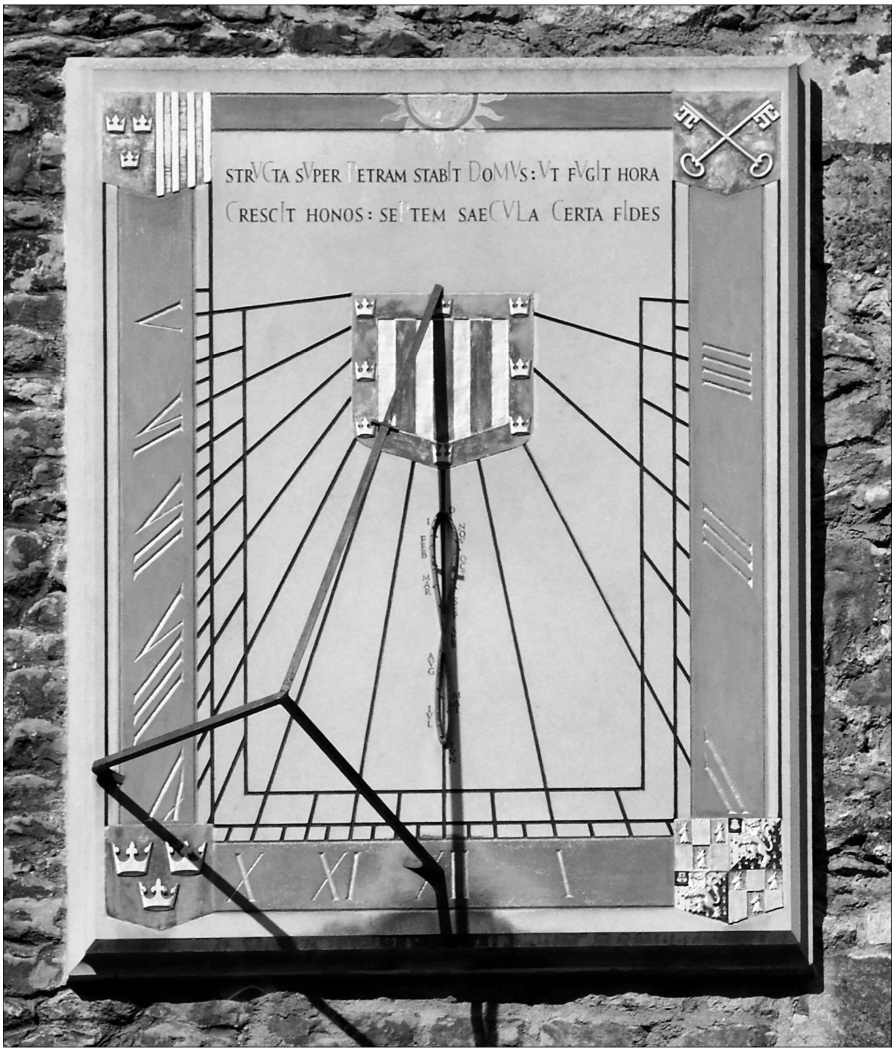
The British Sundial Society



BULLETIN

VOLUME 18(iv) DECEMBER 2006

BSS Bulletin 18(iv)
December 2006

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.davis@btinternet.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 jpg (do not over-compress) or tif 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 black lines 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…). 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 appendix 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 in Arabic numerals, underlined or bold; 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.* **19**, 142-170 (1990)
   W.S. Maddux: 'The Meridian on the Shortest Day', *NASS Compendium,* 4, 23-27 (1997).

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Front cover: *The modern dial (SRN4184) on the Perne Library at Peterhouse, Cambridge. Delineated by Philip Pattenden, it features a chronogram reading STRVCTA SVPER PETRAM STABIT DOMVS: VT FVGIT HORA CRESCIT HONOS: SEPTEM SAECVLA CERTA FIDES ('On Peter's rock our house stands sure. Its flame, hourly increased, seven centuries proclaim') to give the date of 1984, the 700th anniversary of the founding of the college. See page 153 of this issue for another chronogram. Does anyone know of others on dials? Photo: J. Davis.*

Back cover: *St Michael, Kingstone, Herefordshire. Ignore the modern flat gnomon. This dial is quite a puzzle with its division into both twelve and four parts. It is carved unusually high up on the widow stonework which should provide a clue from the history of the church. Photo: M. Evans.*

Designed by J. Davis. Printed by Doppler Press, Brentwood, 01277 224632

BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

ISDN 0958-4315

VOLUME 18(iv) - December 2006

CONTENTS

EDITORIAL

One of the items which was requested in the recent Readership Survey was a listing of solar ephemeris for the coming quarter. Our astronomer member Fiona Vincent has kindly offered to supply this data and the first installment is to be found on page 185 of this issue.

