# The British Sundial Society

# BULLETIN

VOLUME 21(iv)
December 2009

BSS Bulletin 21(iv)

December 2009

# 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).

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***Front cover:*** *The BSS East Anglian Safari group at the Ipswich Marina with Tony Moss's Rotary Club dial. Left to right: Frank Evans, Mike Shaw, Rosie Evans, Marion Bromiley, Tony Belk, Claus Jensen, Tony Moss, David Hindle, Jim Marginson, David Payne, Andrew Ogden, Graham Stapleton, Doug Bateman, Geoff Parsons, Pat Sedgewick, Jack Bromiley, Mary Isaacs, Mike Cowham, Joan Payne, Val Cowham, Kathy Hindle, Liz Ogden, Mike Isaacs, Fred Sawyer. Photography: Mike Shaw & Tony Moss.*

***Back cover:*** *The stained glass dial in the church at Elmdon, Essex, also seen on the East Anglian tour. A panel below the dial records that the 17th-century glass was removed from the nearby St Dunstan's church, Wendon Lofts, when that church was "demolished in 1958". In fact, the shell of the building remains abandoned in a farmyard. Photo: Mike Isaacs.*

Designed by J. Davis. Printed by Henry Ling Ltd., Dorchester, 01305 251066

# BULLETIN

## OF THE BRITISH SUNDIAL SOCIETY

## ISDN 0958-4315

## VOLUME 21(iv) - December 2009

## CONTENTS



## EDITORIAL

The only theme evident in this issue of the *Bulletin* is catenary curves, with two articles (from Allan Mills and Rafael Soler) showing very different dials which make use of this deceptively simple shape. Some themes from recent issues—stolen dials, mass dials, new dials etc.—are continued inside. Otherwise, there is just the usual wide-ranging set of topics which make up our normal varied look at all aspects of dialling and which makes it such an eclectic area of study. Reports of the summer activities naturally get reported at this end of the year. Now is the time for indoor dialling activities, including designing and making new dials and researching old ones. I hope these will form the basis of future articles in the *Bulletin*.

Included with this issue you should find our annual card of key solar (and lunar!) data for the coming year. Once again, we are grateful to Fiona Vincent for preparing this.

A 'Happy Christmas' and sunny winter solstice to all members!

# THE PANTHEON AS A TIMEKEEPER


## ROBERT HANNAH


[The author is Professor of Classics at the University of Otago, NZ. He has a particular interest in archaeoastronomy—his book *Time In Antiquity* was reviewed in the September 2009 *Bulletin*. Ed.]

While spherical, conical and plane sundials were the most popular in Graeco-Roman antiquity, other types, or sub-types, existed. One of these is the 'roofed' spherical sundial, which captured the sunlight within a shadowy, concave interior.[1] A well-preserved example has been found in a Roman house in Baelo Claudia in southern Spain. A plaster cast of it is on display in the local museum there, while the original is now in the Museo Arqueologico Nacional in Madrid (Figs. 1a, b).

The stone block has been carved out into a hollow hemisphere, with a small aperture let into its top surface. Sunlight filtered through this hole on to the hemispherical surface inside. It is economical to cut away the front plane of the stone block, so that the interior of the dial captures only that part of the sky that is occupied by the sun in the course of the year. The interior incised lines represent the passage of the sun on four particular occasions in the year but utilising only three lines: the summer solstice at the bottom of the dial face, the winter solstice at the top, and the two equinoxes, using the same single line between the solstices. In addition, lines criss-cross with these tropical lines to represent the twelve unequal, seasonal hours of the day.


*Fig. 2. The Pantheon, Rome: the north entrance.*

I recently argued the case – first put forward by Oudet – for viewing the Pantheon in Rome (Fig. 2) in a fashion similar to the roofed sundial.[2] The building as it survives is a reconstruction, built from the foundations upwards, from soon after AD 110 under the emperor Trajan, and completed by his successor Hadrian by AD 128. The building's central axis is skewed just 5.5° from true north, so that the entrance faces almost directly north. A columned porch leads through a vestibule into a huge, shadowy interior, over 43 metres in height and as much in diameter. The building's form is essentially that of a sphere with its lower half transformed into a cylinder of the same radius (Fig. 3). Direct sunlight penetrates the interior only through a large,

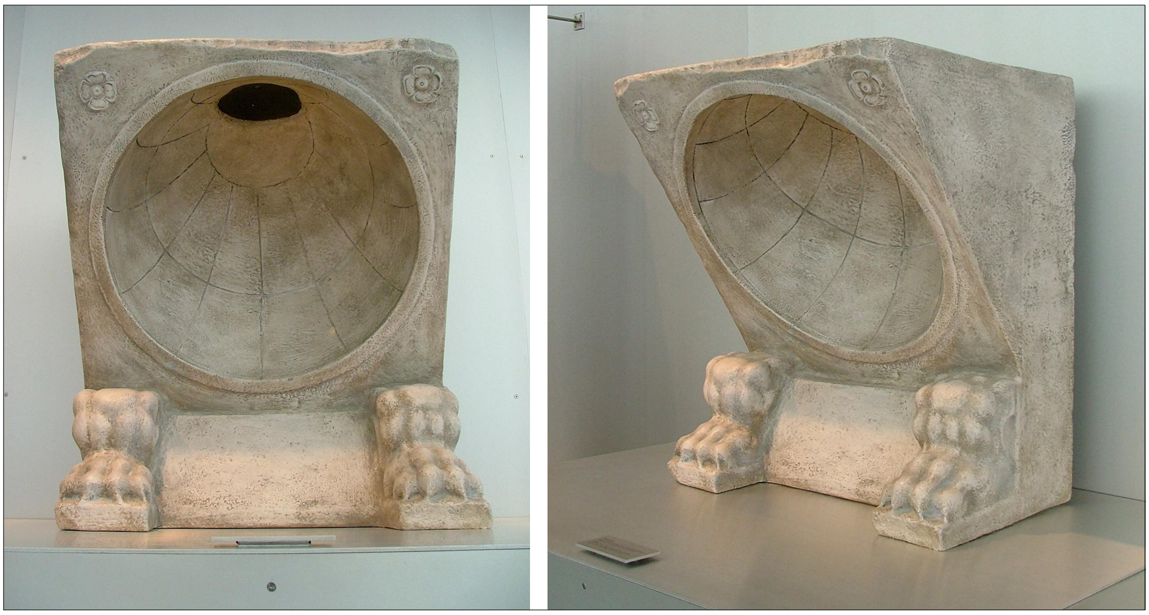


*Fig. 1a, b. Plaster cast of a roofed spherical sundial, Baelo Claudia, Spain.*

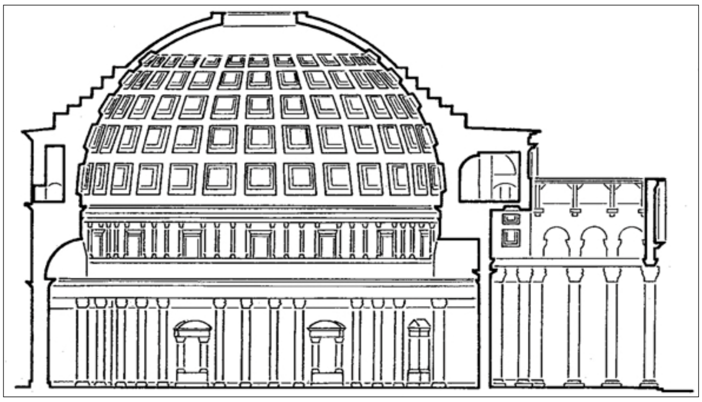


*Fig. 3. North-south section through the Pantheon (north is to the right).*

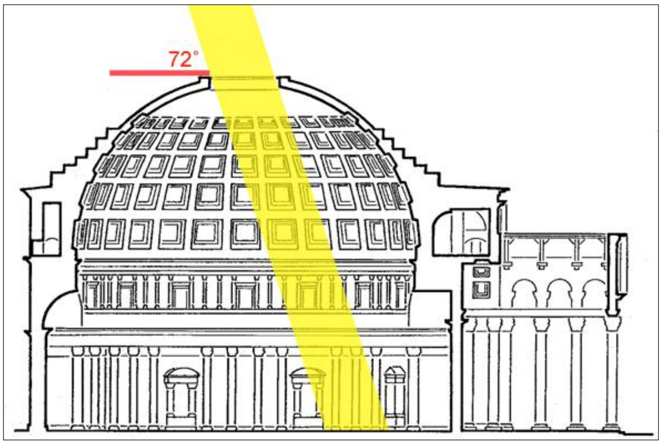
9 metre-wide *oculus* in the centre of the domed roof. Otherwise indirect sunlight can enter the building, but only through the large, north-facing doorway, when it is open.

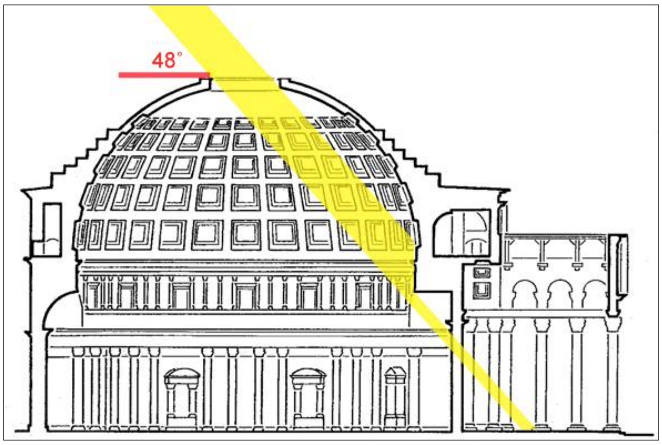
The fall of direct sunlight through the *oculus* into the essentially spherical building leads to the comparison with a roofed sundial. In that frame of mind, if we concentrate on the passage of the midday sun inside the Pantheon, we find that the sun spends six months of the year, in spring and summer, falling below the level of the dome (Fig. 4 shows this at the summer solstice). In autumn and winter, on the other hand, the sun spends six months lighting the surface of the dome (Fig. 5 illustrates this at the winter solstice).

The shift from one semester to the other is marked by the passage of the sun at the equinoxes in March and September. At this point the noontime sun shines partially just below the dome, passing through the grill over the entrance doorway and falling on the floor of the porch outside (Fig. 6). More significantly, however, the centre of this equinoctial, midday circle of sunlight lies on the interior architectural moulding, which marks the base of the dome (Fig. 7).

Whether formal similarity to a roofed sundial is deliberate or not, and whether this type of sundial was in some way an influence on the architecture of the Pantheon, remain speculative. Nevertheless, it must have been a deliberate choice of the architect that the light at the equinox should fall on the ceiling precisely at the base of the interior of the hemispherical dome, that is, on its equator, where the dome appears to end and the cylinder begins. The equator of the interior of the dome has been emphasised for some reason.

It seems to me that thinking of the Pantheon very much as a form of sundial that marked time may provide us with an explanation for this curious emphasis. What sort of time the building kept, though, is not obvious. On a practical level, it seems to make sense only at midday, and then only on certain occasions in the year, so that it has something of the same quality and facility as the Early Modern *meridiane* in Italian churches. They too rely on the midday sun entering the building, this time through a small hole in a vertical wall, so that the sunbeam falls on a line, carefully laid out in the floor so as to follow the local meridian. In these cases, the light and line combined to permit the measurement of the solar year.[3] No such line exists in the Pantheon to direct our attention to specific moments in the solar year.



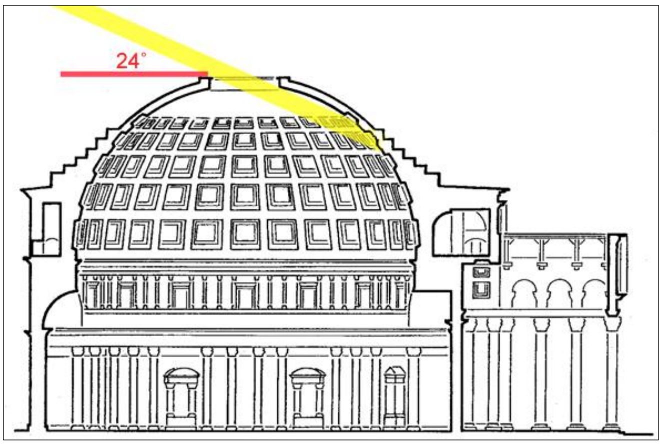




*Fig. 4 (top left). Section through the Pantheon, showing the fall of the noon sunlight at the summer solstice, when the sun is at altitude 72°.*

*Fig. 5.(bottom left).Section through the Pantheon, showing the fall of the noon sunlight at the winter solstice, when the sun is at altitude 24°.*

*Fig. 6 (above). Section through the Pantheon at the equinoxes, showing the fall of the noon sunlight, when the sun is at altitude 48°.*


*Fig. 8 (above). North-south section through the Octagonal Room of the Golden House of Nero in Rome (north is to the right), showing the fall of the noon sunlight on 13 October, when the sun is at altitude 41°.*

*Fig. 7 (left). Sunlight falling above the north entrance of the Pantheon at local noon at the autumn equinox (23 September 2005).*

At best it may be argued that the coffers of the ceiling directly above the doorway and the square-and-circle decoration of the interior marble floor in front of the doorway might serve a similar purpose. Rosenbusch and Sperling have illustrated this idea, which seems to show a tendency for the sun to fall on some of these decorative elements at the moment when it enters a new zodiacal sign.[4] If that is the case, then the sun in the Pantheon would provide a sort of calendar through the year. But to what end?

One particular day in this zodiacal cycle does seem to warrant further attention. Dr Giulio Magli (Milan Polytechnic) has pointed out to me that on 21 April the midday sun shines directly on to visitors to the Pantheon when they are standing in the open doorway, dramatically highlighting them. This day is of particular significance, not just because this was when the sun entered Taurus, but more because it is the traditional Birthday of Rome, a festival preserved from antiquity right through to the present day. Therefore it may also be the case that the apparition of the sunbeam through the grille above the doorway a month earlier at the spring equinox (when the sun entered Aries) would forewarn visitors to the Pantheon, or more particularly its priestly officials, that a month hence the sunbeam would shine directly on the visitor standing in the doorway. And it may be that when the building was officially commissioned in AD 128, the person expected to be standing in the open doorway was the emperor Hadrian himself. But once again, this is speculation. And whether other times of the year – most likely significant dates in the religious calendar – were highlighted in some fashion remains to be discovered. Dr Magli and I are currently collaborating on this problem.

All the same, there is some support for this line of argument in an earlier Imperial building in Rome. This is the palace known as the *Domus Aurea* or Golden House, which was built by the emperor Nero to replace the one that had been destroyed in the fire of AD 64. The new palace was oriented directly along the north-south meridian, so it has none of the slight deviation from this direction that the Pantheon has. At the centre of the complex lies the so-called Octagonal Room, a large, dome-ceilinged room that served perhaps as a banqueting hall but also as a vestibule through its eight doorways to other areas of the palace. From within this room, it turns out that a person standing at the threshold of any of the doorways of the Octagonal Room can see above the rim of the *oculus* in the dome only that part of the sky with an altitude of about 42° and above. Since the latitude of Rome is 41° 54′ this means – as Voisin first pointed out – that from the vantage point of the southern doorway the observer could just see the area of the sky occupied by the north celestial pole.[5] In effect, therefore, the position of the celestial pole defines the perimeter of the *oculus*, and we start to realise that this room's dimensions are governed by astronomy. Voisin has demonstrated other facets of the room are similarly a function of astronomical considerations.

In addition, and perhaps just as significantly, the sun is at about the same altitude above the horizon at noon on 13 October as the celestial pole. 13 October was the anniversary of Nero's accession as emperor in AD 54. At noon on that day the sun was just still visible to an observer standing on the threshold of the northern doorway of the room for the last time until it returned to sight in the first week of March (Fig. 8). In between times, the sunlight would fall above eye-level. So from this date of Nero's accession the sun would ascend up the ceiling and then return down again by March. That this is more than coincidence is suggested by the fact that Nero's personal association with the sun is well-attested elsewhere: in the Golden House complex there was a colossal statue of the Sun, which stood not far from the Octagonal Room (it gave its name eventually to the Colosseum, which was built on Nero's palace grounds later); and in Nero's later portraits on coins and in sculptures he wears the radiate crown usually associated with the Sun god. The emperor got as close to identification with the gods as was possible without being deified while he was still alive.

There are other potential astronomical features in this Octagonal Room. For the moment, though, there is, I hope, enough to indicate that the ideas about the Pantheon outlined here can be replicated and substantiated through careful analysis of other Roman structures. To call the Pantheon a sundial would be inaccurate in the present state of our knowledge, since it appears that no hours other than noon could be marked out in the building (although whether they needed to be is moot for the viewer in antiquity). It is better to regard the building as a timekeeper for certain periods of the year, which remain to be fully identified.

**REFERENCES**

1. P. Pattenden: 'Sundials in Cetius Faventinus', *Classical Quarterly,* 29, 203-12, (1979); S. L. Gibbs: *Greek and Roman Sundials*, Yale University Press, New Haven and London, (1976), 23-27, 194-218.
2. J-F. Oudet: 'Le Panthéon de Rome à la lumière de l'equinoxe', *Readings in Archaeoastronomy: papers presented at the international conference: Current Problems and Future of Archaeoastronomy held at the State Archaeological Museum in Warsaw, 15–16 November 1990*, State Archaeological Museum, Warsaw, (1992), 25–52; R. Hannah: *Time in Antiquity*, London, Routledge, (2009).
3. J. L. Heilbron: *The Sun in the Church: Cathedrals as Solar Observatories*, Cambridge, Mass. and London, Harvard University Press, (1999).
4. G. Sperling: *Das Pantheon in Rom: Abbild und Mass des Kosmos*, Neuried, Ars Una (1999), esp. 113.
5. J-L. Voisin: '*Exoriente Sole* (Suétone, *Ner*. 6). D'Alexandrie à la Domus Aurea', in *L'Urbs: Espace urbain et Histoire (1er siècle av. J.-C. – IIIe siècle ap. J.-C.),* École française de Rome, Rome, (1987), 509–41.

*Author's address:*
*Department of Classics, University of Otago*
*P.O. Box 56, Dunedin 9054*
*New Zealand*

# READERS' LETTERS

**Focussing Spheres**

In the Readers' Letters of the last *Bulletin*, Michael Lowne correctly pointed out that the focal length of a glass sphere is tiny compared to its diameter. However, technology has advanced! At the 2007 NASS Conference in Washington, Professor C. Julian Chen of the Columbia University Applied Physics faculty demonstrated his ingenious solution to overcome this problem.[1] He had taken a sphere of commercial lucite (= perspex) of around 10 cm diameter. Into this, he had drilled a hole of some 1 cm diameter and had then milled out and polished a spherical space in the centre of the lucite sphere – a manufacturing marvel, probably only possible with the availability of a university optics department workshop! The cavity had then been filled with a copper sulphate solution. The hole giving access to the central cavity had then been plugged with an aluminium shaft. Through this shaft another hole had been drilled and filled with silicone rubber. This marvellous combination lens had a long focal length of some three times the diameter of the original sphere – together with a substantial depth of field – making it perfect for a sundial. There were however additional advantages: (i) the copper sulphate solution absorbed the infrared from the sunlight so the image of the sun was cool blue, unlike a Campbell-Stokes sunshine recorder; (ii) the aluminium plug attached to the base of his dial acted as a radiator to prevent significant changes to the temperature of the copper sulphate, when the sun was shining. As a final flourish, by injecting sugar solution though the silicon rubber, Julian was able to focus his image precisely once his dial had been made. Julian's sundial using the sphere looked beautiful.

Since the NASS conference, Julian's invention has been protected by US patent 7,555,840 B2 of July 2009, which is assigned to the Trustees of Columbia University – who are looking for a commercial manufacturer. The patent describes a sundial of similar configuration to a cylindrical equatorial Ferguson solar chronometer, but with a lucite lens (similar but smaller than that described above) replacing Ferguson's shadow caster. Julian has confirmed to me that a focussed line of light could be generated in a similar way using Lucite tubing – which is easily available through suppliers who service the shop display industry. Such a lens could be used to advantage in any alidade type heliochronometer.

**REFERENCE**

1. J.C. Chen: 'Sundials using an omni-directional lens', *NASS Compendium* 14(4), pp.5-8 (Dec 2007).

*Kevin Karney*
*Monmouth*

**Continued on page 13**

# WILLIAM WATSON OF SEATON ROSS (1784 – 1857)

## East Riding Farmer, Land Surveyor, Map and Sundial Maker

MALCOLM YOUNG

[This article is based on one which first appeared in *Around the Wolds and North Yorkshire*, issue 102, pp.9-11, June/July 2005. Ed.]

William Watson was born at Seaton Ross in the East Riding of Yorkshire on Monday 17th May 1784. He was the fourth child of eleven to parents John and Sarah Watson. William's family were farmers and following in that tradition of his parents and grandparents before him, he spent much of his early life in farming. For many years William lived and farmed at Seaton Lodge and in the early part of the 19th century set about cleaning the land of heath and furze, a task that was successfully completed in 1834. From his book of memorandums William describes his early years in farming:

"Began to burn sods about the 14th May 1812" and between the 19th and 26th May 1812 he sowed "Oats Poland". He goes on to say "Work began on the building of the new farmhouse following enclosing of the common fields also in 1812."

His account of the 1812 harvest is as follows: "began harvest to mow oats (Poland) on the common on 19th September 1812 – got all down (except a few friesan oats) on the 26th September. Got all the corn in on the 24th October 1812. Had 173 quarters of oats in the first year about 4 quarters per acre".

Seaton Lodge was a tenanted farm like many others in Seaton Ross. The local landlord was Marmaduke Constable Maxwell of Everingham Hall & Park who leased the farm, sometimes known as Common Farm, of approximately 138 acres, to William Watson.

From his book of memorandums William describes himself and the farm in verse,

> "William Watson is my name
> and with my pen I print the same;
> I am a farmer, and they call
> The house I live in Dial Hall;
> Tis on the Common at Seaton Ross
> About it grows ling and moss;
> I have liv'd all my life at Seaton
> Which village is near Market Weighton;
> On January twelfth I write
> Eighteen Hundred and Twenty Eight"

During the period of his occupancy of the farm, William began to develop his interests in surveying and the making of sundials. Records suggest that he was very likely responsible for several early local field plans of Seaton Ross and Everingham.

*Dial Hall Farm*

His interest in sundials began by making a sundial for the wall of his own farmhouse. This eventually extended to four - a sundial on each wall of the house! William subsequently renamed the farm "Dial House Farm". His learning for sundial making is believed to have been self-taught and he developed a talent for the making of sundials in Seaton Ross and the surrounding neighbourhood, gaining considerable fame by this work. He also wrote poetry and in 1824 advertised the making of sundials in verse "If any Person wants a Dial, Apply to me I'll make a trial, I can make for any man, Upon a much improved plan, Five guineas is the price of one, and each mile distant Half a Crown; I make them to put on a wall, neat strong and true and that is all".

Three fine examples of Williams's sundials still exist in Seaton Ross namely; Dial Farm [1821, SRN 2223], St Edmunds Church [1825, SRN 0254] and Dial Cottage [1850, SRN 0253]. The sundial on Dial Cottage is reputed to be one of the largest in the country being 12 feet in diameter painted on the wall of the cottage.

In 1854, Forth's of Pocklington (printers and stationers) printed William's little book of directions entitled "Dialling Diagrams being examples of fifty-four degrees of latitude; with an explanation for their construction".

William also had another interest and hobby – surveying and map making. He would measure roads and walk miles with a tape measure and paid an assistant to help him – to hold the other end of the tape. He drew every house in Seaton Ross in 1848 listing the occupiers, the landlord and the distance in miles, yards and feet from Pocklington and the distance of each house from the roadside. This skill led to

*St Edmund's church, Seaton Ross.*

him being much in demand with most of his commissions coming from local landowners who required accurate and precise maps drawn of their land.

His local town plan of Seaton Ross June 1811 and his book of roads in Seaton Ross June 1828 are fine records of his early work in surveying and map making.

From William's early maps and drawings his skills developed into his two major works - the detailed town maps of Market Weighton (1848) and Pocklington (1855) The maps show front elevations of buildings with notes of their occupiers, trade and use. The success of the Market Weighton Town Map led to its display at the Great Exhibition at the Crystal Palace in 1851. There is a fine example of his town map of Market Weighton today in the lobby of the Londesborough Arms in Market Weighton, which is well worth a visit to fully appreciate the skill and talent of his surveying, drawing and draughtsmanship. There is also a fine example of his town plan of Pocklington in the local Arts Centre in Pocklington.

