The British Sundial Society

"OUR DAYS ON EARTH ARE AS A SHADOW"
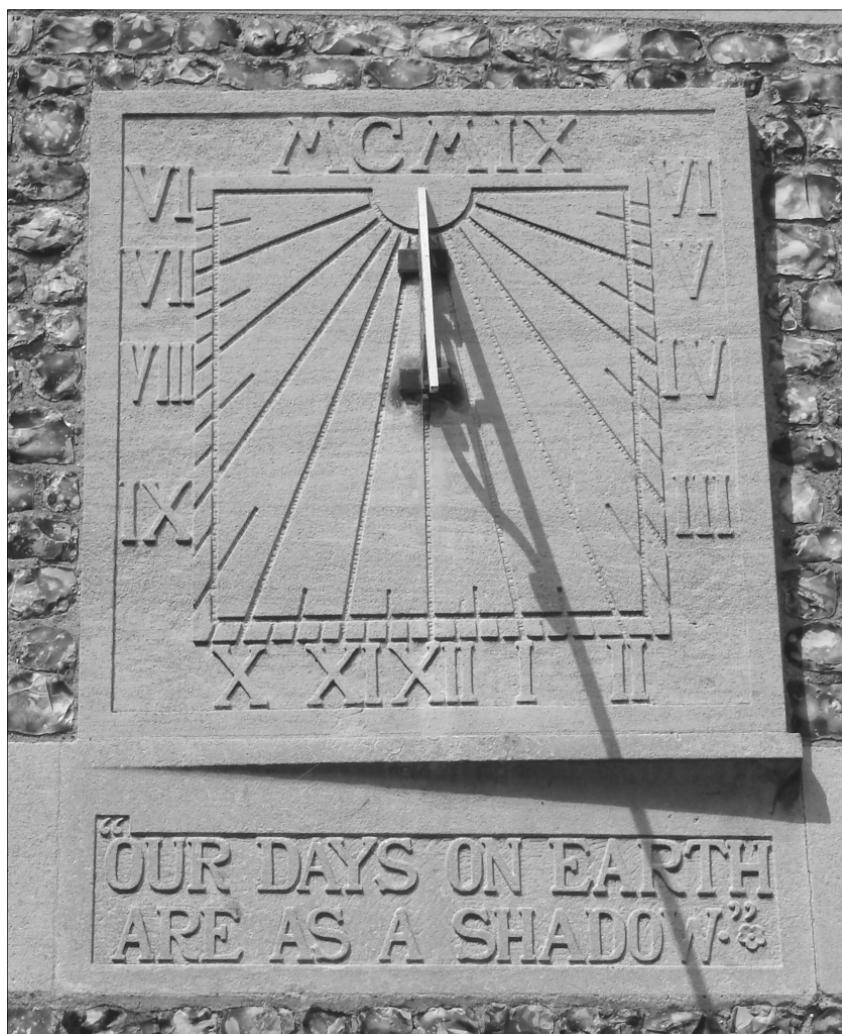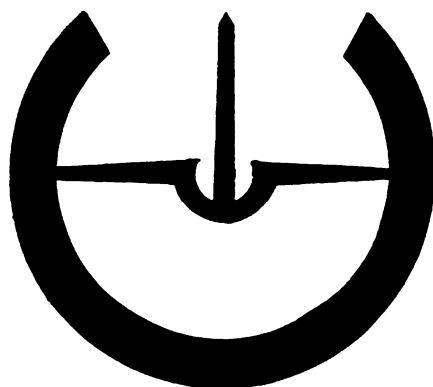
BULLETIN

VOLUME 20(ii)   June 2008

GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics; and, by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.

2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis51@btopenworld.com*. Material can also be sent on CD or as a single-sided typescript, single- or double-spaced, A4 paper.

3. Figures: For photographs, colour or black-and-white prints as large as possible (up to A4). Slides and transparencies are also acceptable. Pictures can be sent electronically as separate jpg (do not over-compress) or tif files—do not embed them in Word files. For email attachments, do not exceed 10 Mbytes per message. Tables should be treated as figures and numbered as part of the same sequence. Drawings and diagrams should be in clear, strong black lines (not pencil) on a white background. Each figure illustrating an article should carry on the back the author's name and a number indicating its relative position in the text (Fig. 1, Fig. 2 etc…). Label the top of the figure if it is not obvious. Captions for the figures should be written on a separate sheet in numerical order. They should be sufficiently informative to allow the reader to understand the figure without reference to the text.

4. Mathematics: symbols used for the common dialling parameters should follow the conventions given in the Symbols section of the *BSS Glossary* (available online on the Society's website). Consult the editor if in doubt or for help in laying out equations.

5. The *Bulletin* does not use footnotes. Where additional information is required, notes should be numbered as a Reference with a superscript number. For very long notes, use an appendix.

6. References: Sources are referred to in the text by a superscript number. They are listed in numerical order under the heading 'References' (or 'References and Notes') at the end of the article. The *Bulletin*'s convention is as follows:

   For books: Author's name; Title of book, in italics; Name of publisher, Place and date of publication.
   For papers and articles: Author's name; Title of article in single quote-marks; Name of journal, in italics (this may be abbreviated); volume number, underlined in Arabic numerals; first and last page numbers; date, in brackets.

   Examples:

   A.E. Waugh: *Sundials, their theory and construction,* Dover, New York, (1973).
   D. Colchester: 'A Polarized Light Sundial', *Bull BSS,* **96.2**, 13-15 (1996)
   A.A. Mills: 'Seasonal Hour Sundials', *Antiquarian Horol.* <u>19</u>, 142-170 (1990)
   W.S. Maddux: 'The Meridian on the Shortest Day', *NASS Compendium,* <u>4</u>, 23-27 (1997).

   If you simply wish to give a short list of books associated with the subject of the article, this may be given at the end of the article under the heading 'Bibliography', using the convention as given for 'Books' above.

7. Acknowledgements: These should be as brief as is compatible with courtesy.

8. The address of the author will normally be printed at the end of the article unless the author, when submitting the article, expresses a wish that this should not be done.

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Front cover: *The dial on the church in Boreham, Essex. It is carefully canted out. With its raised lettering, an interesting optical illusion (?) makes the Xs look upside down. Photo: Peter Meadows.*

Back cover: *The mass dial at St Peter, Peterchurch, Herefordshire. It is on the east side of the south chancel doorway. The unusual left-quadrant-only design might indicate a mid-15C date but the westerly location, near the 'dial desert' of Wales, could mean it is later. Botzum (1988) indicates a second dial but the BSS has no photo. Photo: Mike Evans.*

BULLETIN
OF THE BRITISH SUNDIAL SOCIETY

ISDN 0958-4315

VOLUME 20(ii) - June 2008

CONTENTS

EDITORIAL

Editor's New Email Address

I have been forced to use a new email address:

john.davis51@btopenworld.com

My apologies to anyone who has sent a message to my old address since early March and has not had a reply: please can you resend the message to this new address.

This is a bumper issue containing four extra pages with what I hope are interesting articles on a variety of topics.

It has been suggested that we could have a Picture Gallery showing dials in members' collections. This means that people will need to send me photographs of interesting dials with a few details of what they are. Contibutions will generally be published anonymously unless the owner specifies that they would like their names mentioned. Indeed, it would even be possible for contributions to be sent in anonymously if you don't want the Editor to know where the goodies are, though this would make correspondence difficult. It's up to you whether this item runs. Don't forget, too, that I continue to need items for the New Dials feature.

DIAL DEALINGS — ERRATA

There were a number of errors in the published prices fetched for dials in the Bonham's sale reported in the last Bulletin. The correct prices should be: Culpepper inclining dial £6600; double crescent dial £9600; Coggs Butterfield dial £10,800 and the Dolphin replica £1800. We apologise for these errors.

SUNDIAL FACES

MIKE COWHAM

How often do we come across sundials with faces on them? Why are they there and who put them there?

The image of the sun smiling down upon the Earth is frequently depicted as a face, often with a star- or ray-like border. This image has been used on many sundials, particularly vertical dials. The image of the moon too is a benign one, his light helps us through the otherwise dark nights and this too is usually depicted as a smiling face.

Horizontal dials rarely had the smiling sun image on them but in the last 100 years or so, many of the replica dials that
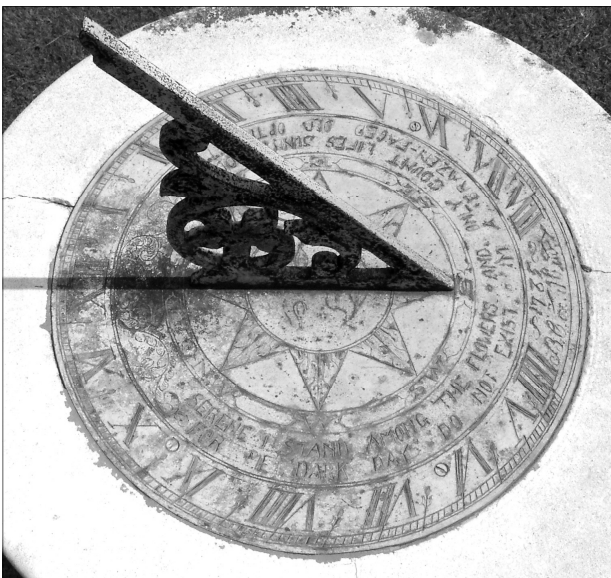

Fig. 1. Twentieth century replica dial at Anglesey Abbey, Cambridgeshire with a large sun image in its centre.

Fig. 2. Finely carved slate dial from St Coulomb Minor in Cornwall.

we find *do have* the sun image. The dial at Anglesey Abbey (Fig. 1) is signed and dated "1785 B. Cox, Kew", an obvious red herring. With a large sun face like that and its corny motto it *has to be* a 20th century replica. The sun face here is rather too large to be convincing. Go to any garden centre and look at the dials on sale. They will almost certainly carry an image of the sun, perhaps suggesting fine weather and wonderful summers in the garden.

Dials with more restrained sun images, like the fine carved slate dial at St Coulomb Minor, Cornwall, ('Sic Transit Gloria Mundi') shown in Fig. 2 and the stained glass dial at Litchborough, Northamptonshire, (Fig. 3), simply state that the sun is their reason for being. Its image is relatively large, but not obtrusive.
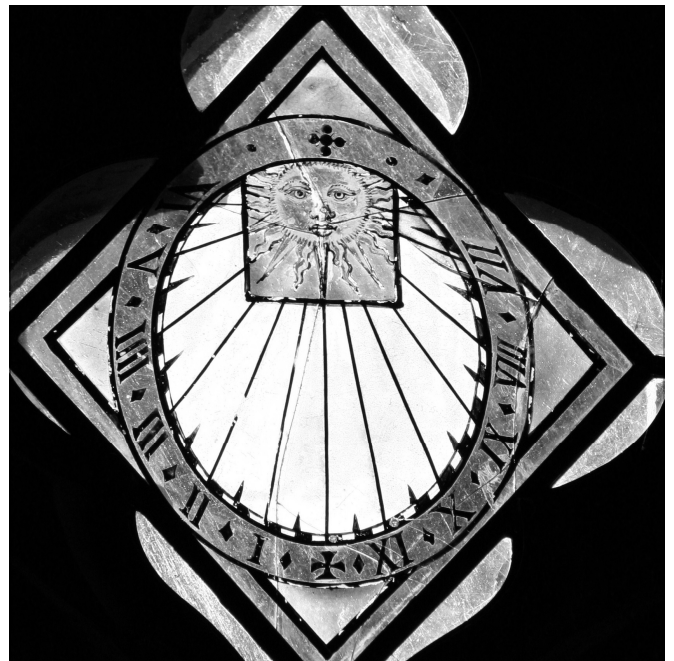
Fig. 3. A fine sun image on the stained glass dial from Litchborough, Northamptonshire.

Another interesting dial with a face won last year's BSS Photo Competition. The picture by Paul Shaw is of the dial in the Time Garden at Carnfunnock Country Park, Co. Antrim - see *Bulletin* 19(ii), page 57.

Other faces are occasionally found, such as the angel (or could it be a bat?) face on the slate dial at Blisland, Cornwall seen in Fig. 4.

Dials from some parts of Europe are often more richly adorned than in Britain and the sun's image is frequently to be found on them. The dial at Riquewihr (Fig. 5) has a very benevolent sun image, obviously well satisfied after drinking the local Gewürztraminer wine. And the sun at Zell-am-Zee (Fig. 6) is really dominant, almost advertising the

Fig. 4. Slate dial from Blisland, Cornwall with an angel image above.

Fig. 6. Dial on a house at Zell-am-Zee, Austria.

Fig. 5. Dial on house at Riquewihr, Alsace, France.

Fig. 7. Reclining dial on a concrete pillar at the roadside in Strakonice, Czech Republic.

fine fresh air and sunshine from this well-known mountain resort. This dial too has the cock and the owl signifying dawn and dusk, but strangely placed on the wrong sides of the dial, the owl in the morning and the cock at evening.

The modern dial at Strakonice in the Czech Republic (Fig. 7) lies besides a main road. I have included this because it is an interesting reclining dial. The sun at the very top is holding the thin gnomon in his mouth. The round concrete pillar that the dial sits on has been cut through at an angle with interesting effect. Notice how a reclining dial places the hour lines very close together, especially around noon.

Portable dials too have their share of faces. Again the sun is the commonest, as may be seen at the lower end of the gnomon on the German dial (Fig. 8), signed simply ·S·A·V·Z· and dated 1643. Many of the ivory diptych dials from Nuremberg also have sun images on them, usually on the vertical dial face, with the string gnomon coming from the sun's mouth.
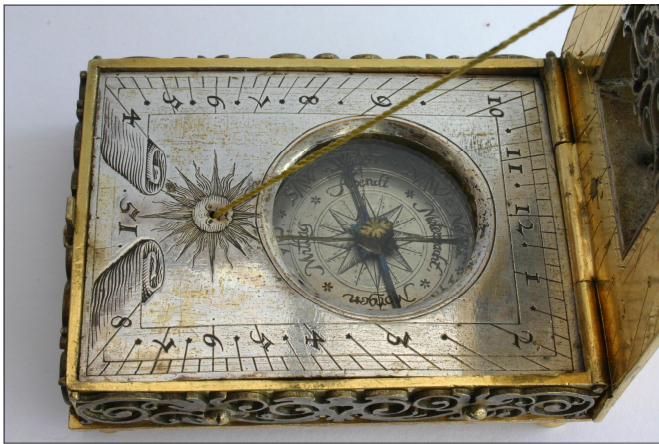
Fig. 8. German diptych dial signed ·S·A·V·Z· with sun's face at the root of the string gnomon.

Fig. 10. The moon depicted on a vertical disc dial.

Fig. 9. The gnomons of two Butterfield type dials, featuring a bird and a lion.

Fig. 11. Full moon and new moon as depicted on a silver vertical disc dial from Germany.

Butterfield dials are well known for having a small bird acting as a gnomon supporter, with his beak acting as a pointer to the correct latitude. These birds come in various shapes and sizes, even a swan is known on one dial. The two images shown in Fig. 9 are of a fairly conventional Butterfield-type bird, made by Richard Whitehead, London, c.1680 and an unusual lion supporter by Bizot of Paris, c.1710.

Lunar faces are also found on dials, particularly those that have conversion volvelles from lunar to solar hours. These often have a round cut-out that revolves over a partly

Fig. 12. Nuremberg ivory diptych dial by Hans Troschel showing the moon in the centre and three small moons punched into the ivory plate.

shaded line that tapers from new moon to full moon. At the full moon there is usually a moon face to fill the aperture such as that in Fig. 10. Some dials show up to four phases of the moon, like the silver disk dial in Fig. 11. Here I have shown just the full and new moon symbols.

On many ivory diptych dials from Nuremberg there is a lunar volvelle and several of these have a gilt brass disc at the centre pointing to the lunar date. This is embossed with an image of the crescent moon encompassing a face with lines radiating from it. On the example illustrated in Fig. 12 by Hans Troschel, c.1600, there are also moon symbols stamped on the scales at their zero points.

The moon's image that is probably more familiar to most of us is the usually smiling face that is frequently found in the arch of a painted dial longcase clock.

Other faces sometimes found on dials are those relating to the four winds. These show heads in the four corners of a dial with radial lines or puffs of cloud representing the four winds. The example shown in Fig.

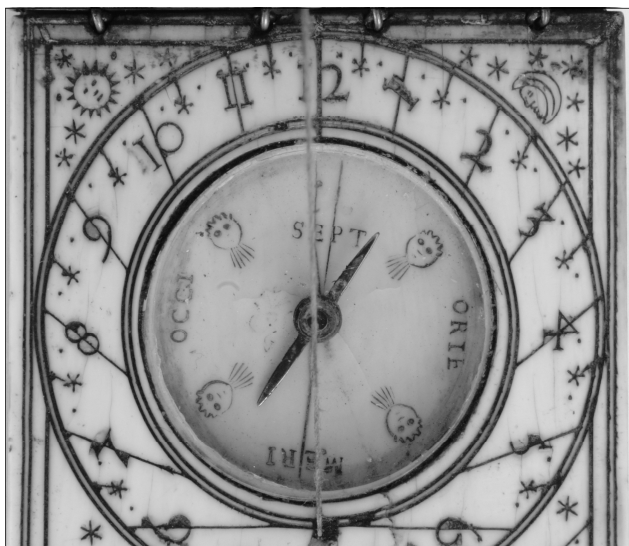
Fig. 15. Grotesque face on diptych dial signed ·S·A·V·Z·.

Fig. 13. Compass bowl of diptych dial by Lienhart Miller, 1628, with the four wind faces, the sun and moon above.

Fig. 14. Grotesque face, probably a lion, on the lid of an ivory diptych dial by Nicolaus Crucefix, Dieppe, c.1660.

13 is in the compass bowl of an ivory diptych dial by Lienhart Miller, dated 1628. Note also the sun and moon faces surrounded by stars in the corners to the north of the compass bowl.

So far I have talked about generally smiling faces but sometimes the face is rather grotesque. Such faces will often be found on the decorated balance cocks of early pocket watches. The face illustrated in Fig. 14 is on the lid of a Dieppe diptych dial by Nicolaus Crucefix, and looks particularly unfriendly. I think that this is supposed to depict a fierce lion.

Another grotesque face is to be found on the ·S·A·V·Z· dial previously mentioned (Fig. 15). This face is on the fretted cover protecting the plummet in the lid of the dial.

My final example of a face is taken from a fine Irish slate dial inscribed: "This was finished with care most fervent by Robert Connell. Your humble Servant" and "Made in the year of our LORD 1815". Careful examination is here rewarded by what can only be described as 'dial graffiti'. The dial has the equation of time engraved on it inside the hour scales. The O of Oct(ober) has a small face in it (Fig. 16), complete with hair, eyebrows and possibly a short beard. There is the vestige of yet another face in the O of LORD! Why these faces are there or who carved them is not known. Perhaps it was a Connell trademark, or just a bit of good Irish humour.
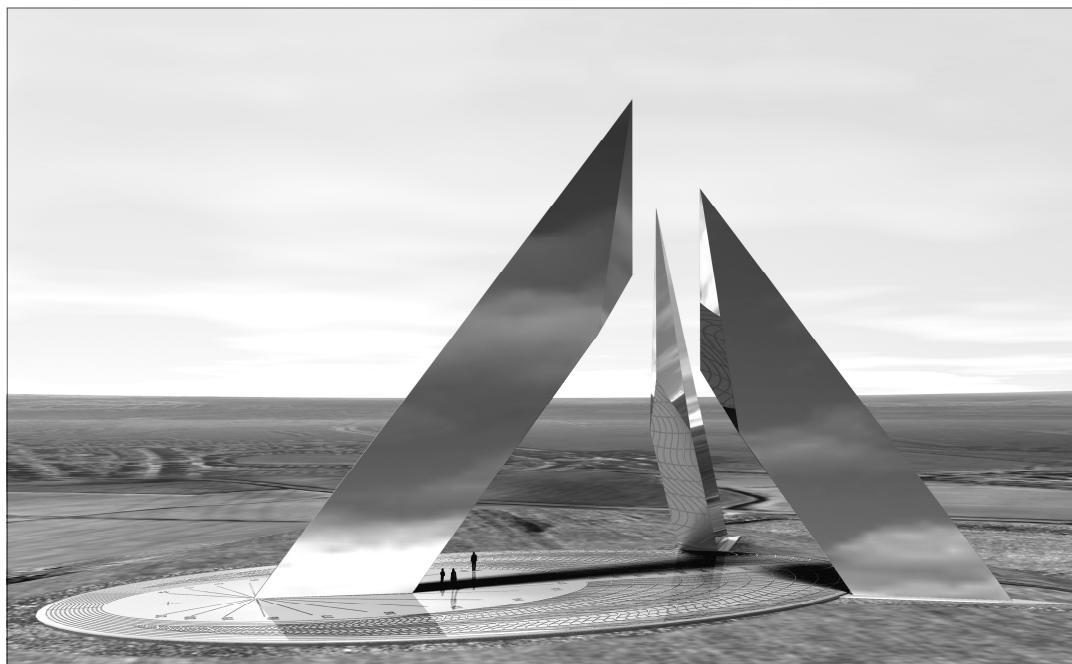

Fig. 16. Sundial graffiti as found on a nonagonal slate dial by Irish maker Robert Connell.

Makers of all generations seem to have enjoyed placing faces on dials and these are just a few of the more interesting ones that I have come across.

THE SOLAR PYRAMID

ROBIN M CATCHPOLE[*]

Fig. 1. The Solar Pyramid, shown in this artist's impression, will consist of three stainless steel clad blades, the tallest rising to 45 metres above the dial.

[*]Institute of Astronomy, Cambridge

Introduction

The Solar Pyramid is primarily a work of art which, when built, will also be the largest sundial in the world. It is the creation of Richard Lester Swain and Adam Walkden who were inspired by their visit to the Egyptian pyramids. It will consist of three inclined skyward pointing blades, shown in the artist's impression in Fig. 1. The designers realised that if the largest blade, which will rise 45 metres above the dial, is aligned north-south, it can be used as a sundial, extending the scope of the project to include both art and science.

At an early stage, Richard and Adam approached the Royal Observatory Greenwich (ROG) to ask for their endorsement and support. That was when, in my role as Senior Astronomer at the ROG, I became involved in the project and took responsibility for the design of the dial.

The site of the Solar Pyramid has not been decided and discussions are currently (January 2008) taking place with a number of interested parties. The original idea was to site it at Staveley in Derbyshire, close to the homes of the designers.

The detailed design has not been finalised but current thinking includes an undercroft beneath the dial that can be used for exhibition, outreach and commercial activity. This has the advantage of providing a rigid box structure to support the three blades, obviating the need for piles and also making the design independent of the ground conditions on which it is built.

It is intended to cover the blades in stainless steel panels produced by Rimex Metals Group. These are polished to a mirror finish and covered in a thin oxidised coating, giving them a colour that varies from green to blue depending on the angle of illumination.

The hour and other marks will be cut into the surface of the dial. The dial paving material has not been decided but we hope this will be a light coloured stone. More details about the project can be found on the project website.[1]

Being primarily a work of art places a number of constraints on the dial design. Firstly, the gnomon will not necessarily be inclined at the latitude of the site. Secondly, the dial, which is to be about 70 meters across, must have a gradient of 1/50 to allow rainwater to run off. Also, the gnomon has a triangular section in plan, which means that different parts of the gnomon cast the time–indicating shadow at different times of the day. Lastly, the great size of the dial and gnomon mean that some method must be used to judge the centre of the shadow penumbra.