Other suggestions for new articles included something on astrolabes, some descriptions of various constructional techniques, descriptions of interesting dials to be found in museums around the world and for some articles on basic dialling for beginners. The first two of these are being worked on (watch for future editions!) and I am looking for some contributions on the last two. Other suggestions for improvement to the *Bulletin* are being heeded wherever possible but more feedback is always welcome.

This issue, like many, has an article (p.172) about the restoration of an old sundial which is very prominent in a town centre but was largely ignored because it had all but faded from sight. Driving round the country, I often see dials which are in dire need of restoration. What is needed is for local BSS members to find the owners of these dials and to suggest that they ought to be saved. Whenever there is a positive response, the BSS Restoration Officer (see inside back cover for contact details) is the first line of approach for advice about what ought to be done. The BSS Grants Policy was announced in the December 2005 *Bulletin* and could help some particularly needy cases. The first award, for a restoration in Gloucestershire, was made in August. The restored dial will appear in the *Bulletin* in due course.

SUNRISE AND SUNSET HOURS ON ANALEMMATIC SUNDIALS

BERNARD ROUXEL

For an analemmatic sundial, the determination of the time of sunrise and sunset may be done using the intersection of Lambert circles with the ellipse of the sundial. But it is not very easy to construct the intersection of a circle with an ellipse. We want to show that it is possible to solve this problem with intersection of a straight line and an ellipse.

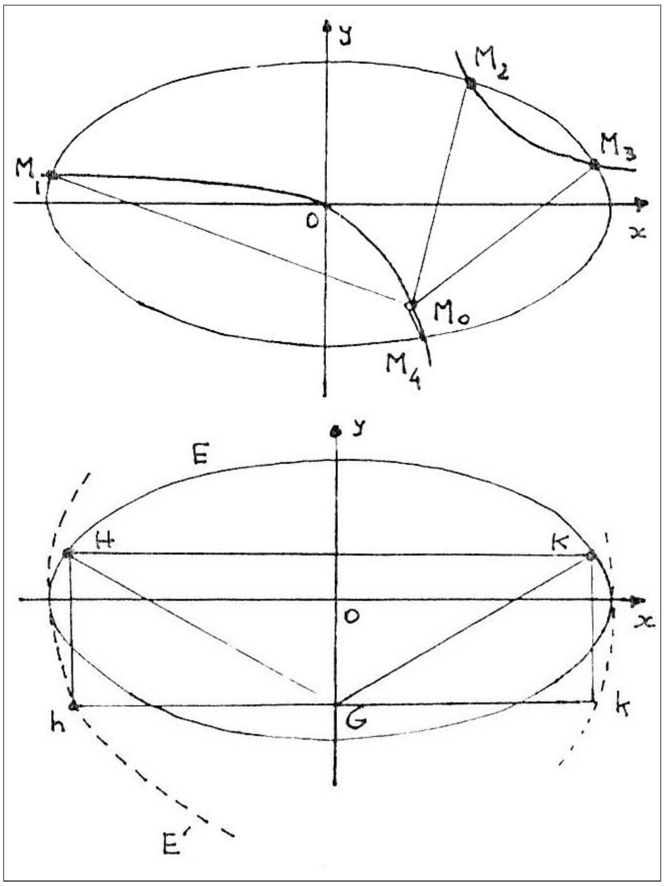

Fig. 1. The Apollonius hyperbola of the ellipse E for (top) a general point M_o and (bottom) the particular case for point G on the y-axis.

APOLLONIUS HYPERBOLA

Let E be the ellipse of an analemmatic sundial and G the foot of the style on the date scale. The hours of sunrise and sunset correspond to two points H and K of E. It is known that HG and KG are normals to E.[1-3] We have then to solve the following problem: when we know G, how is it possible to find H and K? The answer was given by Apollonius of Perga (second century BC) in his book about conics. He showed that the points M_i of a conic E whose normals contain a given point M_0 lie on an equilateral hyperbola ('Apollonius hyperbola') with asymptotes parallel to the axis of E and containing also M_0 and the centre of E. This can be easily proved in a modern way. Let

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$

be the equation of E (Fig. 1). We know that the direction of the normal to a curve $f(x,y) = 0$ is given by the vector

$$\left(\frac{\partial f}{\partial x},\frac{\partial f}{\partial y}\right).$$

Then if the normal to E in $M_i(x,y)$ contains the point $M_0(x_0, y_0)$

$$\left(\frac{2x}{a^2},\frac{2y}{b^2}\right)\times\left[\left(x-x_0\right),\left(y-y_0\right)\right]=\mathbf{0}$$

and then

$$xy\left(a^2-b^2\right)-a^2x_0y+b^2y_0x=0$$

which is the equation of the Apollonius hyperbola associated to M_0. For the point G, $x_0 = 0$ and the equation of the Apollonius hyperbola becomes