William left farming and Dial Hall Farm, Seaton Ross in 1838, with his brother George taking over the farm, and for most of the rest of his life spent time land surveying, map making, making sundials, writing poetry and writing daily accounts of general interest. He was an avid note keeper and diarist and made a comprehensive collection of epitaphs on gravestones in Seaton Ross and the surrounding area. He lived for a number of years in Pocklington and also spent time living in York, London and Market Weighton during the 1840s.

Music also formed an important part of his life - in November 1841 he advertised,

"William Watson would be glad to teach any children and young persons in music gratis at his house on Wednesday evenings and also on the same evenings to assist any full grown persons in singing the church tunes if he can get ten members of each class to be fixed a penny a night for being absent. The former class to commence at six o'clock the latter at seven and he would be glad to admit any persons as hearers if he can find room for them."

His work 'A gamut for Singing Schools' was published in February 1849, price one penny, when at this time William was living at 65 Northgate, Market Weighton.

He had numerous friends who helped him develop his book of penmanship being "autographs of William Watson and his friends". This was a book of poems, drawings and stories from well-known people in the area, such as John Smith from Bielby who was a local inventor and also a sundial maker. William and several of his circle of friends were members of the Mechanics Institute and Scientific Association. In February 1841 an article by William appeared in their Mechanics Magazine on how to construct a simple instrument for finding a meridian line.

William spent the latter part of his life collecting day-to-day information and writing in his journal everyday events. The book of memorandums records details of the weather on particular days, the observations of the night sky and miscellaneous information of day-to-day life in the village. His hobbies also extended into amateur astronomy and it is believed he had an observatory in Seaton Ross for his stargazing from which he drew star charts and constellations of the heavens.

William was a bachelor all his life. He died on Monday 4th December 1857 and is buried in St Edmunds churchyard at Seaton Ross. On his gravestone is the following quaint and appropriate epitaph,

> "At this church I so often with pleasure did call,
> That I made a sundial upon the church wall".


*William Watson's gravestone at St Edmund's church, Seaton Ross.*

Although William died nearly 150 years ago, his memory should live on for years to come. His skills as a sundial maker had a timeless quality relying only on solar power for their inspiration. His maps, plans and memorandums provide us with a vivid and unique record of life in Georgian and Victorian East Yorkshire.

He was a true 'sun' of Seaton Ross.

## ADDENDUM - William Watson's Work

### John Foad and John Davis

Watson is not unknown to the dialling world and his story has appeared before[1] (though not in the *Bulletin*). His two 'cottage' dials are unique and quite clearly the work of an enthusiastic but knowledgeable amateur who had no intention of following traditional forms. Both dials feature a protractor-like hour scale and a gnomon of boards which is erected on the noon line but then canted over with metal stays to allow for the wall declination. That on Dial Cottage appears to be accurate but the one on Dial Hall Farm seems to have suffered since its delineation as the origin of the gnomon has been moved to the west of its true position and some of the hour marks are missing or misplaced.

J. Davis

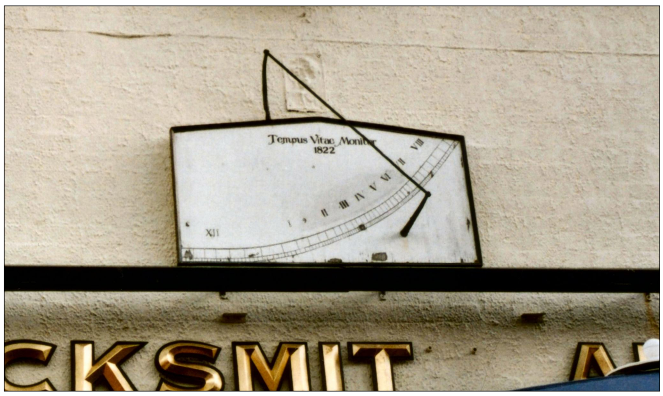
J. Davis

The 'canted-over gnomon' also features in a more restrained way on his small dial for St Edmund's church, Seaton Ross. This dial is signed "William Watson delin." and dated 1825. It appears to have been made of wood and, when seen on the BSS Conference tour in 2001, was in need of restoration as the wood has split. Still, it is remarkable for a wooden dial to have survived nearly two centuries of Yorkshire weather. It features declination lines for the solstices and equinoxes with a very small nodus on the style edge. The motto, "Disce dies numerare tuos" can be translated as *Learn to number your days*.

Although Watson is said to have made dials for a number of houses in his neighbourhood, we know of only one other which survives. This is a large affair on the west wall of the Blacksmith's Arms at Holme-on-Spalding Moor, just three miles from Seaton Ross. The dial carries the date, 1822, and as usual a cheerful motto, in this case 'Tempus Vitae Monitor', or *Time, the warning of Life*. There is no signature, but by tradition it is by Watson, and the style, with only short hour marks and a wide-spreading narrow chapter ring, echoes on a smaller scale his two large cottage dials.

A surveyor and map-maker in the eighteenth century needed mathematical aptitude and artistic flair so it is not surprising that many surveyors also designed and made sundials. Watson clearly understood his art and towards the end of his life he published a small booklet describing how

J. Davis




A. Cook

*Top left: Dial Cottage, SRN 0253. Top right: St Edmund's church, Seaton Ross, SRN 0254. Bottom left: Dial Hall Farm, SRN 2223. Bottom right: Blacksmith's Arms, SRN 2904.*

to construct each of the basic forms. This was *Dialling Diagrams, being examples of fifty-four degrees of latitude; with an explanation for their construction.* A copy is in the British Library, bound in with other titles.[2] It features only 11 small pages and a large fold-out engraving but it did reach a second edition at a price of 1 shilling. The diagram is a fairly simple one showing how to draw dials on any plane geometrically, starting with a basic equatorial dial. This is clearly the method which he used of designing his own "sun-dials". His very individual approach is still apparent. Watson describes various types of time, stating that local apparent (solar) time has recently started to be replaced by Greenwich or Railway time. But clearly he has little use for this. The same can be said for mean time: he gives a form of equation of time table which gives the correction, in minutes and seconds, which must be progressively applied to the hands of a clock on a weekly basis in order to keep it in step with a sundial (all diallists must applaud this method!)

The final section of the booklet is entitled "Dialling by Logarithmic Calculation" and the author admits that he has extracted it from *Hall's Encyclopedia*. In fact, it does not make use of logarithms at all, only the standard trigonometrical function – obviously, this was the limit of his mathematical capacities.

Whatever the limitations of Watson's education, dial makers of today would be very pleased to think their work will last as long.

**REFERENCE**


1. C. Daniel: 'No Poet!', The Sundial Page, Clocks, 16/11 (April 1994).
2. W. Watson: *Dialling Diagrams, being examples of fifty-four degrees of latitude; with an explanation for their construction,* in Tracts on Industrial Art 1845-54, BL shelfmark 1400.B.82.


# Postcard Potpourri 14 – The Butter Cross, Witney, Oxfordshire


**Peter Ransom**


Back to the UK after a couple of postcard excursions further afield recently. This postcard, featuring the dial and clock on the Buttercross at Witney, Oxon., intrigues me because it is theoretically possible to find the day when the photograph was taken!

Close inspection shows the time on the clock to be 12 noon (the hands line up on top of each other) and the shadow on the dial shows 11:00am. This difference of 1 hour tells us that the picture was taken during British Summer Time. The longitude of the dial at Witney is 1° 29' W, so 6 minutes would need to be added to the local solar time to obtain GMT. We can therefore assume that the picture was taken on a day when the equation of time indicates the dial is 6 minutes fast. This would be December 13 or September 18, only the latter falling within BST. It is with a fair degree of confidence than that the picture was taken on September 18! The postcard was sent to a Mrs Fowler of Woking on 31 August 1955.

The BSS Register dates the dial as 1683 with maker G Blake. William Blake, a draper and wool merchant, added the clock to the tower at that date. The Blakes were wool merchants in the Witney area in the 17th century and funded three schools in Witney, so they must have prospered.


*pransom@btinternet.com*


# A TRIBUTE TO ROBERT HOOKE

## ALLAN MILLS

Robert Hooke (1635-1703) is now generally seen as a wide-ranging genius in applied science and technology, although recognition and honours tended to go to others during his lifetime and for many years thereafter.[1] Memorial stones have now been placed in Westminster Abbey and at the Monument, but do not illustrate the breadth and utility of his endeavours. A selection might be:

**Hooke's Law**

Hooke's name is probably most widely associated with the quantification and application of elasticity. This research was published in 1678 in a short work entitled *Lectures de Potentia Restitutiva, or, Of Springs,*[2] in which he formally proposed the rule: 'The extension of any spring is proportional to the tension upon it'. This applies to any elastic body provided it is not stressed above a certain limit, and has become known as Hooke's law. It is the principle behind the spring balance (Fig. 1).

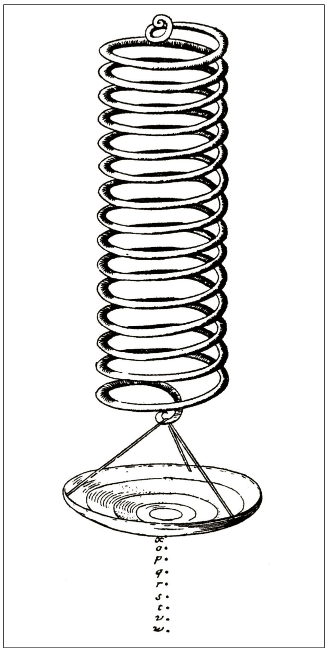


*Fig. 1. Hooke's investigation of the elasticity of springs led to both his law and the 'spring balance'.*

Hooke claims that he had in fact discovered the relationship some eighteen years previously (i.e. 1660), but had deferred publication as he had 'some particular applications' in mind – almost certainly to timekeeping (see below). This secrecy and procrastination is a characteristic of Hooke, but nevertheless the absence of a formal claim obviously worried him because at the end of his *Description of Helioscopes*[3] (1676) he took the opportunity of appending the anagram *ceiiinosssttuu.* In *Of Springs* he deciphers this into the Latin phrase 'Ut tensio sic vis'.[2, 4]

**The Balance Spring and Mechanical Timekeeping**

It is sad that computer simulation of practical scientific experiments is nowadays considered a virtue, for anyone using the apparatus of Fig. 1 to repeat Hooke's work will soon make an additional discovery commonly omitted from the ordinary educational program – namely that if a weight is added a little roughly to the scalepan, then for a short period both weight and spring will bob up-and-down in a rather hypnotic manner! It has already been established that the instantaneous restoring force is proportional to the displacement and this is exactly the requirement for simple harmonic motion. A characteristic of this is that the period of each oscillation is independent of its amplitude. This may be verified by timing a suitable number of decaying oscillations with a stopwatch.

Hooke was an acute observer and would surely have noticed this behaviour when conducting his research on the (static) extension vs. load of helical springs. At that time a reliable portable method of timekeeping was being actively sought for the purpose of determining longitude at sea. A pendulum executing a very short swing closely approaches a simple harmonic oscillator, but suffers 'circular error' when its amplitude becomes appreciable. It is also of an awkward size and very susceptible to disturbance caused by rocking and/or translation of its support. The period of a weight oscillating on a spring is less susceptible to these errors, particularly if it is modified to consist of alternating rotations about a central pivot. I am of the opinion that Hooke might well have hoped that fame and fortune would follow the invention of a spring-controlled timekeeper, so followed his ingrained tendency to delay publication of any relevant material. Michael Wright has come to a similar conclusion.[5] But Hooke was soon to be extremely busy surveying London after the Great Fire of 1666, so never properly developed the idea.[6] The sad story of how Huygens came to be awarded sole credit for the application of a spiral spring to the balance wheel of a clock has been related by Jardine[1] and others.

**Sundials**

Hooke was interested in timekeeping even as a boy,[1] and in 1667 (as Curator of Experiments to the Royal Society) demonstrated to the Fellows a simple device for delineating sundials of all types.[7,8] By 1675 this had been refined into an improved draughting instrument and mechanical sundial-clock.[9] Nowadays it is more likely to be recognized as the 'universal joint', two of which are utilised in the transmission of almost every motor vehicle.[10]

**The Catenary**

A catenary is the curve assumed by a perfectly flexible string or cable hanging freely between two supports and subject only to gravity. In fact, real strings and cables tend to be rather stiff in proportion to their mass, so a machine-made chain is considered to give a better representation. The chain takes up a curve where each link is in equilibrium between its weight (acting vertically downwards at its centre of gravity) and the tensional forces exerted by the links above and below it (Fig. 2). It is in equilibrium: disturb it and it soon returns to the stable position of rest. The

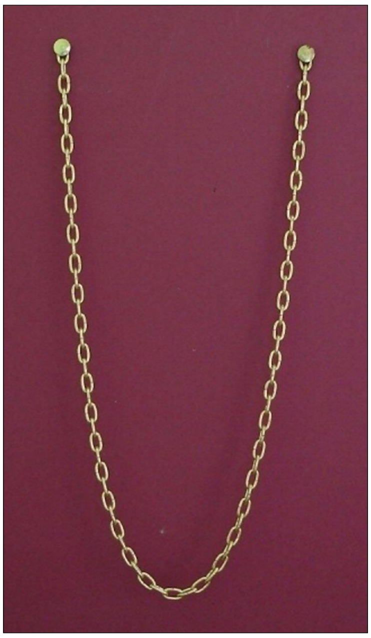


*Fig. 2. A chain hanging freely in equilibrium displays a catenary curve.*

*Fig. 3. Inversion of Fig. 2 shows the theoretical 'catenary arch'.*

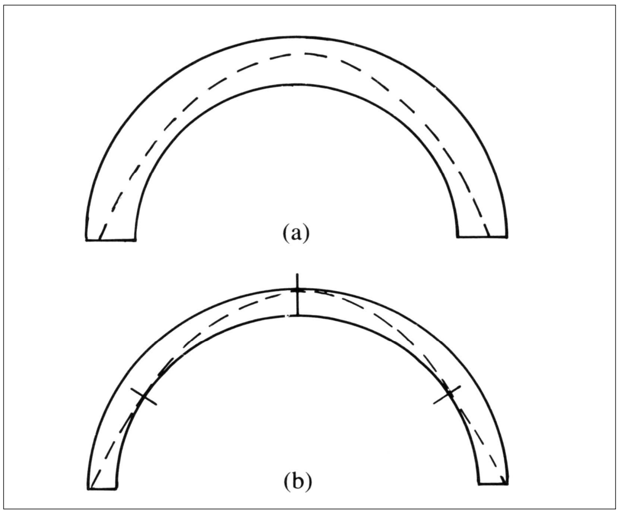



*Fig. 4. Stresses in the semicircular arch according to Heyman.[14] In (a) it is thick enough to comfortably contain the thrust line catenary; but (b) has no such margin of safety.*

curve is not a parabola – although sometimes close to it – but an elegant shape requiring sophisticated calculus for an accurate mathematical description.

Now imagine Fig. 2 to be inverted, giving Fig. 3. We now have a good-looking arch, but a real hanging chain can only be inverted if it is 'solidified' by dipping in liquid plaster. Even then, very gentle handling is essential if the model is not to collapse under feeble forces. Yet Robert Hooke's powerful intuition into mechanical matters enabled him to realise that the resolved compressional forces (the 'thrust line') within a masonry arch should optimally follow an inverted catenary. He claimed his discovery orally at a meeting of the Royal Society in December 1670,[11] saying only that he had found "a true mathematical and mechanical form of all manner of Arches for Building, with the true [a]butment necessary to each of them". He did not so much as mention the word 'catenary', but promised to reveal all in due course. He never did; his claim was premature in that neither he nor anyone else at that time had the mathematical tools to fully describe the catenary curve. Inevitably, nothing was published, although Hooke claimed that he had demonstrated the matter to Oldenburg and Wren.[12] (It is known that Wren valued Hooke's advice when designing St Paul's – and the outermost dome appears to be a catenary of revolution!) Hooke hoped to reserve his priority by the same device as used with his law of elasticity – the Latin anagram. In the same 1675 appendix to his *Description of Helioscopes*[3] he stated the desired curve was given by *abccc. . . .* to 57 letters. Right up to his death in 1703 he never revealed the solution, and not until 1705 did his literary executor Richard Waller[13] publish a decipherment he found in Hooke's papers: *Ut pendet continuum flexile, sic stabit contiguum rigidum inversum*; 'As hangs a flexible cable so, inverted, stand the touching pieces of an arch'.

In view of the impossibility of inverting a hanging chain, this would have been hard for architects to accept, particularly in the absence of mathematical proof. However, in subsequent centuries structural engineers have shown that Hooke's intuition was correct: the resolved forces within a real masonry arch should, for maximum safety and stability, follow an inverted catenary that never leaves the inner or outer boundaries of the stone.[14] (Fig. 4) This, and the related mechanics of domes,[15] is probably the least generally known of Hooke's pioneering advances.

**A Sculptural Memorial**

It seemed to me that nested inverted catenaries would define a graceful arch demonstrating Hooke's principles, and at the same time support a sundial, a clock, and a representation of a spring. A preliminary model has been made by transferring the curves of suitable lengths of hanging chain to hardboard and cutting them out. These arches were then fixed together with wooden blocks of diminishing size to give a tapering section. Cardboard strips were secured aound both edges with white glue. When dry, the model was screwed to a baseboard of medium density fibreboard and painted with white emulsion paint. A circular wooden disc was positioned to hold a sundial and a clock. A view from the north (Fig. 5) shows the latter, the view from the south (Fig. 6) disclosing the direct south vertical dial. The helical spring symbolizing Hooke's law is visible from most directions.

It is hoped that site and finance will be found to turn the model into reality. Although the final structure should theoretically be in equilibrium, this neglects extraneous factors such as wind loading. Even greater stresses are likely to be encountered during construction and erection, so stone (which has limited resistance to tension and torsion) is unsuitable: it is likely to fracture at the apex. Commonsense dictates a material that can withstand both compressional and tensional forces, such as structural steel[16] or reinforced

Fig. 5. Concept model from the north, showing the clock and symbolic helical spring.

Fig. 6. Concept model from the south, showing the direct south vertical dial.

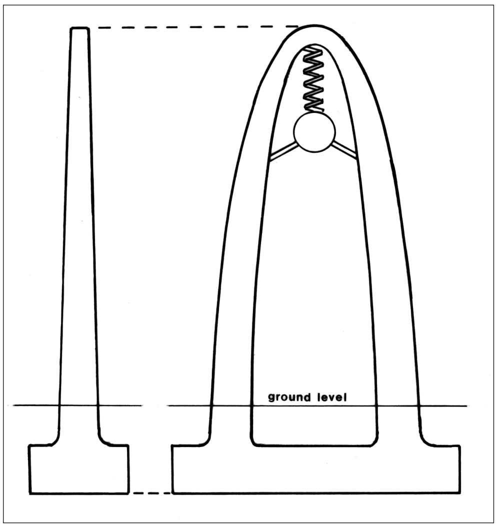



*Fig. 7. Outline cross-sections of the proposed Hooke memorial.*

concrete, with perhaps fibreglass or timber at smaller sizes. Present thinking is a white (aluminous) concrete with embedded steel reinforcement, preferably stainless at the apex where the metal is near the surface. The legs of the arch should be tied together below ground level in a manner that also provides a massive foundation (Fig. 7).

**Catenary Sundials**

The proposed memorial employs Hooke's inverted catenary arch as the supporting structure, the sundial itself being a conventional vertical type with a triangular gnomon sloping up towards the celestial pole. However, sundials with real hanging chain catenaries as part of their dial furniture have been designed by the Spanish engineer and mathematician Rafael Soler Gayá. They indicate time of year from the intersection of its shadow with that thrown by a linear polar gnomon. His computer program[17] enables such a straight line to be combined with almost any chosen curve, and he has designed many beautiful dials incorporating circle, parabola and catenary.[18] Examples of the latter may be seen at Genk Sundial Park[18,19] and in Majorca.[20] [See also p.34 of this issue. Ed.]

**REFERENCES**


1. Lisa Jardine: *The Curious Life of Robert Hooke: The Man Who Measured London,* Harper Perennial (2003).
2. Robert Hooke: *Lectures de Potentia Restitutiva, or, Of Springs, Explaining the Power of Springing Bodies, to which are added Some Collections*, John Martyn, London, (1678). Reproduced in R.T. Gunter (ed.) 'The Cutlerian Lectures of Robert Hooke', *Early Science in Oxford*, Vol. 8 (Oxford, 1931).
3. Robert Hooke: *A Description of Helioscopes*, Cutlerian Lecture No.3, London (1675). Reproduced in R.T. Gunter (ed.) 'The Cutlerian Lectures of Robert Hooke', *Early Science in Oxford*, Vol.7 (Oxford, 1930) pp.436-38.
4. Allan A. Mills: *Springs, and Hooke's Mechanical Genius, Ch.* 8 in Paul Kent and Allan Chapman (eds.) *Robert Hooke and the English Renaissance,* Gracewing (2005).
5. Michael Wright: *Robert Hooke's Longitude Timekeeper, Ch.* 3 in Michael Hunter and Simon Schaffer (eds.) *Robert Hooke: New Studies,* Boydell Press (1989).
6. A.R. Hall: 'Horology and criticism', *Studia Copernicana*, **16**, pp.261-68 (1978).
7. T. Birch: *History of the Royal Society,* Vol. 2, pp.158-60, London (1756-57)
8. Register of the Royal Society, Vol.II, p.310.
9. Allan A. Mills: 'Hooke's joint, sundials and the sundial-clock', *BSS Bull* 18(iv) pp.167-71, (2006).
10. Allan A. Mills: 'Robert Hooke's 'universal joint' and its application to sundials and the sundial-clock', *Notes and Records Royal Soc.* **61,** 219-236 (2007).
11. R.T. Gunther: *Early Science in Oxford* (Oxford, 1930). Vol. VI, Part I: The Life and Work of Robert Hooke. Records of weekly meetings of the Royal Society for Dec 8 and Dec 15 1670.
12. *ibid*. Record of meetings on Jan 12 and 19 1671.
13. Richard Waller: *The Posthumous Works of Robert Hooke,* London, 1705. Introduction: 'The Life of Robert Hooke' p.xxi. (Johnson Reprint Corp. N.Y. 1969).
14. Jacques Heyman: *The Stone Skeleton: Structural Engineering of Masonry Architecture,* (C.U.P 1995).
15. Jacques Heyman: 'Hooke's cubico-parabolical conoid', *Notes and Records Royal Soc.* **52** 39-50 (1998).
16. See the 'Gateway Arch' of St Louis, Missouri, on Google. See also *BSS Bull* 20(iv) p.178 (Dec 2008) for a picture. But you won't find any mention of Hooke!
17. Rafael Soler Gayá: 'An application of the general analytical method for bifilar sundial design', *NASS Compendium,* **13(**4), 20-25 (2006).
18. Claude Hartman: 'Bifilar sundials of Rafael Soler Gayá' *The Compendium* **8(**4), 4-6 (2001).
19. Allan Mills: 'International Sundial Symposium, Genk, 1998', *BSS Bulletin,* **98.**3 24-27 (1998).
20. Rafael Soler Gayá: 'Rellotages del sol bifiliars amb catenària', *La Busca de Paper,* 46, 1-6 and back cover, (May-Aug 2003).

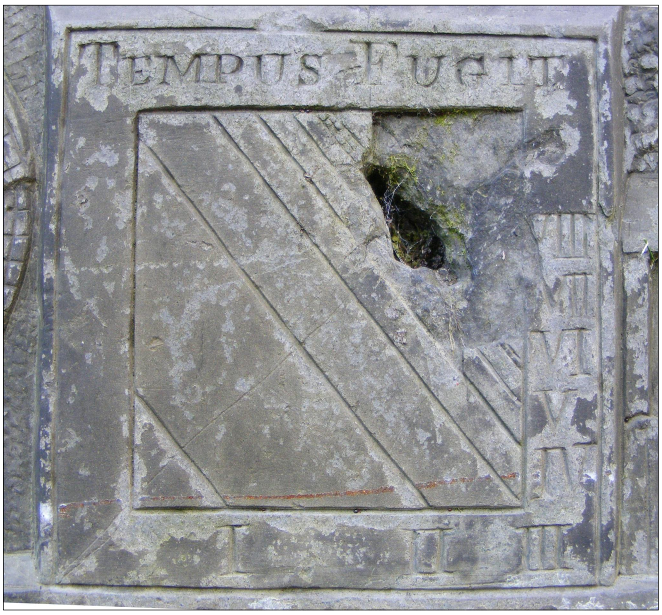


*Author's address:*
*31 Thatch Meadow Drive,*
*Market Harborough*
*Leicester LE16 7XH*
*e-mail: aa.mills@hotmail.co.uk*

# READERS' LETTERS (continued)

**A Question Answered**

In the June issue of the *Bulletin,* there was an article by Roger Bowling on the tombstone of Samuel Turner in the churchyard of St Mary in Arden in Market Harborough. I had just been on a local history tour of the area and had come across the tombstone by chance (I should have looked for dials in the *Register*), so was not prepared for the sighting.