The Dial

The fact that the gnomon is not inclined at the local latitude and the large size of the dial make it both necessary and convenient to expand the dial so it can be read on every day of the year. This in turn makes it convenient to include both the longitude offset and the equation of time in the dial de-
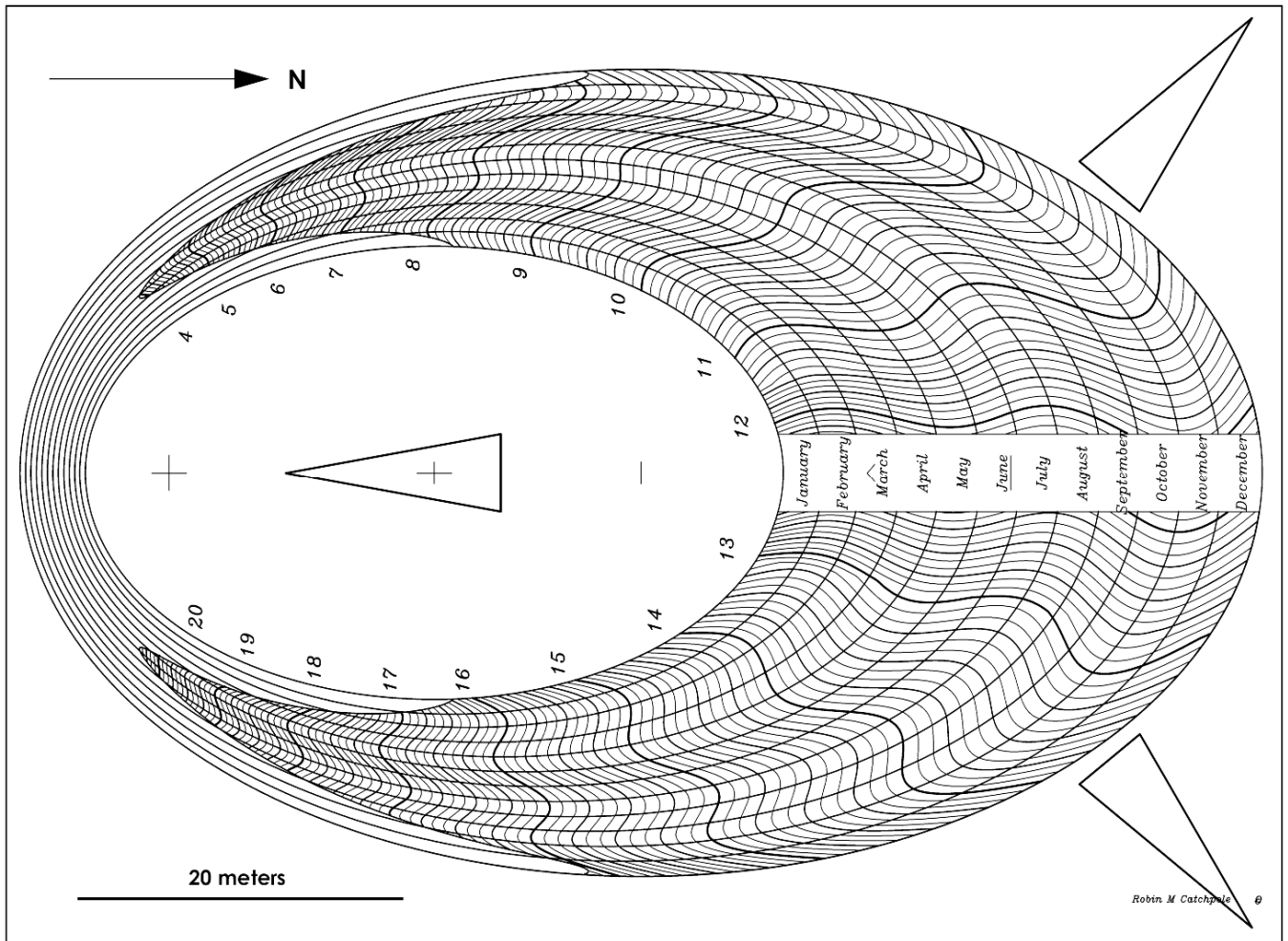
Fig. 2. A plan view showing the location of the three blades and the design of the dial, which is marked to read in GMT. Each elliptical path corresponds to a different month of the year. Hour and minute marks are only drawn for times when the Sun is above the horizon, creating the appearance of 'horns' at the south end of the dial.

sign allowing, at least for the present, the dial to be read directly in Greenwich Mean Time.

All the dial calculations were done using formulae taken from the *Explanatory Supplement to the Astronomical Almanac*[2] (hereafter ES). These include equations for the hour angle and declination of the Sun, the equation of time, and for atmospheric refraction. The time argument in the above equations is in Julian centuries from 12 hrs UT on 1 January, 2000.0. The ES also provides a convenient formula for converting any Gregorian calendar date into Julian day number, which then specifies the time of 1 January for any future year in the above equations.

The methodology is as follows. The first programme takes as input the date, the latitude and longitude of the dial, the dial gradient, the angle of elevation of the gnomon and the height of the top of the gnomon above the dial. Using the appropriate formulae and including corrections for refraction, I calculate the azimuth of the shadow of the gnomon and the length and azimuth of the shadow cast by the top of the gnomon, for every minute of the year. The time and azimuth of sunrise and sunset are also calculated for every

day of the year, but in this case for a horizontal dial, so that the results agree with the local times of sunrise. Following the definition in the ES, the moment of sunrise or sunset is taken as the time when the Sun's upper limb is seen to be on the horizon so that, removing the effect of refraction, the true zenith distance of its centre is 90° 50'.

The second programme takes data from the first programme and plots the dial, as shown in Fig. 2. Time is marked in 5 minute intervals. The dial reads the time given by the mean Sun at Greenwich (GMT). The dial is divided orthogonally to the time axis into the months of the year. The inner ellipse corresponds to 0 hours on January 1 and the outer ellipse to 24 hours on December 31, assuming a 365 day year. The intermediate ellipses mark the beginning of the remaining months.

The shape of the dial is a matter of aesthetic judgement, so the programme is made as versatile as possible to allow for every whim of the two designers. The design shown contains the time marks within two ellipses. Both ellipses have the same shape or eccentricity and have been drawn so that their most southerly foci are coincident. The gnomon is offset from the centre of the small ellipse.

The azimuths of the two secondary blades are orientated in the direction of sunrise and sunset at the time of the summer solstice, assuming that sunrise and sunset occur at the moment of the solstice.

The triangular cross-section of the gnomon remains constant in size and shape for about two thirds of its height so the dial must be drawn so that the shadow cast by this part reaches at least as far as the date of the summer solstice on the dial.

The triangular cross-section of the gnomon also means that between about 11h 20m and 13h 10m GMT, the shadow that must be read on the dial is cast by the respective edges of the triangle's base. Close examination of the dial shows a crowding of the markings and discontinuities in the curves between these times. The precise times depend on the longitude of the dial.

The 'horns' at the southern ends of the dial are bounded by curves that give the time of sunrise and sunset and show how the length of the day changes from winter to summer. Note the small hook in the sunset and sunrise curves at the time of the winter solstice, which does not occur exactly at the end of the year.

Reading the Dial

Between 9 am and 3 pm, the elliptical paths corresponding to each month of the year are between one and two meters wide. Visitors will be encouraged to walk towards the point where the shadow is being cast, along the path corresponding to the current month of the year. To read the time, they will first estimate how many days they are through the month and at that point interpolate the position of the shadow between the nearest five minute marks on the dial. The penumbral part of the shadow will be quite broad and
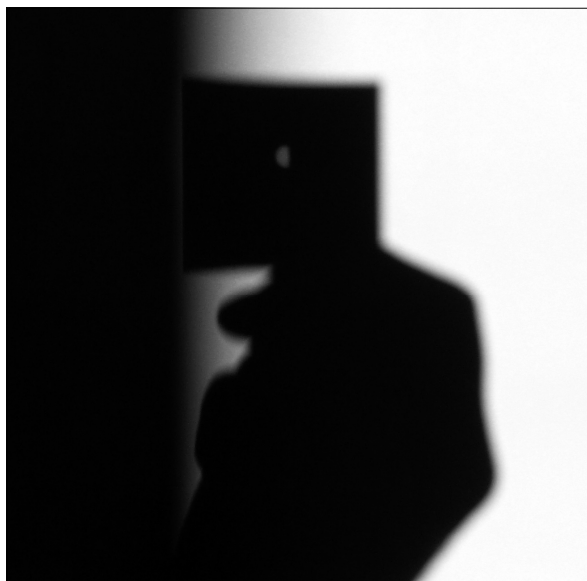

Fig. 3. A pinhole image of the Sun formed within the penumbra of a shadow looks like a 'half-moon' when at the centre of the penumbra.

requires a simple technique to measure its position, as outlined below.

Angles are scale invariant, which means the way the Sun's shadow looks on a model of the dial will be identical to the way it looks on the life size dial. Only the life size dial would require a helicopter to read it with similar ease. To the visitor on the ground, the part of the shadow called the penumbra, where the illumination varies from full Sun light to no illumination, will be up to 40cm wide, making it difficult to judge the centre. To help find the centre, visitors will be issued with a ticket with a 2mm diameter pinhole in the middle. This can be used to cast a pinhole image of the Sun onto the dial face. When the Sun is exactly bisected by the gnomon, as it is when viewed from the centre of the penumbra, the pinhole image will look like a half-moon, as shown in Fig. 3. In practice, it should be possible to estimate the position of the centre of the penumbra with an accuracy of 1/5 of its width, which corresponds to 7 minutes of arc, or about 30 seconds of time.

The easiest way to enjoy the dial will be to wait for the centre of the shadow to cross one of the five minute marks and compare the dial time with wrist watch time.

The Accuracy of the Dial

Because the Equation of Time (EoT) varies with time, incorporating it in a dial so that GMT can be read means that the dial is exactly correct for only one year. This leaves us with two design options, either of which may be still be used. Either we can adopt a given year as the epoch of the dial. This could be an anniversary year, the year of construction, or the year half way through the anticipated life of the dial. Or we can use an EoT curve which has values averaged over the anticipated life of the dial. This would only be important if the dial was to last for about 1000 years.

Before estimating the size of the errors introduced by using one EoT, we will briefly review our calendar.

As the Earth goes around the Sun on an elliptical orbit, its tilted axis of rotation precesses about an axis at right angles to the inertial plane of the Solar System, with a period of about 26,000 years. The tilt of the Earth's rotation axis is responsible for the seasons. We tie our calendar to the seasons and the corresponding length of the year is known as the tropical year (365.2421897 days, Epoch 1900.0), which is the interval between successive vernal equinoxes. This is in contrast to the sidereal year, which is the time it takes the Earth to orbit the Sun exactly once compared to the fixed stars.

Our calendar is designed to approximate as closely as possible to the length of the tropical year. Our civil year has to contain a whole or integer number of days and the first ap-

proximation was the Julian calendar with an extra day every four years. We now use the Gregorian calendar, with the added rule that only century years divisible without remainder by 400, are allowed to be leap years. This is a much better approximation and means that 2000 Gregorian years are completed 15 days before 2000 Julian years and only 0.62 days after 2000 tropical years.

The EoT is the sum of two parts; a projection part and an orbital part. The projection part originates because the Sun's apparent annual motion along the ecliptic must be projected onto the celestial equator. The equinoxes occur when the Sun is at the point where the ecliptic crosses the equator. The orbital part is a consequence of Kepler's second law applied to the Earth's elliptical orbit, causing the Sun to appear to move along the ecliptic faster when closest to the Earth. For a fuller explanation see Karney.[3]

In about 13,000 years time, the time of perihelion, currently close to the beginning of January, will be close to the summer solstice. This is mostly a reflection of the precession of the Earth's orbital axis, rather than the rotation of the Earth's major axis. The orbital part is the most important factor changing the shape of the EoT with time. Choosing the tropical year as the basis for our calendar ensures that the projection part does not move with time. This is another way of saying the equinoxes and solstices or seasons remain, on average, on the same day of the year. The amplitude of both the projection and the orbital parts are decreasing very slowly with time as both the eccentricity of the Earth's orbit and the inclination of the rotation axis are currently decreasing.

Equation 9.311-2 in the ES gives the variation in the longitude of perihelion, while terms for the eccentricity and obliquity can be substituted in equation 9.311-3 to give:

Fig. 5. Each individual curve shows the difference between the time shown by a dial, drawn for the year 2000 AD and GMT, for years taken at 200 year intervals between 2000 AD and 5000 AD. No account is taken for leap years.

$$E = 2e \sin G - \tfrac{5}{4} e^2 \sin 2G + y \sin 2\lambda - \tfrac{1}{2} y^2 \sin 4\lambda$$

$$y = \tan^2 \tfrac{\varepsilon}{2}$$

Where e is the eccentricity and ε the obliquity and their variation with time is given in the ES. G is the day number and λ is the ecliptic longitude.

Fig. 4 shows the EoT drawn every 200 years from 2000AD to 5000AD. The definition of the EoT in terms of the Apparent Solar Time (AST) and Mean Solar Time (GMT in this case), is given by the usual relationship;

GMT= AST - EoT

The EoT is sampled at intervals which are integer multiples (in this case 200) of the average length of the Gregorian year (365.2425 day), thus ensuring that 1 January remains at the left hand side of the diagram.

It is unlikely that anyone in the year 5000AD will look back and check the accuracy of these curves but if they do they
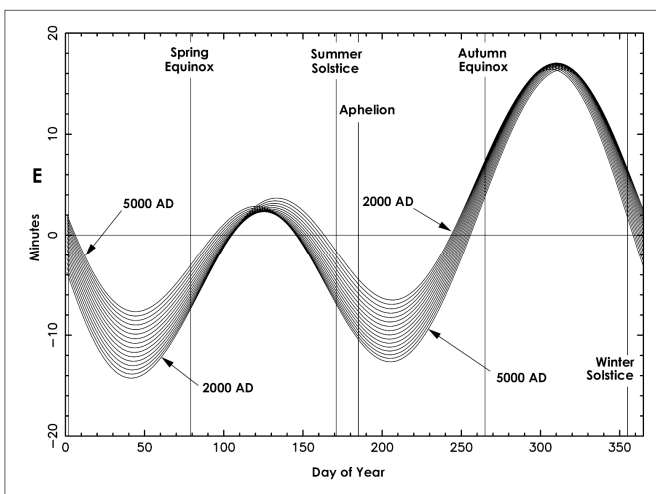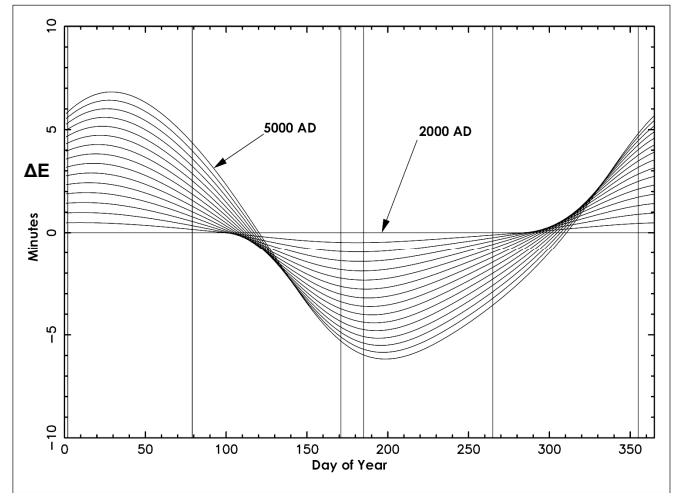

Fig. 4. The equation of time for the Greenwich meridian, drawn every 200 years from 2000 AD to 5000 AD, shows a varying shape, mainly caused by the drift of the time of perihelion from winter towards summer.
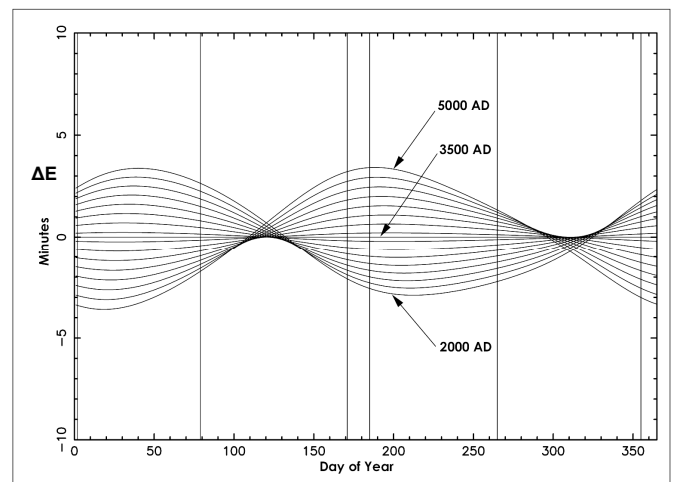

Fig. 6. Identical to Fig. 5 but compared with a dial drawn for the year 3500 AD, showing how the differences can be reduced by using an epoch in the centre of the time span.
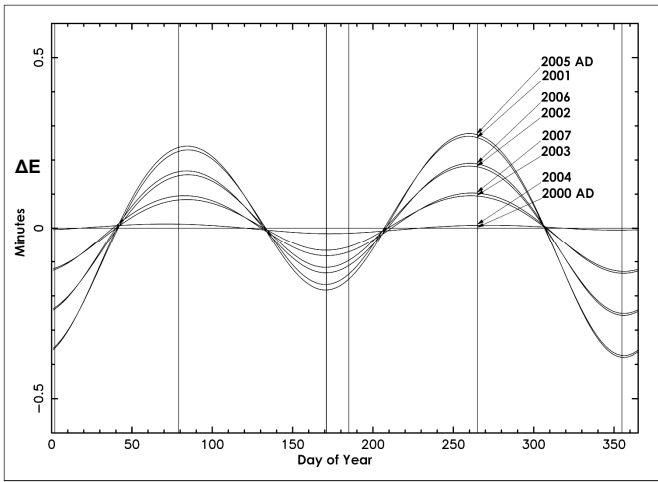
Fig. 7. The difference in time given by a dial designed for 2000 AD when it is read in the next 7 years. The difference is caused by having leap-years. Notice the greatest effect occurs in the year after the leap year (2000 and 2004 AD were leap years).
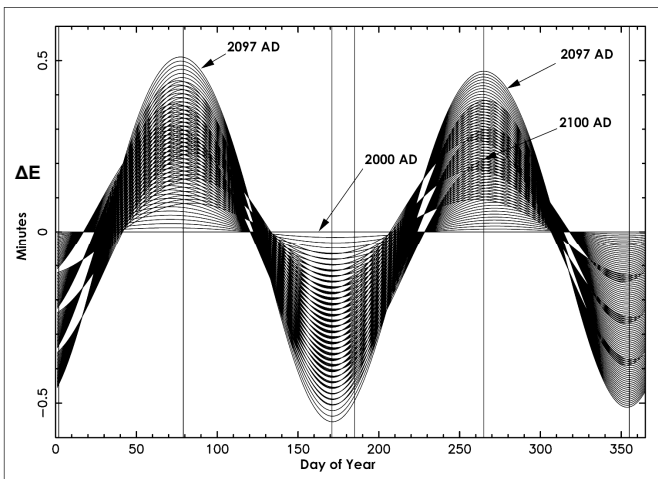

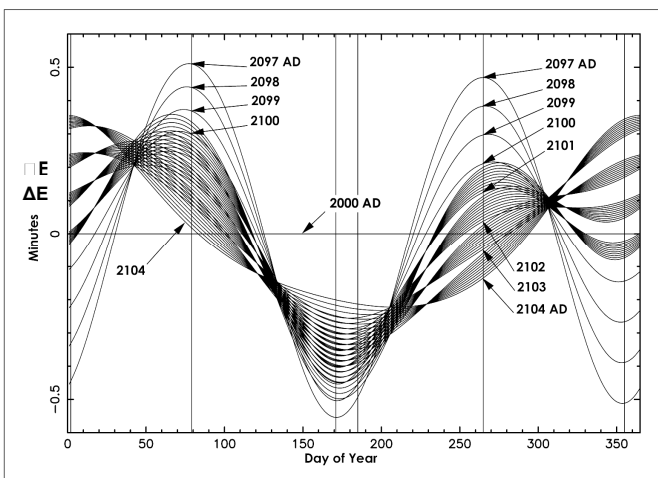Fig. 8. Identical to Fig. 7, but for all the years from 2000 AD and 2100 AD.

Fig. 10. Identical to Fig. 7 but drawn for the last three years of the 21st century and the first 40 years of the 22nd century. Notice how 2100 AD not being a leap year reduces the leap year drift. It is also possible to see the added effect of the long term variation in the shape of the EoT, illustrated in Fig. 5.

will hopefully not be too disappointed. They are based on linear extrapolations of the variation in the obliquity, eccentricity and precession, all of which are approximations and fail to account, for example, for the uncertain lengthening of the day as the Earth's rotation rate slows down.

Fig 5 shows the difference between each curve and the EoT for 2000 AD.

$$\Delta E = \text{EoT} - \text{EoT}_{2000 \text{ AD}}$$

The error reading a dial using the 2000 AD EoT in the year 5000 AD varies from +6.7 to -6.1 minutes during the year. These curves are drawn assuming an average length for the Gregorian year and ignore the effects of leap years.

The correction to the dial time (read from a dial corrected for the longitude and EoT) is related to GMT at any future date by the relationship:

$$\text{GMT} = \text{Dial Time}_{2000 \text{ AD}} - \Delta E$$

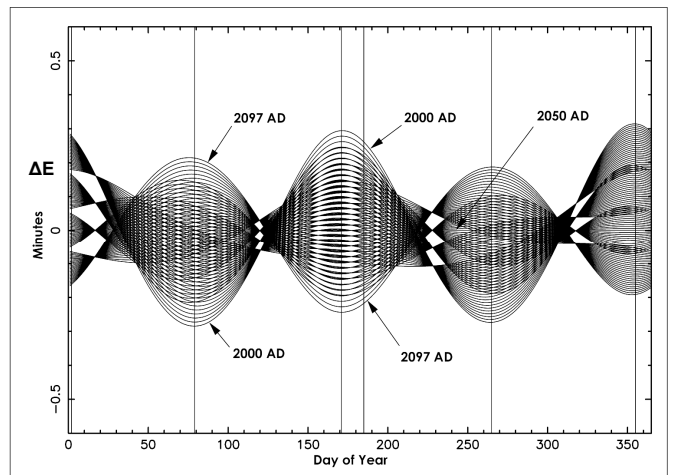Fig. 9. Identical to Fig. 8, but showing the effect of using a dial drawn for the year 2050 and thereby reducing the range of the deviation.
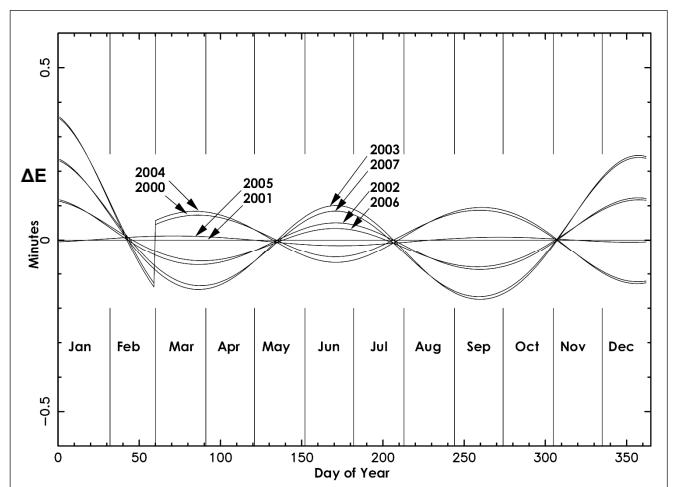

Fig. 11. The difference in time given by a dial designed for the year 2001 when it is read for years between 2000 and 2007. Note that the time of year is given by the calendar date. The curves for the leap years 2000 and 2004 fold up at the end of February compared to the other curves.

The error can be halved over 3000 years by adopting an EoT for the dial for the year 3500 AD, as shown in Fig. 6.

Having years with different numbers of days does not alter the shape of the EoT, it just shifts it from one year to the next with respect to a given calendar date. In Fig. 7 the error, caused by reading a dial using the EoT for 2000 AD in subsequent years, is shown for the first few years of this century. Note that the biggest jump, of 0.25 of a minute, occurs in the year immediately after a leap year. The effect for the whole century is shown in Fig. 8 and ranges between plus and minus 0.5 minute and can again be halved by using an EoT for the year 2050 as shown in Fig. 9. Both figures show the characteristic four braids caused by the cycle of leap years. The steady opening of the braids from one leap year cycle to the next is partly compensated at the end of this century when a leap year is lost in 2100 AD. This is shown in Fig. 10, which plots all the years from 2097 to 2140 AD and should also be compared with Fig. 8. Fig. 10 also begins to show the effect of the long term variation in the EoT, illustrated in Fig. 5.

