tasmanian Botanical Gardens, Hobart.

Fig. 10. Details of the elaborate carvings on the pillar of the sundial in the grounds of the Garden Superintendent's House at the Royal Tasmanian Botanical Gardens, Hobart.

Fig. 11. The author (left) with Tony Sprent and his sundial mechanism in Hobart. An aperture in the upper plate casts a spot of light on an analemma on the lower plate, and the time is read from a scale near the black adjustment wheel.

building had been the Garden Superintendent's house when the gardens opened in 1818. A phone call brought a member of staff half an hour later to unlock two other gates to allow us to get close to the sundial (Fig. 10). The sundial itself was unremarkable but the pillar it stood on had very elaborate figurative carvings on each of its four faces. The style was clearly early 19th century, and a nearby plaque told us that the dial and pillar had been handed down through the generations from the first Superintendent. The carvings were done by a convict stonemason, Daniel Herbert. It tied in very much with the carved eagle on the pillar at Beaufront near Ross (mentioned above). A subsequent Google search informed us that Daniel Herbert had been deported to Tasmania in 1827 when it was a penal colony. He had received a death sentence for highway robbery in the Manchester area but had had it commuted to transportation for life and had subsequently been employed to use his skills as a stonemason on several big projects including the road bridge over the Macquarie River at Ross. This structure still stands and is noted for the 186 unusual and elaborate carvings on its buttresses. Daniel eventually received a free pardon in 1842 and died in 1868, but, to my very great surprise and joy, I discovered that he was born in Taunton, Somerset, UK, barely 20 miles away from my home.

Our daughter, Kate, with whose family we were staying, had worked at The University of Tasmania (UTAS) and had met Tony Sprent there in the course of her business. A visit to Tony was arranged. He and his wife greeted us like old friends, and it was not long before we were shown his working sundial model with the same sort of mechanism as those at Campbell Town and UTAS (Fig. 11).

Finally, back to the sea shells. Amongst the various specimens collected was a spectacular one with exquisite markings and the underside appearing like a view down from the top of a spiral staircase (Fig. 12). A Google search revealed its official name as *Architectonica perspectiva*, and quite common around the southern hemisphere shores. An unexpected delight was that its common name is Sundial Sea Shell, possibly on account of the regular divisions of the markings on its underside which look rather like the chapter-ring of a sundial.

After returning home, and a very rewarding visit to Tasmania, I felt that I needed to re-orientate myself with my 'normal' sundials. Having acquired more sundial sea

Fig. 12. Upper and lower surfaces of the sundial sea shells.

Fig. 13. A crudely-made sundial sea shell sundial.

shells over the Internet, I quickly laid out a crude sundial using the shells as hour points and a screwdriver as the gnomon (Fig. 13). It was good to see the noon shadow behaving itself being cast to the north once again and the shadow moving clockwise. May I present a 'new' design of sundial: the sundial sea shell sundial!

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2. For more details, see *https://monumentaustralia.org.au/themes/conflict/ww1/display/70066-bothwell-war-memorial*

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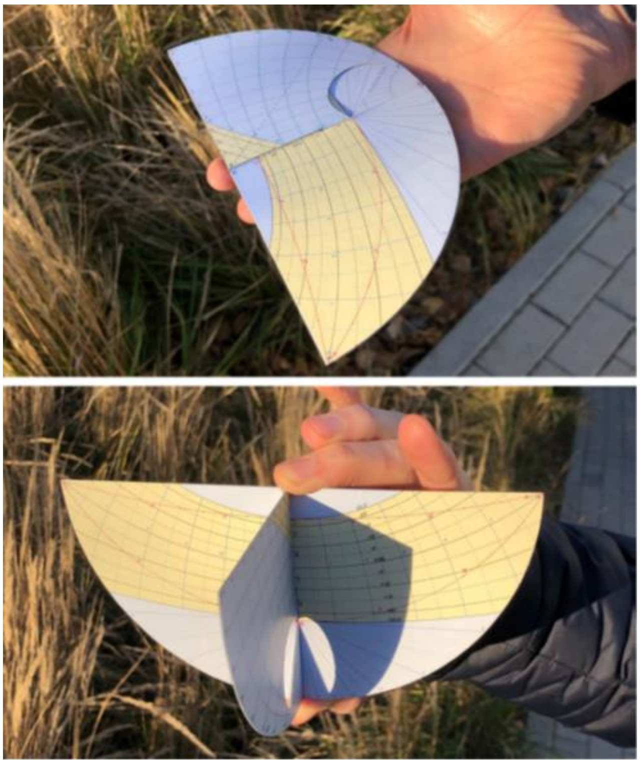
eBOOK REVIEW

VERTICAL STEREOGRAPHIC SUNDIAL: Properties, Construction and Related Instruments

By Maciej Lose. Electronic PDF file, 39pp. Free. ISBN 978-83-62108-52-7. Published by Cursive in Poland, written in English. Download from *http://cursiva.pl/e-ksiegarnia/vertical-stereographic-sundial-properties-construction-and-related-instruments/* or from *tinyurl.com/ymrveseh*

This is a new departure in sundial publishing: essentially an extended article which would be too large to publish in a single *Bulletin* or *Compendium* (the author calls it a 'brochure') which is made freely available to all sundial

Front page illustration of the perspective projection by Peter Paul Rubens for "Opticorum libri sex philosophis juxta ac mathematicis utilis" by François d'Aguilon (Antwerp, 1613).