The top of the stone shows Turner's accomplishments. The extreme left is a survey of Stoney Farm where he lived in Harrington in Northamptonshire. Railway enthusiasts know this village today for the longest and largest brick-built railway viaduct in England. Next are his dialling tools, then the dial. It looks as if the gnomon was iron: in rusting it has enlarged the fixing slot. Then there is a pastoral scene of sheep, in keeping with his early life as a shepherd. Finally, at the extreme right, is a picture of the man himself sitting at his easel. One of the iron pegs can also be seen: perhaps the council should be approached to remove them to prevent any further damage to the stone. It looks as if the peg predates the move of the stone to its present position in 1970.

The answer to the question, "Did he sculpt his own tombstone?" can be seen down at the bottom right of the stone. Here is engraved "S Turner Sculp^t^. 1782." A remarkable and talented man.

*Colin Davis,*
*Northampton*

## BSS Visit to the Royal Greenwich Observatory

### 19 October 2009

Our Chairman, Chris Daniel, was once the curator of sundials at the National Maritime Museum, Greenwich, and so was able to organise a tour of the collection for a group of members recently. We were shown around by the current head curator, Dr Gloria Clifton (in the white gloves in the photo), herself a considerable expert on early mathematical instrument makers. As well as seeing the normal exhibits, including Flamsteed's Octagon Room with several Tompion clocks, and the famous Harrison chronometers, we were able to go to the storerooms and handle a number of superb dials. Amongst these was a horizontal dial by Elias Allen, a silver Butterfield dial by John Rowley, an ivory diptych dial and a dipleidoscope. We were even tested with a compendium and astrolabe signed Christopher

Schissler but an early fake. There is much to see at Greenwich and it is all free! *JD*

# NEW DIALS

### St Petersburg

This sundial is called ‘The Lady with the dog’. The mistress of the manor in Pargolovo, near to St Petersburg, is a big fan of the work of the well-known Russian writer Anton Chekhov (1860-1904). She commissioned the dial designed on a theme of the sad story of Chekhov about love – *The Lady with the [little] dog*, published in 1899. The dial shows summertime: it is carved from felzit – a stone close to marble from Armenia, and the gnomon is cut from stainless steel and covered by a black varnish. The sundial was co-designed with Andrey Evdokov. It has had several sites – in a flower bed, on a column, and now they are established on the pedestal near to the entrance to the house. The sad silhouette of the lady welcomes visitors, reminding them about the transience of time and love.

*Valery Dmitriev*

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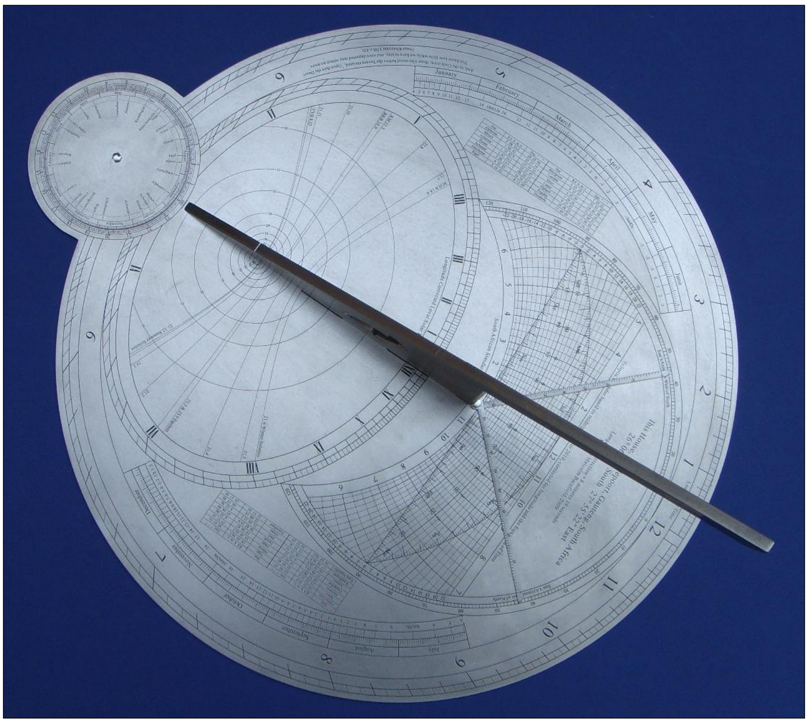
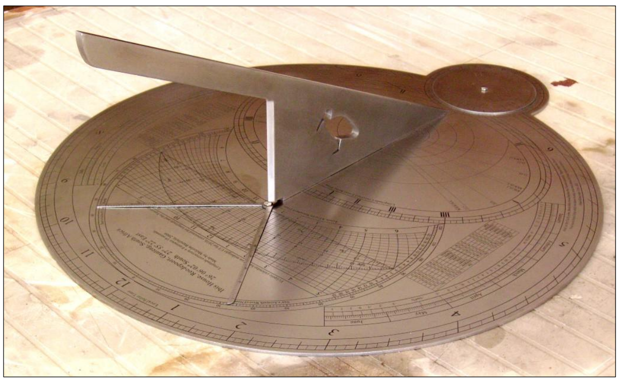
### Roodepoort, Gauteng, S Africa



This is a ‘triple horizontal dial’, made in stainless steel by Malcolm Barnfield. It is designed for his own garden at Ibis House—the gnomon is pierced with the local ibis *Bostrychia Hagedash.* It is 520 mm in diameter and is for a latitude of 26° 06' 02" South, making it only the Oughtred dial known in that hemisphere. The third element, added to the standard Oughtred double horizontal design, is the elliptically-shaped face which fills an otherwise empty area of the dial plate caused by the low latitude. It is delineated for longitude-corrected solar time and has declination lines for family anniversaries.

Another unusual feature is that the ecliptic arcs of the stereographic grid are marked out with calendar dates, carefully positioned so that it allows the grid to read Civil time, i.e. corrected for longitude and EoT (albeit at the expense of not giving an accurate reading of the sun’s declination). The calculations for this were made by James Morrison.



To the north of the gnomon (top left in the picture above!) is a nocturnal which allows time-telling by the stars. Of course, the Southern Cross is amongst the stars featured.

The dial is modern throughout, including not just the modern material but also in the Arabic numerals, general layout and choice of the current epoch for the astronomical data. In this, it neatly mirrors another triple horizontal dial (see *NASS Compendium* December 2008) made in bronze for California, an equally low latitude but in the northern hemisphere.

# DIALLING FROM 'THE LADIES' DIARY'

**PETER RANSOM**

*The Ladies' Diary* began in the year 1704. This yearly almanac contained "… New Improvements in ARTS and SCIENCES, and many entertaining PARTICULARS: DESIGNED FOR THE USE AND DIVERSION OF THE FAIR SEX", though female contributors were prominent by their absence.


THE LADIES' DIARY:
OR,
WOMAN'S ALMANACK,
FOR THE YEAR OF OUR LORD 1810;
*Being the Second after Bissextile, or Leap Year.*
Containing New Improvements in ARTS and SCIENCES, and many entertaining PARTICULARS:
DESIGNED FOR THE USE AND DIVERSION OF THE
FAIR SEX.
*The Hundred-&-seventh Almanack published of this Kind.*

Virtue and Sense, with Female Softne
(All that subdues and captivates Mank
In Britain's matchless Fair resplendent shi
They rule Love's Empire by a Right Divine
Justly their Charms th' astonish'd W
Whom Royal Charlotte's bright example fires.



LONDON:
*PRINTED FOR THE COMPANY OF STATIONERS,*
BY J. ADLARD, DUKE-STREET, SMITHFIELD;
And sold by G. GREENHILL, Treasurer, at their Hall, Ludgate-Street.
[*Price, ſtitched, One Shilling and Ten Pence.*]

*Fig. 1. The Ladies' Diary for 1810.*

Recently, I was fortunate to acquire volumes 3 and 4 of *The Mathematical Questions, proposed in The Ladies' Diary* by Thomas Leybourn in 1817.[1] There two volumes are in remarkably good condition and I was delighted to obtain them since to purchase every volume of The Ladies' Diary would have cost a small fortune and my interest is primarily in the mathematical questions therein. In 1773 Dr Charles Hutton, the then editor of *The Ladies' Diary* and Emeritus Professor of Mathematics in the Royal Military Academy at Woolwich, republished everything either curious or valuable that had appeared in it. Thomas Leybourn, with "… a view to gratify such as are anxious to possess what may be considered as a curious, and valuable monument, of the Mathematical genius of the English nation," published the four volumes in 1817 bringing all the mathematical questions and solutions to 1816 together "… but the Enigma, Rebuses, and such other parts of the work as have no reference to Mathematics are omitted."

As well as 1297 numbered mathematical questions and their solutions, there are also the prize questions published each year. With each question the setter's name and sometimes their town is given and the same occurs with the solutions. This is a most valuable reference to the researcher into major and minor mathematical practitioners (as well as diallists); yet to wade through four volumes of over 400 pages can be quite intimidating. To my delight, there is an index "of the names of the persons who have proposed and answered the questions" with the question number. There is another index "referring the questions to the different branches of mathematics". Imagine my joy when I found that one of the latter entries refers to Gnomonics. There are 19 entries, which includes one prize question for 1743. This represents about 1.5% of the total number of questions.

With the permission of the editor of our august *Bulletin*, it is my intention to reproduce one of the dialling problems in this and each of the subsequent issues with their solution for the delight and erudition of readers. I will happily receive solutions from readers in advance of the solution being published to compare them with the original solutions, but laying no claim to being an expert in the solutions of these problems, I cannot enter into any correspondence on the validity of the published, or their, solutions.

To whet the appetite, the first two problems and the solution to one of them appear in this edition of the *Bulletin.* I would also be most interested to obtain a copy of volumes 1 and 2 of Leybourn's book so that these dialling problems can be printed in their entirety. The problems that occur in volume 1 have been obtained by downloading a copy of this volume from Google Books – a superb source of early dialling literature.

Here is question 78, by Mr G. Hare, published in 1720.

IV. QUESTION 78, *by Mr.* G. Hare.

**In latitude 53° north, a plane declines north-west 43° 15′ and reclines backwards 49° 20′; now suppose this plane to be carried parallel to itself along a meridian till it becomes upright; it is then required to describe a sun dial upon it?**

*Fig. 2. Question 78 from Leybourn's book.[1]*

The solution to this question and the underlying calculations was provided by Mr Hawney and others (Fig. 3 ).

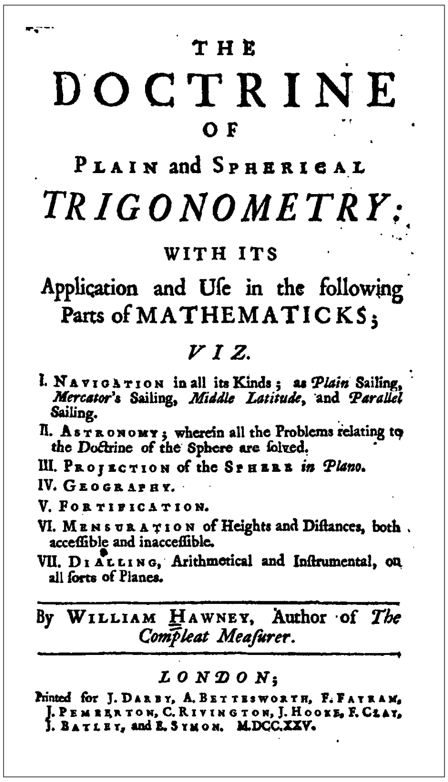
*Answered by Mr.* Hawney, *Mr.* Failes, *Mr.* White, *Mr.* Williams, *and Mr.* Finch.

| | ° | ′ |
|---|---|---|
| The dial's new latitude south.. | 4 | 58 |
| New declination west ........ | 26 | 31 |
| Dist. of substile and merid..... | 78 | 56 |
| The stile's height............ | 63 | 3 |
| Distance of merid. and hor..... | 54 | 29 |
| Plane's differen. longit. ...... | 80 | 9 |

| h. | equin. ° | equin. ′ | h. dist. ° | h. dist. ′ |
|---|---|---|---|---|
| VIII | 140 | 9 | 143 | 12 |
| IX | 125 | 9 | 128 | 20 |
| X | 110 | 9 | 112 | 24 |
| XI | 93 | 9 | 84 | 18 |
| XII | 80 | 9 | 78 | 56 |
| I | 65 | 9 | 62 | 33 |
| II | 50 | 9 | 46 | 58 |
| III | 35 | 9 | 32 | 7 |
| IIII | 20 | 9 | 18 | 8 |
| V | 5 | 9 | 4 | 36 |
| | Sub— | | Stile | E. |
| VI | 9 | 51 | 8 | 48 |
| VII | 24 | 51 | 22 | 26 |
| VIII | 39 | 51 | 36 | 38 |

*Fig. 3. Here is the answer to Q.78 showing the names of the people who solved the problem.[1]*

William Hawney was a Kent mathematics teacher who authored two books on mathematics, one called *The Compleat Measurer* in 1717 that was still being published in 1846 as well as five American editions[6] and the other, shown here, containing his dialling work in 1725.[2]



THE

DOCTRINE

OF

PLAIN and SPHERICAL

*TRIGONOMETRY*:

WITH ITS

Application and Uſe in the following Parts of MATHEMATICKS;

*VIZ.*

I. NAVIGATION in all its Kinds; as *Plain* Sailing, *Mercator's* Sailing, *Middle Latitude*, and *Parallel* Sailing.

II. ASTRONOMY; wherein all the Problems relating to the Doctrine of the Sphere are ſolved.

III. PROJECTION of the SPHERE *in Plano*.

IV. GEOGRAPHY.

V. FORTIFICATION.

VI. MENSURATION of Heights and Diſtances, both acceſſible and inacceſſible.

VII. DIALLING, Arithmetical and Inſtrumental, on all ſorts of Planes.

By WILLIAM HAWNEY, Author of *The Compleat Meaſurer*.

*LONDON*;

Printed for J. DARBY, A. BETTESWORTH, F. FAYRAM, J. PEMBERTON, C. RIVINGTON, J. HOOKE, F. CLAY, J. BATLEY, and E. SYMON. MDCC.XXV.

*Fig. 4. The title page of William Hawney's book of 1725.*[2]

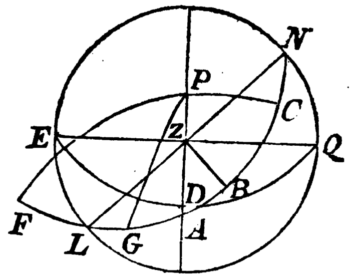
Is Mr Finch the Philomath, John Finch, land surveyor and schoolmaster of Norwich, then Worcester, who operated between 1695 and 1729?[3] Or is it the Jn° Finch whose dial shown here is dated 1723 in Wolviston, Co. Durham?[4,5] Or are they one and the same? The index of Leybourn's book confers the forename of John on this solver.


*Fig. 5. The dial by Finch in Wolviston, Co. Durham.*

The worlds of dialling and mathematics overlap much and the deeper one searches, the more one finds, to the detriment of time but enlightenment of knowledge. Leybourn also shows the construction of the solution for the benefit of readers (Fig. 6).

**Solution.**

***Construction.*** Let ELQN be the horizon and Z the zenith of the place in lat. 53°, P the pole, LZN the position of the plane making the angle EZL = 43° 15′, EZQ being the prime vertical, PZDA the meridian, and EDQ the equinoctial. Perpendicular to LN draw ZB equal to 49° 20′ the reclination, and draw the great circle LABN, which will be the plane of the dial, A being the new place required; also draw the great circle or meridian CPF perpendicular to NALF.




Then DA will be equal to the new latitude south; in which the plane will be upright, the angle ZAB the co-declination, AF the distance of the substile from the meridian, FC the stile's height, AL the distance of the meridian and horizon, and the angle APF the plane's difference of longitude.

*Fig. 6. The construction of the answer to Q.78 as given in Leybourn's book.*[1]

There is also a calculated solution:

**Calculation.**

1. In the right-angled triangle ABZ, given ZB the reclination = 49° 20′, and ∠AZB the declination = 43° 15′. Then,
As cos. ∠AZB = 43° 15′ : radius :: tang. ZB = 49° 20′ : tang. AZ = 57° 58′; from which taking ZD = 53°, there remains DA = 4° 58′ the new latitude.
As radius : sine ∠AZB :: cos. ZB : cos. ∠A = 63° 29′, whose complement 26° 31′ is the new declination.
As radius : sine ZB :: tang. AZB : tang. AB = 35° 31′, the complement of 54° 29′ the dist. of merid. and horiz.

2. In the right-angled triangle AFP, are given AP = 94° 58′, and ∠A = (180° — 63° 29′ =) 116° 31′. Then
As radius : cos. ∠A :: tang. AP : tang. AF = 78° 59′ the distance of the substile from the merid.
As radius : sine AP :: sine ∠A : sine FP = 116° 57′, whose supplement 63° 3′ is the stile's height.
As radius : cos. AP :: tang. ∠A : cotang. ∠P = 80° 9′ the plane's diff. of longitude.

Now this 80° 9′, or plane's difference of longitude shews that the distance, on the equinoctial DE of the hour line PA of 12, is 80° 9′ from the substile PF; and which is therefore set opposite to it in the table to the original solution. The equinoctial distances in the same column of the table belonging to the other hours, are found by the continual addition and subtraction of 15°. And the several distances on the plane of the dial in the other column of the table, against the equinoctial distances are all found by this proportion, As radius : sine 63° 3′ the stile's height :: tang. of each equinoctial distance : tang of the corresponding distance on the plane of the dial. For if PG be any hour circle; then in the right-angled triangle PFG, As radius : sine PF : : tang ∠P : tang. opposite side FG.

*Note.* In the table to the original solution, for the distance on the plane against the hour XI the author has set 84° 18′ instead of its supplement; or rather indeed it should be 95° 46′ the sup. of 84° 14′ as appears by calculation. H.

*Fig. 7. The calculated solution for Q. 78. It has a small H at the end indicating it is a solution by Charles Hutton (1737-1823).*

The notation used is strange to the eye today, but totally in keeping with the 18th century. A little explanation will help the reader understand what is represented here.

As
cos∠AZB = 43°15' : radius:: tang.ZB = 49°20': tang.AZ = 57°58' ; from which taking ZD = 53°,
there remains DA = 4°58', the new latitude.

This section shows the standard way of writing the 'Rule of three direct', which is an old method for solving problems about proportion. This states that if we know quantities $a$, $b$ and $c$ and want to find $d$ such that $a$:$b$ :: $c$:$d$ that is $a/b = c/d$, then $d = cb/a$.

The section thus becomes:

cos 43°15' : 1 :: tan 49° 20' : tan AZ (taking the radius of unit length)
tan AZ = (tan 49° 20')/(cos 43° 15')
tan AZ = 1.59805
AZ = 57° 58'
DA = AZ – ZD = 57° 58' - 53° = 4° 58'

Here is the next question that appeared the following year in 1721.

IV. QUESTION 87, *by Mr.* T. Williams *of Middleton-Stoney.*

A person bought a quantity of land the bounds of which are to be marked out by the shadow of a tree 103 feet high, between the hours of eight and one on the 10th of march 1721: now supposing the sun should not appear on that day, how may the bounds and area be determined the latitude being 52° N.

*Fig. 8. Question 87 from Leybourn's book*[1] *and the problem for readers to tackle. Solvers were expected to use the astronomical data that formed the first part of The Ladies' Diary. Present day solvers might like to see if they can find this data on the internet. Solution in the next edition of the Bulletin.*

Apart from the dialling questions there is a treasure trove of interesting mathematics to be discovered, some of which is stimulating material for my students at The Mountbatten School in Romsey. The new Key Stage 3 mathematics curriculum supports the use of history of mathematics, so what more encouragement do I need! There is so much dialling to explore in these works, do not be surprised to see some more articles featuring these $18^{th}$ and $19^{th}$ century dialling mathematicians in the future!

**REFERENCES**


1. T. Leybourn: *The Mathematical Questions Proposed in the Ladies' Diary*, W. Glendinning, Hatton Garden, (1817).
2. W. Hawney: *The Doctrine of Plain and Spherical Trigonometry*, London, (1725).
3. R.V. & P. J. Wallis: *Index of British Mathematicians Part III 1701-1800*, Phibb, Newcastle upon Tyne (1993).
4. Mrs A. Gatty (edited by H.K.F. Eden and E. Lloyd): *The Book of Sun-Dials*, G. Bell and Sons, London, (1900).
5. J. Wilson: *Biographical Index of British Sundial Makers from the Seventh Century to 1920*, BSS monograph No.2, BSS, Crowthorne, (2007).
6. R.V. & P. J. Wallis: *Biobibliography of British Mathematics and its Applications Part II 1701-1800*, Phibb, Newcastle upon Tyne (1986).



*Author's address:*
*pransom@btinternet.com*


## COLLECTORS' DIALS

Many members have small collections of interesting dials. This example of a universal inclining dial is not one of the cheap Indian replicas found on eBay but the real thing—by Thomas Harris. His London firm of Harris & Son traded from 1802 to beyond 1901 and were really opticians so it is likely that the dial was a commodity item which they retailed.

Do other members have interesting dials?

# THE ENGLISH SCRATCH & MASS DIAL ERA: THE EVIDENTIAL PERIOD c.1250 TO c.1650

**CHRIS H K WILLIAMS**

Hitherto, much of our focus has been on the fate of surviving dials in the post scratch dial era. The analysis of dial loss has allowed us to reconstruct the end (c.1650) of the scratch dial era. This and the next article develop, within the context of the life cycle model (LCM),[1] a picture of the scratch/mass dial era itself. It is a preliminary view on two counts. Firstly, it confines itself solely to prevalence – dial types and their evolution will be examined in subsequent articles. Secondly, to the extent that the analysis of dial evolution permits the age structure of dials to be inferred, the parameters of the LCM can be derived with greater precision than in this article.

The earliest church fabric to survive in non-negligible quantities dates from the twelfth and thirteenth centuries. This coincides with the Great Norman Rebuilding – a rebuilding of epic and unparalleled scale.[2] Within fifty years of the Conquest, the Normans had begun rebuilding every major church in England.[3] The Rebuilding was also monumentally destructive, sweeping away what pre-existed – Saxon churches and Saxon dials. They were replaced by larger churches, and more of them as 6-7,000 Saxon ecclesiastical units increased to 10-11,000 medieval parishes. It is difficult to overemphasise the architectural/rebuilding revolution visited upon the land; the per capita investment involved remained unsurpassed until the industrial age.[4] Such was the scale and nature of the discontinuity wrought that we can presume that c.1250 each church had one new scratch dial. Whatever pre-existed was almost entirely destroyed and replaced. Out of a total of some 5,500 listed/recorded dials only about 50 are thought to predate 1250. It is thus in a very literal sense that c.1250 – c.1650 constitutes the mass dial era's evidential period.