In the preceding discussion we have have divided the year into numbered days. If instead we use calendar date, as is the case for the Solar Pyramid dial, then the error introduced reading the time during a leap year, from a non leap year dial, has a different appearance, as shown in Fig. 11. The error for non leap years is identical to that shown in Fig. 7. For clarity, the comparison in Fig. 11 is with the non leap year, 2001. The insertion of an extra day at the end of February in a leap year is seen to flip the difference curve up on itself, changing the sign of the difference for the rest of the year. There is nothing mysterious about this, it is simply the effect of calendar dates after 29 February corresponding to a day number one day later during a leap year.

It is possible to write a simple empirical equation that combines the 'error' introduced by leap year jitter and the long-term variation in the EoT in the form;

$$\Delta E = 0.32 + 0.22T$$

Where T is in centuries measured from the date of the EoT

Time after dial date Julian Years	Dial reading error minutes	(Solar Mean Time - Atomic Time) minutes
40	±0.64	-0.05
50	±0.65	-0.08
100	±0.73	-0.30
200	±0.90	-1.2
1000	±2.6	-30.0

Table. 1. Dial reading errors.

used for the dial and ΔE is in decimal minutes. The error reading the dial will then be less than or equal to $\pm\Delta E$. This is not of course a true error as it is possible to calculate the exact deviation at any time of any year but, to a casual visitor who just wants to read the dial, it will seem like an error.

If we assume that the observational limit on reading the shadow is ±0.5 minutes (see above) then we can combine the two sources of error as follows;

$$\Delta E_{Total}^2 = \Delta E^2 + 0.5^2$$

This leads to the results in columns 1 and 2 in Table 1. Column 3 shows the difference between sundial time and civil time that will arise if the practice of adding leap seconds, to keep UTC within 0.9 seconds of UT1, is abandoned. It assumes the length of the day increases by 0.001 seconds every 100 years. The discrepancy increases with the square of the time interval, which causes the dramatic increase with time. There have been calls to abandon the insertion of leap seconds and the topic is well summarised by Kuhn.[4] Note that although the Earth's daily rotation rate is slowing down, its annual orbital rate is not.

For visitors to the Solar Pyramid, their greatest practical difficulty will be accurately interpolating the day of the month, before they read the time from the position of the shadow.

Conclusion

The Solar Pyramid will be the largest sundial in the world, with a dial that can be read directly in Greenwich Mean Time. It should be possible to read time off the dial with an accuracy better than ±1 minute of time over several hundred years.

It is hoped that this project will not only be an exciting piece of art but will reawaken an interest in the underlying science and even make a currently topical connection between the behavior of the Earth's orbit and its consequent influences on the Earth's climate.

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2. P.K. Seidelmann (Ed.): *Explanatory Supplement to the Astronomical Almanac,* University Science Books, California (1992).
3. K. Karney: 'Variations in the Equation of Time', *BSS Bull*, 18(ii) pp.64-68 (June 2006).
4. Markus Kuhn; http://www.cl.cam.ac.uk/~mgk25/time/leap/

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NEW DIALS

Burghley House, Stamford, Lincs.

A large and complex new sundial was installed in the new water gardens (the 'Garden of Surprises') at Burghley House near Stamford in Lincolnshire in 2007. It is inscribed in memory of William Cecil (1520-1598), the first Lord Burghley, "who much delighted in making gardens, fountains and walks".

The dial is seven-sided with an elegant brass/bronze gnomon. It is constructed of polished gabbro (a micro-fine igneous rock) set on a Clipsham limestone pedestal and it incorporates a map of the world among other features. It is described by its designer and maker, BSS member William (Will) Andrewes of
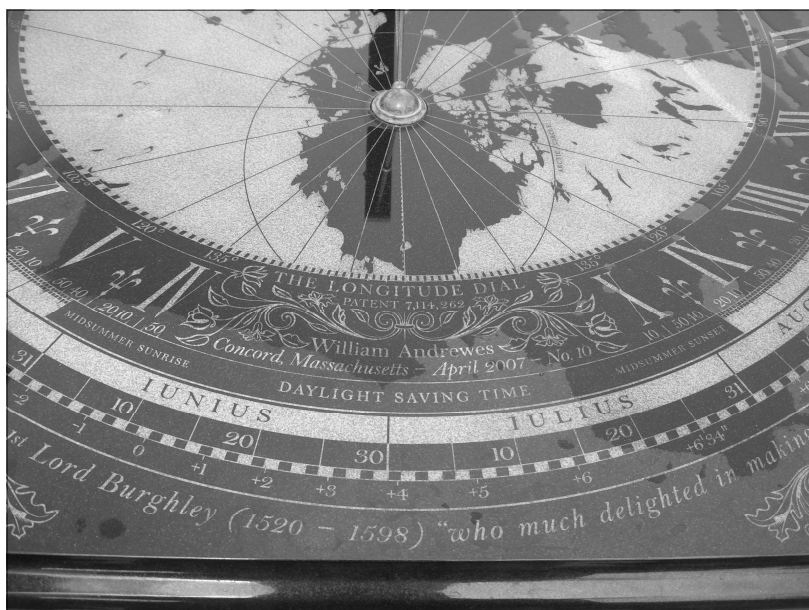
Concord, Massachusetts, as the 'Longitude Dial' because the shadow of the gnomon falls on the map like a line of longitude. Engraved on one side is an explanation of the history of the idea for this dial, which is based on Franz Ritter's 1607 projection of the world which puts the 'home' location in the centre of the map and is known as the central or gnomonic projection. Great circles on the sphere, forming the shortest distance between two points, project as straight lines on the map.

The dial indicates standard time for Burghley House, requiring the application of the equation of time which is given around the chapter ring. The gnomon's shadow also indicates all the locations on the map where it is currently noon. The nodus shadow marks where the Sun is overhead on the map and follows the line of the Equator at the equinoxes and the line of the Tropic of Cancer on the summer solstice. It also traces the appointed date lines for Sept 15 (William Cecil's birthday), Aug 4 (the day he died) and April 1 (the day the garden was opened).

Around the seven sides of the pedestal (one for each day of the week) are polished gabbro plaques providing information on how to use the dial for telling the time, interesting details on the days of the week, what the various shadows on the map are signifying, and yet another explains the history of the idea.

Underneath the table is a small meridian line which includes the length of daylight and night-time throughout the year.

The dial is signed and dated. The design is patented: the Burghley dial is example number 10 .

While you are at Burghley House don't miss the fine 18th century dial signed by "I. Sisson" (but is it by Jonathan Sisson or his son Jeremiah?) in the rose garden outside the Orangery tearoom (new to the BSS Register). There is also a new armillary dial in the water garden.

Irene Brightmer

A St Petersburg Dial

This sundial is only the second the dial made by our new Russian member Valery Dmitriev, together with the architect son, Alex Sosnovski, of an old friend. The intention was to make a dial in the style of a traditional English one to beautify a Russian garden. The sundial is designed to fit on a pedestal in the form of a circular column. It is made of a brass: the outlines of the dial and gnomon, and the engraving, were both executed using a milling machine with a computer control system (CNC). The engraving was blackened with a special solution, then the dial was polished and covered by a protective lacquer. Valery is planning to make more dials so we look forward to seeing them in the future.

Postcard Potpourri 8 - The Willett Memorial, Petts Wood, Chislehurst

Peter Ransom

This vertical south dial is adjusted for summer time since the horizontal line runs from 7 am to 7 pm. It is found in Petts Wood (grid ref TQ44941E 69699N), which is in a suburb of London in the Borough of Bromley. What makes it interesting is that it is a memorial dial to William Willett (August 10, 1856—March 4, 1915), the campaigner for daylight saving hours. In 1907 he published a pamphlet, *The Waste of Daylight*, in which he proposed clocks should move forward by 20 minutes every week in April until time was advanced by a

total of 80 minutes. This was to be reclaimed in September. Willett died in 1915 and on May 21 1916 clocks were advanced an hour for the first time in Britain.

The dial is marked to show the half hours and has the motto HORAS NON NUMERO NISI ÆSTIVAS (I only count the summer hours) underneath the dial. The significance of the dark ellipse below the dial escapes me – it occurs on different postcards of the same dial so is unlikely to be a rogue shadow. The dial dates from 1927 and was made by G W Miller. Its dimensions are 61cm by 45cm. On the reverse are details about Willett. Full details of William Willett can be found at http://en.wikipedia.org/wiki/William_Willett.

Two of the three postcards I have of this dial are identical and although two years apart in posting (1965 and 1967), they were sent to the same address – what are the chances of that happening?

pransom@btinternet.com

READERS' LETTERS

Melville Dial

I read with great interest the article by Douglas Bateman on the 'Dial by Richard Melville' (*Bulletin* 19(iv) pp.187-9) and would like to put forward one or two ideas which might solve the mysteries associated with this dial.

First of all, whereabouts was this dial made for? Hour lines on dials are not the easiest thing to work with when it comes to assessing latitude since the whole of the country from Cornwall to the North of Scotland can be covered by a range of only around 8°. However, the hour lines on this particular dial seem to have been very carefully measured and an analysis of these (see Table 4 in the article) gives a remarkably close spread when considering the probable design latitude. Five of them fall between 52.6° and 53.9° with nothing below – taken in conjunction with the measured gnomon angle of 53.5° it is fairly evident that this dial was intended for a customer living somewhere in the Midlands.

Next, the engraving error and its probable effect. The 6am and 6pm lines on a horizontal dial are extensions of each other and it seems reasonable that they should be engraved together. In this instance, however, I surmise that following a momentary lack of concentration the 'am' side was continued much further than was intended, as can be very clearly seen in the photograph. I imagine that this glaring error would have rendered the dial completely unacceptable to whoever had ordered the instrument and since there was no way in which it could be removed there was nothing for it but to start all over again with another piece of slate.

This would, of course, have left Richard Melville with a rather surplus dial on his hands. Without my commenting on the ethics of the case, perhaps he knew of a potential customer in the Salisbury area – not quite so fussy as the original customer, perhaps – who would be delighted to posses a real 'Melville' at a greatly reduced price! A simple matter to personalise the unfinished dial with a new latitude and longitude time correction to suit the new location and the job was done.

I am not sure where the 1° 56' W came from: 7½ minutes translates to 1° 52' 30" which, at this latitude, equates to 4km further east than suggested. I am not surprised that Grovely Lodge denied all knowledge of it.

Meanwhile, the replacement dial would have winged its way to the North. According to the article, of all the known Melville dials there is only one other one which is circular. But the replacement dial we have been talking about must also have been circular – in fact alike in every way apart from the scratch! Could they not be one and the same? It would be interesting if someone with access to the BSS Register could check to see how closely these two match up.

I realise that all this is mostly speculation but I hope it covers some of the questions raised in the article.

Michael Maltin, Gloucs.

[Michael Harley, who is researching Melville's career, reports that the 'other' circular Melville dial is in the National Museums of Scotland, features eight subsidiary dials and is from Melville's time at Liverpool, a decade before his Crystal Palace period. So it cannot be a replacement for the Andover dial. Ed.]

Mystery Dial - a sad story.

In the March *Bulletin* under the title 'Mystery Dial', is a plea for identification of a good churchyard dial depicted on an old lantern slide. I immediately recognised the distinctive pedestal as I have walked past a picture of it many times a day for the past 22 years. The watercolour hangs in our hall and was painted by my daughter for A-level art exams in 1985. The picture (left) is a pastiche of three local churches and churchyards.

The lantern slide was taken by the south porch of Prestbury Parish Church, near Macclesfield, Cheshire, and is SRN 0149 in the BSS Register.

My wife and I went to Prestbury to try to re-photograph the lantern slide scene but, for some reason which we could not understand, no matter upon which gravestone my wife stood she could not get the same arrangement of small window, cross above the porch and the dial as on the lantern slide. Another oddity was that if the church roof in the background
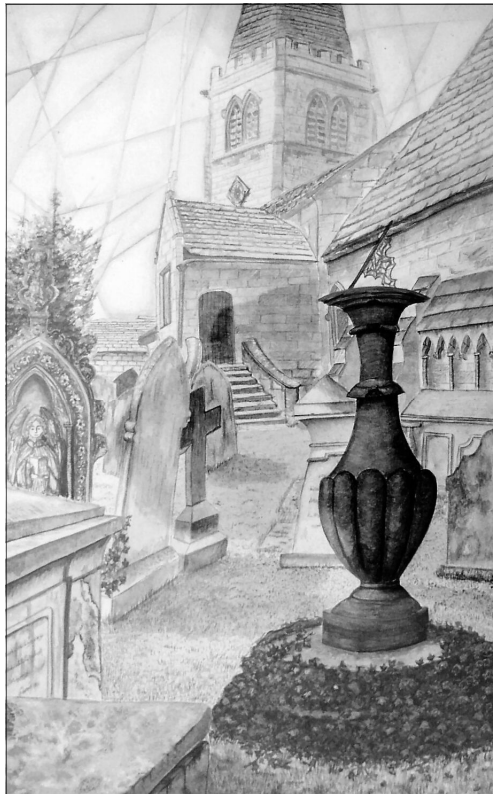
was correct then the dial was shown as aligned well to the east of north. Either the dial or the church had over the years moved. But my wife found the simpler explanation: the photo in the *Bulletin* was printed the wrong way round. Our photo, together with one I had taken in the early 1990s, were e-mailed to the editor later the same day. The real answer to the puzzle returned very quickly. John Foad, who had scanned the lantern slide to send it to the editor, had reversed it on the scanner.

The sad part of the story is that despite my several pleas to a good friend who was curate at the church to take the dial inside, nothing was done. By a strange chance exactly a
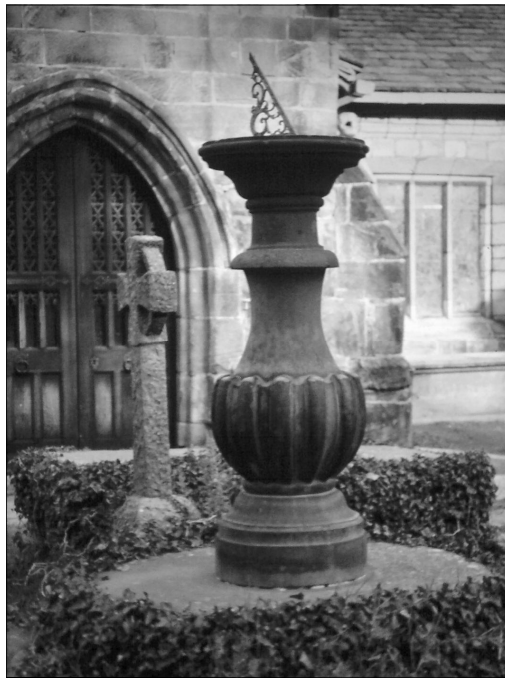
week after the *Bulletin* was delivered I was due to talk to the Prestbury Probus on 'Sundials'. I had been warned that one of the churchwardens would be present so I got the story. Yes the dial had been stolen, but when, even to the matter of years they did not know, and they had never thought that it might have been valuable. They tell me there is no reference to the dial in the church records and they have no photograph of it either, but they have asked for copies of mine. A poor substitute for the real thing.

A further twist to the story is that in Alice Morse Earle's book *Sun-dials and Roses of Yesterday*, a very similar picture to that on the lantern slide appears. However the vegetation is taller on the slide, dating it to post-1902. Clearly this dial was much photographed and highly regarded for very many years, sadly no longer.

My thanks to the Johns Foad and Davis.

Roger Bowling, Macclesfield.

GEORGE WATTS' DIAL

This picture, like the reference above, is also from Alice Morse Earle's 1902 book *Sun-dials and roses of yesterday.* It shows the renown Victorian artist George F Watts RA in his garden at Limnerslease, Compton. Dials and pedestals by Watts' wife, Mary Fraser, featured in several *Bulletin* articles last year. It seems that this dial, with its motto *The Utmost For The Highest*, was made in terracotta by the Arts & Crafts Association of Compton. The dial is clearly modelled on traditional Scottish ones and it is said that the photograph was provided especially at the author's request. What has happened to the dial?

St Symmachus seated on a bench, conversing with a monk. A print made by Jan Sadeler, after Marten de Vos, published in Venice between 1595 and 1600 and from a series entitled *Oraculum Anachoreticum.*

Note the dial with its horizontal gnomon and a timescale counting hours to sunset.

© Trustees of The British Museum
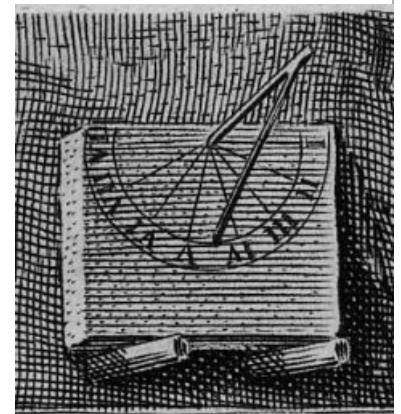
CHARLES DARWIN'S SUNDIAL

JOHN DAVIS

Charles Darwin (1809-1882) is one of the most important scientists who has ever lived. After his famous voyages in the *Beagle*, he lived at Down House, Downe, in Kent from 1842 until his death. His life there was one of much routine – he wrote soon after moving there:[1]

> "My life goes on like clockwork and I am fixed on the spot where I shall end it."

and he was making similar comments in a letter 25 years later.[2] So, as a good Victorian gentleman, it is not surprising that he had two longcase clocks in the house and, to regulate them, he had a horizontal sundial on the terrace. We know that he actually used the dial for this purpose because he specifically mentions the need for correction in a letter (Fig. 1) to his friend Leonard Jenyns on 21 January 1847:[3]

"Dear Jenyns

I am very much obliged for the capital little almanack; it so happened that I was wishing for one to keep in my portfolio.........— There is one point, I sh^d like to see a little improved, viz the correction for the clock at shorter intervals: most people, I suspect, who like myself, have dials, will wish to be more precise, than with a margin of three minutes. I always buy a 1^s almanack for this *sole* end.— "

The almanac to which Darwin refers at the end of this extract is probably the *British Almanack*, issued annually at a price of 1 shilling by the Society for the Diffusion of Useful Knowledge. The likelihood is that Darwin purchased the dial soon after he moved to Downe.[4]

The sundial and its pedestal can be seen in Fig 2a. This picture, which can be dated to just after 1872 by the newly-built verandah, shows the dial in virtually the same position as it occupies today. After Darwin's death, Down House stayed in the family until the end of the 19th century. Since then it has been occupied by several owners, including the Downe House School and the British Association for the Advancement of Science, until it was taken on by English Heritage in 1996. They have done much to put it back into the condition that it was in when Darwin lived there. The sundial, it seems, has remained there throughout (Fig. 2b).

Darwin was a very unpretentious man and his dial (Fig. 3) reflects this: it is a scientific instrument made to do a job. It is small (10" in diameter) and nicely hand engraved but unsigned and with hardly any
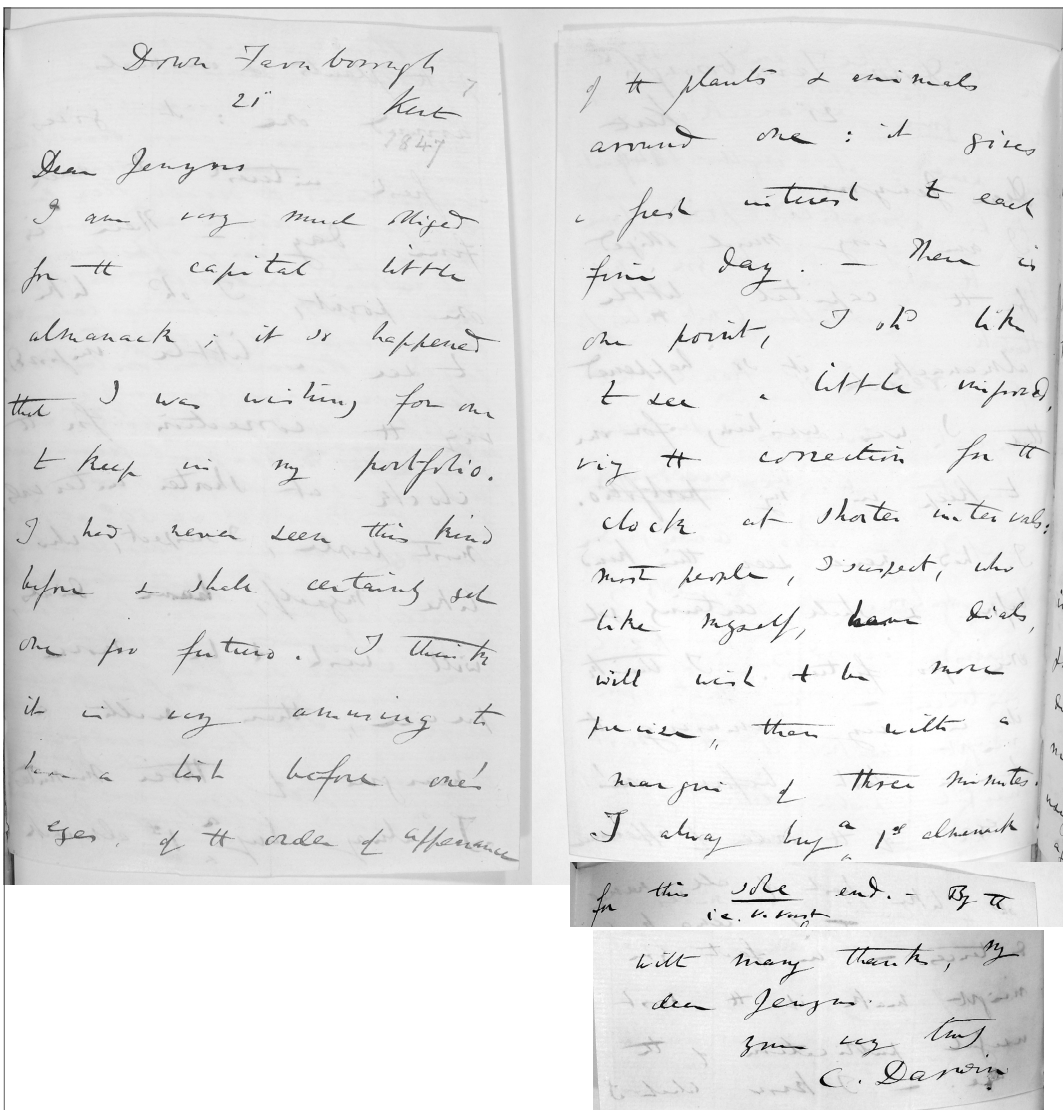

Fig. 1. Extracts from a letter written by Charles Darwin to Leonard Jenyns, mentioning his dial. Courtesy of the Bath Royal Literary and Science Institution.

Fig. 2a (left). Photograph of the rear of Down House, c.1874. DAR225:29a, courtesy of the Syndics of the Cambridge University Library.

2b. (below left) Close up of part of Fig. 2a, showing the dial. The figure on the left, looking like a young version of Charles Darwin, is his eldest son William Erasmus. The other sitters (L to R) are believed to be Francis Darwin, AR Darwin (née Ruck) and Horace Darwin.

decoration.[5] It is delineated to individual minutes around its perimeter and to simple quarter-hours inside the chapter ring. It could have been supplied by one of several London mathematical instrument makers. One possibility, suggested by the zig-zag border between the compass rose and the chapter ring, is that it came from the firm of Troughton. It does not have an Equation of Time table engraved on it: Darwin preferred the more accurate method of using a published table for the current year.

In recent years, the dial has suffered at least two accidents. First, a lorry reversed into it, knocking it over and snapping the baluster pedestal at its narrowest point. Then, in 2007, a swinging scaffold pole swiped off the gnomon. At this point I was privileged to be asked to restore it. The dialplate was fixed to the top of the pedestal by three brass bolts inserted from the underside and these had to be carefully drilled out. It could then be seen that the two screws retaining the gnomon had failed by being pulled through slightly oversized holes in the dialplate leaving their heads looking like thick washers trapped between the dial and the pedestal. But the dialplate had three holes for retaining the gnomon which prompted a closer inspection once the

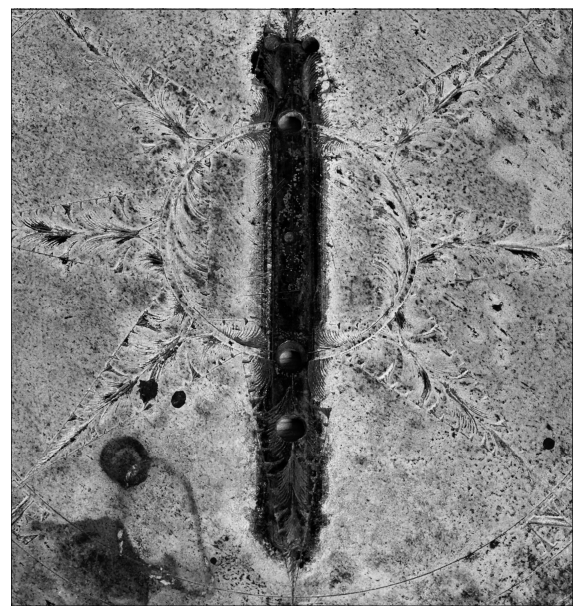Fig. 3. The restored dial ready for re-installation.