Cardboard mock-up of a foldable, double stereographic sundial. The double sundial is of the self-aligning type. Lower photo taken at 1:55 PM solar time on 3rd December 2021. Photo: M. Goncerzewicz.

enthusiasts. Here, the very popular double horizontal dial is extended to produce a range of vertical dials based on the same stereographic projection. After explaining the basis of the projection and its use in double horizontal dials and astrolabes, the booklet develops the idea for vertical dials, starting with a relatively simple direct south wall and progressing to dials facing the other cardinal directions and to declining walls, together with some free-standing multiple dials.

The final third of the booklet gives drawings and instructions for making practical dials, showing cardboard mock-ups of a number of examples to show what can be done. The booklet is primarily directed at using geometric constructions rather than algebraic methods – you will not find pages of trigonometrical equations. Readers are encouraged to develop the ideas and to correspond with the author. A whole new field opens up!

John Davis

READERS' LETTERS (2)

Belgian Portable Altitude Dial

Sue Manston's exploration of this interesting pocket dial (*BSS Bulletin* 34(iii), 32-4) sent me to look out my copy of Mike Cowham's *Study of Altitude Dials* (BSS Monograph No. 4). In it, Vertical Disc 4 – 'Heliochron' is very similar with respect to layout, though not outline. Minded to experiment, I made a simplified version on card.

As the cord and bead appear to be replacements, and so just possibly mistaken, I wanted to see if the dial could be used without them. Trials showed that provided it is held by the fingertips and there is no breeze, it could be used successfully, but that adding a cord in the same position definitely simplifies the handling (Fig. 1). Given how small the original dial is, I would expect that only the lightest finger pressure would be needed on the lower edge to stop it from turning.

I surmise that the last paragraph of the article correctly describes how the dial is used, that it is suspended by the cord. The orientation of the figures is suggestive of this, but the lack of an alidade or any sighting device very strongly suggests that the long sides should be held horizontally. The dial is held up and rotated until the face just emerges from shadow and the hour read from a pin gnomon.

That there was a pin gnomon is suggested by the other scale being along a channel – which it could slide along – rather than an open slot. A cord could be held in place by a wedged peg, but this strikes me as fiddly and unreliable. If a cord were used as a plumb-bob, it would have been easier and neater to drill a series of threading holes. The dial's precision is such that they would not have much affected the accuracy.

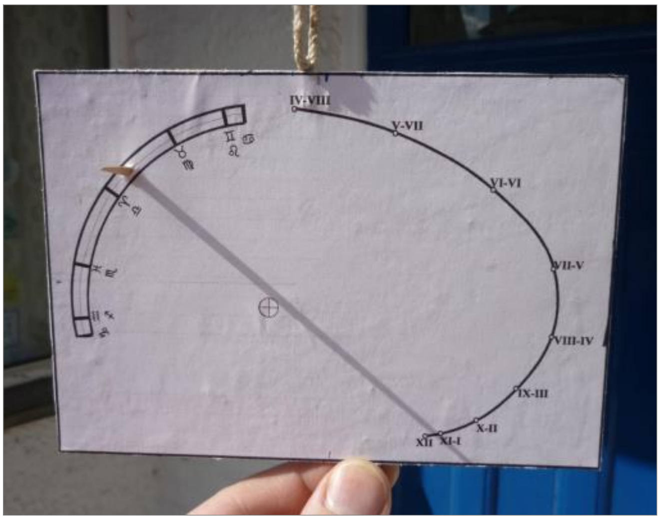


Fig. 1. Simplified model of the Belgian portable sundial.

The most interesting feature of this dial to me is the use of the time of sunrise as a proxy for solar declination. Being in familiar units, it is surely more understandable to the layperson and possibly less prone to mistakes. Perhaps we should use it sometimes?

Graham Stapleton

Charlemagne Viet Polar Dial

This portable dial was made by Charlemagne Viet (fl.1673-95) in Blois, France. It has two polar dials, one on the outside of the lid and another on the inside. A folding arc allows the user to set the dial at the correct latitude (Elevation du pole). Sixteen cities are listed with latitudes from Cairo (30° 0') to Stockholm (60° 15'). The compass is labelled S(eptentrionalis), Or(ientalis), M(eridionalis) and Oc(cidentalis) for North, East, South and West respectively.

When not in use the gnomon is stored in a small hole near the compass. The dial measures 71 mm x 36 mm x 14 mm.

Sue Manston

Photos courtesy of François Juge.