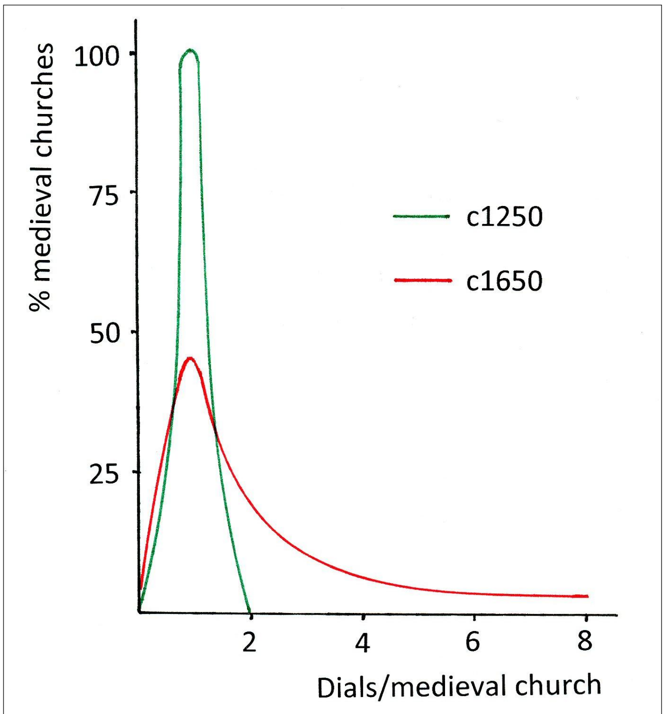



*Fig. 1. Scratch dials per church in the evidential period.*
***Notes:***
*(1) Due to the Great Norman Rebuilding the evidential period begun with all churches having one dial (see maintext).*
*(2) By the end of the evidential period there was an increase in both the number of dials – 2 to 3 per church on average – and their dispersion (see Chris H. K. Williams: 'The Prevalence of English Scratch (Mass) Dials c.1650 – Part 1', Bull BSS, 21(ii), 43-4, (2009)).*

What can be said about individual components of the LCM? Most obviously the number of dials/church (Fig. 1) increased (equivalent to 0.2–0.3% pa). Regarding dial loss due to building, circumstantial evidence abounds. The oldest church fabric is invariably in the nave or chancel, with later medieval additions in the form of aisles, porches and trancepts. Some half to two-thirds of all Norman churches subsequently underwent substantial rebuilding in the Early English, Decorated or Perpendicular style(s) before the Reformation.[5] Churchwarden accounts are testament to the fact that not insignificant periodic repairs and alterations were an ongoing feature of the sixteenth and seventeenth, and presumably earlier, centuries. All this rebuilding, alteration and repair must have been most destructive of scratch dials. Considered reflection does not suggest a lower rate than our earlier, essentially post scratch dial era, estimate of dial loss attributable to rebuilding (0.1–0.2% pa)[6] is appropriate. Indeed, a case can be made that rebuilding dial loss in medieval times exceeded that of the post dial era. Turning to weathering loss, as dial age was close to zero in 1250 and subsequent aging diluted (by loss to rebuilding and new dials) it must have been zero to low (by post c.1650 standards) for most of the evidential period.[7] In combination therefore overall dial loss would have been of the order of 0.2% pa.

A major determinant of the c.1650 dials/church profile is the temporal profile of scratch dial displacement by scientific dials/clocks. The lower a church's scratch dial count, the earlier (ceteris paribus) its displacement of scratch dials. The other determinant of the c.1650 dial profile is the joint statistical interplay of redundancy and loss: as such, the high dials/church tail reflects the concurrence of above average redundancy and below average loss (vice versa). The c.1650 incidence of low dials/church thus reflects below average redundancy combined with above average loss as well as earlier displacement.[8] Churchwarden accounts indicate the seventeenth century was the main concentrated period of displacement.[9] The c.1650 profile, with about half of all churches having three or more dials, is consistent with that. It is also more than suggestive that earlier displacement was not uncommon. Any assessment at this juncture is (for reasons explained earlier in this paragraph combined with not knowing when the last dial in use on a church became obsolete), more a matter of judgement than precision. That said, assuming all churches with no dial, most with one, and some with two had displaced scratch dials prior to the seventeenth century, suggests that about a third of all churches had done so.[10]

It can be seen that dial redundancy emerges as the largest single component of the LCM during the evidential period. Clearly redundancy must offset both the increase in dials and dial loss (a combined total of 0.4–0.5% pa). Allowing for the progressive displacement of scratch dials, the true rate of redundancy (in churches that still used them) was in excess of 0.5% pa. The in-use lifetime of the average scratch dial was thus in the region of 100 years.

To conclude, it is the overall picture portrayed by the LCM, rather than the magnitude of current estimates of its individual components – all hopefully subject to further refinement – that is the important and crucial message. The scratch dial era was far more dynamic than previous students were apt to realise. The very fabric on which dials were incised was not permanent; the actual usage of any dial nothing but transient. The overwhelming impression is one of continual churn. Dials were continually being destroyed by rebuilding[11] – the probable fate (by 1650) of half the dials of the Great Norman Rebuilding. If a dial was not destroyed whilst in use, it was most probably abandoned and replicated rather than displaced by newer technologies. It can now be appreciated that, in addition to surviving dials having been decimated in the post dial era, life was no less uncomfortable in the scratch dial era itself. Even then it was the fate of most dials to be culled by abandonment or destruction.

**REFERENCES AND NOTES**


1. In the LCM, the number of scratch dials on a church is determined by the combined interplay of dial loss, dial redundancy and dial displacement. See Chris H. K. Williams: 'The Life Cycle of English Scratch (Mass) Dials', *Bull BSS,* 20(iv), 164-5, (2008).
2. The Rebuilding encompassed military and ecclesiastical infrastructure plus the personal requirements of the new alien aristocracy. See E. Fernie: *The Architecture of Norman England,* OUP, (2002); H. M. Thomas: *The Norman Conquest: England after William the Conqueror,* Rowman and Littlefield, (2008).
3. E. Fernie: 'Architecture and the Effects of the Norman Conquest', in Eds. D. Bates & A. Curry: *England and Normandy in the Middle Ages,* p105-116, (1994).
4. J. C. Holt: *Colonial England 1066-1215,* London, (1997).
5. G. Hutton & O. Cook: *English Parish Churches,* (1976); J. J. Scarisbrick: *The Reformation and the English People,* (1984); R. Strong: *A Little History of the English Country Church,* Jonathan Cape, London, (2007).
6. See Chris H. K. Williams: 'The Prevalence of English Scratch (Mass) Dials c.1650 – Part 1' & 'English Scratch (Mass) Dials: The Ravages of Time', *Bull BSS,* 21(ii) & 20(iii), 43-4 & 110-111, (2009) & (2008).
7. It is hoped that cross sectional analysis of the database will permit the age structure of dials and precise (pre and post 1650) weathering rates to be estimated. Interim work in progress is encouraging.
8. To disentangle the two effects requires both the mean and variance of both loss and redundancy rates. Currently we have some average loss estimates mainly for the post scratch dial era, with the prospect of their enhancement (note 7). Average redundancy can only be estimated as an algebraic residual in the LCM. Loss and redundancy variances are, sadly, beyond retrieval.
9. See note 1 reference.
10. Depending on the extent to which the parameters of the LCM can be estimated with greater precision and detail, it might be possible to derive (or establish limiting bounds of) the temporal profile of displacement.
11. Any prior expectation of a 'normal' rate of weathering loss has been obviated by the impact of the Great Norman Rebuilding (main text). By destroying virtually all pre-existing dials it 'artificially' rendered weathering impotent until such time as dial age recovers. Incidently, the true significance of the Rebuilding lies not in its impact on weathering, but that it allows us to numerically specify the c.1250 number of dials and their age (one per church and zero respectively). Without that, analytically insightful as the LCM might be, in terms of a complete numerical solution of all parameters it is, technically, underidentified. Students of scratch dials have real cause to thank the Normans!



*Author's address:*
*chkwilliams@googlemail.com*


## The Sun-Dial at Wells College

## Henry Van Dyke (1852-1933)

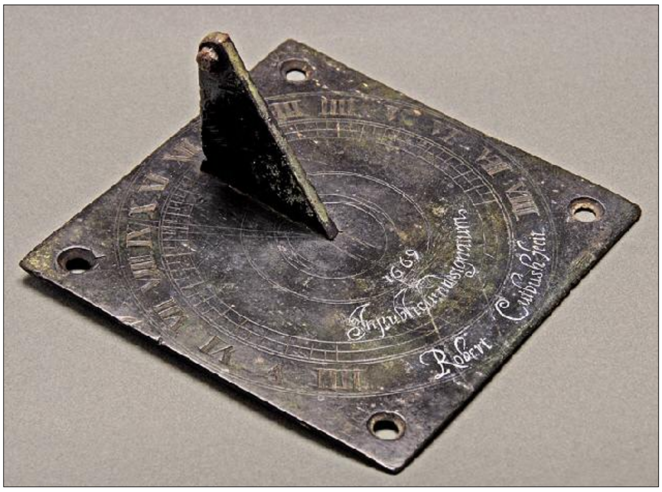
The shadow by my finger cast
Divides the future from the past:
Before it, sleeps the unborn hour,
In darkness, and beyond thy power:
Behind its unrelenting line,
The vanished hour, no longer thine:
One hour alone is in thine hands, -
The NOW on which the shadow stands.

*Wells College is in Aurora, New York. But does the dial still survive? Van Dyke wrote other sundial poems (equally bad!) though it is this one that appears on modern dials.* JD

# ROBERT CUTBUSH
# a provincial dialmaker

JOHN DAVIS

[This article is a version of the talk given at the BSS Newbury Meeting, September 2009.]




P. Delehar

*Fig. 1. General view of the Robert Cutbush dial.*

In the Spring of 2009, I came across a horizontal dial (Fig. 1) for sale on the website of Peter Delahar, a well-known dealer in scientific instruments. It was an interesting little dial, 6.4" square, dated 1699 and signed "Robert Cutbush fecit". Cutbush was an unknown maker to me so, intrigued, I investigated further. Not all of the usual reference sources[1-6] list Cutbush, although Wilson, Clifton and the Websters have some information of him as a scientific instrument maker. They quoted a 1656 Gunter's quadrant on the lid of a small tobacco box in the Oxford Museum of the History of Science. This quadrant is shown in Fig. 2 and the style is clearly the same as that of the dial: the engraving hand is competent but not as fine or controlled as might be expected for a London instrument maker of the time. The unusual signature on the quadrant, "Robert Cutbush Hæc otia fecit " was translated on the Oxford label as "RC made these fruits of leisure" and the date of 1656 is some 13 years earlier than that of the dial, suggesting perhaps that it might have been made for personal use when Cutbush was an apprentice. But there were no more leads as to who Cutbush was.


*Fig. 2. Gunter's quadrant on a tobacco box, by Robert Cutbush. Photo courtesy of the Oxford MHS. Inventory no. 44784, accession no. 1944/1.*


P. Delehar

*Fig. 3. The dial face.*

**The Dial**

A picture of the dial face is shown in Fig. 3 and its gnomon is shown in Fig. 4. It can be seen that the origin of the delineation is in the centre of the square plate, a style that had gone out of fashion in London over half a century before. The dial is divided to quarters of an hour and the Roman numerals, which face inwards as would be expected for a dial of this date, feature the quite broad strokes of an experienced hand. There is a noon gap for the relatively thick gnomon which is quite plain and has a very old break with the remains of a bolt through the tip whose purpose is not clear. Its angle was measured as 50.4° which is appropriate


*Fig. 4. The gnomon.*

*Fig. 6. The inscription on the dial, highlighted with white wax.*

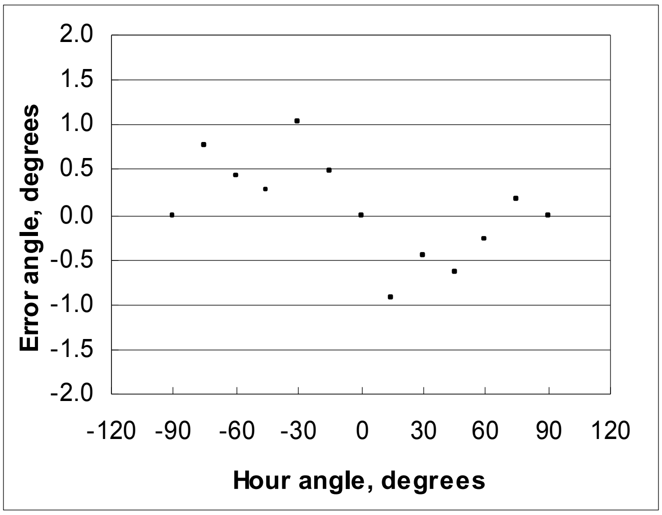




*Fig. 5. Error profile for the hour-line angles. The Error Angle is defined as the difference between the measured and theoretical hour-line angle for an assumed latitude of 52° N, the value giving the minimum least-squares fit.*

for the very south of England but the variability did not preclude a dial for London at 51.5°. An analysis of the measured angles of the hourlines was performed to find the most likely design latitude and the resulting error profile is shown in Fig. 5 for an assumed latitude of 52°. This angle gave the best least-squares fit but the spread of the errors is significant and a tolerance of ±1° must be added to this latitude. As a result, the best that can be said is that it is a south of England dial.

The inscription on the dial is shown in close-up, highlighted with white wax, in Fig. 6. It shows the Latin motto "In publicum designatum" (three words) which can be translated as 'laid out for the public', or 'laid out for public use'.[7] This tends to imply that the dial was designed to be installed in some public space but Gatty[8] does not list it. I turned next to Google where I obtained exactly one hit – an unusual occurance in itself. The reference was to a 1907 book *Ightham – The story of a Kentish village*, where the key extract read:[9]

> Another link with the past, which in many places has long since vanished, is the sundial bearing the inscription: "1669. In publicum designatum Robert Cutbush fecit."

This was a major clue as it was clearly referring to the right dial and it had been at the Ightham church in 1907. Searching for more information on Ightham church (shown in Fig. 7) led to the Kent Archaeological Society website[10] where there was a facsimile of a hand-drawn map of the gravestones. It was drawn in 1922 (Fig. 8) and includes a sundial with the listed annotation of "1669. In publicum Assignandum [sic] Robert CUTBUSH fecit." Despite the transcription error, the location of the dial in 1922 was now known to have been in a quiet corner of Ightham churchyard.


*Fig. 7. Ightham church.*

I next made contact with one of the present churchwardens at Ightham, Dr A.J. Watson. He did not immediately have any knowledge of a sundial but he soon phoned me back with a reference from a local guidebook of 1978 which said of the churchyard: [11]

> The little sundial* outside the porch is inscribed "In publicum designatum Robert Cutbush facit [sic] 1669"

Thus at some time between 1922 and 1978 the dial had been moved from the outskirts of the graveyard to nearer the porch. Unfortunately, the footnote read " *Now Lost"!

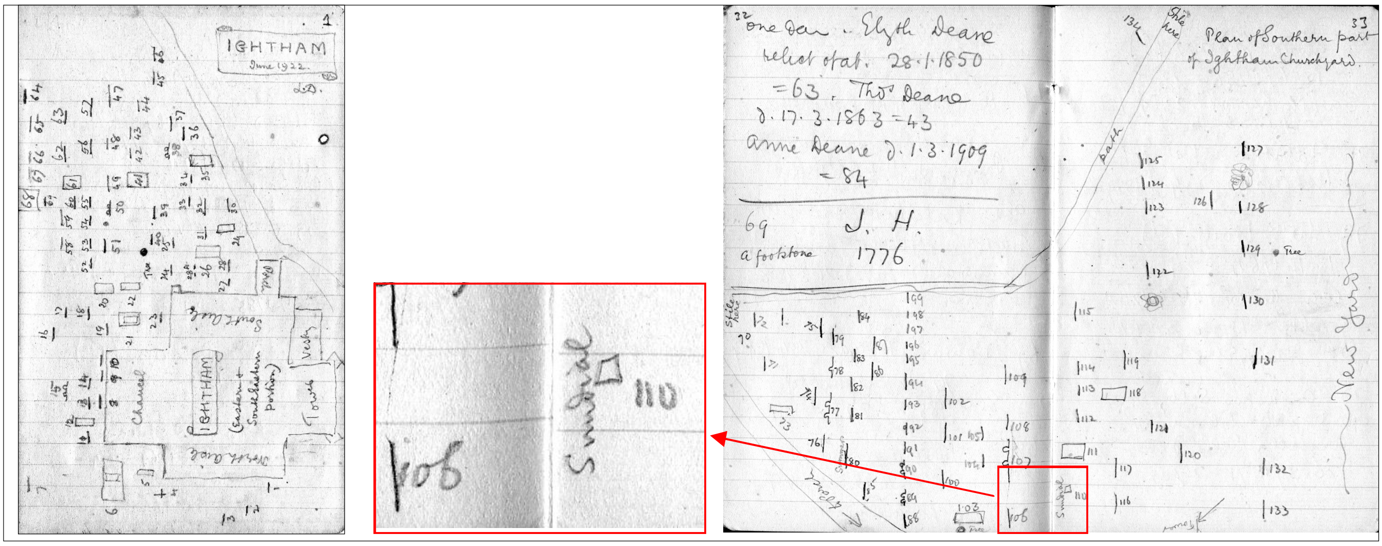



*Fig. 8. Ightham churchyard map, as drawn by Leland L. Duncan (1922). Courtesy of the Kent Archaeological Society.*

This suggests that the dial had gone missing, probably stolen, not long before 1978, during the writing of the book. Dr Watson had also remembered that there was a wooden post, in rather poor condition, that was now in the church porch and used for supporting flowers, which had once been a dial pedestal.

**Robert Cutbush**

I now discovered[12] that the Cutbush family of Maidstone (the nearest large town to Ightham) were well known clockmakers. In his book on *Kent Clocks and Clockmakers*,[13] Pearson devotes a whole chapter to a dynasty of around 15 Cutbushes. It seems that 'our' Robert Cutbush was apprenticed to his father Edward, a locksmith, in 1652. The story is a confused one as another (?) Edward took a Robert into apprenticeship in 1702 but it seems this is a case of a family recycling first names. It does mean that identifying the makers of clocks signed Edward or Robert without a year is very difficult. Numerous examples of both lantern and longcase clocks with these signatures are known.

Assuming Robert was about 14 when he started his apprenticeship would place his date of birth at around 1638, when his father was just 24 and could not have been long out of his own apprenticeship to his father, yet another Edward. Robert would have been about halfway through his apprenticeship when he made the Gunter's quadrant for his amusement. Quite where he learned the mathematics to delineate it is unknown. He would have been about 31 when he made the churchyard sundial. Whether he made it as a paid commission is not known but there is a long tradition of charitable acts by the family leading to the endowment of an almshouse by Thomas Robert Cutbush in 1865.

**Conclusions**

I left the matter in the hands of Dr Watson, the local rector and the dealer. The legal position was not clear as it was likely that the dial had been through many hands since it went missing, the dealer had bought it in good faith and there was no photographic evidence that it was indeed the same dial. Nevertheless, I am pleased to report that the dial was returned to Ightham in September.

**ACKNOWLEDGEMENTS**

It is a pleasure to thank Peter Delehar for his help and support in producing this story and for donating the dial to Ightham church. Dr A. Watson was active in pursuing the dial. David Brown, Chris Williams, Mike Cowham, Ted Connell and John Foad all helped in the research.

**REFERENCES**

1. J. Wilson: *Biographical Index of British Sundial Makers from the Seventh Century to 1920*, 2nd edition. BSS monograph No.2. BSS, Crowthorne, (2007).
2. G. Clifton: *Directory of British Scientific Instrument Makers 1550 – 1851*, pub. Zwemmer, London, 1995.
3. B. Loomes: *The Early Clockmakers of Great Britain.* NAG Press, London (1981).
4. R.V. & P.J. Wallis: *Index of British Mathematicians Part III 1701-1800*, PHIBB, Newcastle (1993).
5. E.G.R. Taylor: *The Mathematical Practitioners of Tudor & Stuart England*, Cambridge University Press (1954).
6. The Websters' online database of mathematical instrument makers is at www.adlerplanetarium.org/research/collections/websters/about.shtml
7. I am indebted to David Brown for this translation.
8. A. Gatty and H.K.F. Eden & E. Lloyd (Eds): *The Book of Sun-Dials,* 4th edition, Bell & Sons, London (1900).
9. F. J. Bennett F.G.S (Late of H.M. Geological Survey): *Ightham - The Story of a Kentish Village*, Frederick Warne & Co., London (1907).
10. Kent Archeological Society website: www.kentarchaeology.org.uk "Some Monumental Inscriptions of Ightham Church, Noted by Leland L. Duncan June 1920. Typed up by Ted Connell, checked by Frank & Zena Bamping".
11. Edward V. Bowra: *Ightham – notes on local history,* Ightham and District Historical Soc, (1978).
12. I am grateful to Chris Williams for making me aware of this.
13. M. Pearson: *Kent Clocks & Clockmakers*, Mayfield Books (1997).

*Author's address:*
*john.davis@btinternet.com*

# BSS NEWBURY MEETING—26 September 2009

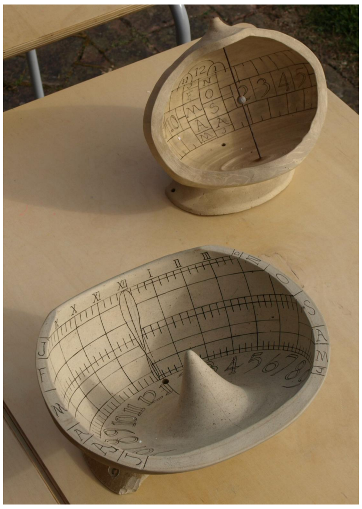
## JOHN LESTER

A fine sunny day greeted the 48 members and visitors who were welcomed by Peter Ransom to what was to be another interesting and successful Newbury Meeting.

*Fred Sawyer*

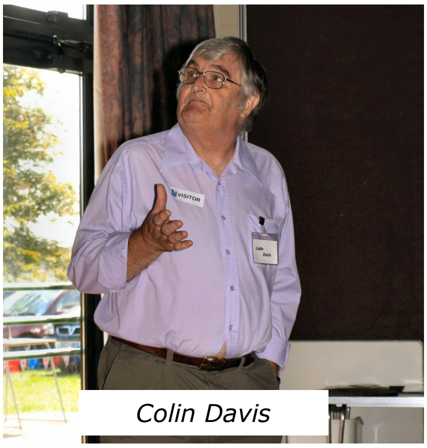
Fred Sawyer was the first speaker and told us of his encounter with John Twysden (1607–88), whom he described as the Dr Watson to Samuel Foster the dialling mastermind's Sherlock Holmes. Twysden was no mean performer himself and wrote extensively on dialling and other matters. His papers included 'A Disquisition touching the Sibylls' (1662), 'The Semicircle on a Sector' (1667) and in addition to covering other topics such as reflex dialling, solar eclipses, comets and the use of the planisphere he also produced an edition of Foster's papers under the title 'Miscellanies'. The speaker had investigated Twysden's family tree in great detail and was surprised to discover that he himself was Twysden's third cousin ten generations removed – and that they shared the same birthday.

*Martin Birdseye*



Martin Birdseye then described how he made various types of ceramic sundials (above right). Two of these resembled hemicyclia and were derived from thrown pots which were then sliced open. Hour and declination lines were inscribed in the wet clay using specially constructed jigs and these lines were then filled in with manganese dioxide before firing. One example had a clay gnomon which needed to be hollow in order to survive in the kiln. An ingenious and attractive birdbath horizontal dial had a series of polar aligned vanes along the half-hour lines which shaded all the numerals except that of the current hour. All his dials were left unglazed since this made them less prone to frost damage.

Colin Davis then described the discovery of the slate tombstone of one Samuel Turner in the churchyard of St. Mary in Arden at Great Bowden near Market Harborough. (See the article by Roger Bowling in *Bulletin* 21(ii).) This had a direct west dial engraved centrally near the top of the headstone. To the right of this appeared a number of dialling instruments and a picture of Samuel Turner at his desk. To the left of the dial was a map of Stoney



*Colin Davis*

Farm where Turner had lived and worked. All this suggested that Turner was a diallist but the discovery of his initials at the bottom of the headstone indicated that he had also carved his own tombstone leaving the mason little to do except add the date of his death.

Michael Maltin followed with an entertaining account of the erection of a garden sundial which had a chromed steel Archimedean screw, 17 feet long and weighing a ton, as its gnomon. The problems and hazards of aligning this gnomon at 51.72° and due north were described (a dipleidoscope was one of the aids), and the massive foundation which had to be put in place to support it were


Michael Maltin

shown. The owner wanted plants along the hour lines but these grew luxuriantly and spoiled the accuracy so in the end 'dial furniture' – in this case garden chairs and tables – was used to mark the hours.


Tony Moss

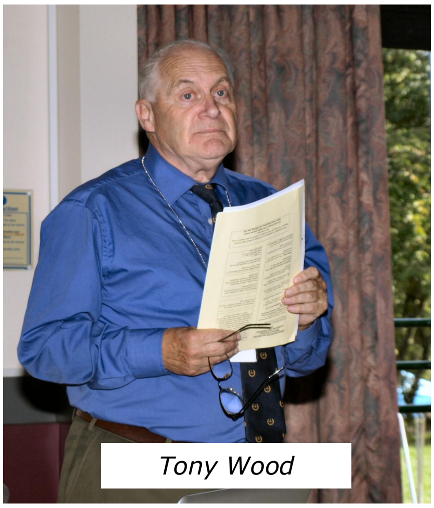
The leisurely lunchtime period included the traditional group photo and time to look at some of the exhibits. As always, there is never enough time to discuss everything that one wants.

Tony Moss opened the afternoon session by describing 'A Sundial for the Polar Bears' at Longyearbyen. It had been commissioned by a lady and was to be the most northerly sundial in the world. The design not only included the familiar noon-gap but also had a midnight overlap. It was erected among the less than picturesque environs of a coal mine and, because the ground was frozen too hard to dig a foundation for the pedestal, it was mounted on wooden piles driven into the permafrost. This talk was followed by a series of pictures taken on the Portland Dial Tour during the 2009 NASS Conference.