Fig 4. Close-up of dialplate showing how the infill engraving is absent in a rectangular region in the centre of the compass rose, with a few random engraved lines instead.

Fig 6. The style edge of the damaged gnomon. The name CHARLES DARWIN can just be seen stamped into it.

Fig. 5 (left). Extreme close-up from Fig. 2(a) showing the outline of the gnomon in the 1870s.

Fig. 7 (extreme left). Underside of the dial after restoration.

Fig. 8 (below). The restored dial in March 2008. Compare with the earlier pictures of Figs. 2a and 2b.

dial was in the workshop. The retaining screws looked to be 4BA but were in fact much closer to M4, suggesting a rather recent repair. Also, closer inspection of the dialplate near the centre (Fig. 4) showed that rectangular region (1¼" × 1⅜") was devoid of the decorative infill engraving: instead, it had a few random strokes as the engraver was trying out his burin on a normally unseen region of the dial. Thus there would originally have been a gnomon supporter with a rectangular footprint and the gnomon must be a replacement. Clearly it is a relatively old one as the patina is continuous over the dial. A detailed examination of the dial in the photograph Fig. 5 shows that the gnomon in c.1874 was a solid (unpierced) one. The angle of the current gnomon was measured as 51° 35' which is in close agreement with the latitude of Downe at 51° 20.2' N and it is also of quite an appropriate design for a mid-19th century dial. Further study shows that the name 'CHARLES DARWIN' is either punched or machine engraved along the style edge (Fig. 6). Whoever the earlier restorer was, they did competent job though a more accurate representation of the original design would now be possible.

Metallurgical analysis[6] of the dial plate by energy dispersive analysis of x-rays showed that it is a brass (78% Cu; 22% Zn) with small amounts of precipitated lead. This is not atypical for a late 18th or early 19th century dial but the zinc content is lower than most modern brasses.

This restoration was quite straightforward. New screws were fitted together with a small brass plate (engraved with details of the restoration) below the dial to spread the load (Fig. 7). The tips of three new screws were patinated to match the dial surface and fitted into deep collars which

could be fixed into the holes of the pedestal with polyester resin.

The bicentenary of Darwin's birth will be in 2009, which will also be the 150th anniversary of the publication of *On the Origin of Species*. Many celebrations are planned in Cambridge[7] and undoubtedly there will be many visitors

making a pilgrimage to the Great Man's house in Kent. It is good to know that his sundial, as well as much else, will be on display there (see Fig. 8).

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge the help of Sally Johnson and Tori Reeve (English Heritage) in accessing the dial and to Adam Perkins (CUL) and Matthew Williams and David Cunliffe-Jones (Bath RLSI) for access to Darwin archive material. Trevor Brown, Irene Brightmer and the SEM technicians at Derby University are thanked for the metallurgical analysis.

REFERENCES AND NOTES

1. *Down House – The home of Charles Darwin*. English Heritage guidebook (1998).
2. "….my life is as regular & monotonous as a clock." Darwin Letter 13060 to V.O. Kovalevesky, 22 February 1869.
3. Darwin Letter 1055 to L. Jenyns, 21 January 1847. Transcribed by the Darwin Correspondence Project, *www.darwinproject.ac.uk*. The original belongs to the Bath Royal Literary and Scientific Institution.
4. Downe village was originally called Down. The 'e' was added during Darwin's residence but he retained the original name of the house.
5. The dial is BSS SRN 5143, first recorded 2001.
6. Analysis at Derby University in a Leo 1450VP SEM.
7. See *www.darwin2009.cam.ac.uk*.

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Sundial Trail Presentation

Doreen Bowyer

This picture shows our Chairman in New Zealand (suitably attired!), presenting Rosaleen Robertson with the SotI 'Sundial Trail' Award first prize of US $250 for the best 'sundial trail' for 2007. The presentation was made at the Crowne Plaza Hotel in Auckland, New Zealand, on the evening of Sunday 3rd February 2008 in recognition of Rosaleen's 'Timaru sundial trail', as cited by Piers Nicholson on behalf of the judges.

Rosaleen has taken up the challenge to form a New Zealand sundial society and it is to be hoped that the BSS will give her every support and encouragement.

In 2008, the sundial trail competition is being jointly sponsored by Sundials on the Internet (SotI) at *www.sundials.co.uk* and the British

Sundial Society. The first prize has been substantially increased to £250 and there is a second prize of £100.

Sundial trails are great fun to do, both for your own locality or for somewhere you are visiting yourself. They are very popular with visitors and fulfil a need for people visiting an area who want clear directions to good sundials in a place they may not return to for many years.

There are full instructions at the above web address.

MAKING PORCELAIN SUNDIALS

ELENA F VASILEVSKAY and ALEKSANDR M BOLDYREV

The porcelain artistic technique is too sophisticated to be widely used for making sundials. In this article we are very glad to share our experience with BSS *Bulletin* readers. Elena has developed the subject of the image and has made the main part of work. Aleksandr has delineated the dial and has written this text. He was extremely happy when ordered to make other casual work of the kind. The text enclosed in quotes is Elena's direct speech.

Making the slurry

Granulated porcelain, imported from the renowned region of Limoges (France), was dissolved in water and mixed carefully together with softeners that help to maintain the proper rheological features of the slurry. As a softener we used a mixture of sodium hydroxide, liquid glass and liquid ammonia. The total weight of softeners should not exceed the level of 0.4% and the percentage of water should be in a range 30-35%. The proper slurry should be homogeneous and should not be sedimented when storing.

Casting pottery in a mould

The pottery which we produce results from casting the slurry into a mould. The mould is a 3D mirror image of the resulting product. Commonly, a mould consists of three or more parts. But the form of a round dial is very simple and we have used a mould consisting of only two parts: an up-

Fig. 1. Mould with two funnel-shaped holes.

per and a lower, the upper one having two funnel-shaped holes for the slurry to flow into the mould (Fig. 1).

The pottery properties depend on the mould's suction capacity. We have made the mould in gypsum (plaster of Paris) that absorbs a part of the water, the solid fraction of the porcelain slurry being deposited onto the inner mould surface.

After the two parts of the mould are separated, the pottery ('greenware') is finally dried. When drying, in order to prevent the pottery cracking and distorting, we wrapped it in paper. The surface of the dried pottery is covered with very small pores and spots. We polished the surface with a sponge and a soft brush made of squirrel fur. Now everything is ready to make a scientific instrument and then to turn it into a piece or art.

Scientific instrument

We have made a dial drawing calculated for the Moscow geographic coordinates and, with a pointed nail, transferred it onto the pottery surface (Fig. 2). Then, using a small sharp chisel, we have cut out the V-profile figures. The edges of V-profiles reflect and refract the rays in the best way. The figures will be visible from afar.

In order to make the gnomon we used the same method as described above. We have moulded a pottery slab, drawn the outline of the gnomon on it and cut it out (Fig. 3). We were eager to supplement it with a nodus but we had to reject this idea because we needed the space on the dial plate for our experiments.

At this point we consider that the scientific features of the sundial are defined and we may start with the following stages: modelling, painting, firing and enamelling. All these stages are very laborious. It would be a disaster to have to remake the whole sundial simply because we had made a mistake in transferring the dial drawing onto the pottery. All the figures and lines should be checked carefully before we proceed with our work (Fig. 4).

Subject of the image

Elena writes:

"I draw sketches only rarely. I prefer to make sketches in my mind, improving them in the course of work and trying to obey the brush. The main matter is to start with work. I like to work with 'inspired rhythm' which means to me a combination of strength, proficiency, vivid sensation, generosity and equilibrium between art and nature.

Fig. 3 (above). Elena cuts out the gnomon.

Fig. 4 (above right). The last examination before turning the pottery into the porcelain dial.

Fig. 5 (right). The 'grapevine river' made in porcelain paste.

Fig. 2(below). Transferring the dial drawing.
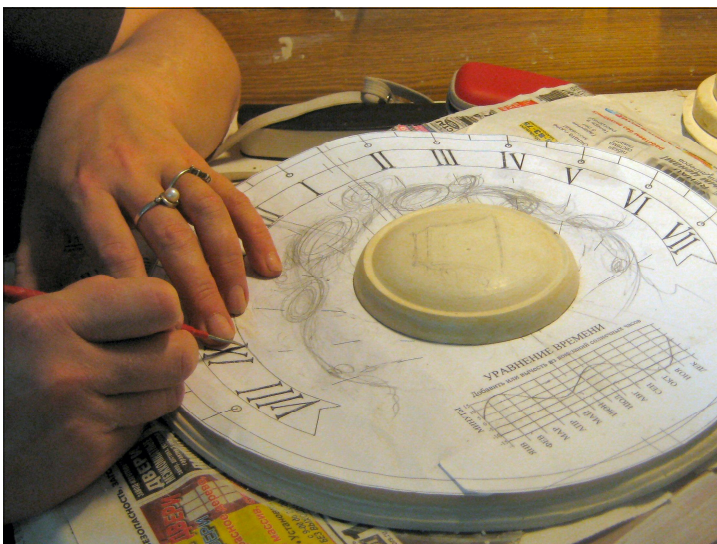
Two worlds, the earthly and celestial, are united in a sundial. I think that there is no more suitable subject to express the universe in a small object as a sundial. Unlike physicists and philosophers, I am freer to chose the method of analysis. I think that a sundial is the best subject to realize the entity of time by means of the artistic method.

Time is probably the happiness to see stars through a grapevine and the vine connects the two united worlds. "I am the true vine" [John, 15(1)]. I have decided to create a 'grapevine river of life' which represents the entire universe and gives life to all living things."

Modelling and painting

For the modelling we use a porcelain paste. We put a small amount of slurry on a gypsum slab, dry it for a few minutes and then knead it until it does not stick to the hands. With this paste we have prepared the leaves and the bunches of grapes. Then, using the slurry, we have stuck them step by step onto the dial surface trying to produce the 'river of life' comprising the entire universe (Fig. 5).

Fig. 8 (above). The first stage of painting (unfired).

Fig. 6 (right). The gnomon should be very simple.

Fig. 10 (below). The final product with the 'Grapevine river of life'.

Fig. 7. A butterfly as a central feature of the composition.

"Now it is time to make a decision on the gnomon. We can measure time but we do not really understand what it is that we measure. Time is just a philosophical abstraction. So let this abstraction be very simple and let it be devoid of decoration." (See Fig. 6.)

"Having installed the gnomon on the dial, I found that its architectural domination broke the composition of the 'grapevine river'. In order to resolve this problem, an additional local centre was created. I think that a butterfly can serve as a sort of the local centre (Fig. 7). First, I love butterflies very much and, secondly, I believe that the butterfly, judging just from its appearance, denies Darwin's theory of natural selection. My co-author Dr Boldyrev (PhD in biology) thinks that he is a convinced Darwinist but I must not take his private opinion into account."

Painting
The paints (glazes) we use are oxides and salts of cobalt, nickel, chromium, titanium, iron and gold. The shades of colour depend on the concentration of the compound, the thickness of the colouring layer and on the firing conditions. To achieve the additive affect we usually mix the paints or apply them layer by layer. The final colour of such a mixture is not predictable to a high degree of accuracy. But the properties of pure compounds are well known. For example, the salts of nickel give a shade of beige. The compounds of chromium give shades of green. The neutral solution of nitrohydrochloric gold gives very nice rose colour. Fig. 8 shows how the dial looks after the first layer of paint is applied.
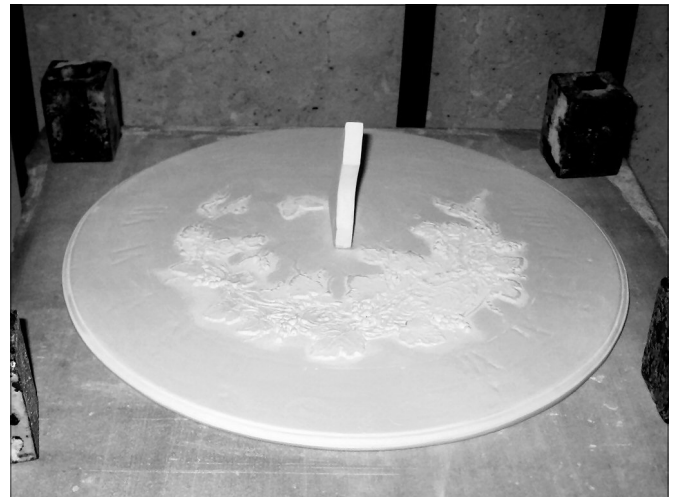
Fig. 9. The enamelled dial is ready for firing in a kiln.

Firing, enamelling and gilding
As a rule, no fewer than four firings are required. The first of them is the initial stage of turning a pottery into a porcelain piece of art. Its aim is to eliminate the combined water and dissolved and trapped gases which tend to form hard and unattractive globules on the pottery surface. Globules can spoil the whole thing as it is very difficult matter to remove them with a hand diamond cutter. All gases are considered to be removed by temperatures in the range 800º – 1000º C.

Firing shrinks the size of a pottery in a range of 15–18%. The shrinkage is equal in all directions inside the porcelain body. Hence we were convinced that firing does not affect the relative positioning of the lines that form the dial.

Before the second firing, we have applied on the dial surface a thin layer of enamel with the help of an airbrush. Enamel consists of the same substances as a pottery but its structure is slightly different. In the course of firing at the temperature 1230ºC, the enamel and the pottery turn into a single whole due to the similarity of the structures. Fig. 9 shows the dial covered with enamel and ready for firing in a kiln.

After the second firing, the co-authors disagreed on the way this piece of art should be advanced. Aleksandr was completely satisfied with the result and proposed naming the sundial 'The Grape Galaxy' and to sell it as quickly as possible. Elena was of opinion that only one third of the work was completed and that she could not allow "sticking anybody's nose" into her business.

As a result, we have agreed that the rim of the dial plate, the narrow edges of the gnomon and the EoT diagram looked rather inexpressive and should be enriched with gold. Elena mixed powdered gold with a flux and, with a very small brush made from the fur of a Siberian weasel, applied this paint onto the dial. Thus the gold paint is applied right on the enamel surface. In order to fix the gold on it we have to

make a third firing at the low temperature of 750ºC. The flux serves as a combustible flux that allows the penetration of the gold into the enamel. It is important to maintain the temperature accurately at 750ºC: at lower temperatures the flux does not burn away and at a higher temperature the gold fades.

After this third firing, Elena decided to draw the wavy gold lines on the noble-greyish border that encircles the south part of the dial and turns into the hour marks on the north part of it. It was very dangerous decision as the previous gold paintings might have faded away during the fourth firing. But the risk was taken to achieve the 'inspired rhythm'. The final results are shown in Fig. 10.

As far as we know, we have made the first porcelain sundial in Russia. We will probably make another porcelain sundial and we would be happy to receive any information on our forerunners and on porcelain sundials from all over the world.

ACKNOWLEDGEMENT

We would like to thank John Davis for help in translating this article.

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MINUTES OF THE 19TH ANNUAL GENERAL MEETING, LATIMER CONFERENCE CENTRE, BUCKINGHAMSHIRE, 30 MARCH, 2008

1. The meeting was opened by the Chairman, Christopher St J H Daniel at 12:40pm. He commented on the excellence of the conference and thanked all the speakers. About 50 voting members were present.

2. Apologies for Absence: none reported.

3. The minutes of the 18th Annual General Meeting, held at Fitzwilliam College, Cambridge, on 15 April 2007, published in the Bulletin in June 2007, pp 59-61, were taken as read and approved by a show of hands. There were no matters arising: the minutes were adopted by a show of hands and signed by the Chairman.

4. Council Members' Reports

The reports of the Honorary Secretary and other members of Council had been circulated and are shown below.

Secretary: Doug Bateman. Liaison. Since the last AGM I have dealt with 9 enquiries by letter, quite a number by e-mail and a few by telephone. Many have sought advice about about dials in their possession. A number have been about restoration and these were referred to Graham Aldred. Whilst we are undoubtedly helping to 'educate the public' as part of our charitable status, few of the enquiries have led to membership.

Conference 2008, 28 - 30 March. The Latimer conference centre, Buckinghamshire, is a promising venue with high standard accommodation but, disappointingly, the attend-ance is much lower than average with 74 participating at the time of writing.

Conference 2009, 15-17 May. The Cumbria Grand Hotel in Grange-over-Sands has been booked. This will be our 20th conference and AGM.

Editor's Report: John Davis. This has been a busy year for publications. There have been the normal four issues of the *Bulletin*, now with a gradually increasing colour content. Slightly fewer articles qualified for the New Author Award this year but it was pleasing to see it go to an overseas team of authors. A unified listing of the contents of all the *Bulletins* since 1989 has been assembled (see the website). My thanks to all the authors who have contributed items, no matter how long, and to Tony Ashmore for his help with proofreading.

The second edition of Jill Wilson's *Biographical Index* has been produced and we have also published, jointly with the AHS, the book of *Mrs Crowley's Sundial Sketchbooks*, edited by John Lester. For the future, another four or five BSS monographs are at various stages of preparation and will be published over the next couple of years. The topics include mass dials, altitude dials, double horizontals, stained glass and so on.

Membership: John Foad. Over the last five years, our membership has been fairly steady, fluctuating between 470 and 490. We are currently at the lower level, with 70% from the UK, and the balance from 29 countries all around the world, including 72 from continental Europe and 53 from the USA. This is my last year as Membership Secretary, and it has been a pleasure to
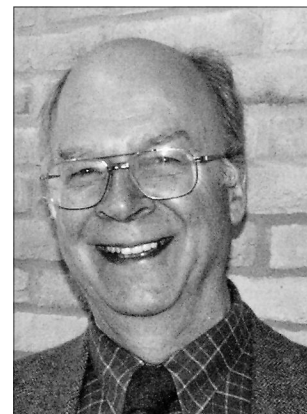
have known so many of you, 'old' members as well as new. I am very pleased to say that Jackie Jones has volunteered to take over the position and will take over officially on the 1st of May.

Advertising: Mike Cowham. My report is really the same as last year. Little has changed and the new advertiser that I expected then did not materialise. I recently quoted to Sotheby's agent for advertising but nothing more has come of it yet.

Restoration: Graham Aldred. Six sundial restorations have been completed successfully in the last year. It is quite probable that other restorations do occur that are not reported. In addition nine restoration advice enquiries have been received, some of these are progressing well, driven by local enthusiasm and appreciation of the advice that BSS freely offers.
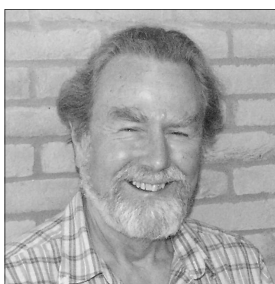
Three restorations are in progress. Members are urged to report any recent sundial restorations that they notice and also to make me aware of any sundials that need attention. The society can be proactive and try to trigger remedial work.

One member has set up a substantial fund to be used for sundial restoration work particularly on churches or on dials in public places. This will be administered outside of the Society for reasons based on the charity status, but BSS will provide support and advice for any projects. This fund is independent of and in addition to the Somerville Fund that is available under the BSS Grant Scheme announced previously.

Reference Library at Nottingham: Graham Aldred. Sixteen new books were delivered to the Bromley House this year, with some titles detailed in a recent newsletter. Shelf space has become critical and negotiations are in hand to expand the space available for our collection and to provide more satisfactory storage for the valuable books. The charges have been increased to £130 pa which still represents a very reasonable cost when viewed against commercial storage costs, with all the additional attributes of Bromley House and potential daily access to all the BSS dialling books and material. There has been modest interest in the BSS Reference Library Catalogue and consequently there are still copies available. It is hoped that this catalogue will reveal the extent of the BSS collection of dialling material and stimulate members to visit the attractive location at Bromley House. Copies will be available for sale at the annual conference or by post from Peter Lane, the Sales representative.

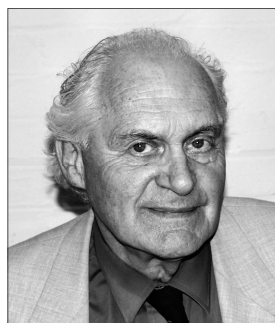**Fixed dial register: Patrick Powers**. (April - December 2007) Members will recall that at the last AGM I announced my intention to stand down as Registrar after some ten years in the role. The Society has been fortunate in securing the services of John Foad as the new Registrar and the formal handover took take place on 1st January 2008 with John using his own PC rather than the Society's one.

Much of the period from the AGM up to that date was spent in preparing for handover and entering a backlog of sightings. As a consequence no further work has yet been done on a draft concept for electronic input of Members' dial sighting data and images.

I have much enjoyed my time as Registrar and would like to thank all those who have helped over the years in keeping the Register current by sending in their dial sighting reports and in helping me to resolve queries from time to time.

John Foad (December 2007 - March 2008) As the new Registrar who only took over on 1st January, I have as yet little to say, other than to thank Patrick Powers for the immense amount of help that he has given me. It is a privilege and a delight to be at the heart of the Society's store of wealth. I have already seen the quality of the new reports that pour in and that, with your help, will continue. New technology continues to pervade our lives, in many cases for the good, and the impact of e-mail and digital photography on how we can receive reports will be one of my priorities in the year ahead.

Mass Dial Group: A.O.Wood. Agreement has been reached with the Borthwick Institute Archive in York for the safekeeping of our mass dial records, which now number over 5000 and occupy a substantial space. It is hoped to make the first deposits shortly and then continue as the database/register is compiled. Alan Cook has completed a comprehensive survey of O.S. square SE, centred on York and this will be published as a monograph. Reports continue to come in from our small band of regular recorders led by John Lester, Ian Butson and Irene Brightmer. NADFAS, as ever, are very good at alerting us to any dials they find and a recent report from Eydon, Northamptonshire, claims some dials on local houses as well as the church.

Modern (1912) scratch dials have appeared at Canna Island in Scotland and are noted for future reference if they were to be reported again. Chris Williams has completed his statistical analysis of dials countrywide and the results are to appear in the Bulletin.

Saxon Dials: A.O.Wood. The position regarding Saxon dials is still unsatisfactory but Mike Cowham's recent studies have shown that there is still a great deal to learn

about them. Currently they are mainly included with mass dials. It is hoped that Mike Cowham can publish his findings in the not too distant future.

Museums Survey: A.O.Wood. The Survey has been 'completed' in 18 phases and has covered the whole of the British Isles. Much interesting information has surfaced and been passed on to specialists, in particular to John Davis for 'classic' dials and Jill Wilson for Sundial Makers. It has been requested that the results be published and Ian Butson has agreed to edit the returns into book form and will initially receive assistance from Jill Wilson.

Exhibitions: David Young. I have had no requests for exhibition material, but a successful display took place in Brighton during February. Personally I have given several talks locally including U3A Science section, Round Table and Historical Societies. Archives are slowly mounting up and I have received some worthwhile early history of the Mass Dial Group from Tony Wood.

Website: Richard Mallett. The Society website www.sundialsoc.org.uk has been transferred to a new hosting company (AFMU) which will enable the use of more features such as photo galleries, forms and search engines on the website.

The Society also owns two domains www.sundialsociety.org.uk and www.britishsundialsociety.org.uk which are currently 'parked' with a different hosting company. These will also be transferred to the new hosting company (AFMU) and one of them will be used to recreate the Society website to World Wide Web standards, which will make it easier to maintain in the future using Microsoft software.

The currently active website *www.sundialsoc.org.uk* will be kept up to date while the new site is being developed.

Publication sales: Peter Lane. Sales continue to remain steady. The BSS Monograph No 1 (Analemma) has now sold out although the occasional order is still received with most enquirers happy to receive a copy of the Bulletins which featured the original article. The campaign to reduce and sell the remaining BSS 2005 Full Registers has been successful with only a few copies now remaining on stock. There are however a significant number of the Abridged version remaining. The BSS Monograph No 2 (Biographical Index) and Mrs Crowley's Sketch-book have been introduced this year and are selling steadily. Mike Cowham's book *Sundials of the British Isles* is also available along with the BSS Library Index although the latter is available to members only. We have also managed to sell on to new members full sets of the BSS

Bulletin. These sets have been donated to the BSS and then sold on at a modest but reasonable profit. Sales for 2007 have been successful, exceeding £2000. A member of the BSS has now come forward to take over the Sales role and arrangements are in place for transferring the stock and ensuring a seamless transition. I would like to take this opportunity to thank everyone for supporting me in the Sales Coordinator rôle.

Foreign tours 2008: Mike Cowham. *Alsace, 5 - 11 September*. At the moment the numbers are 39 against a maximum of 40. Past experience is that the numbers drop through illness but are unlikely to fall below a minimum of about 30.

5. Treasurer's Report: Graham Stapleton. This year, work has been done to ensure that the Society both stays in a comfortable state and can meet its future requirements. Better use of our reserves have come from the change to a more favourable bank account. Likewise, Council members have contributed by promoting income and finding savings. Our present good state means that there is no need for an increase in the subscription rates this year and, potentially, none next year.

A data security exercise was completed in compliance with new finance industry regulations, which allows the Society to continue taking credit card payments. We are not, however, emulating the arrogance of other large organisations – cheques will remain very welcome at all times.

In an early response to the new Charities Act, a sub group of the Council is preparing a new form of budgeting. With this, it will be possible to show that the Society has proper funds to maintain its functions in future years. Also, we will be able to securely allocate sums for projects, publications and dial restorations.

6. Election of Officers. Nominations had already been proposed and seconded according to the constitution, and all were approved by a show of hands, as follows.

Chairman, Secretary and Treasurer. Chris Daniel, Doug Bateman and Graham Stapleton respectively.

Members of Council. Jackie Jones, John Foad, Graham Aldred and John Davis.

The Chairman noted that Patrick Powers had resigned from the post of Registrar and Tony Wood wished to continue as a mass dial specialist, but be co-opted as necessary rather than be a trustee. They were thanked for their work to very warm applause.

Auditor. Geoff Parsons had kindly audited the accounts for 2007 and was willing to do so for 2008. The appointment was approved by a show of hands.

7. Any Other Business. There being no other business the meeting was closed at 12:55pm.

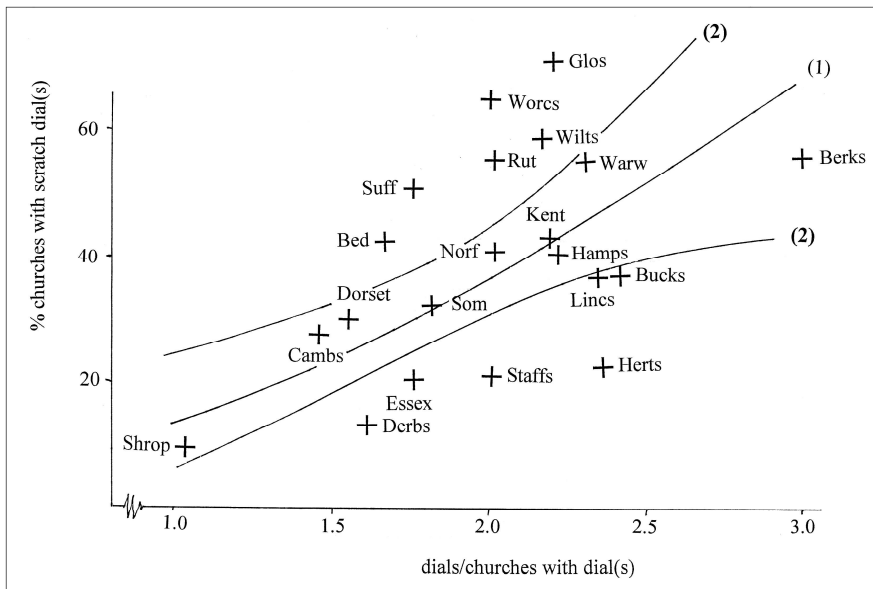The 2007 Accounts will be published in the September *Bulletin*.

THE GEOGRAPHICAL DISTRIBUTION OF SURVIVING ENGLISH SCRATCH (MASS) DIALS

CHRIS H.K. WILLIAMS

Although English scratch dials survive by the thousand,[1] their occurrence is far from uniform. Before establishing this, three salient features regarding the data employed in this and subsequent articles warrant specific mention.

A primary objective has been to base analysis on the totality of information available. Accordingly, a composite database has been compiled that includes, in addition to the BSS Mass Dials Group's records (c. 5000 scratch dials), all other sources judged to be substantive – some 35 independent listings.[2] For every church, the number of dials listed by each (dated) source is noted and cross-referenced to detailed recording information.[3] It is thus possible to exhaustively interrogate the entire national database.[4]

Although the county has been the traditional focus of study, it has not been a stable currency – the BSS uses current county boundaries, the literature a wide variety of vintages. Clearly, establishing and consistently investigating a composite national database requires unchanging boundaries. It was decided, essentially on grounds of pragmatism, to adopt the historic pre-1832 parish and county boundaries.[5] In particular, it most closely accords with the original distribution and number of medieval churches, i.e. where scratch dials are to be found. The strongest argument in favour of current boundaries – familiarity – will be lost with future local government reform.

Sadly, almost the entire corpus of earlier work has lost part of the information originally available because, with very few exceptions, churches without scratch dials were not reported.[6] Whilst this reflects the natural human tendency to report hits rather than misses, statistically each is as valuable as the other and both are required. How else are churches without dials to be differentiated from those not yet examined?[7] Happily, by contacting individual recorders, it proved possible to redeem the situation for several counties.[8] As a consequence, half the counties in the composite national database include full listings of churches without scratch dials.

Returning to the distribution of surviving scratch dials, the simplest and most revealing indicator is the proportion of medieval churches with one or more scratch dials (Fig. 1).

Notes
(1) Estimates for Herefordshire, Nottinghamshire and Yorkshire North Riding straddle the watershed.
(2) Where estimates straddle the relevant figure, the county is shown with striped shading.

Fig. 1. Geographical distribution of medieval churches with surviving scratch dial(s).

Estimating this for each county is very much a tale of two halves. For the well surveyed half,[9] where effective survey rates exceed 80%,[10] this can be directly estimated from the number of churches with and without scratch dials. Given the high survey rates, these are very accurate and reliable estimates.

For the remaining half, the proportion of churches with scratch dials cannot be estimated directly. For these counties we neither know the number of churches without dials nor the effective survey rate. That said, an indirect method of estimation is possible with the assistance of a statistical relationship established for the well surveyed counties. Fig. 2 shows that as the proportion of churches with scratch dial rises, the more dials there are on those churches. Whilst this relationship is neither perfect nor absolute, it does, when

Fig. 2. Relationship between percentage of medieval churches with scratch dials and average number of dials on those churches.

Notes:
(1) Estimated by standard least squares regression for the 21 well surveyed counties.
(2) Statistical range with theoretical 90% chance that the true figure lies within it.

combined with such information as we have for the less certainly/less well surveyed counties,[11] permit a range estimate to be formulated.[12]

There is a marked watershed and regional clustering in the distribution of surviving scratch dials (Fig. 1). East of the watershed, scratch dials typically survive on more than 30% of medieval churches, with a hot cluster of over 50%, but also a cold cluster failing to achieve the watershed level. West of the watershed, survival rates collapse. Although the area has less evidence of systematic surveying than to the east, the consistency and pattern of the picture painted leaves little doubt regarding its veracity. Most of these counties have less than 20% of medieval churches with scratch dials, with a very low (under 10%) fringing cluster – an English fringing cluster extending into Wales, Scotland and Ireland.[13] Whilst various ideas might immediately spring to readers' minds – e.g. the fringing and cold clusters correlate with the geologically oldest and home counties respectively – the implications of the surviving distribution for either original scratch dial prevalence and/or their subsequent loss must await future articles.
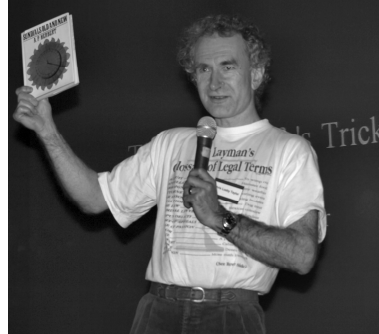
REFERENCES AND NOTES

1. Chris H.K. Williams: 'Historical Overview of the Listing/Recording of English Scratch (Mass) Dials', *Bulletin BSS*, 20 (i), 11-12, (2008).
2. Brevity dictates their citation must await the (forthcoming) monograph.
3. This permits, as will be seen throughout this series of articles, numerous insights and summary information to be extracted e.g. the overlap or otherwise between county listings indicates the extent of their coverage and quality, dated listings potentially indicate dials that have been destroyed, dials that have been moved can be totalled and each dial can be systematically categorised.
4. Rather than rely on one county or the experience of a single recorder – a marked tendency in the literature.
5. As mapped and listed by The Institute of Heraldic and Genealogical Studies. See C.R. Humphrey-Smith, *Atlas & Index of Parish Registers*, Phillimore, (2003).
6. Only four counties have a significant number of churches without scratch dials reported in the literature. The BSS does not record churches without dials.
7. With implications starker than may be immediately apparent. Neither the extent of surveying nor the proportion of churches with dials can be directly or definitively estimated.
8. Especially Ian Butson and John Lester (7 & 4 counties respectively). Also Bob Adams, John Ingram, Gordon Le Pard, Peter Ransom, Lyn Stilgoe, Chris Williams and Tony Wood ('their own' counties).
9. Identified in Fig. 2.
10. A county's survey rate is the number of churches listed with and without scratch dials divided by the number of historic parishes. The latter is the maximum number of medieval churches a county can be expected to have had, not all of which have (wholly) survived. The effective survey rate is based on those churches with not insignificant medieval components. Information established by inspection, architectural studies, or N Pevsner *The Buildings of England* series (provided by recorders note 8) suggests eligible churches fall short of the number of parishes by between 5-20%.
11. The average number of dials (on churches with dials) is of course known for the less certainly/less well surveyed counties thereby permitting Fig 2 to be applied. The Fig 2 range (for the proportion of churches with dials) can be cross-checked with other information (especially the number of recorded churches with dials and qualitative assessment of survey coverage/reliability) and if necessary adjusted. In fact this indicated that many of the hitherto apparently less certainly surveyed counties are likely to be reasonably well surveyed. It can be estimated that 90-95% of surviving English scratch dials have already been found. The two counties with the greatest number of dials (more than 50 each) yet to be discovered are Yorkshire and Sussex.
12. The entirety of the data and analysis underpinning this article will be published in a forthcoming BSS monograph. This will include detailed tabulations for each county and a full explanation of the technical statistical procedures employed.
13. Less than 20 scratch dials are known in each of Wales, Scotland and Ireland (BSS records). See also M. Arnaldi, *The Ancient Sundials of Ireland*, BSS (2000) and W. Linnard, 'Welsh Scratch Dials', *Archaeologia Cambrensis* (forthcoming). Although there must be doubts how well surveyed these countries are, known dials imply an exceeding low survival even by English fringe standards.

BSS ANNUAL CONFERENCE
Latimer Conference Centre, Bucks - 28-30 March 2008

CHRIS LUSBY TAYLOR

The well-established format of our annual conferences served to give us another thought-provoking and enjoyable weekend. The breadth of members' dialling interests, and the depth of their erudition, continue to amaze. Latimer Conference Centre, in the grounds of a stately home in the Chilterns, proved an ideal place for such a conference, although the surrounding area is not as rich in sundials as some cities we've visited previously. By dinnertime on Friday most people had arrived and our Chairman, Chris Daniel, was able to welcome visitors from Russia, Norway and the USA to join members from every corner of Great Britain.

After dinner, we settled in the lecture hall for the first talks. Piers Nicholson showed us his slides of the Jantar Mantar in Jaipur; Emperor Jai Singh II's vast observatory which includes perhaps the most impressive sundials in the world. As well as the huge equatorial dials, Piers ran us through the other instruments used to measure the altitude, azimuth, declination and meridian transit of the sun and other heavenly bodies.

Given that all shadows are fuzzy, Piers had wondered whether such huge instruments could be read any more accurately than much smaller ones. Were the two-second divisions meaningful? He showed an experiment he had performed with a toothpick held close to an enormous dial. He confirmed that he could tell to within a couple of seconds when the toothpick's own shadow appeared. Allan Mills, who addressed a previous conference on the use of shadow sharpeners, wondered why he hadn't used a disk with a pinhole in it. Such devices had been known in China but not, perhaps, in India. He felt they would be even better. I trust someone will get a chance to visit and test this. My money's on the pinhole.

Piers was followed by your correspondent who showed that what A.P. Herbert called "The Housewife's Trick" – rotating a horizontal dial to make it read clock time – can be made

to work, within limits. Those limits exclude anywhere much further south than the UK and exclude turning the dial to show Beastly Summer Time (APH's own term). But a dial carefully made for a location in Scotland should, it was claimed, tell GMT to within a minute practically all year.

Saturday

On Saturday morning Chris Williams, a professional statistician, showed how one can infer reliable statistics from the Society's accumulated records of scratch dials. Chris however chided those who, on not finding a dial at a church, don't record that fact. Rather like Donald Rumsfeld's "known unknowns" it is valuable to know what isn't there.

Once we accepted that, Chris was able to prove that 90 to 95% of surviving scratch dials have most likely been found, that all medieval churches probably had scratch dials, and most had several. He felt confident that further analysis should reveal the evolution of dial types and confirm his hypothesis that scratch dials were in use up to the seventeenth century. Rather sadly, he showed that dials are still being lost at a rate of about one a fortnight.

Our Vice President Fred Sawyer, no mean inventor of sundials himself, rates Hugo Michnik's bifilar sundial as the most significant twentieth century invention. We owe it to Fred that Michnik's design is now well-known via his publications, starting with his first ever sundial-related paper in 1978.

He explored Michnik's statement that the bifilar sundial is a special case of the Steiner Transformation. This

turned out to be a rigorous proof of the much simpler geometric demonstration that Fred also showed: how to stretch an ordinary horizontal sundial and its gnomon in an east-west direction to make the dial circular. The goal of this was to make an equiangular dial. Such a dial is universal and can be rotated, with no need to resort to Housewives' Tricks, to show GMT, BST or any other time.

After a coffee break we learned, from his daughter Celia James, of the astonishing interests and inventions of her late father, James Richard. In the Society we had no idea his eccentricity extended to putting a sail on his bike, using an abacus and writing only with a quill pen. Nonetheless, his engineering achievements included the rebuilding of the engines on the SS Great Britain.

Celia had brought with her a sundial he had made for their house in Bristol, designed for passers-by to admire. As the average passer-by knows how to read a clock, he wanted the dial to go clockwise and to show GMT and BST accurately. He achieved these goals with a vertical dial and a gnomon at the strange angle characteristic of Foster-Lambert dials. He would adjust the dial and gnomon daily for the Equation of Time and the sun's declination. When he was away from home he would take the dial indoors, rather than let it tell incorrect time. Graham Aldred has analysed the dial and his results will be published later in the Bulletin.

Chris Daniel commented that it was sad that a member's other interests and achievements shouldn't be known to us during his or her lifetime. He proposed that members overcome their modesty and provide the Bulletin with a Who's-Who-like entry.

Next came Julian Lush, fresh from Armenia where there are a good number of scallop-shaped sundials on churches. As many of the churches date back as far as the fifth century, some of these dials may be very old. But they are very elaborate and well preserved. They consist of a semicircle divided by hour lines on which a horizontal stick gnomon would have cast its shadow. The 'Ar' in 'Armenia' is Ar, the sun god, so Armenia would seem to be a truly sundial-friendly country. When Julian invited members' thoughts on the significance of the scallop design they suggested that it has been used as a fertility symbol, a symbol of St James, and a mark of pilgrimage.

The morning concluded with our Editor, John Davis, talking on the career of a great sundial maker of his favourite period, the early eighteenth century. He was John Rowley who made the original orrery for the Earl of Orrery. He also made oval Butterfield-like portable dials, Gunter's quadrants and large horizontal dials. These were very refined, with transversals to read minutes, previously only found on scientific instuments. He was, perhaps, the originator of outward-facing Roman numerals on horizontal dials, which allow you to read the dial without your own shadow obscuring it.

Rowley made four large dials for Blenheim Palace in 1710. These all survive, though one was thought lost for over 300 years. They include a moondial with a chapter ring for every day of the moon's age, a double horizontal dial, a 'geographical dial' that shows noon in 48 places worldwide, and an equation dial. We were asked to note the gnomon supports – truncated pyramids – and to compare them with two known dials signed by Thomas Tompion. John's theory is that Tompion got Rowley to make them. Although these dials don't say 'Tompion fecit', Andrew James pointed out that the word 'fecit' was often omitted so the omission doesn't tell us that Tompion did not make them. A puzzle, then.
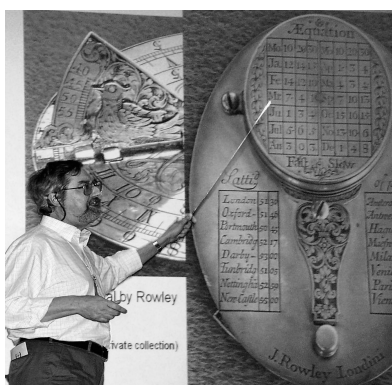
Another puzzle was the change in Rowley's career. From making delicate instruments he was put in charge of monumental waterworks for Hampton Court and Windsor Castle. Perhaps this paid more, or justified his title of "Master of Mechanicks to the King".

This took us to lunchtime. After lunch, we bundled into two coaches, going to Cliveden or to Leighton Buzzard. In Leighton Buzzard, Ian Butson pointed out a splendid vertical sundial of which a sketch appears in Henslow's book. On the buttresses of the south transept of the church are four sundials, apparently all made at the same time. This being a BSS outing, the sun was not in evidence, but at least it wasnt raining.

The BSS group at All Saints', Leighton Buzzard

Left: Patrick Powers photographs the Ben Scott dial (right) at Cliveden while Alison Morrison-Low and Andrew James discuss its coat of arms.

Above: A range of altitude dials from Mike Cowham—look out for a monograph of them later this year.

Left: The 3-D EoT cam for the Clock of the Long Now.

Below right: An unusual direct north vertical dial on All Saints' church, Leighton Buzzard.

The other coach tour went to Cliveden, the location of famous mis-deeds in the 1960s. (One member was persuaded to sit on a chair in Christine Keeler fashion, but we won't say who!) The grand house is now a hotel but the grounds are looked after by the National Trust. Ian Butson had found recently that their horizontal dial had been removed but they kindly brought it out for us and we were delighted to find that it was a rare instrument made by Benjamin Scott, Rowley's first apprentice.

During the weekend there were many short periods when one could pop in to see the members' exhibits. The strangest was Kevin Karney's three dimensional Equation of Time cam from the Clock of the Long Now.

Notable exhibits included Armenian wood carvings brought by Julian Lush, a Second World War sun compass brought by Doug Bateman and a gorgeous double horizontal dial by John Rowley shown by John Davis.

Members showing their own work included a most impressive collection of portable altitude dials made by Mike Cowham. I had no idea there were so many types. Leonard Honey showed the reproduction dials and instruments he sells – mostly Victorian and all delightful. David Brown and Andrew James showed lots of photographs of their dials. Their craftsmanship, humour and design are exemplary. The author of this report showed two dials he has made – one incorporating the Housewife's Trick, the other with a conical gnomon that shows Italian hours.

Saturday evening brought the Society's annual black tie dinner. The winners of the Photographic Competition were awarded their certificates and it was time for the auction.

A scene at the banquet: Sally and Tony Ashmore in the foreground talk to Gerald Stancey while our new webmaster Richard Mallett listens to Allan and Pauline Mills in the background.

Below left: Chris Lusby Taylor's brass-and-slate dial (by CNC engraving) demonstrates the Housewife's Trick.

Below: Photographers gather round to see who's won!

Bottom: The old Latimer House, now Latimer Place, was originally gifted to William Latimer in 1331.
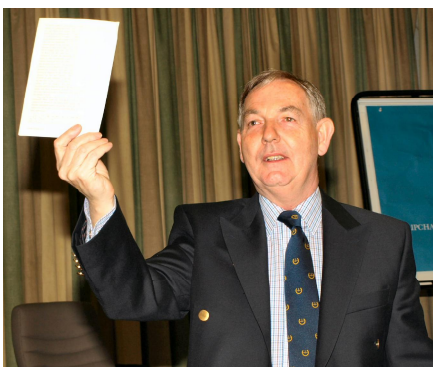
Geoff Parsons was the porter at the auction, seen here with yet another 'very rare' dialling manuscript.

During the weekend there were three opportunities to enlarge one's library. Rogers Turner books were there, of course, with a good selection of new and old books, as was Peter Lane, selling the Society's own publications. Then, there was the auction. Only one lot was unsold, the rest realising a splendid £719. A Dr John Davis seemed to have the deepest pockets.

Sunday

Several regular attendees' faces had not been seen, and all were sorely missed, but a few turned up on Sunday, including our other Vice President, David Young.

Unfortunately, Tony Belk couldn't make it, but Martin Jenkins filled his slot with a very humorous explanation of the calculations required at every turn when installing a sundial. Did you know that you should pick up a sundial by the tip of its gnomon if

you don't know how hot it is? Or that sundials weigh less in summer? It really is a wonder any get finished, though we were comforted to learn that we're all breathing molecules of air that have previously been exhaled by Fred Sawyer. Not so much standing on the shoulders of giants as gaining inspiration from them.

The rest of the morning was truly international, starting with another regular contributor, Johan Wikander from Norway. Norway, like England and Armenia, has mass dials. One, dating from 1200AD, from Tingvoll Church at 63° North, is set into the wall a good 5 metres above ground level. It appears to have had Roman hour numerals added in the sixteenth century to an older dial marked in tides. Johan asked for help in interpreting the mid-tide marks on the dial, speculating that they might be stonemason's marks. Also, if the Roman numerals relate to a polar gnomon, what latitude do the hour line intervals 7, 8.5, 10, 13.75, 21.75 and 29 degrees imply? (My answer, about 61 to 62 degrees.)

Next, Kevin Karney used us to try out a talk he has written for a non-specialist audience: a history of the sundial, civilization's most enduring timekeeper. Throughout the ages, the philosopher, the poet and the cosmologist have given us a perspective of time and of our place in the heavens, and the technologist has given us devices to measure its passage: both to measure duration – how long something lasted – and when something happened. Clepsydras, sand glasses, clocks and watches do the former quite or very well, sundials have always been better at the latter.

Kevin, in a typically polished presentation that used graphics to great effect, found philosophers generally all at sea in trying to give us an understanding of time, whereas poets from Sappho onwards did a much better job. His knowledge of history is immense. It is easy to get lost among all that information, but he cleverly packaged it up into seven parcels, each with a catchy tag relating to the maturity of the age. So, we are now moving from Wise Old Age, characterised by monumental and sculptural sundials, into the era when sundials will have The Last Laugh. Why? Well, the first machine ever designed to last 10,000 years – the Clock of the Long Now, needs to synchronise itself every now and them. And to achieve this it will use a sundial to act as a master escapement, the clock being just a slave. For the ultimate in reliability, use a sundial.
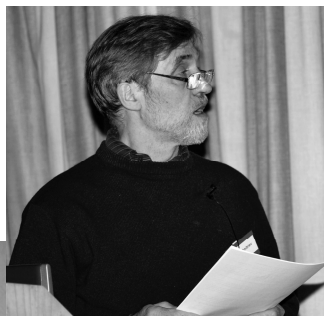
The sundials of St Petersburg were the subject of our next speaker, Valery Dmitriev. He covered both fixed dials and the outstanding collections in museums there. The city was founded only 300 years ago by Tsar Peter the Great to be the capital of Russia, so it had great parks, palaces and grand roads from the start. As mileposts on the road to the imperial palaces at Peterhof, there were imposing obelisks, thought to have been of Italian or French design. Several of these included sundials. Valery's photographs showed that the gnomons are missing but the dials in good order. We also saw sundials from the same period in the grounds of the palaces.