'Roman Sundials in the UK' was Tony Wood's subject. He pointed out that Roman sundials were merely copies of Greek dials and, though dated to Roman times, would probably have been made

*A fine slate dial by David Brown*


*Michael Maltin demonstrates his dipleidoscope azimuth-finder*



Tony Wood

by Greeks who were employed in the Roman Empire. A visit to the British Museum in the company of a French student had involved a search through material stored in the basement which revealed some hemicyclia, an engraving of a dial on an urn and remnants of a complex vertical dial (described as a Greek dial by Mrs Gatty). Elsewhere there were dials in the museum at Chesters, a dial at Dover Castle (from Richborough) and one at Hever Castle. At Brading in the Isle of Wight a sundial is depicted on a Roman mosaic. Modern replicas are to be found at South Shields and in the Jewry Wall Museum at Leicester.

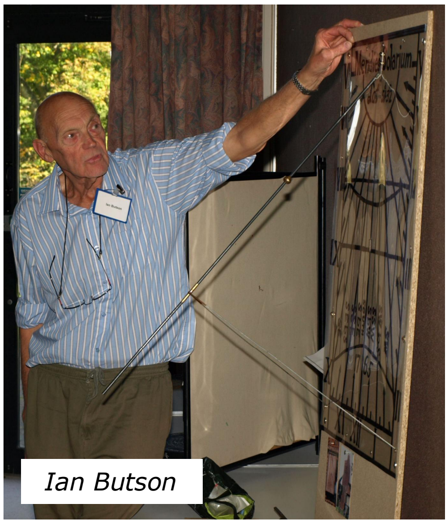
'Cadrans Solaires du Perche' was Peter Ransom's subject and he showed pictures of dials which could be seen in this area of France. Four circuits starting from

Peter Ransom

Mortagne, Longny, Bellême and Rémalard are described for interested tourists and an abundance of interesting dials is to be found by those who follow them. Heart-shaped dials are frequent and the average quality of the dials is good. This is an area which should appeal to other BSS members.

'Robert Cutbush – a provincial dialmaker' was the final talk, given by John Davis. The discovery of a horizontal dial dated 1669 and bearing the inscription 'In publicum designatum' started an investigation which uncovered facts about the diallist and identified a quadrant made by him. More details will be found on p.20 of this issue.

It was now the turn of the exhibitors. Ian Butson (top right) told of his involvement in the restoration of a wooden vertical dial at Nazeing, asking whether azimuth lines were likely to have appeared on it.



Ian Butson

Michael Lee (below) showed a moondial (see *Bulletin* 21(i) , March 2009), a sun compass (see p.28) and an equatorial dial with a split gnomon which produced a ray of light rather than a shadow.

The day ended with a vote of thanks to David Pawley and his team for all their work in organising another very successful Newbury Meeting.

Michael Lee

*Pictures from JD*

# A PHOTOGRAPHER'S SUNDIAL

**TONY BELK**

As a photographer, have you ever wanted to know where, if the sun is pointing in a particular direction at a particular time today, will it point at some time later that day or indeed on any day of the year? A pocket-sized device which can be made at home will tell you this with surprising accuracy. If you photograph buildings you may well like to know when a particular wall will be in sun or in shade or when the sun will graze the surface to highlight its texture or shine through an arch, or even illuminate a sundial.

I had been striving to produce a photographer's dial for a while but had used an analemmatic ellipse as its basis. This works with a dowel but both ends are moveable. After seeing the collection of double horizontal dials at Ipswich on the BSS Safari, it struck me that Oughtred's use of a horizontal stereographic projection would be better. Here one end is fixed and a ruler can be used to line up the time and date point. This, combined with the dowel as both gnomon and ruler and the coloured bands to help locate the time and date point, led to the present design. Other modern designs, described in the forthcoming monograph[1] on double horizontal dials, have used the horizontal stereographic projection but none I think have used a dowel as gnomon rotating about and aligned with the centre of the projection.

The device (whose origin is described in the appendix below) is shown in Fig. 1 and consists of a U-shaped set of scales with a piece of square dowel, the anticlockwise side of which is aligned with the centre of the scales. The dowel can rotate about the centre and align with any part of the scales. The scales plot the direction of the sun for every hour of every day of the year and are shown more clearly in Fig. 2. The months of the year are given around the outside. There is a mark for $1^{st}$, $11^{th}$ and $21^{st}$ of each month to enable the particular date to be found. The red, yellow, green and blue bands are intended to help follow round for a particular date. The whole of December is covered by the outermost date line and June the last two innermost lines. To use the dial, find where the time (measured in 10 minute intervals) intersects the date line and align the anticlockwise edge of the dowel with that. Now with the sun in the open end of the U, rotate the whole instrument until the sun just grazes both sides of the dowel. The instrument is now oriented. Keeping the plate fixed, rotate the dowel until it points in the direction of interest and read off the time using the same date line. It is also possible to find the time at other seasons of year by choosing different date lines (see examples given below). Fig. 1a shows the dial set correctly at 2:40 pm at the equinox. The shadow of the dowel runs along its length at grazing incidence to both sides. In Fig. 1b the dowel has been offset by 5 minutes and a thin line of shadow can be seen on one side of the dowel. A 5 minute offset in the other direction gives a thin shadow on the other side of the dowel.

**Examples of Use**

On May $1^{st}$ at 9:00am, a building's south face is lit with the glancing sun. At what time will the sun be just illuminating the west face of the building? (i.e. its azimuth will have moved 90°). May $1^{st}$ is about the centre of the red band. Rotate the dowel to the 9:00am, May $1^{st}$ intersection. In practice you would then align the whole device so that the sun just grazed both sides of the dowel equally. Holding the plate still, now rotate the dowel through 90° so that it is parallel with the west face of the building. Read the time on the May $1^{st}$ line as 1:35pm.

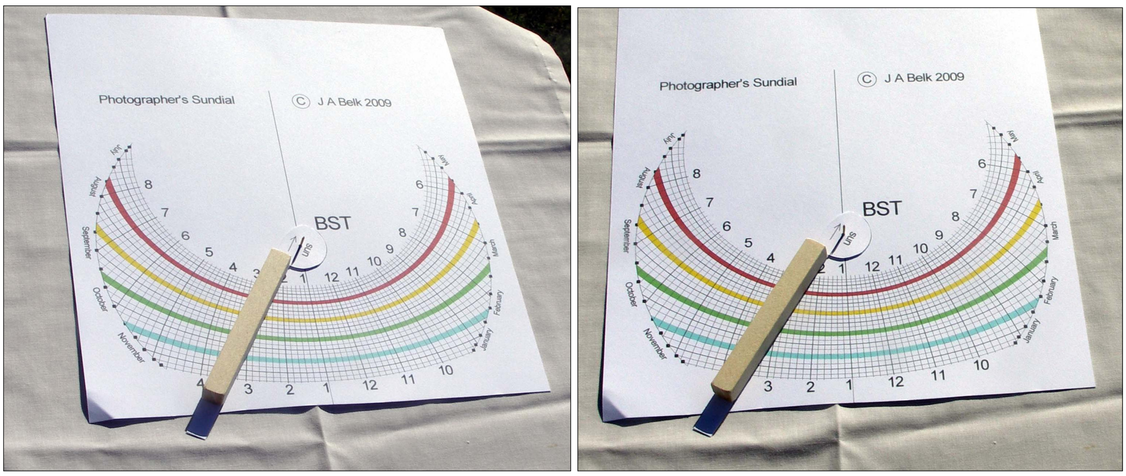



*Fig. 1. (a) Dial set correctly at 2:40pm September $21^{st}$. (b) Dial offset 5 minutes at 2:40pm on September $21^{st}$ to show shadow alongside the dowel.*

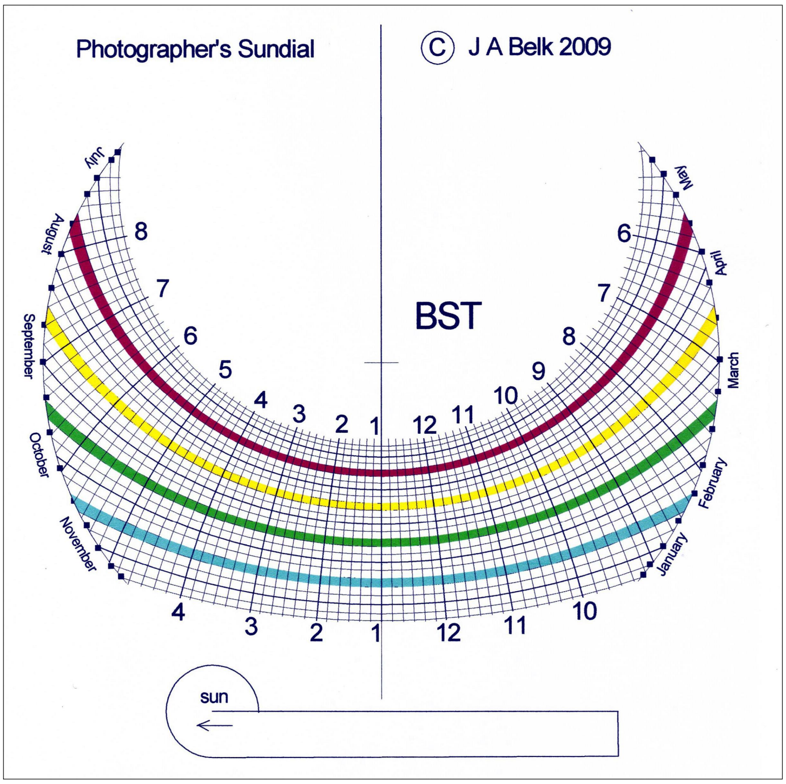



*Fig. 2. Drawing of the photographer's dial for 51.5° N. The coloured bands are guides to allow the eye to follow the declination (date) arcs.*

If the date for this exercise were March 1st and again the sun was grazing the south face of a building, the date line would be just on the blue side of the green band. Setting this at 9:00am and rotating through 90° gives the time on March 1st as 2:40pm and on December 21st as 3:05pm.

The device is designed for the latitude of London, 51.5°, but it will operate satisfactorily, giving one sun's direction based on another sun's direction with an error of no more than 15 minutes if the latitude error is only two degrees. A 4° latitude error will give double this time error around the summer solstice. The time error at equinox is about a third of that for the summer solstice. It is of course possible to produce a design based on, say, Newcastle-upon-Tyne and that would be valid from Aberdeen to Nottingham with an error of 15 minutes or less. The errors I have quoted are the worst case, setting up at mid-morning and estimating for mid-afternoon. The errors are smaller around 6:00am and 6:00pm and around noon, and in the winter.

The altitude, or height of the sun above the horizon is also of interest to photographers. This could easily be read from a simple scale placed along the side of the dowel. To use this it would be necessary to make the equation of time and longitude corrections. A further article in the *Bulletin* will contain such a scale and also a version of the present device for latitude of 54° N, usable from the midlands to southern Scotland.

Without any alignment the device will also give the time of sunrise and sunset for every day of the year, also of some interest to photographers. Sunrise is the time at the extreme outside of the scale for the particular date. For instance April 1st 6:36am. Sunset is given at the other extreme end of the date line i.e. 7:24pm. I have chosen to use solar time plus one hour to allow for summer time but with no correction for equation of time or longitude. 60% of the year is timed using BST, and that is the most photographic part of the year. November, December, January, February and March should use Greenwich time, one hour slower than BST. Surprisingly if the device is used as described above and no correction is made for type of time there will be an error of only 4 or 5 minutes to the final reading as the same correction applies in one direction to the hour of setting and in the other direction to the hour of reading off. The small size of the error is also partly because GMT applies in the winter months when the sun is lower in the sky and the errors are less.

This does not apply if the instrument is used in an absolute sense, to find the NS meridian or the declination of a wall. A 30 minute longitude/EoT correction leads to a 8.1° error at summer solstice, 7.62° at equinox and 6.3° at winter solstice, hence it is necessary to use local apparent time for accurate readings of geographical directions.

It is possible to use a dial of this type that is only 10 cm or 4 inches across. In that case I have used a dowel, obtainable in most craft shops, of 6 mm or 0.25 inches square. A slightly larger version with a dowel of 1 cm or 0.375 inches square can be used with a dial that fits on a 6 inch by 4 inch card for greater ease of reading and accuracy.

**APPENDIX**

The stereographic projection is a long standing means of plotting the features on the surface of a hemisphere onto a flat surface. Important features of the projection are that a circular arc on the hemisphere becomes a circular arc on the projection and the angle between two lines on the surface of the hemisphere is preserved as the same angle in the projection. These features make it ideal for use in sundials[2]. Lowne[3] has described Oughtred's use of the projection for horizontal sundials and indicated how the horizontal stereographic projection can be drawn.

The U-shaped scale is the stereographic projection of the sun's directions throughout the day and year projected onto a horizontal plane at a particular latitude. Oughtred produced this in 1633 and called it his 'Horizontal Instrument'.[4] I referred to it in an earlier article[5] indicating its many uses and in particular commenting on its use as a horizontal sundial with a vertical gnomon as originated by Oughtred. A vertical gnomon is however inconvenient for a portable device and I propose here a vertical-sided piece of dowel which can be aligned to the sun's direction by ensuring that the shadow is grazing both sides of the dowel

*Continued on page 39*

# A UNIVERSAL HELIOCHRONOMETER

**MICHAEL LEE**

Living in Wiltshire, I am fortunate to be just a few minutes away from Stonehenge. In an isolated landscape with its imposing ring of Sarsens, you would find it hard not to be inspired should you be interested in dials.

During the final stages of producing my 'Calendar Moondial',[1] my thoughts turned to constructing a complementary 'Time Dial'. In 2006, I produced a wooden prototype of a 'Universal Heliochronometer'. From this I recreated a prototype in metal but was not satisfied with the result. Some of the design features were not pleasing and I discovered more attention would have to be spent on the calibration mechanisms.

During a weekend of unpleasant weather, I decided my workshop was not going to be on the agenda and settled down to a collection of old *Model Engineer* magazines. Three of these magazines attracted my attention, a series of articles from November and December 1989 and January 1990.[2] The subject, an instrument by the author H Christopher H Armstead, named a 'Phoeboscope'. I discovered a similar article was also published in the then recently-formed British Sundial Society.[3]

Hugh Christopher Holl Armstead (1904-2000) was one of the early members of the BSS (membership number 284). An internet search revealed an interesting career.

During WW2, Armstead was stationed in an "Indian Princely State" in charge of certain Government departments. There were extensive workshop facilities at this location. In 1941 the Commanding General of a garrison asked Armstead to arrange for the production of sun compasses for use in desert warfare in North Africa.

A crude and critical description of a wartime army sun compass is apparently a soup plate with a knitting needle stuck in the middle accompanied by a box of charts. By slipping a chart over the knitting needle, North is established by observing where the shadow falls. The General required only 20,000 sun compasses by yesterday. Armstead, it seems, said yes. He also considered that an improvement in the design was possible and could be manufactured in the extensive workshops under his command. As a Naval Cadet he possessed the rudiments of navigation and as an engineering student of surveying had grasped elementary astronomy.

The sun compass used by the army relied on *solar azimuth* for establishing the meridian. Armstead concluded that using the *hour angle* would be an improvement. Knitting needles for gnomons required a fresh approach involving rigidity.

In a matter of weeks, Armstead's new design had been produced in the workshops as a working model for demonstration and inspection. The model was sent for evaluation to the Director of Armaments in Simla, capital city of Himachal Pradesh, India, during August 1941, together with a set of operating instructions. Sixteen months later it was discovered in its unopened box in an office in Calcutta. Eventually, in 1942 Armstead was asked to demonstrate its use to a new General. Many 'brass hats' assembled for the demonstration. The outcome following the demonstration was 30 seconds of silence followed by the words "too damned highbrow for me to understand". The attending Chief Royal Engineering Officer did appreciate

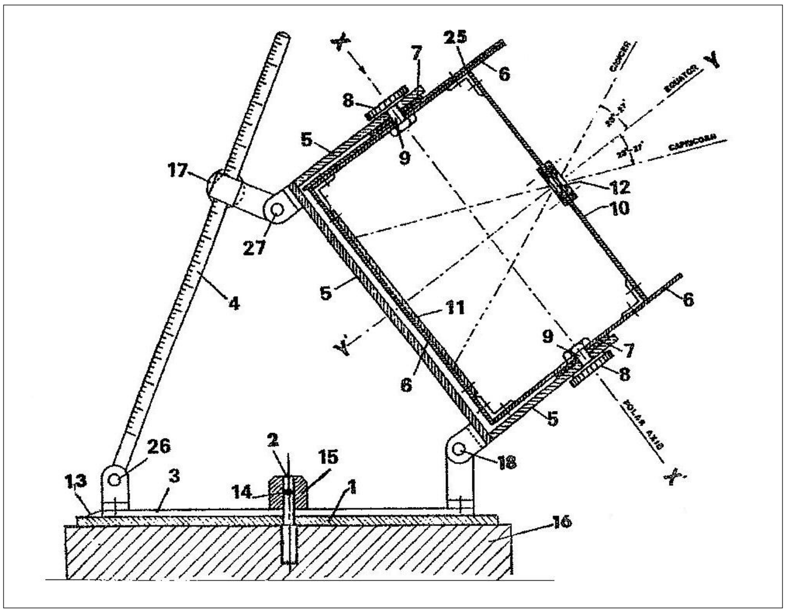



*Fig. 1. The parts of the Phoeboscope (after Armstead[1]).*

*1. Base plate; 2. Hub pin; 3. Azimuth bar; 4. Latitude bar; 5. Polar frame; 6. Hour-angle rotor; 7. Friction washers; 8. Knurled grip screws; 9. Trunnions; 10. Gnomon; 11. Shadow plate; 12. Lens; 13. Azimuth cursor; 14. Azimuth locking pin; 15. Hub; 16. Foundation; 17. Latitude setting locking screw; 18. Polar frame pivot; 19. LST scale; 20. LST cursor; 21. LMT scale; 22. Time cursor; 23. Gripping screws for hour-angle disc; 24. Arc-shaped slot; 25. Hour-angle disc; 26. Latitude bar pivot; 27. Polar frame tilt pivot.*


*Fig. 2. The compass base plate.*

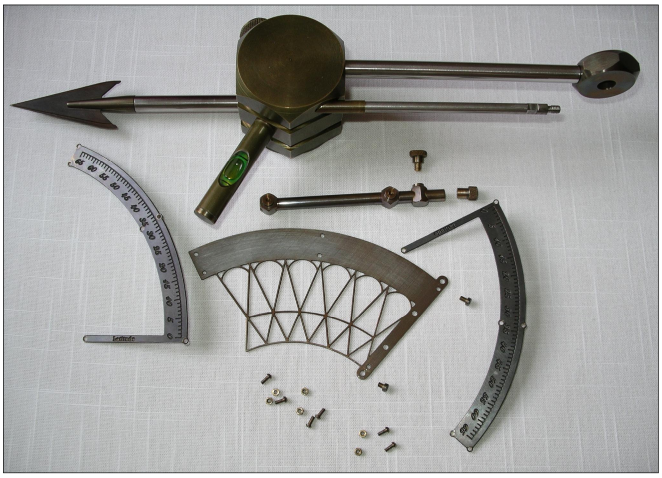


*Fig. 3. The central hub and latitude arc.*

Armstead's developments to the sun compass and took it to Poona for trials. He wrote to Armstead just two weeks later acknowledging the superior features of Armstead's design but advised regret as the Libyan campaign was now over and demand no longer existed for sun compasses.

A letter from the General regarding Armstead's sun compass was to point out to him the demand would have been there a year ago. Armstead was left to reflect on the fact he had submitted his sun compass design some sixteen and a half months before.

Armstead did not see his redesigned compass again but after the war he commissioned a firm of qualified instrument makers to produce one for him. In April 1947 he exhibited it at the Physical and Optical Society Exhibition.[4] (I have obtained from a friend who is involved in the world of optics a copy of the write-up from this Exhibition. Regrettably nothing is mentioned of the modified sun compass.) At the Exhibition, Armstead met an official from the Admiralty Gunnery Establishment at Teddington. In November 1947 he demonstrated the instrument to two Admiralty officials. Despite their interest, drastic cuts in Admiralty budgets for development work ensured Armstead heard nothing more.

The modified Army sun compass sat on Armstead's desk at his home for 34 years until the National Maritime Museum at Greenwich expressed an interest in 1981, so he presented his frustrated effort to them. I visited this museum some years ago but cannot recall the instrument being on display.

In handing the instrument over to the museum, Armstead was motivated to carry out further developments to his design. The instrument did everything he claimed it would do with one shortfall, adjustment for the daily equation of time compensation. He considered this could be incorporated. The further redesign inspired him to call the instrument a 'Phoeboscope' named after Phoebus Apollo, the Sun God.

**Constructing a 2008 Instrument**

I have called my version of Armstead's design a 'Universal Heliochronometer'. Upon reading his 1989 publications, I reached two conclusions. First, Armstead's design was originally intended for use in war and therefore needed to be of heavy-duty construction to stand up to abuse. Secondly, his articles are very comprehensive and technical. In adopting Armstead's Phoeboscope features, my intention was to modify it to a lighter construction and hopefully give a modern appearance to the instrument. This would involve a complete redesign.

The key features of my dial are the use of a spot of sunlight from the mouth of a sun image (the gnomon) falling onto an analemma (marked with each month, January to December). Locating the spot of light on the calendar month of the analemma involves moving the polar frame assembly of the instrument (see Fig. 1), which by rotating gives a numerical display of the time on the clock face. The instrument will work in the Northern and Southern hemispheres subject to simple adjustments and will also function as a compass.

Achieving these functions requires the mechanisms of the instrument to be able to establish true North at the site it is placed, adjustment for latitude and longitude, compensation for the equation of time and also for BST.

Creating an instrument comparable in some respects to my moondial, I have adopted design and mechanical features I know work successfully on this new instrument, and retain a 'family' resemblance.

A compass rose (Fig. 2), attached by hexagon bolts to a wooden plinth fitted with adjustable feet, gives a feature platform.

In the centre, there is a substantial hexagon hub (Fig. 3). Four of the six hub facets are used to support (1) an

*Fig. 4. The first stage assembly.*

*Fig. 5. The decorative support plates.*

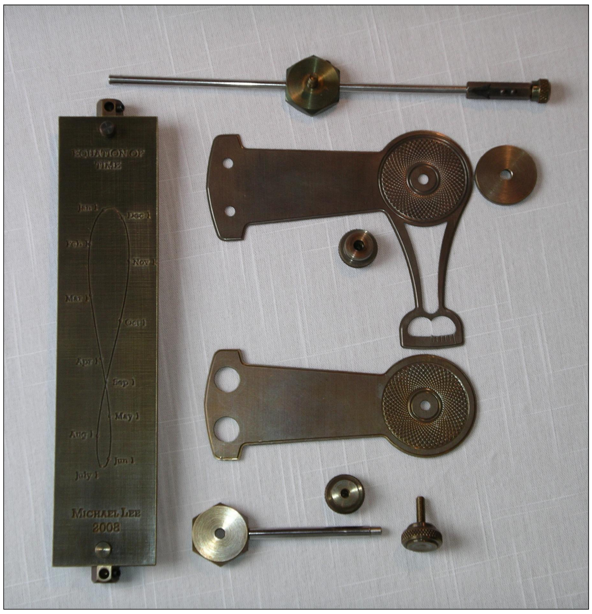



*Fig. 6. The receiving surface components.*

*Fig. 7. The sun face and supports.*

accurately calibrated spirit level essential for accurate levelling of the Heliochronometer, (2) an arrow pointer for indicating North, (3) a locking screw to hold all assemblies *in situ* and (4) a single stainless steel shaft supporting the central hinge hexagon In order to swing a quadrant in position, a smaller stainless steel shaft is situated parallel to the hinge shaft to receive the quadrant support tube and knurled locking screw. In the foreground of Fig. 3 are the quadrant fittings with 10 BA fastenings. Calibration of the quadrant is in single degrees numbered in 5s. Dependent upon which side you view a quadrant, the numbering of the degrees has to read correctly from zero degrees, hence three elements to this fitting. Flats on the stainless steel shaft enable a vertical location when in use and a horizontal location parallel to the compass plate when completed. This is the first stage of the assembly (see Fig. 4).

There are two large stainless steel shafts, required to swing in unison and parallel with one another on either side of the centre hinge. They carry two decorative support plates (see Fig. 5). The left-hand shaft has a small arrow pointer relating to the quadrant when choosing a latitude to set the instrument up. The fitting seen at the extreme right of Fig. 5 is the main locking handle to secure the three hexagon hinge fittings together.

In Fig. 6, above and below the decorative support plates are the fittings which, when assembled, enable the equation of time plate on the left-hand side to swing between the support plates. Accuracy in all connections and concentricity are key for all assemblies so far.

Finally (Fig. 7) a spot of light on the equation of time plate is achieved by the small hole in the mouth of the sun's face.

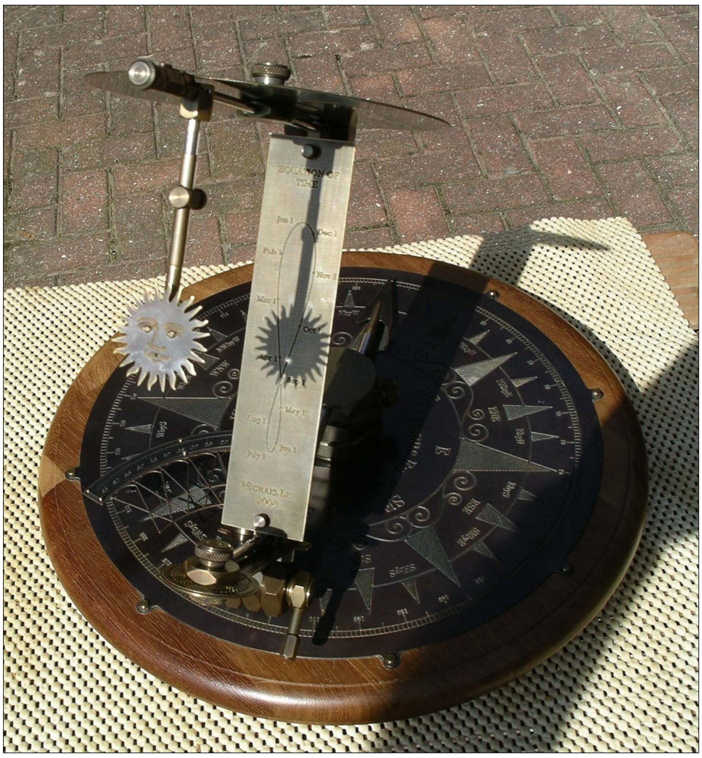


*Fig. 8. The assembled dial in the sun.*

To calibrate the focal point of this hole vertically and axially to the equation of time plate, the fittings to the right of the face (when assembled) will enable calibration. Once correctly done, no further adjustments are required and the real sun's rays will shine accurately through. The image of the instrument's sun face causes a sufficiently large shadow on the plate to make the spot of light on the plate prominent (see Fig. 8, where the spot of light has been computer-enhanced for improved visibility).

*Fig. 9. The main time dial.*

*Fig. 10. The completed dial from the east.*

Having rotated the assembly to enable the spot of light to fall on the equation of time plate during the current month (September 2009 in the figure), the observer now requires a means of reading the time (see Fig. 9). A clock face shows a numerical readout of 2:55pm (the *hour angle*). At the top of the clock face, an arrow pointer and locking device indicates on a vernier any adjustment required for longitude and BST.

The vernier is scaled in degrees, 30-0-30. The clock outer ring shows time in five-minute intervals. The outer set of numbers is for use in the Northern hemisphere and the inner ring of numbers for the Southern hemisphere. A repeater on the right-hand edge of the decorative arm gives five-minute intervals to assist the observer.

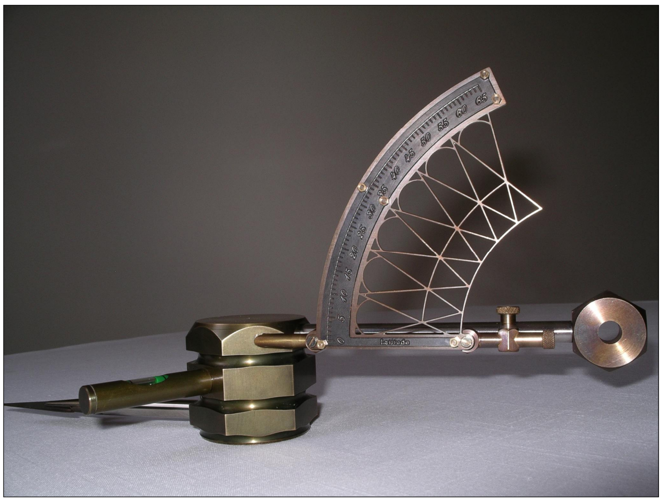


*Fig. 11. The latitude arc in position.*

Having outlined the design and construction of my dial I will now describe the various parts by name, their function and setting up the instrument for use in any location.

The drawing in Fig. 1 appeared as part of Armstead's *Bulletin* article published twenty years ago. It will be useful to compare the differences between the two instruments.

**Using the Heliochronometer**

1. The dial must be placed on a reasonably level surface. If the direction of North is known then the compass rose should be aligned as closely as possible when the instrument is first set down.

2. Being a portable instrument, I have included a spirit level tube (Fig. 3) in the design as an essential feature. Three adjustable feet supporting the wooden plinth enable the surface of the compass rose to be easily levelled whilst observing the spirit level bubble. The spirit tube is attached to the main hub allowing rotation of the hub to ensure accuracy through 360°.

3. To set the latitude (assuming this is known - if not, refer to the description given later) slacken the knurled grip screw on the quadrant shaft (see Fig. 11) and raise the quadrant to its vertical position. (Armstead's drawing shows a latitude bar part #26.) Now slacken the hinge lever (see Fig. 10) and tilt the polar frame (part #5), siting the small arrow on the stainless steel shaft against the readout of degrees on the quadrant to the latitude of the site location. Lock the hinge lever and return the quadrant to its horizontal position. Unless the instrument is moved to a new location, this task will not be repeated.

4. To compensate for longitude and, when required, BST, a vernier is located at the top of the clock face (see Fig. 9) above the 6 o'clock position. Above the vernier is a small arrow held in position by a knurled grip screw. By slackening the knurled grip screw, the clock face can be adjusted by 15° for BST and the number of degrees west or east of Greenwich that you are located (left for western longitudes and right for eastern ones). Locking the knurled grip screw ensures that the clock face is permanently adjusted against the hour angle rotor (#6 in Fig. 1) until reset for another location, or the end of BST.

5. To determine true North, slacken the knurled grip screw (see Fig. 11) on the central hexagon hub (#15) and rotate the whole dial assembly until a spot of sunlight shining through the dial's sun face (see Fig. 8) falls on the analemma at the current date. In Fig. 8, the light falls on mid-September. Using an accurate watch, compare it with the value on the instrument's clock face. True North is achieved when watch and clock face show the same time. Above the compass rose, the large arrow pointer will now be indicating true North. Now is also the time to make any adjustment to the compass rose to achieve its correct orientation. Check the spirit level to ensure that the compass rose remains level. Re-tighten the grip screw on the central hub. Repeat the exercise to ensure the procedure is correct. This task is only done once if the dial is to remain at its location. A watch is no longer required and the Heliochronometer will function as an accurate clock. Note that Armstead's Phoeboscope uses a lens (#12) to focus on the analemma. My experiments using a simple pin-hole in the sun face of my dial gave an accurate light spot on the analemma relative to the clock face readout.

**Using the Instrument as a Clock**

Slacken the knurled grip screws (#8) and rotate the polar frame assembly which swings between the grip screws until the light spot falls on the analemma at the current date. Examining the clock face (#6) the time will have appeared numerically in the window of the cursor located in the upper support arm.

**Setting up the Instrument for an Unknown Latitude**

Provided you know the date and have an accurate watch, setting up is straightforward.

1. Use the methods previously described to level the instrument.

2. Release the main hinge and tilt and bias the polar frame until the gnomon enables a spot of light to fall on the analemma during the current month. Tighten the main hinge. Follow the procedure for establishing true North.

3. Longitude is established as the difference between the wristwatch and the clock face readout on the instrument. The difference in minutes, when converted into degrees, can be adjusted permanently on the clock face vernier with an additional 15° for BST if appropriate. This procedure calibrates the instrument to the wristwatch time. The instrument will now give GMT time whenever required by locating the spot of sunlight on the analemma.

**Using the Instrument in the Southern Hemisphere**

1. Undo the two small knurled grip screws holding the analemma plate to the frame. Reverse the analemma.

2. Refer to the innermost time ring on the clock face.

3. Set up the instrument for latitude and longitude as described previously.

**Making the Instrument**

Design and construction has been an interesting challenge. Concentricity of the structures during manufacture and assembly is important to achieve accurate calibration of the completed instrument.

The materials used are a mixture of hardwoods for the base, brass and stainless steel for the other parts. Patination fluid was used to giving the brass a range colours from copper to steel blue.

Equipment used included my trusty Myford lathe, Wabeco milling machine tool, taps and dies, digital vernier, micrometer, files, piercing saw, wire wool, polishing cloths, patination fluid and beeswax polish.

Finally, after all the time and patience required in constructing my dial, a poem by Charles Wade, entitled *Craftmanship* seems appropriate.

CRAFTSMANSHIP

Some ever would be where they're not,
Would ever have what they've not got.
True happiness – contented mind
Sufficient near at hand will find.
Absorbing interests lie all round.
Will by observant mind be found,
Create something however small,
There lies the truest joy of all,
When brain and hand together strive,
Real happiness becomes alive.
In the pursuit the pleasure lies,
The how and wherefore to devise.
Though vision dreamed will far excel
The work achieved, yet it is well,
To have attempted is not in vain.
Failure urges one on again.
Great craftsman, asked once to decide
Which was his greatest work, replied
Simply with these two words '*My next'*.
For *'ever better'* was his text.

*Charles Wade*

**Design and Construction Time**

It took one year of leisure time in research, eighteen months in the workshop and a huge amount of support from a good friend for CAD drawings and layout for the etchwork.

**ACKNOWLEDGEMENTS**

It is a pleasure to thank the following for their assistance: Gordon Brooks (CAD drawing and etchwork plan layout); Tony Moss (CAD drawing) and Frances Lee (typing and photography); Hayley Gaisford-Gotto at Snowshill Manor (NT) for the Wade poem.

**REFERENCES and NOTES**

1. M. Lee: 'A Moondial for the Northern Hemisphere', *BSS Bull* 21(i) pp.10-13, (March 2009)
2. see H.C. Armstead in *Model Engineer, pp.558-9* (Nov 1989); pp.728-9 (Dec 1989) and pp.20-1 (Jan 1990) publication of a similar article.
3. H Christopher Armstead: 'The Phoeboscope', *BSS Bull,* **92**.2, pp.24-29 (June 1992).
4. Jon Maxwell (private communication). Research of the 1947 article reporting on the Physical Society's Exhibition of Optical and Allied Instruments.

*Author's address*
*amichaellee@hotmail.co.uk*

# SUNDIAL CAKES

We have had sundial cakes before, to mark various anniversaries, both for the Society and privately. Here we have two rather different ones. On the left is a cake with the NASS logo, presented to Tony Moss at their annual conference in September. It marks Tony's formal retirement as a professional dialmaker, though that doesn't seem to have prevented him making more 'for fun'.

On the right is a wedding cake for the marriage on 12 September of our member Andrew James to Phyllida. It is by Ann Ockenden of Milton Keynes and features a horizontal dial on the top tier (an accurate model of a dial by 18th-century Midlands maker Thos Onions). The middle tier is a sheet of appropriate music to represent their choral activities and musical interest. A world map completed the bottom tier.

It was good to see them all at Newbury, where Phyllida was being introduced to that strange breed—diallists. We wish them all a sunny future.

# A DOUBLE CATENARY BIFILAR SUNDIAL FOR THE BALEARIC ISLANDS UNIVERSITY CAMPUS

**RAFAEL SOLER**

On a green in the 'Universitat de les Illes Balears' campus, (latitude 39º 38' 43" N, longitude 02º 38' 46" E) an area of ground has been prepared as the foundation for four stainless steel sheet cylindrical poles, each with a circular section 0.50 m diameter. On the cylinder tops there are balls of 0.40 m diameter supported on cones. From the theoretical centres of the balls and in North-South and East-West directions two stainless steel chains, ten millimeter gauge are welded to the balls. (See Fig. 1.)

The axes of these poles are 4.5 m from the centre of a 11.25 m diameter circle and positioned at the four cardinal points. The heights above the dial's horizontal plane of the centres of the balls are 3.410 m for the North-South poles and 6.148 m for the East-West ones.


*Fig. 1. General view of the dial from the south.*

The horizontal platform consists of a concrete slab, lightly reinforced to prevent cracking, 10 m diameter and which is reached by three steps. A ceramic pavement, with a trimming curb, is laid on the foundation, consisting of 41 cm × 41 cm tiles together with 3 mm joints. Prior to firing the tiles, patterns were drawn for the hour lines for every quarter-hour and the declination lines of the zodiacal months (i.e. those that give the date of the reading day or calendar) as well as legends, numbers and emblems of the sponsors.

The two stainless steel chains are suspended at the virtual heights indicated in Fig. 2 so that their directions correspond to the catenary lines. The vertex (lowest point) of the North-South catenary is exactly at 2.000 m above the dial horizontal and the East-West one is 1.500 m. The theoretical chain length North-South is 9.564 m and the East-West is 13.695 m.

To the south of the dial is a small lecturn with three ceramic tiles which have printed on them the instructions for the dial in Catalan, Spanish and English.

## Reading

The instructions describe how to read the dial, giving the meaning of the numbers appearing on the seven declination lines (corresponding to the twelve zodiacal months of a year) and the method to convert the red hour of true time to the time shown on a wristwatch. The English version reads:

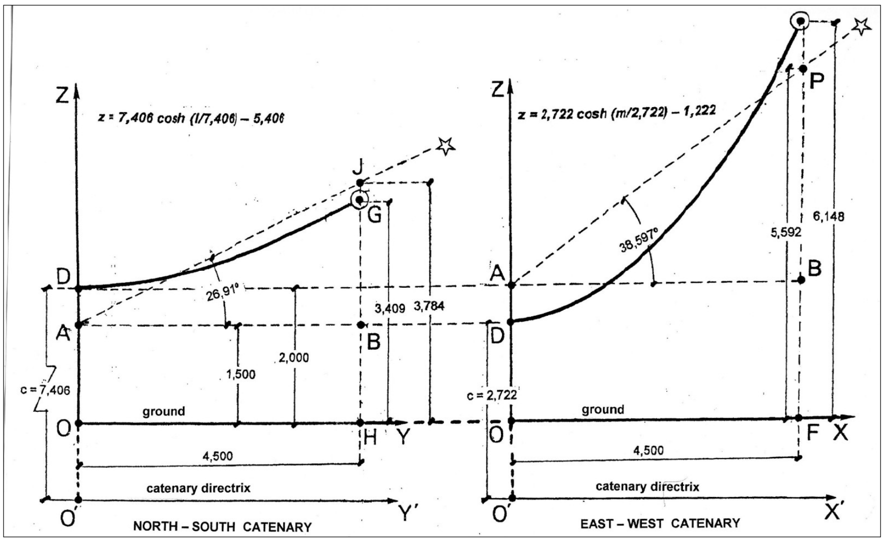



*Fig. 2. The geometry of the catenary chains.*

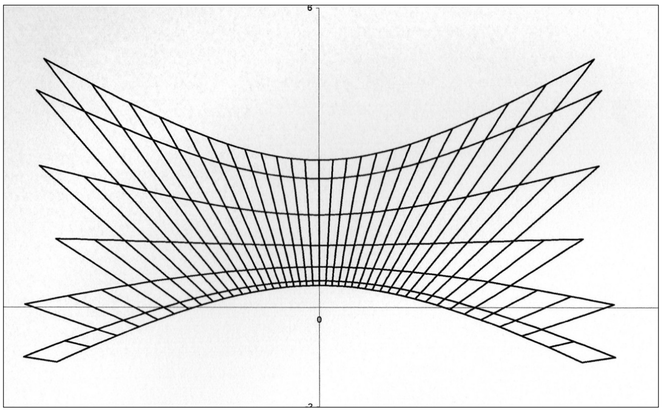


*Fig. 3. Hour lines (for quarter-hours) and declination lines for the entrance of the sun into the zodiac signs, from the computer calculations.*

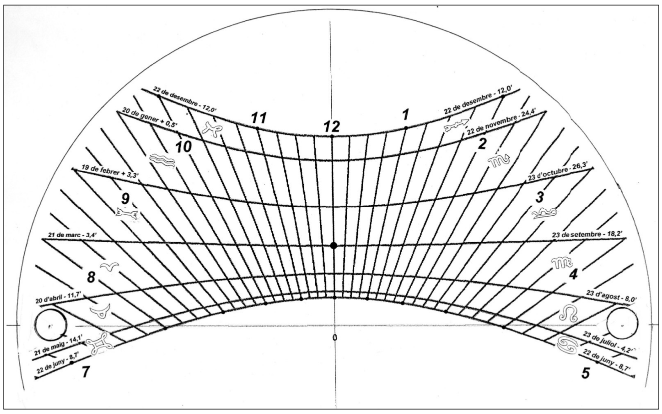



*Fig. 4. Grid of hour and declination lines adapted to fit the circular space and with corrections for mean time.*

HOW TO READ

*Observe the point where the chain shadows cut each other. This point gives: a) on the horary lines bundle, the hour in local true time, and b) on the calendar lines bundle, the reading day date estimated- following the horary line direction- between the two nearest calendar lines corresponding to zodiacal months. On these lines are indicated the corrections to introduce, adding (+ : sundial retards) or resting (- : sundial advances), in every date, in order to convert the red time into Greenwich mean time (this of our wrist watches adding one or two hours according the season and Government rules).*

**Justification and calculations**

The dial uses two curves that are naturally formed catenaries: chains hanging from two pairs of equal-height poles, symmetrical about the centre of the dial. Both curves are the classical catenary with a well known equation.

The general method for calculating bifilar sundials is described in the author's book[1], whose notations are followed here. [Not the conventional BSS notations, Ed.] The full analysis of the book has been simplified for the design of the hour lines and declination lines by articles in several languages.[2-5] Thus we give here only the formulae for our particular case with the following conventions (see Fig. 2). The notation used is shown in the Appendix.

a) the origin of coordinates (see figure) is at the centre of the circle
b) the OX axis is the west-east line (positive eastward),
c) the OY axis is the line north-south (positive values towards the south) and
d) the vertical axis is OZ (positive values toward the zenith).

**Parametric equations of the N-S catenary**

If $l$ is the coordinate on the axis O'Y' and the parameter of its equation, the ordinate of the catenary is determined by $l$ and by the height $c$ of its vertex on the axis of the directrix (not to be confused with the axes of coordinates of the general method). This then allows the calculation of the main construction requirements, namely the height OD above the horizontal plane of the quadrant of the vertex and the chain stretching requirements.

To obtain the optimum distribution of the hour- and declination-lines, the vertex of the north-south catenary is 2.00 metres above the floor and the east-west one is 1.50 m (i.e. with its highest point 0.5 m below the north-south). The poles have their centres 4.50 m from the centre of the dial circle and toward the cardinal points.

The height of the north-south poles are calculated by considering the shadow on the other catenary at the winter solstice. At noon of this day the solar altitude JAB is

$$\text{JAB}^\circ = 90^\circ - \varphi + \alpha = 90^\circ - 39.64^\circ - 23.45^\circ = 26.91^\circ$$

$$\text{JB} = \text{AB} \tan \text{JAB}^\circ = 4.5 \tan 26.91^\circ = 2.284 \text{ m}$$

$$\text{JH} = \text{JB} + \text{BH} = 2.284 + 1.500 = 3.784 \text{ m}$$

However, to avoid projecting the shadow of the suspension ball on the point of reading, this theoretical point is shifted from J to the point G of another catenary with the same $l$ = 4.500 m (the maximum allowed by the circle 5 m radius, leaving room for the bases of the poles) at an altitude of 3.409 m (estimated from the J peak 3784 mm at 375 mm below, slightly less than the diameter of the ball, so that the shadow is 200 mm radius and does not interfere with that of the chain). Thus $c$ = O'D, the height of the catenary. With OD = 2.00 m by construction, the equation of the catenary with the parameter $l$ referred to the axis OY, and not to its directrix O'Y', will be:

$$z = c \cosh(l/c) - c + 2.00$$

which, for $l = 4.500$ gives $z = 3.409$.

Solving this equation in $c$ results in $c = 7.406$ m

And the catenary parametric equations referred to the 3-D axes will be:

$$x = 0, \quad y = l, \quad z = 7.406 \cosh(l/7.406) - 5.406 \quad \text{(metres)}$$

and the theoretical pole height $z$, for $l = 4.500$ m, $z = 3.409$ m (ball centre).

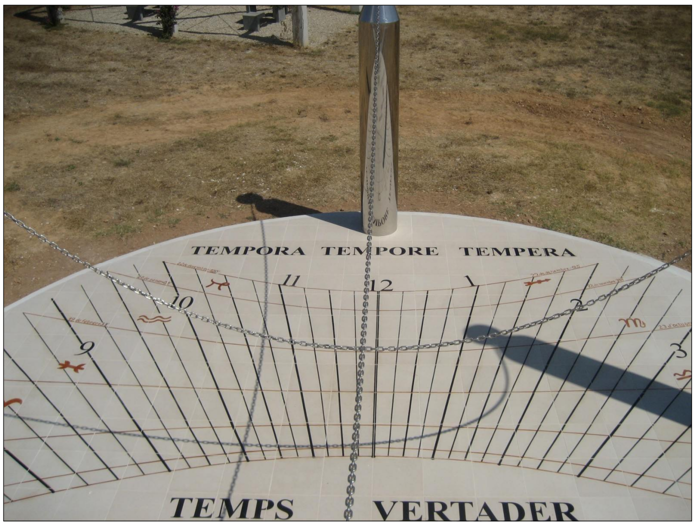



*Fig. 5. The grid of hour and declination lines. The intersection of the chains' shadows shows 10:05 True Time ("Temps Vertader" on the dial) for 1 August.*

**Parametric equations of the East-West catenary**

Similar to previous case, the height $c$ = O'D of the catenary on its directrix will be determined on the condition that the height of the vertex point above the ground is OD = 1.500 m. On the summer solstice, the shadow of this catenary cuts the other catenary shadow with an altitude of the sun, PAB, and at an hour angle $\varepsilon$ given by[1]

$\cos \varepsilon = \tan 23.45° / \tan 39.64° = 0.5236 \qquad \varepsilon = 58.43°$

and resorting to the corresponding tables of altitudes:

12 – 58.43/15 = 8.10 h and entering in the tables for $\varphi$ = 39.64º:

Table of 40.0º:
$o$ = 37.38 + 0.10(48.,82 – 37,38) = 38,784º = PABº

Table of 39.5º:
$o$ = 37.37 + 0.10(48.91– 37.37) = 38.524º = PABº

For 39.64º:
38.524º + 0.14(38.784 – 38.524)/0.5 = 38.597º = PABº

PB = AB tan PABº = 4.5 tg 38.597º = 3.592 m
BF = AD + DO = 2.000 m

PF = PB + BF = 3.592 + 2.00 = 5.592 m

However, at this instant the shadow cast by the ball and the pole coincide with that of the support chain and thus the ball should be raised in the interests of readability. If the increase in height is 556 mm, approximately $^4/_3$ the diameter of the ball, the height of the centre of the ball would be:

5.592 + 0.556 = 6.148 m

The height of the catenary is O'D = $c$ and its equation with the parameter $m$ referred to the axis OX, and not to its directrix O'X', would be:

$z = c \cosh (m/c) - c + 1.500$

which, for $m$ = 4.5 m due to $z$ = 6.148 m.

Resolving this equation in $c$:

$4.648 + c = c \cosh (4.5/c)$

is $c$ = 2.722 m and the parametric equations of the catenary referred to the 3-D axes are:

$x = m,\ y = 0,\ z = 2.722\cosh (m/2.722) - 1.222$ (metres)

**Dial plane equation**

The dial plane is simply the horizontal plane passing through the origin of coordinates. Obviously its equation will be $z$ = 0, and, in the notation of the stated article are followed:

A = 0 , B = 0, C = 1

taking $x' = x$ and $y' = y$ on the dial plane.

The previous calculations are now ready for application of the method in ref. 1

$-z_0\, m = x_0 (7.406 \cosh(1/7.406) - 2.722 \cosh(m/2.722) - 4.184$

and from the two expressions (10) of that article produces:

$l\, x_0 = m\, y_0,\ \ l = -m\, (y_0 / x_0)$ and substituting:

$-z_0\, m = x_0 (7.406 \cosh(-y_0\, m/(x_0 7.406)) - 2.722 \cosh(m/2.722)$

This equation in $m$ can be solved numerically to find the values of $x$ and $y$ defined by the expressions (8) of ref 1:

$x = -(x_0 / z_0)(2.722\cosh (m/2.722) - 1.222) + m$

$y = (y_0 / z_0)(2.722\cosh (m/2.722) - 1.222)$

and giving values for the solar declination $\alpha$ corresponding to the changes of the zodiacal months and values of the horary angles $\varepsilon$ corresponding to quarter hours (3.75º), are obtained the calendar lines (values of $\alpha$) and horary lines (values of $\varepsilon$) interested and the curves involved as are shown in Fig. 2.