Valery had to skip through the museum collections rather quickly, but they are clearly first class, with many famous makers represented. The Hermitage has so many sundials it cannot display most of them at any time.

The final talk, the culmination of the conference, is always the prestigious Andrew Somerville Lecture, given by an invited speaker. Andrew was, of course, Scottish so would surely have approved of this year's subject and speaker. Dr Alison Morrison-Low, Principal Curator of the History of Scientific Instruments and Photography at the National Museums of Scotland, treated us to a comprehensive and masterful analysis of the museums' collections of Scottish sundials.

Not all the museums' sundials are by Scottish makers and not all noteworthy sundials in Scotland are in the museums, so Alison put her collections in context by starting from Maeshowe, the magnificent 4700 year-old Orkney cairn into which the sun shines only at the winter solstice. We know of five mass or scratch dials from Scotland, but Tony Wood suspects there may be more. Somewhat more recently a characteristically Scottish form, the multifacetted dial, evolved. The NMS has four examples. In this period Alison believes the geometrical secrets of stoneworking were linked to arcane masonic practices, and the significance of some symbols and forms may have been lost. She suspects that dials may have advertised their owners' knowledge of masonry, whereas later owners were more concerned with advertising their scholarship.

Chris Daniel presents the prizes for third third place in the Photographic Competition to John Lester and, inset, Mike Isaacs who was second.

The earliest metal dials in Scotland (1660 on) were made for Scottish latitudes by well-known London and Paris craftsmen but by the early 1700s there were makers in Edinburgh, Stirling and Aberdeen. The NMS collections have many fine examples from this period, as well as later slate dials by Melville, lighthouse dials, portable dials and fine mechanical dials – equinoctial and armillary.

The bad news is that the Instrument Gallery is to close this month for four years. Alison invited scholars who wish to see any instruments to make an appointment.

The last event of the conference, excluding the AGM, is the awarding of the annual New Author Award. Frank King accepted the award but was at pains to point out that he merely translated the article on the meridian line in the Specola Museum, Florence written in Italian by Stefano Barbolini, Guido Dresti and Rosario Mosello.

The success and smooth running of the conference is largely attributable to the Society's Secretary Doug Bateman to whom I'm sure all attendees feel hugely grateful. In the AGM he expressed his desire to stand down, after serving in this role for many years, if a successor can be found. We must hope this succession succeeds.

Photographs from Chris Lusby-Taylor, John Davis, Ian Butson and Patrick Powers.

In Mrs Crowley's Footsteps

John Lester

When it was suggested that I might produce an edition of *Mrs Crowley's Sundial Sketchbooks of Devon and Cornwall,* I accepted the challenge without thinking too hard about how I might accomplish it. There soon came the awesome realisation that if I was to have any hope of writing intelligibly about the 216 dials which Jeanie Crowley had drawn or described I would have to go and see every single one of them for myself. The first step was to mark the locations of all the dials on a map and plan itineraries which would be as economical as possible in both time and distance. The task of finding and photographing all the surviving dials was completed during four trips to the West Country during 2005–2006, totalling just over a month in duration.

It might be thought that driving round Devon and Cornwall looking at country churches, a few farms and some manor houses would be a pleasantly relaxed way of spending one's time. The truth was rather different. On some days it was necessary to visit a dozen villages connected by lanes only six inches wider than the car, with grass growing down the middle and, all too often, a milk tanker coming the opposite way. Driving for miles in

reverse is an exhausting experience.

There was seldom time to spare and photographs often had to be taken when lighting conditions were far from perfect. I even photographed one dial during a partial solar eclipse because there was not time to wait until it had ended. I was fortunate in that all the owners of private dials, to whom I had written to arrange a visit, were happy to let me take pictures and often invited me in for a cup of tea.

Apart from recording the dials, I also spent some time trying somewhat unsuccessfully to discover some facts about Mrs Crowley's life. She had written papers in West Country antiquarian journals and an abstract of these became one of the introductory chapters. A visit to the Guildhall Library to examine the original sketchbooks led to fresh insights concerning Mrs Crowley's methods. I encountered problems for which my meagre knowledge could find no answer and I had to seek advice from experts both within the British Sundial Society and outside it. The Acknowledgment section of the book grew to a considerable size by the time the book was finished in almost exactly three years since the project began.
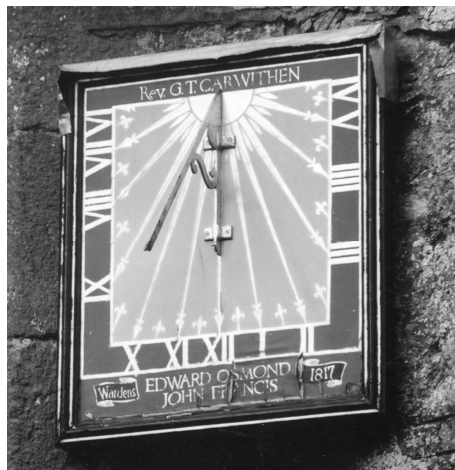
BOOK REVIEW

Mrs. Crowley's Sundial Sketchbooks of Devon and Cornwall, Edited by John Lester. pp.386 + xviii, 245×189mm, softcover, b&w drawings & photographs throughout, ISBN 978-0-9518404-8-1. Jointly published by the BSS and AHS; £15.50 inc UK p&p from BSS Sales.

This idea for this book originated from the discovery of a series of sketchbooks deposited with the AHS towards the end of the 20th century. They were the work of Mrs Jeanie Crowley who, in the 1950s and early 1960s, visited many places in Devon and Cornwall, noting and making pencil sketches of as many sundials as she could find. In all she filled five 30 page sketchbooks in Devon and three in Cornwall.

In 2003 the AHS journal *Antiquarian Horology* published eight sample drawings from the sketchbooks, attracting the attention of the BSS, which recognized them as an important record of dials. As a consequence, the sketchbooks were scanned and copies made available to the BSS before the books were deposited in the Guildhall Library.

Dr John Lester undertook to edit the sketchbooks for publication, but he has done much more than this. He visited every site mentioned and took photographs of all of the extant dials. He also consulted many other commentators, such as Mrs Gatty and Pevsner, where these other authorities have noted the particular dials.

Pencil sketches have the advantage of being able to show the essential details of a dial as observed from an idealized view point, but photographs have to show the dial from where the camera is positioned. Some of Dr Lester's photographs required precarious locations – "the middle of holly bushes or near the edge of small precipices", but nevertheless he has succeeded in producing clear photographs of the dials in their current (2004 to 2007) condition.

The vast majority of the dials recorded in the sketchbooks are vertical dials - 216 in all, with one horizontal and one cube dial, together with four mass or scratch dials. A number of other dials were noted by Mrs Crowley but not sketched. However, Dr Lester has provided photographs of these extra dials to complete the record.

The current book is laid out with four initial sections - An Introduction to Sundials, Mrs Crowley and Her methods, Her Publications, and Maps of the two counties, followed by the main part (380 pages), devoted to the eight sketchbooks.

Each right hand page carries a reproduction of one page of Mrs Crowley's sketchbook, with the opposite page bearing one or more photographs of the corresponding dial. The sketches are dimensioned, with notes about the dial's condition and also the maker and clergy associated with the church. Dr Lester's comments on the dial, both on its present condition and its possible originator are placed next to the photograph. The OS map reference and BSS Register number for each dial are also given.

The first five chapters show the Devon sketchbooks, which were recorded between 1952 and 1962 (the last book only contained two dials), whilst the remaining chapters, recorded between 1957 and 1962, cover the three Cornish sketchbooks. These latter dials are also all described in greater detail in Len Burge's *Cornish Church Sundials*.

It is in the commentaries that the editor's gentle wit and erudition makes its appearance, which in my view raises this volume far above a bald list of dials. For instance, of the dial at All Saints, Beaford, he comments that "It is not a brilliant dial, but it does not deserve what appears to be a bullet hole at IIII o'clock".

Another dial is remarkable for the fact that "Pevsner, in a rare moment of approbation, describes [it] as very pretty". Of the St. Ia dial at St Ives, we have "St Ia came from Ireland and by an astonishing feat of seamanship sailed over to Cornwall on a leaf". The St Madernus dial at Madron bears the Psalm "My days are like a shadow that declineth..." to which the editor responds by remarking "The dial, mounted on the rood-stair turret, declineth a little to the east".

This volume is an excellent contribution to dialling history and will repay many hours of study to find the subtle nuggets scattered throughout the text. It should make a useful companion on a trip to the West Country. The AHS and BSS deserve congratulations for their support for this worthwhile project.

Michael Isaacs
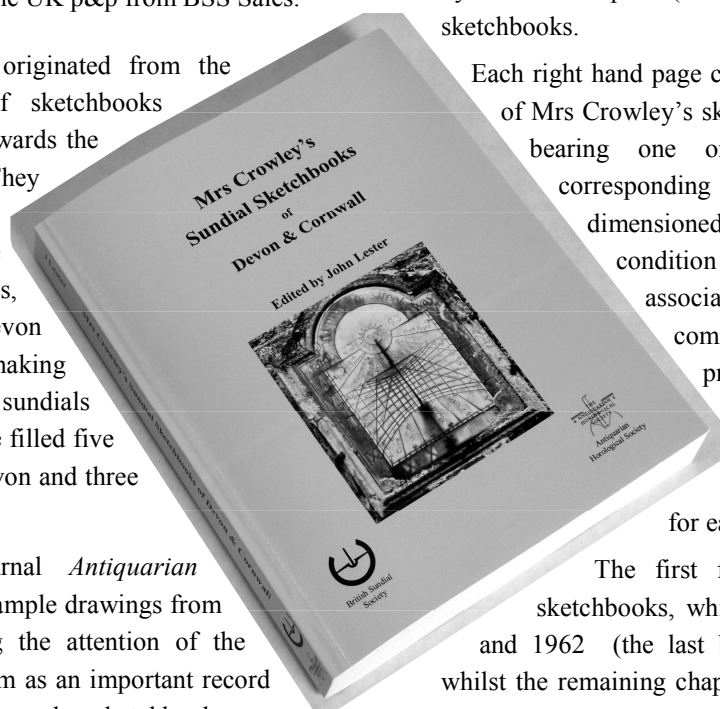
A CELTIC QUARTET

TONY WOOD and FINOLA O'CARROLL

Introduction

Mass dials are usually carved into the stonework of churches. The excavation of such dials is a rare occurrence and the examples described in this article form a group with features in common with each other and with the more familiar carved mass dials. As ever, the dating of such dials is difficult and a fuller description of the archaelogical background is given for one of the dials which illustrates this. The creation of the British Sundial Society has enabled these disparate discoveries to be related and compared, which would not have happened prior to its formation.

The Dials

The discovery in 2001 of a slate sundial in Cornwall and the subsequent excavation of a similar slate dial in Ireland prompted an investigation into two other dials held in museums and the possible establishment of a common design. Also in common was the location in 'Celtic' areas which were outside the regions where mass dials are usually found.
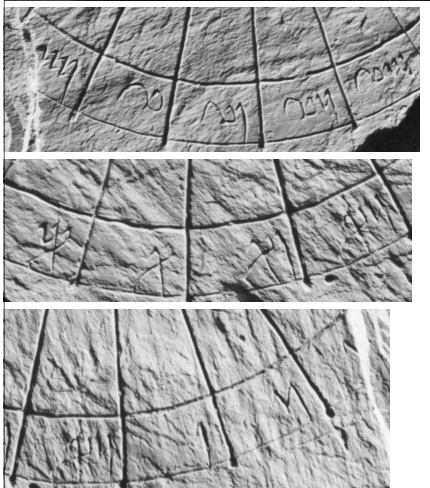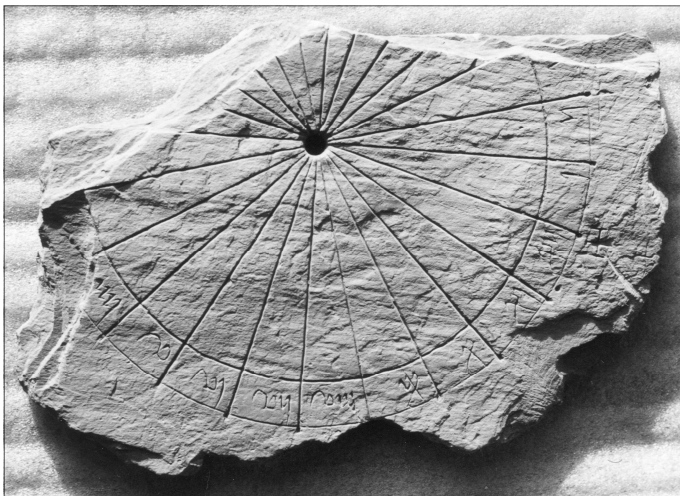
Fig. 1. The Crowan, Cornwall, dial. The three enlargements show, top to bottom, the numerals running left to right.

The dials concerned are regarded as mass dials or scratch dials; no evidence of a fixed sloping gnomon is present and the delineation in all cases consists of hour lines at 15° intervals all round the complete circle. There are numbers round the edge in four cases and a cross at noon in two cases.

Dial 1. In August 2001, a piece of muddy slate was found in the ditch of a farm at Crowan, near Cambourne in Cornwall. It was marked out as a sundial, the numerals running anti-clockwise (Fig. 1). The diameter of the outer circle is 174mm. It was identified as a mass dial with the supposition that, being slate, it was nailed to the wall of the nearby church of St Crewenna and served the same purpose as the more commonly scratched dials in most of England.[1] Further features comprised a cross at noon in addition to the numerals xii. The range of hours was from 4am to 3pm.

Dial 2. Next to appear, in 2003, was a dial which had been excavated in 2001 at Bremore, Balbriggan, Co. Dublin by Finola O'Carroll of CRDS Ltd. This dial is somewhat smaller at 125mm diameter and is again in slate with a full circle of 15° interval hour lines and numbers round the edge, this time in a clockwise sense (Fig. 2). It also has a cross at noon and additional pock marks on the radii at '6 a.m., 9 a.m., noon, 3 p.m. and 6 p.m.'. There is a hole at mid radius 10/11 p.m. but not apparently related to any gnomon. It seems possible that the noon xii was omitted as a cross is marked at this position. The form of the numerals is the same as for the Cornish dial, being 'secretary hand', a
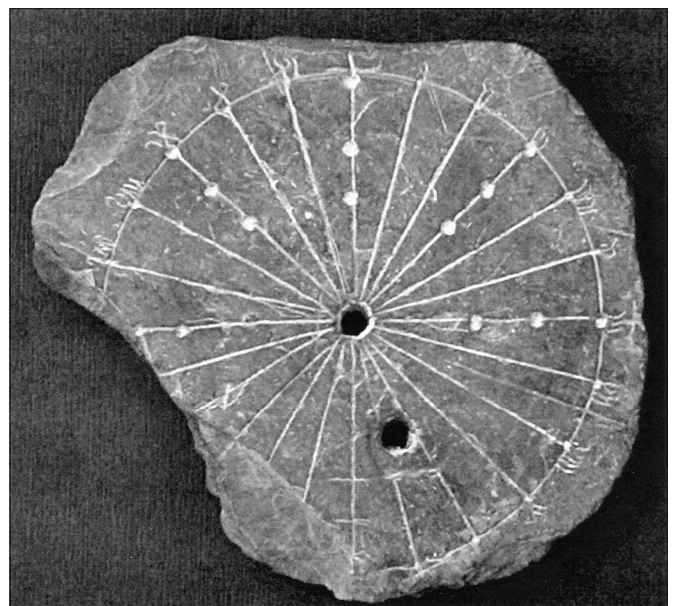

Fig. 2. The Bremore, Co. Dublin, dial.

well known manuscript form. The dial was found amongst artefacts provisionally dated 13th or 14th century which is earlier than that suggested by the script, undoubtedly formed by an educated hand i.e. the priest.

Archaelogical Background

The following extracts are from refs. 2 and 3 (with the figure number amended here). It should be noted that a further two horizontal mass dials have been recorded in western Scotland.

"Excavations at Bremore, Co. Dublin were carried out in the summer of 2001 at a site in a field near Bremore Castle.

"Evidence of farm working and small dwellings was uncovered. A deep pit was discovered and when excavated was found to be funnel shaped, around 3m diameter near the surface reducing to 850mm diameter at a depth of 1.65m. Above a layer consisting of a charcoal and ash dump was a silty clay in which a slate scratch dial or mass dial was recovered. It was of unusual form, as it would have been placed horizontally, not vertically, presumably outside a chapel. It has the hours marked by lines and Roman numerals, and they run clockwise. It is probably 16th century in date.

"The finds from the pit, with the exception of the mass dial, were predominantly of medieval pottery, both 13th to 14th and 14th to 15th century. No post-medieval pottery was recovered from it, but the overall quantity of post medieval pottery was small and perhaps begs the question as to whether wares which have been considered to be 14th – 15th centuries in date, do in fact continue in use into the 16th also.

"The date of the mass dial [Fig. 2] recovered from one of the possible cisterns in the field is unclear. From the associated pottery finds it could be argued to be no later than 15th century. However, given the history of the site, the backfilling of these pits may relate to the activities of a slightly later date, and dials of such a type are dated anywhere from the 15th to the 17th centuries. It is 12.5cm in diameter, etched onto slate, with equal spacing of all the hour lines. It is damaged, so the numbers, which are etched as roman numerals around the circumference, do not fully survive. As the numbers run clockwise it is a horizontal dial, and this makes it very rare, though it is very closely paralleled by one from Nendrum (Arnaldi 1999, fig. 3). There is a dial from Donaghpatrick in Co. Meath which is similarly laid out but not numbered. This was studied by Patricia Ryan, who believes it too was a horizontal dial (Ryan 1982). There are records of only three horizontal mass dials in Britain, two in Scotland on the west coast and one in Cambridgeshire (Bowling and Wood).[8] It is likely that the Bremore dial came from the manorial chapel attached to the estate."
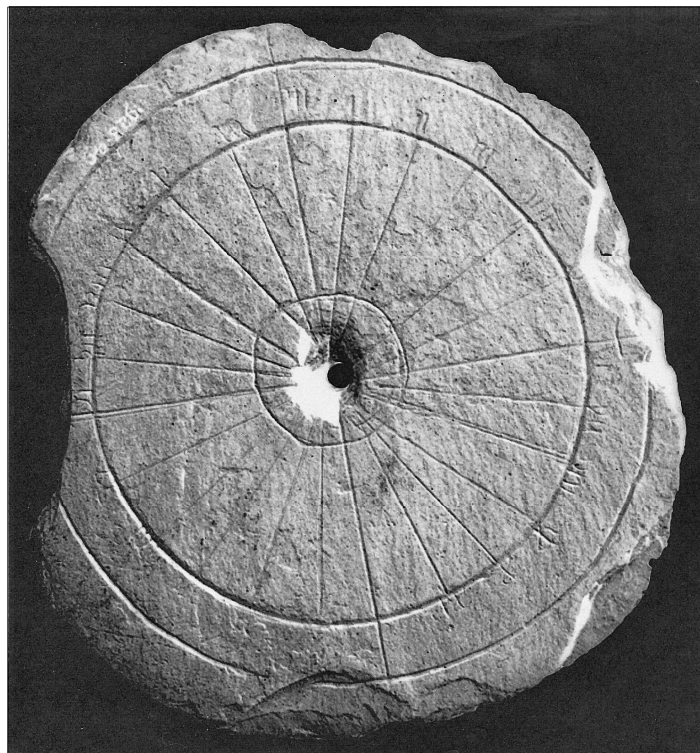
Fig. 3. The Nendrum, Co. Dublin, dial.

Dial 3. A similar dial is in the Ulster Museum in Belfast. It is illustrated indifferently in Arnaldi's 'Ancient Sundials of Ireland'[4] and is from Nendrum on Mahee Island, County Down. On obtaining a good photograph (Fig. 3) from the Museum, it was evident that it is very similar to the Bremore dial. Again it is a smaller dial of 104mm diameter to the outer circle and again it has a full circle of hour lines at 15° intervals with Roman numerals round the edge going clockwise and similarly read from inside (the Cornish numerals are read from the outside). The Belfast Museum dial is not quite as carefully delineated, having some double lines and slightly variable spacing. There is a cross at '6pm' but not at noon although the line is extended across the two bounding circles. The numerals are again in a manuscript form but not so carefully engraved. There is an apparent gap in the numeration between xi and iii. The stone is worn here so it is difficult to be sure but certainly xii (midnight) is not marked.

The undoubted similarity of these three dials is complemented by two further dials which have some affinity in style.

Dial 4. In the National Museum of Scotland, Edinburgh is a fragment found at Kilchoman House, Craig More, Islay, Argyll (Fig. 4). At about 165mm in diameter it is comparable with the Cornish dial in size and consists of about 90° worth of marked hour lines and a central hole. The lines are roughly drawn at 15° intervals and there is one symbol visible at the edge (Fig 4a), probably a cross, but no other markings remain. Whether it is horizontal or vertical is not known but four horizontal mass dials are recorded in
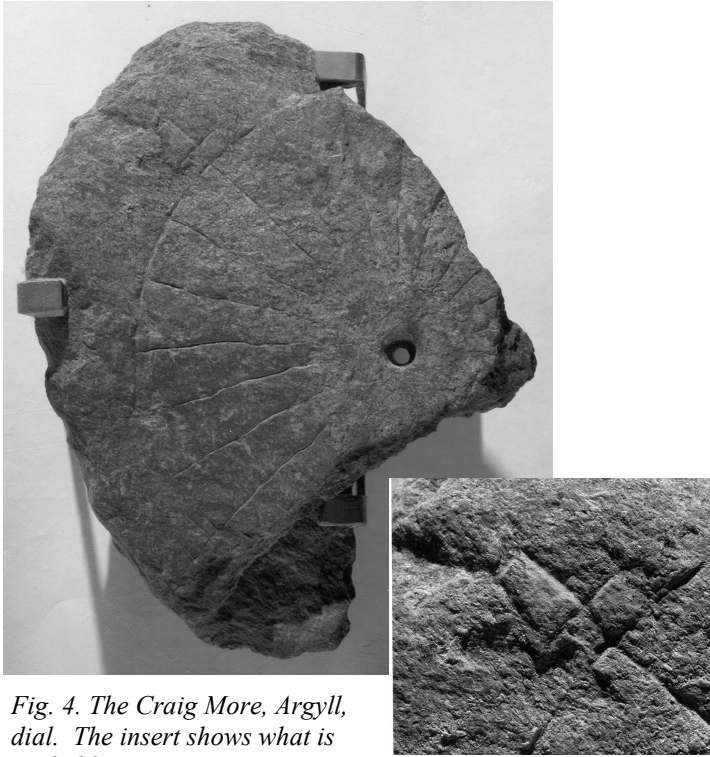
Fig. 4. The Craig More, Argyll, dial. The insert shows what is probably a cross.

Argyll, all on cross bases. [5-7] This dial is 'independent' rather than part of larger stonework and must have been mounted in some way but we cannot say further.

<u>Dial 5.</u> In Carmarthen Museum is a mass dial from the local church of St Peter (Fig. 5). It was attached to the south wall by four hooks. It is relatively large ("one foot diameter") i.e. 300mm and has in common with the other dials a full circle of radial lines at 15° intervals. These lines, however, are terminated by small holes (pocks) and there are four larger ones at 90° intervals. It seems likely that they would have indicated noon, '6am', '6pm' and midnight. It was taken down in the early 20th century and differs from the
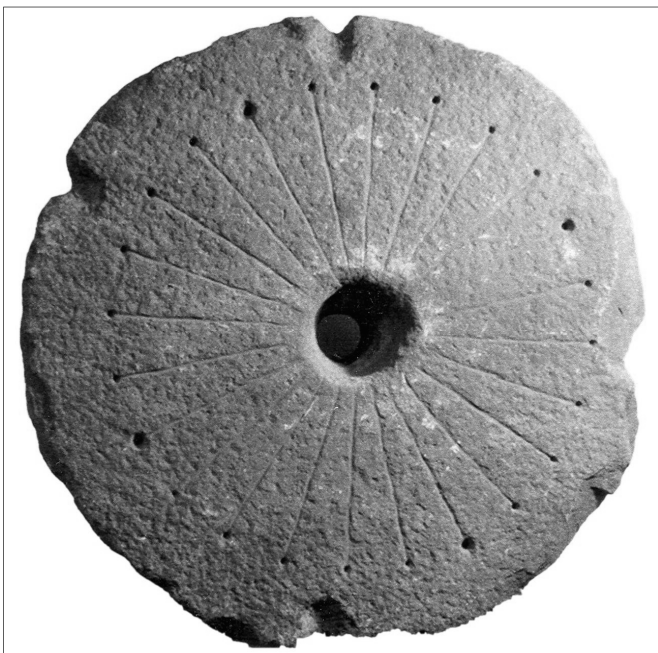
Fig. 5. The St Peter, Carmarthen, dial.

other dials in being larger and on a much thicker stone rather than slate or schist and no numerals are evident. It does however establish that, on occasion, separate mass dials were fastened to church walls rather than having a dial scratched into the existing stonework.

Is there a 'Celtic' connection? It would be difficult to read into the locations more than a vague suggestion of common origin but the two Irish dials are very similar and the numerals' style connection with the Cornish may well indicate a roughly common date of origin. The 'horizontal' form of the Irish dials is outside the main tradition of English mass dials but, as mentioned, horizontal dials are known in Scotland[8] and Norway[9] with only one in England although none have numerals. Although there was a Scandinavian kingdom in the west of Scotland and the Western Isles in the 11th and 12th centuries it is not likely that any direct connection can be made with any Scottish dials as they appear to be rather later.[10]

Consultation has been made over possible dating from the 'secretary hand' letter forms but since only i, j, x and v are available no conclusions could be reached.

It is worth mentioning that alternative scenarios have been proposed for two of the dials. The possibility that the Cornish dial was an equatorial was raised by Burge who was the first Society member to examine it.[11] This would require mounting at an angle and the delineation would be for 'winter'. Powers and Wood[12] preferred the more traditional explanation of a mounted mass dial, on slate because the granite churches of Cornwall were not easily receptive to amateur scratchings.

The Ulster Museum dial has also been offered an alternative origin – as a clock face. Lamont-Brown[13] has proposed that it is from a monastery clock, with one hand, and there is an illustration provided[14] of such a clock, driven by water. Arnaldi[4] discounts this explanation.

The sole example so far noted of 'secretary hand' on an English dial occurs at Wickhampton in Norfolk (Fig. 6). The dial is a vertical one of 140mm diameter but the numerals are not as well or clearly formed, the 'hand' of the engraver not being so sure. It is interesting that the dial also has a complete 24-hour delineation, with crosses at noon and midnight. It is carved onto a buttress stone and may have been moved at some stage. Unfortunately, it is quite worn and some numerals are not readily identifiable. A complete 24-hour marking is quite rare and, even if it were possible to date the Norfolk dial, the use of secretary hand stretched over a considerable period of time so any correlation with the 'Celtic' dials would be difficult to establish. The design however adds further weight to the supposition of Powers and Wood that the above dials are mass dials
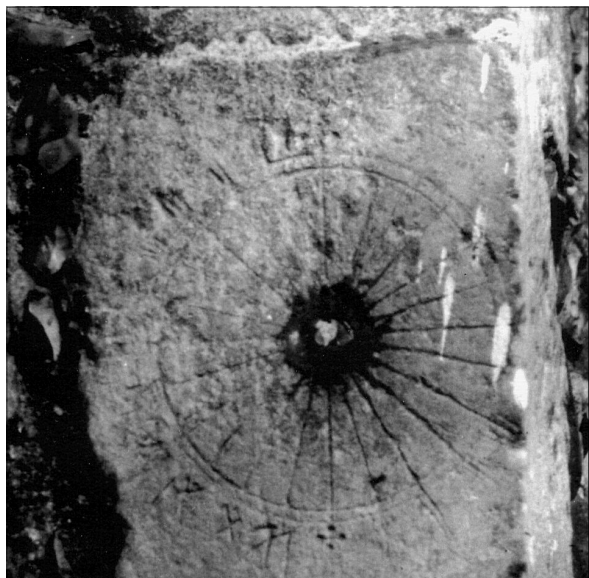
Fig. 6. The Wickhampton, Norfolk, dial.

Summary of the Dials

No.	Site	Material	Hor/ Vert	Numerals	In/ Out*	Crosses
1	Crowan Cornwall	Slate	Vert	iiii-xii, i-iii	Out	Yes
2	Bremore Ireland	Slate	Horiz	vii-xi, i-ix	Inside	Yes
3	Nendum N. Ireland	Slate	Horiz	ii-xii, i-xi	Inside	Yes
4	Craig More Scotland	Schist	Horiz?	None		?
5	Camarthen Wales	?	Vert	None		No
6	Wickhampton Norfolk	?	Vert	i-xi, i-xi#	Out	Yes

* Read from inside/outside
\# Possibly some numerals omitted

within our normal canon. Comparison with other mass dials would normally give a late (16th century) date to such a dial.

The authors are of the opinion that we have mass dials, albeit in both vertical and horizontal form, it being a re-markable coincidence that four have been dug up and their details have been made available to a central register. There is no apparent commonality in size; it is difficult to invoke 'medieval inches' in any way.

ACKNOWLEDGEMENTS

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According to Mrs Gatty, this 19 foot shaft was in Malvern churchyard and the cube had dials on all four faces. The motto, on the northern face, was believed to have been *Hinc vivere disce, Illine disce mori* (From the one learn to live, from the other learn to die).

What has happened to it?
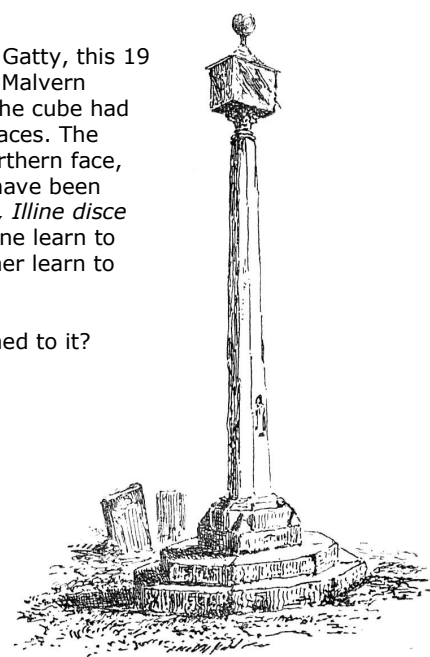
LUTYENS' VERTICAL SUNDIALS

JOHN FOAD

Fig. 1. An early Lutyens in Buckinghamshire.

Introduction

Not long ago I came across a fine pillar dial in a private garden in Buckinghamshire. A close-up of the south face is shown in Fig. 1. It had direct south, west and east dials, with elegantly carved furniture and bronze gnomons reminiscent of the scroll work on the now-fashionable 'Lutyens' garden benches. Edwin Lutyens had planned the gardens with Gertrude Jekyll so it seemed likely that he had de-
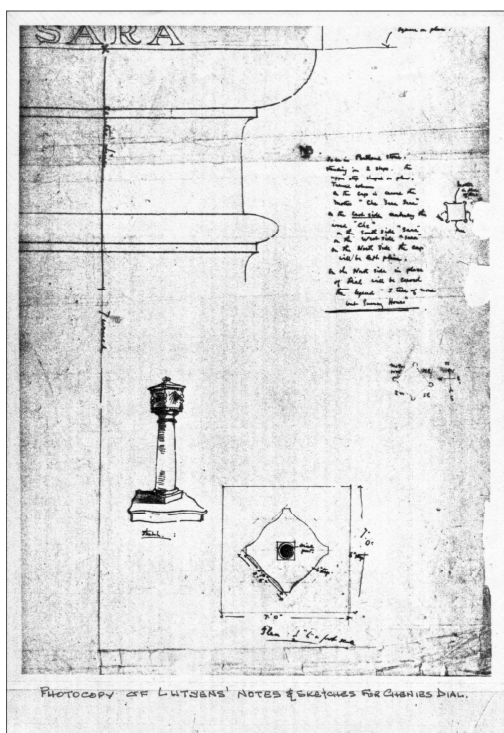

Fig. 2. Part of Lutyens' full scale drawing. From the estate of Mr E Martin.

signed the dial, but it was not signed. There the matter rested for a while, until a call came from Tony Wood. He had found, among the effects of Edward Martin, a copy of a design in Lutyens' own hand of this very dial. Lutyens had made a full-scale drawing of the whole dial, including its pillar and base: Fig. 2 is a reproduction of a small portion. My interest was aroused and I started on a quest for any other vertical dials that might be found in Lutyens' gardens or on his houses.

The Salutation

SRN 3320, at Sandwich in Kent, is one well known example. The dial is a vertical east decliner, clearly incised and carrying the unusual but helpful inscription:

"CLOCK & DIAL AGREE
APRIL 16 JUNE 15 SEP 1 DEC 25"

The elegant gnomon support can be seen from its shadow in Fig. 3. The carving is crisp and clear, with Arabic numerals from a slightly optimistic 3am to noon. The lighter brick surround, which at first sight might suggest a restoration, is typical of Lutyens' designs. It is used on all the windows at The Salutation and can be seen again on his terraced town houses at Hampstead.

Fig. 3. The Salutation, Kent.

The Pleasaunce and Overstrand Hall

I soon found two more Lutyens dials, both in the small town of Overstrand on the north coast of Norfolk. Again, they are strong but simple designs. The first is at The Pleasaunce. Built in 1898 for Lord and Lady Battersea, it is now a Christian Endeavour holiday centre. The dial is a
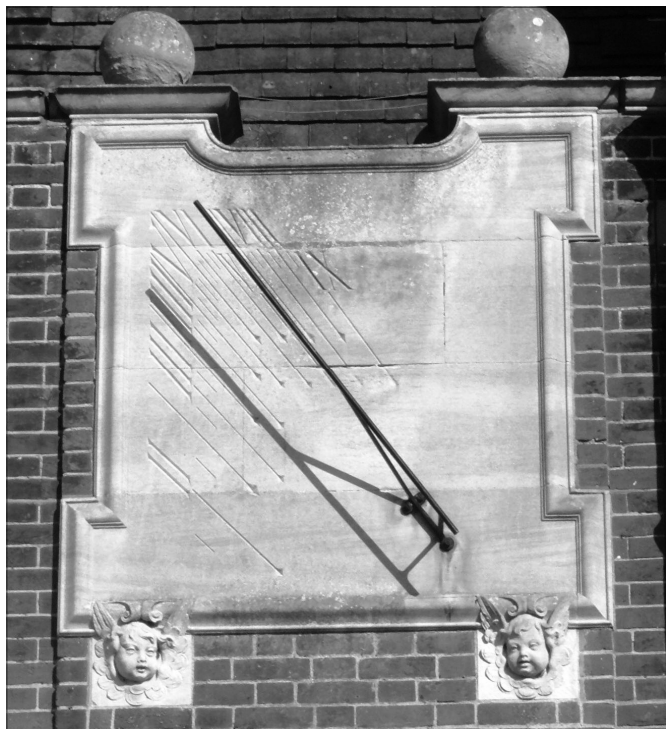
Fig. 4. The Pleasaunce, Norfolk. Photo © Mr C Buxton.

west decliner with an elegant light framework to support its long bar gnomon (Fig. 4). The furniture is a bare minimum, just elongated aligned Roman numerals, sketched on a bare stone base, running clockwise from 2pm to 9pm, with half and quarter hour lines. But the whole is enlivened by the irregular rectangular banded frame, supported by two cherubs' heads and balanced by two orbs above.

The second Norfolk dial is at Overstrand Hall, which was built only a year or two later and is only a mile or two away. Mounted on a wall where the unusual brick pattern is varied with flint inlays, the white stone dial is more ornate, with a leaf and fruit border and heraldic birds, and a sturdier gnomon support filled with the same design features (Fig. 5). It declines about 15º west, has Arabic hours for

Fig. 5. Overstrand Hall, Norfolk.

8am to 5pm and again has quarter and half hour markings. The two Norfolk dials, both still in excellent condition, are neither signed nor dated.

Tigbourne Court

The following year, 1899, Lutyens was at work on Tigbourne Court in Surrey. A Country Life photograph of 1905 shows a feature sundial, placed in a focal position below the two large gables of the garden front and illustrated in Fig. 6. The border uses bricks paired and chamfered in much the same way as at Overstrand Hall, setting the dial off from the stone block work of the wall. The inscription above the dial reads "Horas Nullas Nisi Aureas", or "I Count None but Golden Hours".
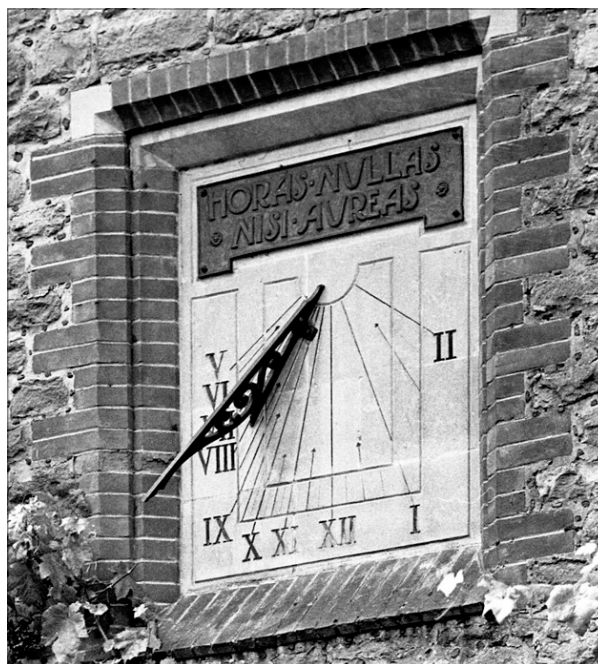

Fig. 6. Tigbourne Court, Surrey. Photo © Country Life, 1905.

Hampstead Garden Suburb

In 1908, Lutyens designed the two churches at the heart of the new Hampstead Garden Suburb and also some of the terraced town houses around the central square. One of these houses bears a dial dated 1920, some twelve years later, but it would not have been added without Lutyens' knowledge and approval. It was not unknown for dials to be installed long after the completion of his buildings. Greywalls, for example, (see below) was built in 1902, but the dial had still not been put in place when Weaver used a photograph in his 'Houses and Gardens' of 1913.[1]

As far as I can tell the Hampstead dial (Fig. 7) is painted on a wooden panel but, from the stone surround, it is clear that a dial was foreseen from the start. It differs from the earlier stone dials in other ways also. It is his only dated dial and it is an early Summer Time dial, with the Roman GMT hours supplemented by small Arabic numerals giving BST. Al-

Fig. 7. Hampstead Garden Suburb.

though Summer Time was introduced in 1916, the only other early dial showing BST that we have in our records is SRN 0912 at Corpus Christi College, Cambridge, also dated 1920.

The motto here at Hampstead is the popular "Let others tell of storms and showers, I'll only count your sunny hours". Another from the family of "Horas non numero nisi serenas", this very traditional motto is seen in one variant or another on many twentieth century dials. The sentiment would seem to have been a favourite of Lutyens. He used it on his Tigbourne Court dial above and, in addition, his drawing for the pillar dial in Fig. 2 shows "I tell of none but sunny hours". In that case, however, the motto was altered to a text from the Greek Testament before the dial was completed.
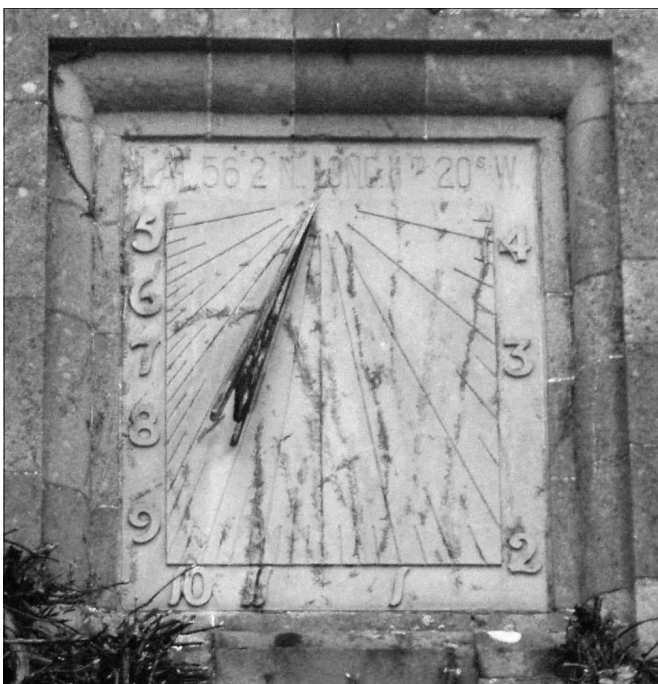

Fig. 8. Greywalls, Gullane, Scotland. Photo courtesy of Mrs R Weaver, 2007.

"Let others tell ..." was chosen by Queen Alexandra when she commissioned the Sandringham vertical dial (SRN 1299) from the firm of Francis Barker in 1892. Although it had been reported earlier (Gatty[2] records it in 1870 in Ireland), it was probably its use by royalty that gave rise to its popularity and it remained as one of Barkers' standard mottoes, continuing in their catalogues at least from 1907 to 1924. It is given pride of place as the first motto quoted in 'The Book of Old Sundials and Their Mottoes', published with the drawings of Warrington Hogg in 1914.[3] There are 37 examples reported in the Register. Ignoring the 22 which are spuriously dated 1767(!), the Sandringham dial of 1892 is the earliest.

Greywalls

Another fine vertical is displayed in the central gable of the Scottish house of Greywalls, built in 1902 on the edge of the golf course at Muirfield and now a luxurious hotel. Here again, as at The Salutation, we have an inscription that reminds us that a dial is a serious instrument. It is slightly puzzling at first glance, reading

LAT 56º 2' N   LONG 11^m 20^s W

though it may not be possible to read it in the illustration (Fig. 8). The longitude at Greywalls, expressed in the normal way, is 2º 50' W. But expressed in terms of time, this translates to 11 minutes 20 seconds, the 'longitude correction' which must be added, together with the Equation of Time, to get back to Mean Time.

The hour numerals are in a relaxed 'modern' Arabic font, and strangely the '12' for noon is absent. Every detail of Lutyens' work is so meticulously planned that I feel there must be some reason for the missing noon figure. Possibly it was to avoid over-crowding on the chapter ring, but I am not convinced.

Mothecombe

My final example dates from rather later in Lutyens' career. By 1925, at the age of 56, he was the Grand Old Man of English architecture. Seven years earlier he had been chosen as one of the three Principal Architects to the Imperial War Graves Commission, and knighted for his work on the Viceroy's house at New Delhi. He was a member of the Royal Academy and Gold Medallist of the Royal Institute of British Architects. The heyday of his work on the English country house was behind him, though he continued with alterations and extensions, with garden design, and with a limited amount of municipal work.

In 1925 he added a new wing to the Queen Anne house of Mothecombe, on the South Devon coast, and also remodelled the terrace and the walled garden. On the bare brick south wall of the new dining room extension, Lutyens placed a large simple painted dial (Fig 9). It is out of char-

acter with his earlier, more elaborate, carved stone productions. The sturdy curved supports of the gnomon overpower the thin rod of the style itself and, were it not for the fact that his own drawings for the dial exist, one might question whether it is in fact Lutyens' design. Nevertheless, this was an accurately laid out dial, delineated to accommodate the fact that the wall faces just one and a half degrees east of south. The orientation of the numerals is odd, with IX being read from outside the chapter ring, but all the rest from inside. The result is that 11 and 12, on the horizontal, appear as IX and IIX. The dial reads to 5-minute divisions, while all Lutyens' others confine themselves to half and quarter hour marks only.
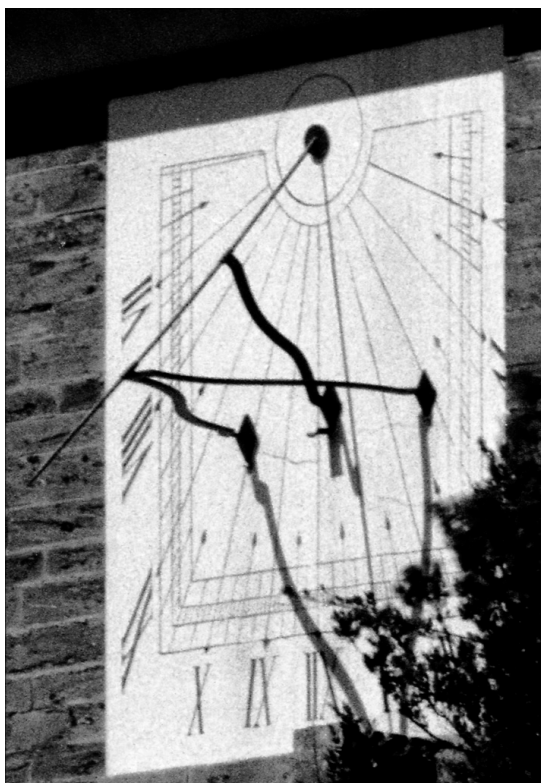

Fig. 9. Mothecombe House, South Devon. Photo © Country Life, 1956.

Conclusion

All these examples show how Lutyens appreciated the value of a dial; how he poured his energy as much into the design, the setting and the materials, as he did into all the other minor components of his work, be it the hinges of a door, the beds, even a coal scuttle or a billiard table. I wish that I had been able to determine who delineated and manufactured his dials, but I have found no record. I am sure he will have used local masons and other craftsmen in the making, as he did for all the stone and purpose-made brick work of his houses. It may be that he used one specialist for both the gnomonic and the artistic aspects of the delineation. Francis Barker is an obvious candidate, but apart from the very tenuous link of the motto of the Hampstead dial, I have found no clues.

Note – all these dials have been registered, but I would welcome further sightings of these and other Lutyens verticals, and any additional details.

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The Dial That Never Was
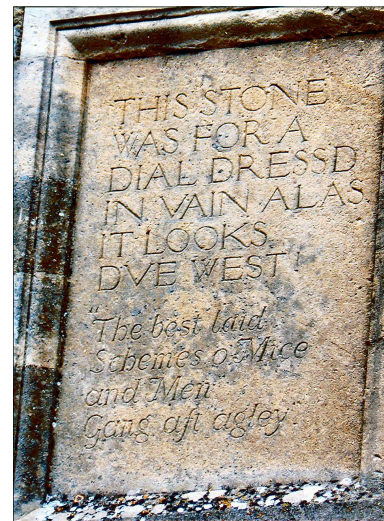
This stone is on the west elevation of a house called Highcroft in Eynsham, Oxfordshire. The house (previously known as Hythe Cottage and Highcroft Lodge) was originally built some time before 1832 and extended by the architect Clough Williams-Ellis in 1907.

The quotation at the bottom is from the Robert Burns poem *To a mouse, on turning her up in her nest with the plough* (1785).

It would, of course, have been perfectly possible to have put a direct west dial in place of the plaque although the depth of the recess would have limited its operational hours.

Dennis Stukenbroeeker

A VERTICAL ARACHNIDEAN SUNDIAL INDICATING ISLAMIC PRAYER TIMES AND THE DIRECTION OF MECCA

ORTWIN FEUSTEL

For over a millennium, traditional Islamic science (especially astronomy) has been vitally important for the religious life of Muslims. This includes, amongst other things, mathematical procedures based on astronomical phenomena for defining the prayer times and for calculating the direction (*Qibla*) to the Islamic sanctuary Kaaba, a stone construction within the great mosque in Mecca.

According to the Koran's rules, the believer must say his prayers five times a day. Their sequence and intervals harmonize with the sun's path through the firmament. The prayer times at night depend on the brightness of the sky (twilight) which means they depend on sunset as well as the times both for the end of dusk and the beginning of dawn. In the daytime, the prayer times are strictly in accordance with the increasing horizontal shadow length (after its minimum at midday) of a vertical object.