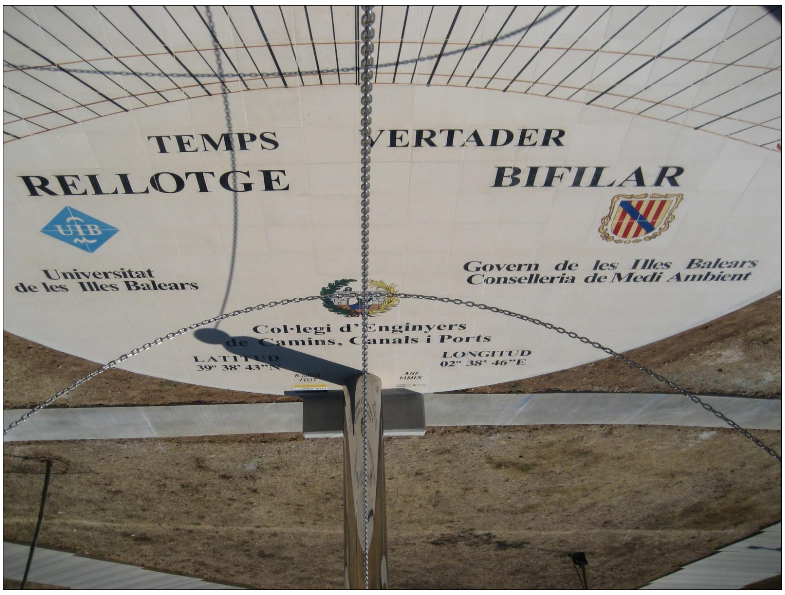



*Fig. 6. The logos of the three sponsors.*

**Appendix – Notation**

$l$ = parameter in the N-S catenary.
$\phi$ = latitude.
$\alpha$ = solar altitude.
$c$ = catenary height (distance from the vertex to the directrix, not the ground).
$x$ = abscissa of the catenary (W-E axis).
$y$ = abscissa of the catenary (N-S).
$x'$, $y'$ abscissas referred to 3-D in this case coincide with $x$ and $y$.
$z$ = catenary ordinate (height of a point above the ground).
$\varepsilon$ = hour angle.
$m$ = parameter of the catenary E-W.
$x_0$ = direction cosine of a sunray along the x-axis.
$y_0$ = direction cosine of a sunray along the y-axis.
$z_0$ = direction cosine of a sunray along the z-axis.
$\mu$ = angle of the direction of sunrise (or sunset) with the meridian line.

Note: cosh = hyperbolic cosine

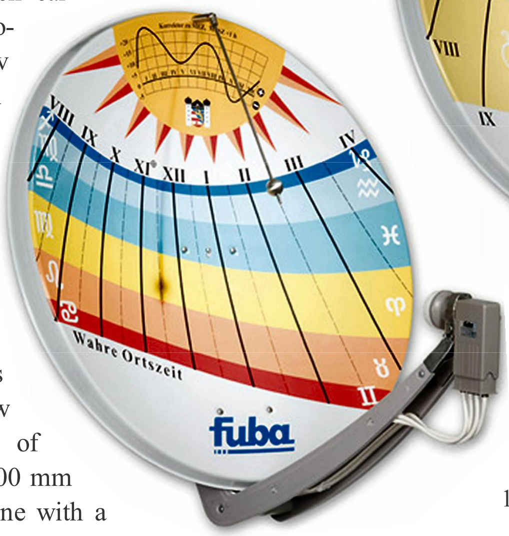
**REFERENCES**

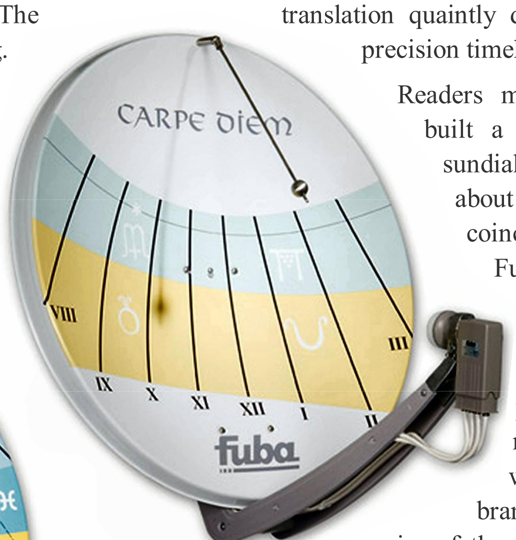
1. R. Soler: *Diseño y Constucción de Relojes de Sol y de Luna,* Colegio de Ingenieros de Caminos, Canales y Puertos in its Collection of Sciences, Humanities and Engineering seies. (in Spanish).
2. R. Soler: 'Aplicaciones del método analítico de diseño de relojes de sol bifilares*'*, *Analema*, No. 32, April-August 2001 and corrigenda at No. 38, April-August 2003 (in Spanish).
3. R. Soler: 'Application de la Methode Analytique aux Traces de Cadrans Solaires Bifilaires'*, Cadran-Info*, No. 6,of the SAF, October 2002, (in French).
4. R. Soler: 'Aplicaciones del método analítico de diseño de relojes de sol bifilares' in *Carpe Diem*, nº 18, 1 June 2006, which includes these corrections (in Spanish).
5. R. Soler: *'*An application of the general method for bifilar sundial design'*, NASS Compendium*, 13(4), (December 2006).

*Author's address:*
*C/ Tous y Maroto nº 6, 1º, 2ª*
*07001 PALMA DE MALLORCA*
*solergaya@hotmail.com*

# SATELLITE DISH SUNDIALS

A German member of the Sundial Mailing List, Josef Pastor, has made the dialling community aware that you can now buy a commercial satellite dish which is also a sundial. The firm of Fuba,[1] from Muenster/Westphalia, offers a choice of two 85 cm parabolic satellite antenna sundials, as seen in the pictures. The price is a very reasonable €29.95 excluding shipping. The dials were calculated by Heinrich Stocker, a member of the Austrian Sundial Society – he described them at their meeting at Oberperfuss in 2004. They are designed for a geographical location of Frankfurt-am-Main (50° 7' N; 8° 41' E) and for the Astra satellite, which carries most of the domestic European tv stations and is in orbit at longitude 19.2° East (and latitude 0°, as for all geostationary satellites). The dials have an adjustable gnomon and the instructions give details of how to set the position of the nodus exactly 200 mm above the rim, in line with a target spot on the dial face. The instructions also give time correction curves combining the equation of time and longitude corrections for four German towns; Frankfurt, Hamburg, Munich and Berlin. Of course, with a single delineation, it is not possible for the dial to be exact at all these locations – though the region is quite small compared to the earth-to-satellite distance. The instructions do make it clear that the dial is for interest only ("a scoreboard of passing time" as my computer-generated translation quaintly describes it!) and not precision timekeeping.




Readers may remember that I built a similar satellite dish sundial in 1999 and wrote about it in the *Bulletin*.[2] By coincidence, one of the Fuba designs even has the same motto – Carpe Diem – that I used. I should have patented the idea! In my version, the dial was on a flat membrane stretched across the rim of the dish. The calculations for the paraboloid surface of the dish will not have been trivial so both the designer and the makers of the Fuba dials are to be congratulated. Who will install one in England?

**REFERENCES**

1. See http://shop.fuba.de/index.php?cat=c1816859_85-cm-Klasse.html for purchasing details.
2. J. Davis: 'Satellites and sundials', *BSS Bulletin*, 11(ii), pp.77-80, (1999).

*John Davis*

# PRISM DIALS – A REGIONAL VARIETY?

**TONY WOOD**

A recent visit to Atcombe Court in Gloucestershire produced the dial shown in Fig. 1. High up and quite old, it is of a form called ‘prism dial’, being a cube sliced vertically on the diagonal leaving two vertical faces which become SE and SW declining dials. The utility of the prism dial arises from the fact that a direct south vertical is limited to a maximum period of illumination from 6am to 6pm but the SE/SW pair can just cover ‘All Oure Sunny Houres’ (as long as it is not mounted on a south-facing wall), providing a good motivation for such a dial.

*Fig. 1*

One is tempted to ask if there is a relationship to the cube dial declining 45° which is usually described as being a ‘conceit’ to demonstrate the diallist’s skill. I suspect that the prism dial came earlier, demonstrating that declining faces were a useful extension. All previous examples of prism dials have been connected with churches so the Atcombe Court dial is unusual. The churches were within a rough local region leading to the thought that we may have a local regional variety. A short gazetteer of these dials follows.

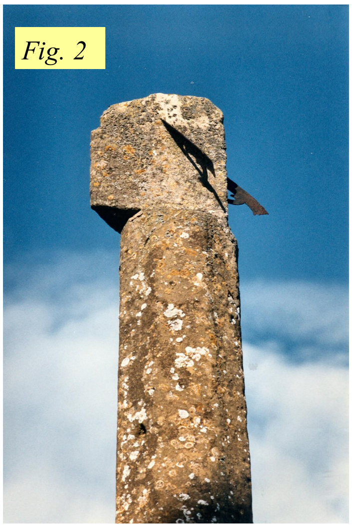


*Fig. 2*

**Ashton-under-Hill, Worcs.** (Fig. 2)
Just outside the lych gate of the church and mounted on a column, good gnomons but no delineation remaining.

*Fig. 3*

**Avening, Glos.** (Fig. 3)
High on the ridge of the nave at the west end and very badly weathered. The gnomons have gone, as has the delineation. It is so high up that reading it must have been difficult even when new.

**Brokenborough, Wilts.** (Figs. 4 and 5)

*Fig. 4*

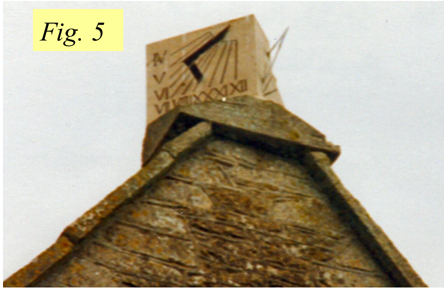


*Fig. 5*

Mounted above the east wall. Here all three faces of the prism are used, facing west, south east and north east. The original dial was in poor condition with the gnomons rusting and delineation all gone (Fig. 4). In 1997 a new dial was mounted, being a near copy of the original with clear delineation and an unusual west gnomon (Fig. 5).

*Fig. 6*

**Daglingworth, Glos.** (Fig. 6)
This church has a Saxon dial, a mass dial and a scientific dial. The scientific one is on the porch and is very early. It is a form of prism dial consisting of two faces declining equally to east and west, the dial then being offset with respect to the wall. The faces are more SSE/SSW and the block has finished up being an untidy shape but just within our definition of ‘prism dial’.

**Little Somerford, Wilts.** (Fig. 7)
Mounted on the porch and offset from the line of the wall to ensure the faces are SE/SW. There are restored (stainless steel?) gnomons and the delineation is readable. The faces are rectangular and the ‘back’ of the dial block is not a straight slice however but slightly concave with a central bump.

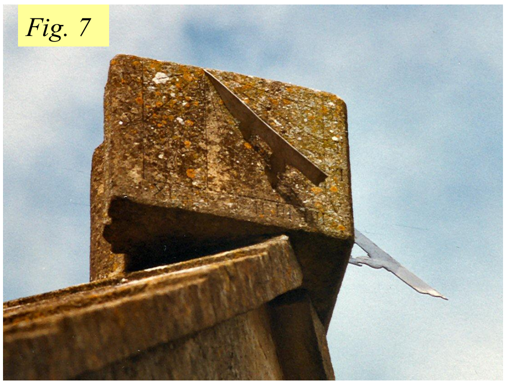


*Fig. 7*

*Fig. 8*

**Tresham, Glos.** (Fig. 8)
Barely recognisable as a dial and mounted on a column in the churchyard to the south of the church. There are no gnomons (although the roots are just visible) and no visible delineation; additionally the block is mounted so that the square faces face south and west.

**Regional Variety**
The presence of such a number of these dials within a relatively small region prompted the question as to whether this was a local variety and to more general thoughts about such variation. Regional variety is common in many man-made objects due to limitations of available materials and adaptation to local conditions. Churches are an obvious example with 'Somerset' towers, Hertfordshire 'spikes' and the round towers of East Anglia. At sea, we have the Humber Yawl and Thames Barge, and innumerable local fishing boat varieties can be identified by the expert eye.

It is a little surprising that such a variation is not apparent in our vernacular dials across the country. There are however some examples, the Scottish multiples for instance;[1] a remarkable collection of dials whose origins presumably lie in the nobility's desire to impress. (This seems to account for the 'outlier' in Worcestershire at Elmley Castle.)

Another example in the family/local craftsman tradition, is that of the 'Berry' slate dials of Devon and Cornwall[2] where sufficient commissions permitted the establishment of a little group. In North Wales, horizontal church dials are mounted on plain stone columns, probably following the direct carving of dials onto the top of such columns.[3]

Perhaps commissions for new dials were not sufficient for anyone to establish a local reputation or style and so dials were 'one-offs' apart from the expensive 'classic' dials which were in any case spread around the country to whoever could afford them.

**REFERENCES**


1. A.R. Somerville: 'The Ancient Sundials of Scotland', *Proc Soc Antiq Scot*, 117, pp 233-264, (1987).
2. J.P. Lester (Ed.): *Mrs Crowley's Sundial Sketchbooks of Devon and Cornwall*, BSS/AHS, (2007).
3. M.I. Brightmer & A.O. Wood: *Early Horizontal Dials*, presented at BSS Newbury Meeting (September 2008).



*Author's address:*
*Churchdown, Gloucs.*


# A PHOTOGRAPHER'S SUNDIAL


**(continued from page 27)**


equally. This seems to be as accurate as aligning with the edge of a shadow from a vertical knife edge. This instrument can also be used as a sun compass – to find north given the date, time and sun's direction. To do this accurately, local apparent time is required. This in turn requires knowledge of the equation of time and the longitude correction and is unlikely to be of interest to photographers.

**REFERENCES**


1. J. Davis & C.M. Lowne: *The Double Horizontal Dial*, BSS Monograph No.5, (t.b.p. 2009).
2. J.A. Belk: 'The Stereographic Projection as a Graphical Method for Designing Sundials. Part 1' *Bull BSS*, 13(ii), 85-88 (2001).
3. M. Lowne: 'The Design and Characteristics of the Double-Horizontal Sundial' *Bull BSS*, 13(iv), 138-146 (2001).
4. William Forster: *The Circles of Proportion and the Horizontal Instrument &c. Both invented, and the uses of both Written in Latine by W. Oughtred Ætonens. Translated into English and set forth for the publique benefit by W.F.*, London, (First published 1632).
5. J.A. Belk: 'The Stereographic Projection as a Graphical Method for Designing Sundials. Part 2' *Bull BSS*, 13(iii), 123-127 (2001).



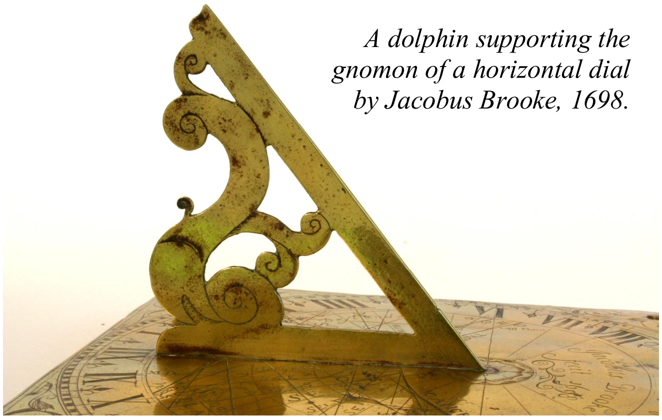
*Author's address:*
*tonybelk@btinternet.com*

# GNOMON SUPPORTERS

## MIKE COWHAM

The gnomon of a sundial is often overlooked and dismissed as being purely functional. As long as it is set correctly, and at the appropriate angle, it should function properly.

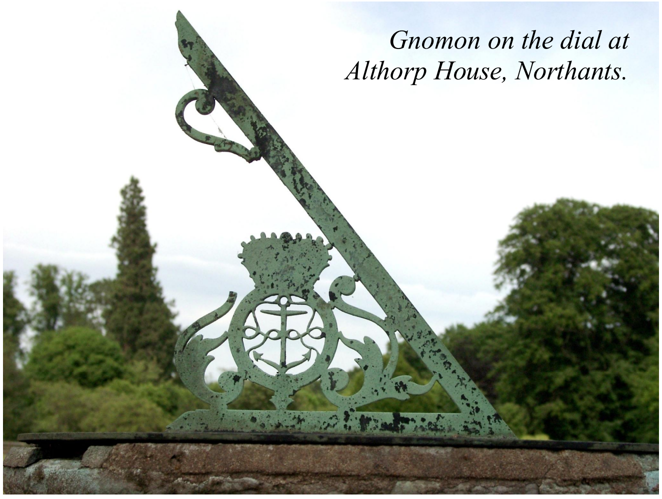
However, most gnomons are not just plain triangles of metal and often have elaborate decoration, sometimes referring to the dial's ownership or to mark some particular event. The structure of the gnomon is therefore a place where the dialmaker can show off his skills and many of these are worth studying for the tale that they have to tell. Those detailed below are just a few of those that I have found that are typical of this fine decorative art. [For other examples, see John Moir: 'Shadowy Secrets Part 4 - The art and artifice of the gnomon', *BSS Bulletin* 20(iii), pp.112-4 (September 2008). Ed.]



*A dolphin supporting the gnomon of a horizontal dial by Jacobus Brooke, 1698.*

The traditional supporter for the garden dial, used by many old dials, is the dolphin, often just in outline but sometimes engraved with its features. A pair of intertwined dolphins were also used on the decorative frets of lantern clocks in the late 17th century. The dolphin too is used at Greenwich where a pair of them pose beautifully with their tails almost touching to show the time on this fine dial. The 'Dolphin Dial' was erected to commemorate the Silver Jubilee of Queen Elizabeth II in 1977, designed by Christopher Daniel and made by Edwin Russell.

*Two dolphins at Greenwich.*



*Gnomon on the dial at Althorp House, Northants.*

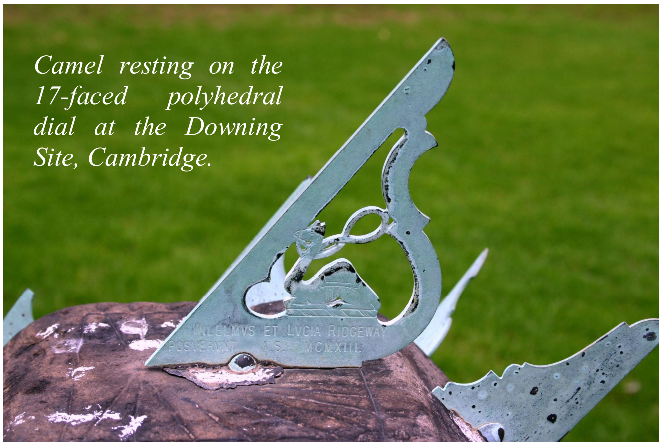
The support on the dial by Watkins of Charing Cross at Althorp House near Northampton, home of the Spencer family, shows a crown and anchor. It is a rather flimsy supporter and has already suffered some loss of the scroll on the left. A good support ideally should be strong to resist attacks by vandals and similar disturbances.

The dial at Anglesey Abbey by Watkins & Smith, London, dated 1769, has as its supporter a snake curled as if waiting to catch his prey.

*Snake at Anglesey Abbey, Cambridgeshire.*

The polyhedral dial of 1913, in memory of William and Lucy Ridgeway, at the Downing Site in Cambridge, has its uppermost gnomon supported by a camel.

At the Horniman Museum in South London are several fine modern dials, but the finest gnomon has to be that formed by a butterfly. This dial designed by Edwin Russell was made by Brookbrae and commemorates the 20th wedding anniversary of



*Camel resting on the 17-faced polyhedral dial at the Downing Site, Cambridge.*

*Butterfly forming the gnomon on dial at The Horniman Museum.*

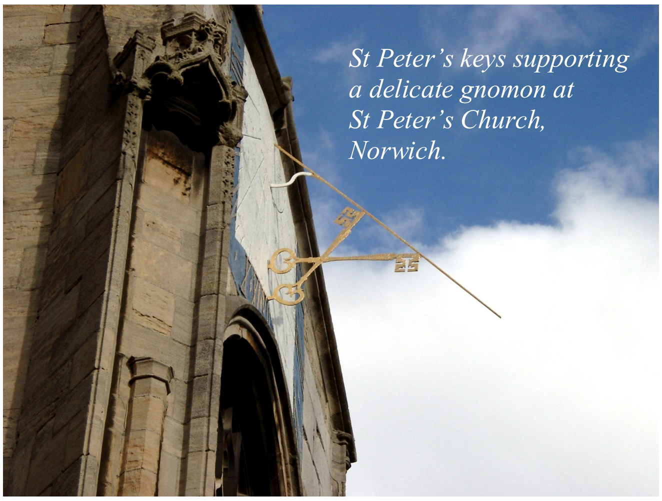
Noel and Margaret Ta'Bois. In this case, the butterfly in its folded wing pose is the gnomon, the straight edge of the wings throwing its shadow onto the dial.

Vertical dials too have their share of interesting gnomons. The large dial at Market Harborough, Leicestershire, high on the church tower, has a most elaborate gnomon support consisting of many fine scrolls in wrought iron. Three of the scrolls appear to be like bracken leaves.

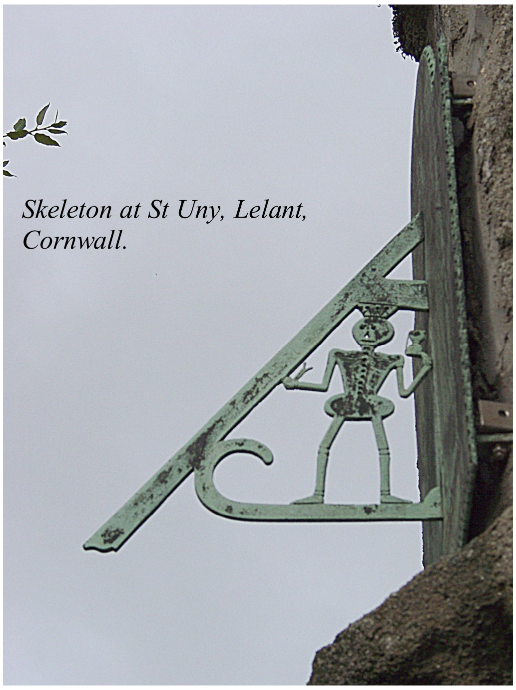
*Fine scroll gnomon on St Dionysius' Church, Market Harborough, Leicestershire.*

The vertical dial at St Peter's Church in Norwich is supported by a fine set of St Peter's keys to heaven. Such a delicate gnomon as this would never survive on the usual horizontal dial, but here it appears to be immune from interference.

A more morbid reminder of death is to be found at Lelant in Cornwall, the gnomon being held up by a crowned skeleton holding a bone in one hand and an hour glass in the other.



*St Peter's keys supporting a delicate gnomon at St Peter's Church, Norwich.*



*Skeleton at St Uny, Lelant, Cornwall.*

*Replica of a fine horizontal dial by Thomas Tompion at Hampton Court Palace*

One of the horizontal dials by master clockmaker Thomas Tompion at Kew has a most ornate gnomon. It consists of various foliate scrolls, fashioned boldly in three dimensions to make a very sturdy gnomon.

Returning again to Market Harborough, just up the road from the church is a most unusual gnomon supporter. It is known as the 'Man with a Plank' dial, where a bargee ap-


*'Man with a Plank' dial at the Old Union Canal Basin in Market Harborough.*


*Two children charmingly indicating the hour of noon at Dunscore*

pears to hold a plank of wood which functions as the gnomon. It is a most appropriate dial for its situation in a canal basin.

Human supporters can be used to great effect as on the dial at Dunscore, Scotland, where two children are climbing over the wall. The boy has formed his right hand into a circle to make a spot of light fall onto a vertical noon dial showing the analemma for the first half of the year and beside him is a girl holding a long flower leaf that throws its shadow onto a second analemma for the last half of the year.