The first prayer (*Maghrib*) at sunset coincides with the beginning of the civil day. The second prayer (*Isha*) is the evening prayer. The third prayer (dawn prayer *Fajr*) begins at daybreak; it has to finish before the sun rises. At midday, after the sun's culmination,[1] the time for the fourth prayer (*Zuhr*) begins. The afternoon prayer (*Asr*) is the last one of the five. A special significance is attached to it;[2] furthermore, one distinguishes between the first *Asr* (*Asr ewwel*) and the second *Asr* (*Asr sani*). Al Biruni[3] points out that the first and second *Asr*s characterize the beginning and end of the *Asr* respectively.[4-6]

Reliable timepieces are necessary to say a prayer punctually in accordance with the aforementioned religous rules. For centuries one used, as well as astrolabes and quadrants (sometimes with additional astronomical tables), horizontal sundials (*Bazithah*) with a vertical style (gnomon). A straight line through the gnomon's base indicated the direction to Mecca which was an essential component to the furniture of each *Bazithah*.[5,7]

This paper describes a vertical south arachnidean sundial[8] from which one can read the time for the midday prayer *Zuhr*, the time interval for the afternoon prayer *Asr* and the azimuth (*Qibla*) of Mecca. With appropriate design, the dial may be read from a significant distance. Using the laws of astronomy, it will be shown how to obtain the formulae for calculating the curves both for the prayer times and for the prayer's direction. Afterwards, these results will be applied

to a sundial's face located in Istambul. Furthermore, the conditions for the sundial's illumination will be analysed.

Horizonal & Equatorial Systems

Using the relationships

$$\cos h \cdot \sin a = \cos \delta \cdot \sin \tau \tag{1}$$

$$\sin h = \sin \phi \cdot \sin \delta + \cos \phi \cdot \cos \delta \cdot \cos \tau \tag{2}$$

$$\cos h \cdot \cos a = -\cos \phi \cdot \sin \delta + \sin \phi \cdot \cos \delta \cdot \cos \tau \tag{3}$$

between the horizonal coordinate system (altitude h, azimuth a) and the equatorial system (declination δ, hour angle τ), as well as the geographical latitude ϕ, we obtain the expressions for the sun's azimuth

$$a = \arctan \frac{\sin \tau}{\sin \phi \cdot \cos \tau - \cos \phi \cdot \tan \delta} \tag{4}$$

$$a = \arcsin \frac{\cos \delta \cdot \sin \tau}{\pm \sqrt{1 - \sin^2 h}} \tag{5}$$

$$a = \arccos \frac{\sin \phi \cdot \cos \delta \cdot \cos \tau - \cos \phi \cdot \sin \delta}{\pm \sqrt{1 - \sin^2 h}} \tag{6}$$

Equations (5) and (6) are necessary to determine uniquely the correct quadrant for *a*.

Islamic Prayer Times by Daylight

Numerous Arabian manuscripts - mostly written by muezzins - give different details for the lengths of a vertical object's shadow assigned to the prayers *Zuhr* and *Asr*.[9] The most usual definitions for the length of the horizontal shadow L_{pray} used in Arabian astronomy are:

Zuhr: gnomon midday shadow + ¼ gnomon length

Asr 1: gnomon midday shadow + 1× gnomon length

Asr 2: gnomon midday shadow + 2× gnomon length

The prayer curves for a large number of astrolabes and quadrants have also been designed with these definitions.[6,10,11]

As well as the horizontal shadow length L_{pray}, we require the corresponding prayer hour angle τ_{pray} and their functional dependence on geographical latitude ϕ and sun's declination δ. Considering equation (2), a gnomon with the length G has in general a horizontal shadow with a length

$$L = G \frac{1}{\tan h} = G \sqrt{\frac{1}{\sin^2 h} - 1}$$

$$= G \sqrt{\frac{1}{(\sin\phi\sin\delta + \cos\phi\cos\delta\cos\tau)^2} - 1} \qquad (7)$$

With $\tau = 0$, (i.e. the sun's culmination on the meridian), we obtain from (7) the gnomon's minimum midday shadow

$$L_{min} = G \tan(\phi - \delta) \qquad (8)$$

As explained above, the shadow length at the beginning of a prayer time will be

$$L_{pray} = L_{min} + v_{pray}\,G = G\big[\tan(\phi-\delta) + v_{pray}\big] \qquad (9)$$

where the variable v_{pray} is assigned the values $v_{zuhr} = 0.25$; $v_{asr1} = 1$ and $v_{asr2} = 2$.

Setting equation (7) equal to (9) and solving with respect to the hour angle of prayer required produces

$$\tau_{pray} = \arccos\left\{ \frac{1}{\pm\cos\delta\cos\phi\sqrt{1+\left\{\tan(\phi-\delta)+v_{pray}\right\}^2}} - \tan\delta\tan\phi \right\} \qquad (10)$$

Direction to Mecca

Naturally, the gnomon shadow of a *Bazithah* and the *Qibla* line on the dial face coincide once a day. It occurs, of course, at different points in time. Therefore each great mosque employed an astronomer. He was watching for that event and which he then called out. For obvious reasons, the believers' shadows all have the same azimuth so that each recognizes with his own shadow the direction to Mecca.[4]

This basic procedure is also useful for the shadow of the horizontal gnomon of a vertical arachnidean sundial. For calculating the necessary *Qibla* curve – equivalent to the one on a horizontal sundial – we need the azimuth of the shortest distance (the arc of a great circle) between the sundial's location and Mecca.

In Fig. 1, applying the cosine law twice and the sine law to the spherical triangle *PNM*, leads to the relations

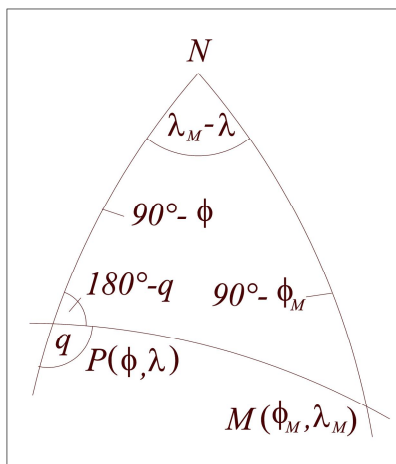$$\sin\phi_M = \sin\phi\cos PM - \cos\phi\sin PM\cos q \qquad (11)$$

Fig. 1. Spherical triangle with north pole N *and dial location* P *for determining the prayer direction (azimuth) Qibla q to the Kaaba in Mecca (lat 21° 25' 32" N, long 39° 50' 32" E).*

$$\cos PM = \sin\phi\sin\phi_M + \cos\phi\cos\phi_M \cos(|\lambda_M - \lambda|) \qquad (12)$$

$$\sin PM = \sin(|\lambda_M - \lambda|)\frac{\cos\phi_M}{\sin q} \qquad (13)$$

After the insertion of (12) and (13) in (11), it follows that the angle between the arc of the great circle *PM* and the local meridian *NP* at dial's location *P*, i.e. for the direction *Qibla* pointing to Mecca,

$$q = \arctan\frac{\sin(|\lambda_M - \lambda|)}{\sin\phi\cos(|\lambda_M - \lambda|) - \cos\phi\tan\phi_M} \qquad (14)$$

Each day, the sun has this azimuth at a different point in time; therefore the function required is $\tau_{qib} = f(q, \delta, \phi)$. Setting $a = q$, we obtain after appropriate shaping of (4), the following two variants

$$\tau_{qib} = \arccos\left(\frac{W\tan q\sin\phi \pm \sqrt{V - W^2}}{V} \right) \qquad (15)$$

$$\tau_{qib} = \arcsin\left(\frac{-W \pm \tan q\sin\phi\sqrt{V - W^2}}{V} \right) \qquad (16)$$

with the terms

$$V = 1 + (\tan q\sin\phi)^2 \qquad (17)$$

$$W = \tan q\tan\delta\cos\phi \qquad (18)$$

Expressed like this, it is possible to assess in which quadrant of the hour angle *Qibla* belongs. τ_{qib} will be used later for the shadow angle S_{qib}, which is used for calculating the curve of the prayer direction.

Shadow Angle for a Vertical South Arachnidean Dial

It is only possible to design the curves of a vertical arachnidean sundial if one knows the functional dependence $S = f(\delta, \phi, \tau)$, in which S represents the angle between the shadow of the horizontal gnomon and the meridian line. It can be calculated from the following expression[12]

$$S = \arctan\frac{\sin a}{\tan h} = \arctan\left[\pm\sin a\sqrt{\frac{1}{\sin^2 h} - 1} \right] \qquad (19)$$

The insertion of (2) and (5) into (19) yields the required function

$$S = \arctan\frac{\sin\tau}{\tan\delta\sin\phi + \cos\phi\cos\tau} \qquad (20)$$

Equation (20) will be used amongst other things to calculate the time lines.

Shadow Angle of the Prayer Time Curves

With $t = t_{pray}$ from equation (10) substituted into equation (20) we get

$$S_{pray} = \arctan\frac{\sin\tau_{pray}}{\tan\delta\sin\phi + \cos\phi\cos\tau_{pray}} \qquad (21)$$

Shadow Angle of the Curve for Determining the Prayer Direction

With the substitutions $a = q$ (see equation 14) and $\tau = \tau_{qib}$ from equations (15) and (16), equation (19) transforms into

$$S_{qib} = \arctan\left(\pm \sin q \sqrt{\frac{1}{(\sin\phi \sin\delta + \cos\phi \cos\delta \cos\tau_{qib})^2} - 1} \right)$$

(22)

A Sundial Located Westwards from Mecca

To infer the local apparent time from the shadow angle (see equation 20) it is necessary that the face of an arachnidean sundial includes lines for the sun's declination, for instance twelve values according to 30° signs of the zodiac (in the ecliptic). Seven circular arcs, equidistant from each other and concentric around the gnomon base, are sufficient because the sun's declination range from -23.44° to +23.44° is crossed twice a year, once with increasing values and once with decreasing values, see Fig. 2. The inner arc represents the summer solstitice and the outer one corresponds with the winter solstice.

For calculating the Cartesian coordinates for the curves of local true time, prayer times and the *Qibla* are needed

$$x = R(\delta) \sin s$$

(23)

$$y = -R(\delta) \cos s$$

(24)

with

$$s = \begin{cases} S \\ S_{pray} \\ S_{qib} \end{cases}$$

(25)

corresponding to equations (20) to (22). $R(\delta)$ represents the nonlinear relationship between the circle's radius and the sun's declination.[12]

As is well known, the illumination of a vertical south sundial depends on the geographical location and the sun's declination. The illumination begins when the sun's altitude has reached a distinct value; the sunrays leave the face when the sun falls below a certain altitude. This topic has been treated in detail in Ref. 13. Using the relations derived there one gets, with for example $\phi = 41°$ N and at the solstices (subscripts *w* and *s*) and the equinoxes (subscript *e*) the following ranges of hour angle (within these ranges the sun's position is in front of the face):

$$-67.859° \leq \tau_w \leq 67.859° \qquad -90° \leq \tau_e \leq 90°$$

$$-60.082° \leq \tau_s \leq 60.082°.$$

REFERENCES AND NOTES

1. Muslims are not allowed to pray if the sun is on the meridian or on the horizon. The reason is that at these times the followers of Satan – i.e. the troop of the unbelievers (sun worshippers) – pray to the sun (see also ref. 6).

2. Tradition ascribes to the prophet the following remark: "If somebody prays 4 *Rakahs* at this time and at the same time performs correctly the Koran's recitation, the knee bend as well as the genuflection, then 70000 angels pray with him and entreat to God for forgiveness of one's sins, and then heaven's gates are opened at this hour." Furthermore, it is worth mentioning that at the *Asr* one willingly lets somebody declare under oath in a court of law, because in consideration of the holy consecration at this time of the day the sworn person would not have the courage to swear a perjury. According to Mohammedan tradition, the angels – which are dispatched down to the mankind – change the guarding of the world at the *Asr*; the day's angels come back to heaven while the angels of the other day's half appear onto the earth (refs 7 and 9).

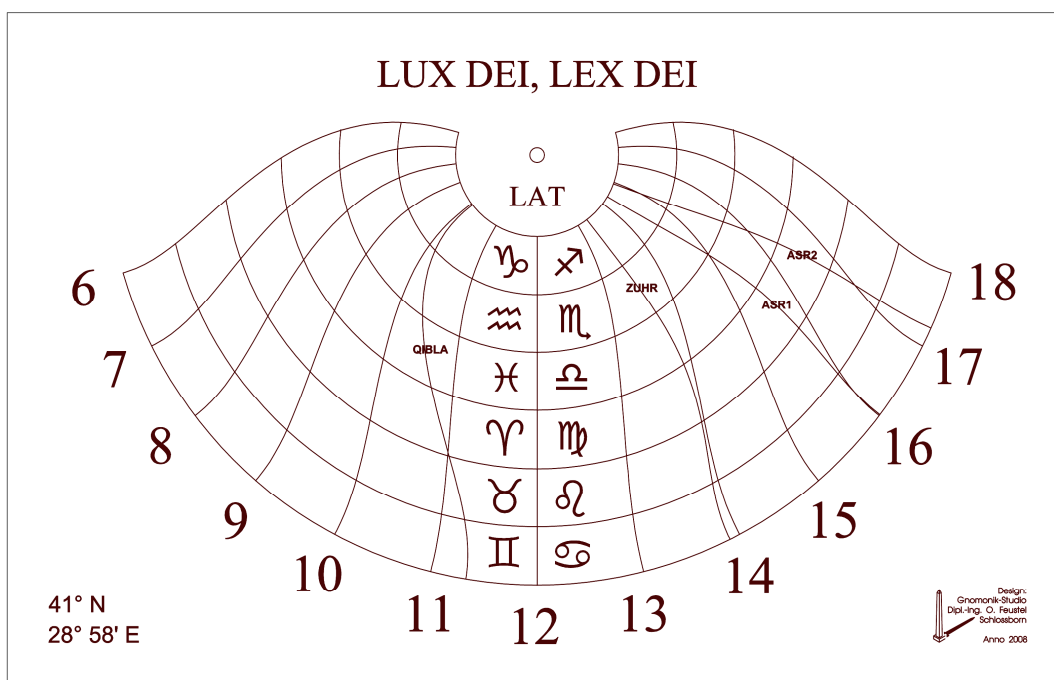3. Al Biruni (973-1048), an eminent Arabian scientist and astronomer.

LUX DEI, LEX DEI

Fig. 2. Face of a vertical arachnidean sundial for Istambul with Islamic prayer hours (Zuhr, Asr) and Qibla (q = 28.447°). The gnomon would be fixed at the origin of the Cartesian coordinate system (small circle) which is the centre of the circular arcs. One can read the local true time at the intersection point of gnomon shadow, actual circle of declination (date circle) and hour curve; the same is valid for the prayer hour. The sun points towards Mecca if the gnomon shadow, declination arc and Qibla curve intersect each other. Intermediate values have to be interpolated.

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Overall Winner
John Davis – *Ship's Time*

Second Place
Mike Isaacs – *It's Too Early For Ice Cream*

Third Place
John Lester – *Strictly For The Birds*

Top Ten

Mike Cowham – *Did You Get Paid For That Job?*

Top Ten

John Davis – *The Bishop's Dial*

Top Ten

Mike Cowham – *After a Shower at Burghley House*

Top Ten

Irene Brightmer – *Many Times*

Top Ten

Ian Butson – *Time Lines*

A MILLENNIUM DIAL IN CHESHIRE AND AN 18TH CENTURY TREATISE ON DIALLING

IRENE BRIGHTMER

The first volume of *The New Royal Encyclopaedia or Complete Modern Dictionary of Arts and Sciences* goes from A to F. Under 'D' there is a 6-page 'Treatise on Dialling' written by "Robert Moody of the Excise Office, Broad Street". It includes a fine engraving dated 1789 showing "Various Dials with the Gnomic Projection of the Sphere," (Fig. 1). In the same volume Robert Moody also wrote the much longer entries on Algebra and Arithmetic. The treatise is divided into eight sections and he acknowledges consulting "various authors on the subject, particularly Emerson". There is much that can be said about Emerson (see below) but we know little about Moody except that he was an Excise Officer in London, working at least from 1770 to 1788 and was a natural philosopher and author.[1]
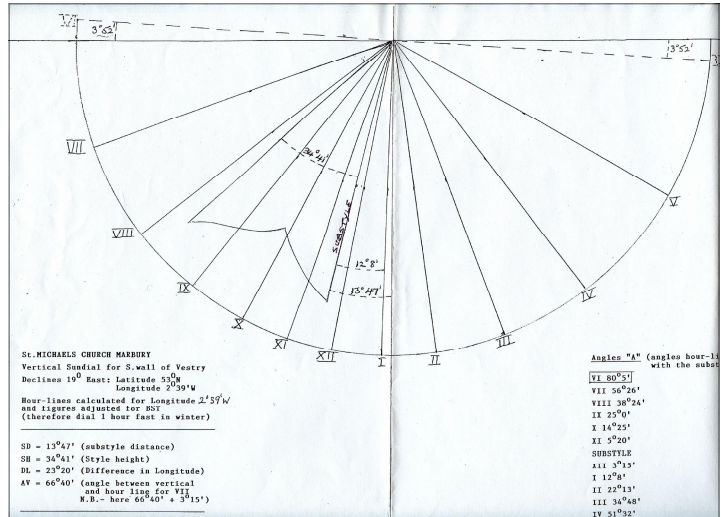

Fig. 2. Dr W.E. Flewett's calculations for the Marbury dial.

The treatise by Moody was the inspiration for a fine new dial for the parish church of Marbury-cum-Quoisley in Cheshire (SRN 4646) designed to mark the millennium by BSS member, the late Dr W.E. Flewett. St Michael and All Angels is a large mediaeval church in a rural area near the Shropshire border. Dr Flewett's widow describes the many hours he spent making the calculations and she has provided some of his drawings (Fig. 2) and also a photo of an
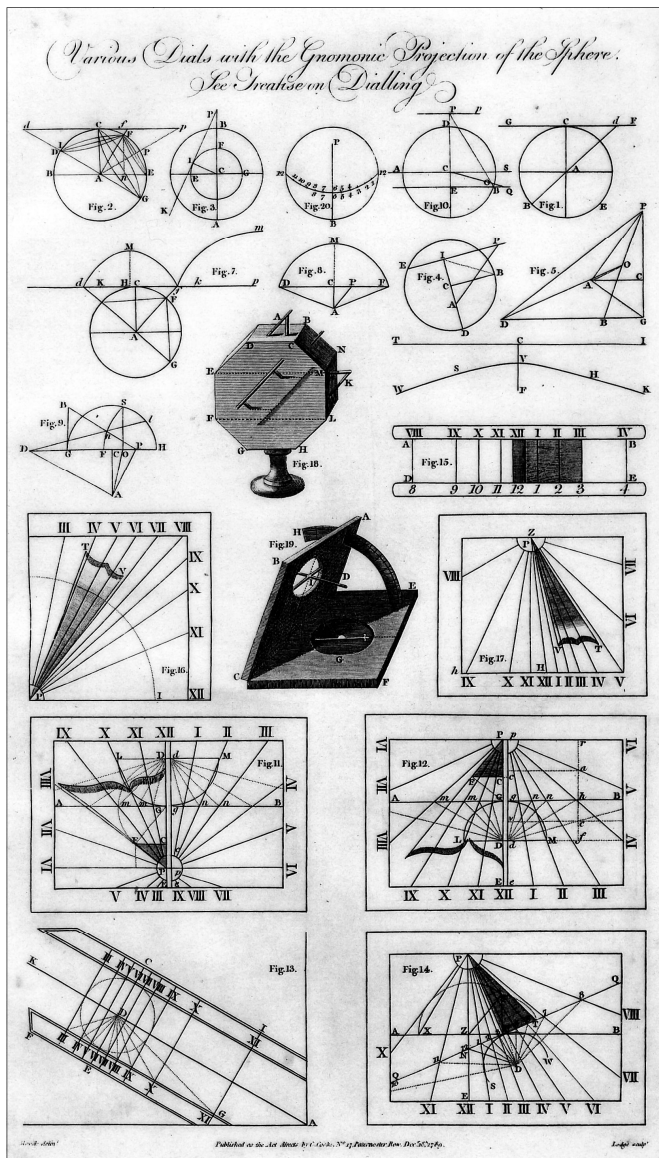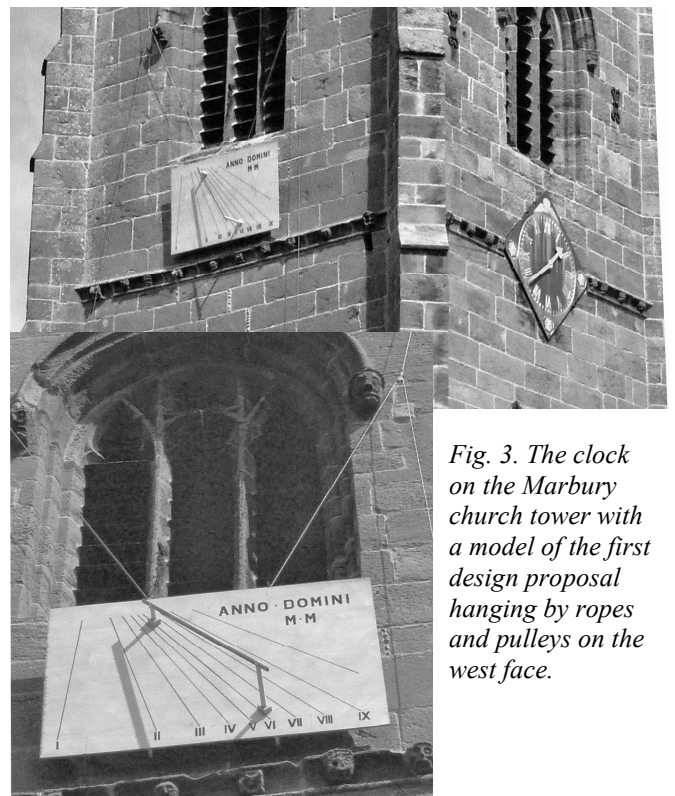

Fig. 1. Engraving from the New Royal Encyclopedia.

Fig. 3. The clock on the Marbury church tower with a model of the first design proposal hanging by ropes and pulleys on the west face.

Fig. 4a & b. The final dial on the south porch.

earlier prototype which didn't come to fruition. The prototype was rectangular, delineated for the west-facing wall of the tower, and would have been placed high up, level with the tower clock (Fig. 3). However, it would not have been very visible and so the final Marbury dial was designed to go above the south door on the 1823 vestry wall which declines 19° east (Fig. 4). It is the same size and shape as the stone shield to which it is fixed; the shield was there already, its purpose is unknown.

The dial is adjusted to take account of Marbury's longitude of 2° 39' west, hence 10½ minutes behind Greenwich. It is also adjusted to British Summer Time: the reasoning for this was that the summer is when the sundial is most useful <u>and</u> when there are more people in the area. An unusual attention to detail is that the Equation of Time is taken into account through an explanation and a table provided both in the church porch and in the church guide.

There was previously a horizontal sundial near the entrance porch to the church, but it is long gone. It may have predated the fine tower clock of 1849 by Thomas Joyce of nearby Whitchurch. This clock has a square face of Welsh slate; the same material was used for the plate of the millennium sundial. The dial was made by E.J. Edgerton and Son of Bradenheath, Whitchurch.

Much more is known about Emerson than Moody. William Emerson (1701-1782) from County Durham was a teacher before he became a mathematician and successful writer. He is said[2] to have turned down a Fellowship of the Royal Society and was regarded as eccentric, "his manner and address were extremely uncouth, and though he could talk well on almost any subject, he was very positive and impatient of contradiction".

His many books include *Dialling, or the Art of Drawing Dials on all Sorts of Planes Whatsoever (1770)*. This is now available as volume III in the series of digital facsimile reprints of rare works on dialling, sponsored by The North American Sundial Society. It is available via their website and is held in the BSS Library. Emerson also made sundials and is said[3] to have been a great champion of the sundial over the mechanical timepieces of his day. There is a 1739 vertical dial by him in stone and metal over the arch of the Bay Horse Inn in his hometown of Hurworth in Co. Durham (SRN 0830). It was said to have been in excellent condition when registered in 1991, but was reported to be "carrying some very strange lines" when visited by the BSS Northumbrian meeting in June 1999.[4] There may be more dials by him. Gatty[5] quotes an earlier writer (William Howitt in 'Visits to Remarkable Places') who attributed the many dials in Hurworth to William Emerson and described him as "a rough fellow but one of the first mathematicians of his age".

We can safely say that the Marbury millennium dial indirectly owes much to Emerson, a mathematician and diallist from two and a half centuries ago.

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