Portable dials too have their share of gnomon supporters. Perhaps the best known is the small bird found on the 'Butterfield' dial. This bird comes in various forms and if we try to decide what these are, there is almost certainly a robin and a dove. A swan is known on one dial and the crested bird (which may be a lark) is found on a few dials of English manufacture. On a dial by John Rowley there appears to be a dog lurking in the undergrowth behind the bird, so perhaps it is meant to be a game bird. Rarely, other supporters are found such as a golden lion and a rather grumpy looking dolphin, this time using his tail as the latitude indicator.

I am sure that there are many more interesting gnomon supporters around and I would like to invite other Members to submit pictures of some of these to show the wide variety of ideas that have been used on dials over the ages. [Our US member John Carmichael has recently set up a web-page for gnomon photographs on the Flickr photo-sharing website at *www.flickr.com/photos/tags/gnomon/* . Ed.]


*A selection of gnomon supporters from 'Butterfield' dials: John Rowley - crested bird (possibly a lark); Françoise De Laistre – robin; Le Febvre – swan; Samoilov - turtle dove; J Bizot - lion and Jacques Le Maire – dolphin.*

Apart from the Butterfield dials I have been unable to find interesting gnomon supporters from anywhere except Britain. Does anyone know of any abroad that are as interesting?

*Author's address:*
*PO Box 970*
*Haslingfield*
*Cambridge, CB3 7FL*

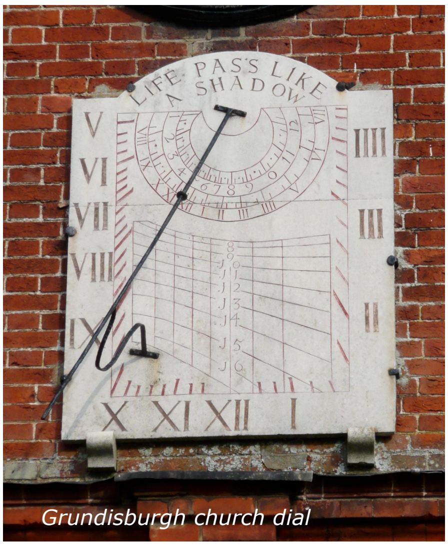
# BSS Sundial Safari to East Anglia

## 19-25 September 2009

It was decided to visit East Anglia for the 2009 Safari. This region is often thought of as flat and boring but we hoped to dispel this myth during the week. Suffolk's coastline is designated a Heritage Coast and we were able to enjoy this during our visit to Aldeburgh. East Anglia has many grand churches paid for by wealthy wool merchants who had made good profits from the wool trade. Long Melford and Lavenham are among the most impressive. For those interested in architecture and history, Bury St Edmunds is fascinating, as it has been a cultural centre since the eleventh century and Colchester is steeped in Roman history. Norwich, the capital of East Anglia has several good museums, the Castle, Cathedral and churches every few metres. Beautiful villages abound in the region and most are unspoilt. These are only a few of the attributes of the region.

At the end of the Safari we were thrilled when we were presented with a sundial made by Tony Moss. It is inscribed "BSS Safari 2009 for Val' & Mike Cowham with Many Thanks from your Fellow Travellers". The dial has 52 names of recent Safari travellers. We will treasure this and we are sure that in the future it will be well cared for and people will be curious about these Safari Travellers. A *real antique* of the future.

*Val Cowham*




*Grundisburgh church dial*

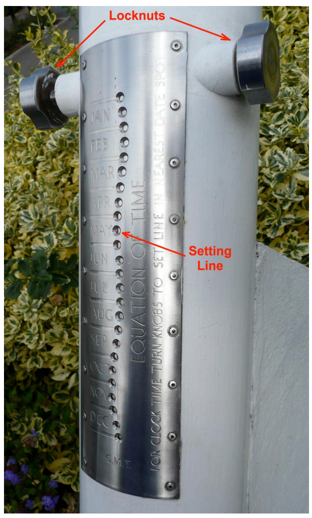
**Sunday 20 September**

Sunday 20th September dawned fine and clear following our first comfortable night at the Elizabeth Hotel in Copdock. Leaving the hotel by coach after the usual over-generous breakfast, our first destination was the dial on the church at Grundisburgh after crossing the impressive Orwell Bridge over the wide estuary *en route*. The large stone, east-declining dial with elaborate furniture is high above the door of a red brick 'water tower' stuck rather incongruously on the front of a handsome flint church. A proprietorial plaque explains "This Steeple Was Built.....and Fixt. At The Charge of ROBERT THINGE Gent. .....1731 - 1732". The very fine 'hammer beam' roof in the church is a spectacle in itself. A lovely church and a fine dial...shame about the tower.

Onward to Woodbridge with a welcome coffee stop in a garden centre. From there it was a short walk to Clock House in Cumberland street where an unusual dial was set on the narrow side wall of a projecting

*Clock House, Woodbridge*

porch with a circular 'noon mark' type of aperture plate supported on modern iron scrollwork. The hour lines from X am to III pm are continued around onto the adjoining wall. A garden to the rear contains an elegant vertical dial on a stone pillar by Martin Cooke. The hand-cut inscription in fine uppercase letters and a single gilded XII upholds the tenet that 'less is more'. Continuing our walk we passed the 'Old Bell and Steelyard' pub with its overhanging beam balance to see a square brass horizontal dial in Elmhurst Park with roman numerals and a repaired or reinforced gnomon on a crumbling brick pillar. The over-engineered repair partially obscured the central Sun face. Not far away is a quite remarkable 'compensating equatorial' dial at 52° 6' N and 1° 19' E,




*Frank Evans and Andrew Ogden frame the equatorial dial by R.S. Simon in Elmhurst Park with, right, the EoT compensating scale.*

designed and made by Robert Scott Simon in 1988. The dial is cleverly adjusted for the equation of time by rotating the extended polar gnomon and its surrounding scale until a setting line appears in a series of dated analemmic holes in the supporting tube. After 21 years of weather and public attention the design is proven to be very sound.


Snape Maltings, with its world famous musical associations, was our destination for a buffet lunch after which we travelled to Saxmundham to see perhaps the smallest dial of the whole safari on, or rather cut into, the west face of a gravestone dedicated to John Noller and his wife Mary in 1724/5. The east-facing but unfinished complementary dial was on the opposite face.

Thereafter to the holiday village of Thorpeness and a 2007 dial painted on wood(?) with a gilded sun and a single 'peg' nodus marking the equinox and solstice lines with an anonymous declination line indicating a date in perhaps October or February.

Four dials in Aldeburgh completed the day's outing. The largest, on the Moot Hall, was very crisp and new in appearance although dated 1650. An elegant break-arch/swan neck surmounts an architectural frame with the motto 'HORAS NON NUMERO NISI SERENAS' above. Although less flamboyant, the remaining three dials were worthy of the long walk to find them. Two horizontal dials in the churchyard were beyond my walking range but I did manage to shuffle to our end-of-day slap-up cream tea at the Craggs Sisters cafe.

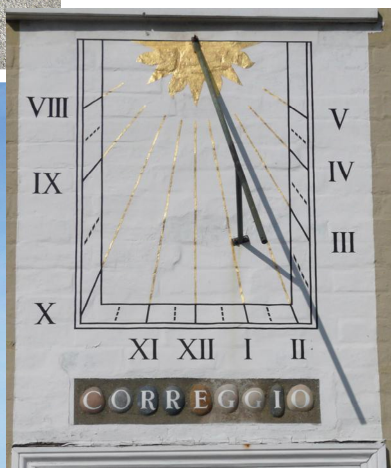
*Tony Moss*

**Monday 21 September**

The weather was overcast as we took our coach through the flat agricultural land, devoid of any cows, to Norwich. By the time we arrived in the city centre we were in bright sunlight with instructions to see the many sites and not concentrate too much on dials. The group split up and we went our separate ways. I joined our friend Claus Jensen from Demark to discover some of the Norwich curiosities. The centre was very busy and alongside the market we saw the church of St Peter Mancroft (Great Field) with its fine dial (see page 41 in this issue).

When proceeding to the Cathedral we found in the pavement a computer keyboard. The Cathedral itself had its own curiosities with its Green Man, a recycled copper chocolate cooking pot being used as a baptismal font. There was also a labyrinth, constructed to celebrate the Golden


*Cathedral Close, Norwich*




*At the Aldeburgh Moot Hall, Geoff Parsons shows members of the Safari how to get to the other three dials in town.*

Jubilee of Queen Elizabeth II. In the Cathedral Close, whose houses are built in the local flint, we saw a dial.

From there we went to the other large medieval building in Norwich, the Castle Keep, now a museum. Amongst the items there we saw Cromwellian armour, displays of medieval life and a dragon and snap dragon. Dragons are dominant in Norwich. There is a Dragon Festival, a Dragon hockey team, Dragon (with George) pubs, Dragon restaurant, and Dragon Hall built in 1430 that has a carved dragon spandrel. There is even a dragon gargoyle on the Cathedral.

The people of Norwich are also crazy about elephants. Indeed a strange people. Finally, on St Andrew's Church Tower we saw a dial with a bent gnomon.

After lunch we regrouped outside the Cathedral and boarded the coach for Ditchingham Hall near Lowestoft. There we were greeted by Lady Tamworth. In the 18th-century landscaped garden we were shown an original Henry Wynne double horizontal dial and its fine replica by Tony Moss. (A full description of the making of the dial is in the *Bulletin,* March 2006.)

*John Davis and Tony Moss flank Lady Tamworth, standing behind the replica Henry Wynne double horizontal dial, with the original on the ground in front.*

After such a fine afternoon we returned to our hotel at Copdock for dinner. Afterwards, there was a display of six double horizontal dials, four dating from the 17th century – a world record gathering.

The surprise of the day was, for some of us, our Vice President Fredrick W. Sawyer III (also President of the North American Sundial Society) presenting John Davis with the NASS Sawyer Dialing Prize for his outstanding services to dialling.

*Jim Marginson*

**Tuesday 22 September**

Today's tour went west and made many stops in little villages – a complete contrast to yesterday's two venues of a big city and a stately home.

The day began with the sun shining brightly, with the coach arriving on time. We had a younger, very taciturn driver, compared to our first two drivers, but he thawed out as time went on. It was the first day we needed sunglasses from the very start. We also nearly left the hotel leaving two diallers behind, not a good omen!

The first leg was a long drive, well over an hour, to the first stop at Widdington, near Stanstead airport. On the way we passed through the village of Ugley, which rejoiced in possessing the Ugley Women's Institute, and the Beautiful Ugley Chequers Pub.

*The Widdlington stained glass dial*

Widdington is a delightful village, with the church reached by a short walk up a narrow lane. The church possesses an interesting stained glass dial, unfortunately placed on the north side of the church. No gnomon was present. The village had many yew trees, and was quite hilly, with many narrow lanes. As we left, we saw a forlorn notice fixed to a telegraph pole, seeking a missing grey parrot!

*The wooden dial at Newport with its motto 'Many be well paid for abusing Time' (not in Gatty).*

Next, we moved north to Newport, a pleasant village with a splendid flint-faced church. The wooden dial was placed high up over the south-facing porch, and has its markings and lettering in relief. It was interesting to see that the dial was a decliner, and was also canted out from the wall. It gave the appearance of being rather warped, as well. The interior of the church had some interesting artefacts, including a large portable altar, dating from the 13th century.

On the way to our next venue, we stopped for refreshments at the Farm Shop and Deli, before arriving at Elmdon.

This village has a splendid church, and we had a conducted tour of it by the very erudite landlord of the village pub. The pub itself is named 'The Elmdon Dial', and has a fine painted inn-sign showing the stained-glass dial. The actual 17th century dial (see back cover) was taken from a demolished church

*Refuelling stops are essential!*

nearby at Wenden Lofts in 1958, and is located in the west end of the church together with other interesting stained glass panels. The landlord had a good story of when he had asked the vicar if he minded if the adjacent pub could be renamed 'The Elmdon Dial'. "What dial?" was the response! There is also a fine cast-iron royal coat of arms.

After this entertainment, we repaired to the 'Elmdon Dial' itself for a splendid buffet lunch in one of the several spacious rooms.

After this repast, Saffron Walden was the next stop. This is a pleasant town, with much pargetting on the buildings. (This is decorative plasterwork on the walls of the houses.) A small market was near the church, which has the longest nave in Essex, nearly 200 ft long.

As we drove into the town, we passed a turf maze, or labyrinth, which dated from 1699.

We wandered around the town, looking at the numerous small shops, especially the second-hand bookshops. The weather by now was getting very hot. On our reaching the coach pick-up point in the municipal car park, we were fascinated by the automated toilet set there. On placing a coin in a slot, a vast curved door slid back, revealing a dark cavern. We wondered if you would ever emerge again!

*Saffron Walden—a dial would make it perfect!*

A brief stop was made at Stoke-by-Clare to see the wooden dial in the church, but by now fatigue was setting in, and only a hardy few left the coach to see the dial – the rest of the party staying put.

Tea was taken in Clare itself, at the Bell inn. Much pargetting was seen on buildings, and a fine renovated dial was found on the church, bearing the motto 'Go about your Bufinefs'. Sundial mugs were for sale in the church, which unfortunately were not priced, although by general consent, £4 was deemed a fair amount.


Our last visit was to Cavendish, to see a mass dial on the porch. We then returned to the hotel, tired but having enjoyed a very good day.

The entertainment was not over, however! After dinner, Mike Cowham gave a slide show of portable dials, ranging from dials from the Tudor warship, the Mary Rose, up to Butterfield and universal ring dials.

*Mike Isaacs*

**Wednesday 23 September**

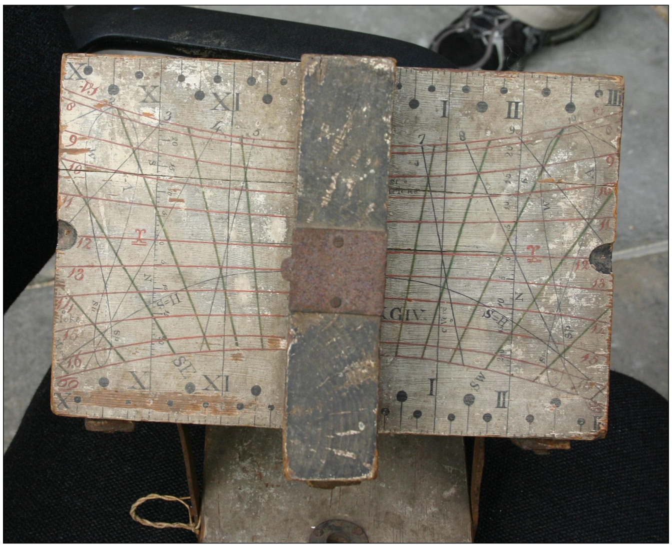
Our first call was to Ipswich Docks to view a fine large dial made for the local Rotary by Tony Moss (see front cover). It was set beside the marina basin on a low pedestal, with a forest of yacht masts for a background. On the other side of the marina lay one of the last Thames barges and behind it again the Custom House where Tony Belk's dad once worked. It was a modern


*Holbrook Royal Hospital School. A familiar motto...*

scene with the shadow of history upon it. From Ipswich we drove to a viewing point for the magnificent Orwell Bridge of 1982, which carries the A14 across the Orwell River, avoiding the town. Nearby we paused at the Royal Hospital School, Holbrook, founded in 1712 as an adjunct of Greenwich Hospital, for the support of the children of indigent seamen, particularly orphans. It is now a public school. On the central gable of a line of school dwellings is a handsomely decorated stone dial again bearing the familiar motto 'Horas non numero nisi serenas'.

It was Tony Moss who spotted the indications in concrete at the school entrance gate of the display site of a large captured Turkish gun dated 1790, but now removed.

Colchester Castle was an impressive structure. It is rather unlike the massive fortresses of our northern fastness, being constructed, not of familiar stone blocks, but of cobble and flint. In Colchester we had time to view the town, a medieval grid, and find lunch; for ourselves we also spent a little time in the Natural History Museum. In the afternoon we were delighted to visit Tymperlys Clock Museum, where there was a fine horological treat, a collection of Colchester clocks brought together by one Bernard Mason, who in 1956 bought the building and commis-



*The rather strange wooden cross dial in Tymperlys Museum*

sioned an architect to carefully renovate it in the style of a sixteenth century house.

Here we saw a strange wooden cross dial, believed to be of the nineteenth century and possibly used for instructional purposes. As well as conventional time it was marked out in Italian hours.  Time variants for many places (Madras, St. Helena, Lima and so on) were listed on the cross. A curator brought out for us a small wooden shepherd's dial which she held out in a gloved hand for our examination. Our leader, Mike Cowham, declared this dial to be a late work and not of the highest quality but we made a plan of the gnomon and noon line in the hope of later finding the latitude for which it was made. A rather similar dial was later to be seen in Moyses Hall.

*Constable's painting of East Bergholt church shows a sundial which is still in position. The figures in the foreground are a boy with his mother and grandfather, evoking the timelessness of the scene.*

On, then, into Constable country, calling at Dedham on the River Stour where a house of 1735 bore a plain but pleasing painted dial high over the door. Our last call was to East Bergholt where the dial on the church was not dissimilar but told us that time passeth away like a shadow. More impressive was the ring of bells housed in an ancient wooden cage. They were strangely mounted mouth upwards at ground level and uniquely were rung by hand-tilting them. The church tower originally intended to house them has remained unfinished since 1530 when the money ran out.

*Frank and Rosie Evans*

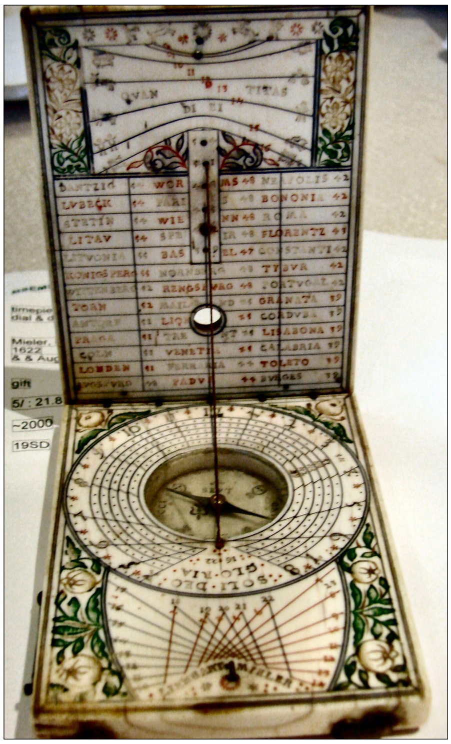
**Thursday 24 September**

Our visit to Bury St Edmunds started in Moyses Hall Museum accommodated in one of East Anglia's oldest town houses, erected originally in 1180, facing then as now the adjoining Market Place, where commerce was controlled and supported for centuries by the nearby wealthy and powerful St Edmund's Abbey.

Heritage officer Peter Jones welcomed us and gave us an interesting introduction to the building and the museum's collections, which trace aspects of the local and social history of West Suffolk, for instance gruesome objects pertaining to crime and punishment, like a gibbet and a man trap.

We, however, were caught first and foremost by the museum's fine collection of clocks, watches, and sundials, one of the absolute highlights of our safari. Most of the sundials are normally placed in store, but Peter Jones and his assistant Alex McWhirter most hospitably brought them out especially for us to handle and examine in every detail. Among the many fine objects, I especially

enjoyed a small wooden dial excavated in the nearby St Mary's Church. This dial, which is equipped with a 52° gnomon, the latitude of Bury St Edmunds, is otherwise similar to those salvaged from the wreck of the ship Mary Rose. Furthermore, the collection includes some beautiful ivory diptych dials, for instance one by Leonhart Miller (signed Lien-



*Ivory diptych dial by Leonhart Miller.*

hart Mieler), dated 1622. The permanent collection even boasts a Tibetan shepherd's timestick from the early 19th century whose numerals are surprisingly intelligible to European eyes.

In the afternoon we visited the impressive site of St Edmund's Abbey, where the medieval cathedral has recently had a new spire added. St Mary's Church, on the same site, has a small dial on its corner, and inside there is a fine Tavern Clock. Besides these timepieces of the church I was impressed by its magnificent roof, equipped with pairs of hammer-beam angels, thus symbolising that matter is based on - and carried by - spirit. I wonder whether Dorothy L. Sayers was inspired by this roof when she wrote her detective story *The Nine Tailors,* which is set in a church of a fictitious village of the East Anglia marshes?

*A Tibetan timestick in Moyses Museum.*

Two further dials were admired on the site, one situated on the wall of the very cathedral, the other one - a cube dial – placed on a pillar in the surrounding park. The latter (see right) has on one of its faces a device for determining the equation of time [the famous 'Bury St Edmunds curve'], although the details of this might be more easily discernable when lit sideways.

*The pillar dial in the Abbey Gardens.*

On our way back to HQ we visited two exceptional and richly decorated village churches both having mass dials, i.e. those of Lavenham and Long Melford. In the latter we were most kindly invited to enjoy our afternoon tea. According to a picture shown to us, this church once had still another sundial placed high up on the south wall of the nave.

*Claus Jensen*

# SAFARI TAILPIECES

*"Which way to the coach?"*
*Geoff Parsons and Mike Cowham carrying the 1685 double horizontal dial from the cellars of Ditchingham Hall.*



*The sundial presented to Mike and Val Cowham as a 'thank you' for their work as BSS tour organisers. Made by Tony Moss, it is inscribed with the names of 52 of their fellow travellers over the last few years.*

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## COUNCIL MEMBERS

Mr C St J H Daniel (Chairman)
8 The Maltings
Abbey Street
FAVERSHAM
Kent ME13 7DU
Tel: 01795 531804
chrisdaniel180@btinternet.com

Mr G Aldred (Secretary, Librarian and Restoration)
4 Sheardhall Avenue
DISLEY
Cheshire, SK12 2DE
Tel: 01663 762415
graham@sheardhall.co.uk

Dr J R Davis (Editor)
Orchard View,
Tye Lane
FLOWTON
Suffolk IP8 4LD
Tel: 01473 658646
john.davis51@btopenworld.com

Mr J Foad (Registrar)
Greenfields
Crumps Lane
ULCOMBE
Kent, ME17 1EX
Tel: 01622 858853
Register.BSS@keme.co.uk

Ms Jackie Jones (Membership Secretary)
51 Upper Lewes Rd
BRIGHTON
East Sussex
BN2 3FH
Tel: 01273 673511
jackie@waitrose.com

Mr G Stapleton (Treasurer)
50 Woodberry Avenue
NORTH HARROW
Middlesex
HA2 6AX
Tel: 020 8863 3281
manaeus2000@yahoo.co.uk

Mr R C Mallett (Webmaster)
21 Cantilupe Close
Eaton Bray
DUNSTABLE
Beds., LU6 2EA
Tel: 01525 222215
100114.573@compuserve.com

Mr P Powers (Conferences and Photographic Competition)
16 Moreton Avenue
HARPENDEN
Herts., AL5 2ET
Tel: 01582 713721
patrick_powers@dunelm.org.uk

## SPECIALISTS

Mr M Cowham (Advertising)
PO Box 970
Haslingfield
CAMBRIDGE
CB3 7FL
Tel: 01223 262684
ads@brownsover.orangehome.co.uk

Miss R J Wilson (Biographical Projects)
Hart Croft
14 Pear Tree Close
CHIPPING CAMPDEN
Gloucs., GL55 6DB
Tel: 01386 841007
jill.wilson@ukonline.co.uk

Mrs E Hill (Sales)
4 The Village
Stonegate
Nr WADHURST
East Sussex, TN5 7EN
Tel: 01580 201720
Elspeth@ehill80.fsnet.co.uk

Mr David A Young (Acting Archivist)
Brook Cottage
112 Whitehall Rd
CHINGFORD
London E4 6DW
Tel: 020 8529 4880
davidyoung@essexcongress.org.uk

Prof J A Belk (Sundial Design Competition)
16 Colton Rd
Shrivenham
SWINDON
Wilts., SN6 8AZ
Tel: 01793 782707
tonybelk@btinternet.com

Mr A O Wood (Mass Dials)
5 Leacey Court
CHURCHDOWN
Gloucester, GL3 1LA
Tel: 01452 712953
aowood@soft-data.net

Mr J M Shaw (Newsletter Editor)
3 Millwood
Higher Bebington
WIRRAL
CH63 8RQ
Tel: 0151 608 8610
jmikeshaw@ntlworld.com

Mr D Pawley (Newbury Meeting Organiser)
8 Rosemary Terrace
Enborne Place
NEWBURY
Berks., RG14 6BB
Tel: 01635 33519
info@towertime.co.uk



The British Sundial Society
c/o The Royal Astronomical Society
Burlington House
Piccadilly
London, W1J 0BQ

The Society's website is at www.sundialsoc.org.uk
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