$$x\left[y\left(a^2-b^2\right)+b^2y_0\right]=0$$

The Apollonius hyperbola is composed of two straight lines and we find

$$\left(a^2-b^2\right)y_H=-b^2y_G$$

The ratio of y_H and y_G is constant and for an analemmatic sundial at latitude ϕ :

$$\frac{y_H}{y_G}=\frac{y_K}{y_G}=-\tan^2\phi$$

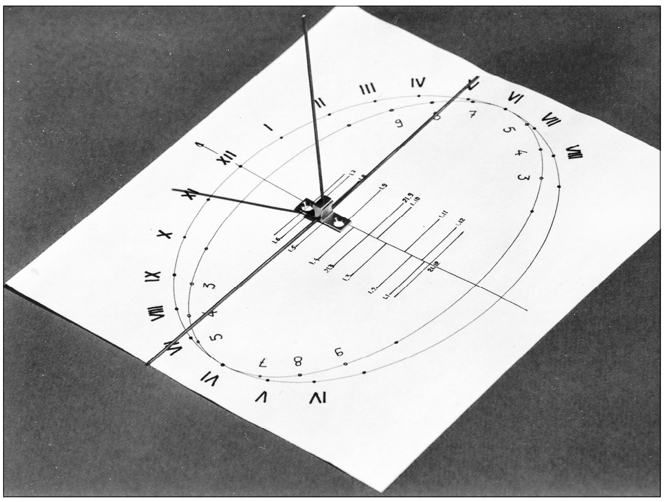

Fig. 2. A standard analemmatic sundial with a second ellipse E' (with Arabic numerals) for the sunrise/sunset times.

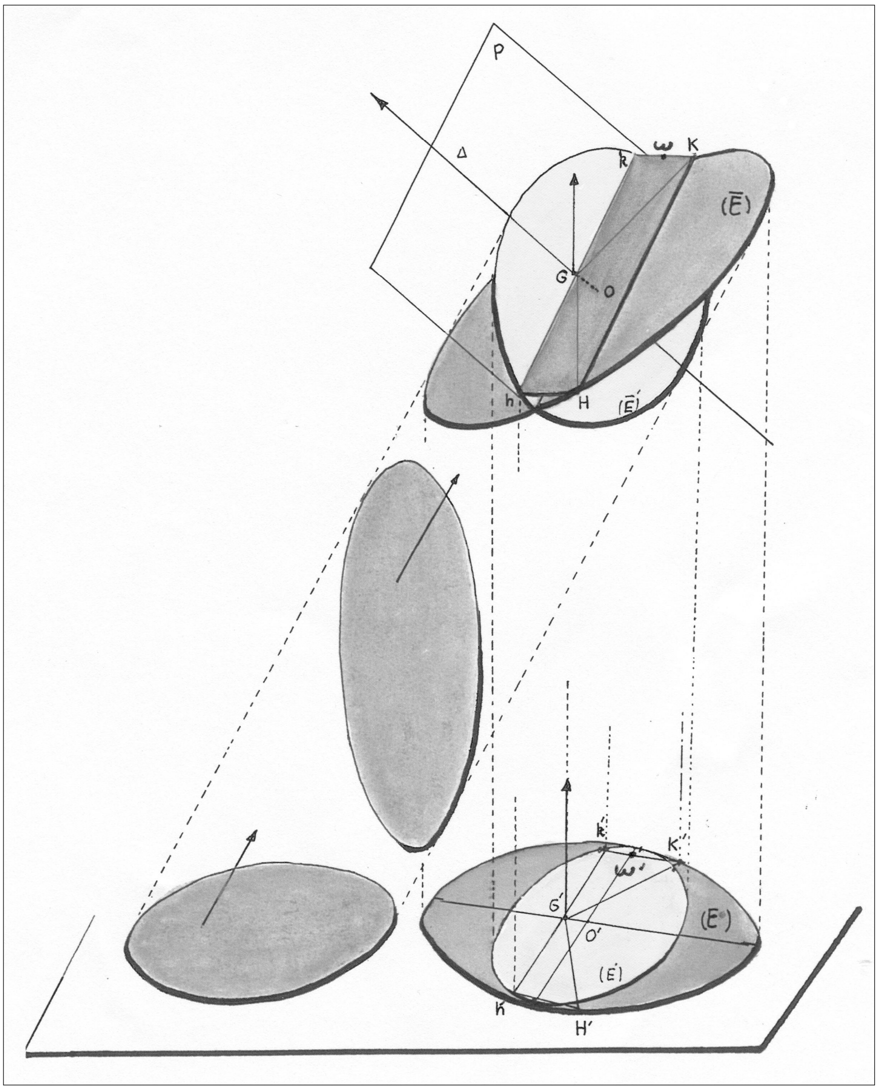

Fig. 3. The analemmatic sundial E projection (bottom right) of the equatorial sundial $\overline{E}$ (top) which also shows the polar direction Δ.

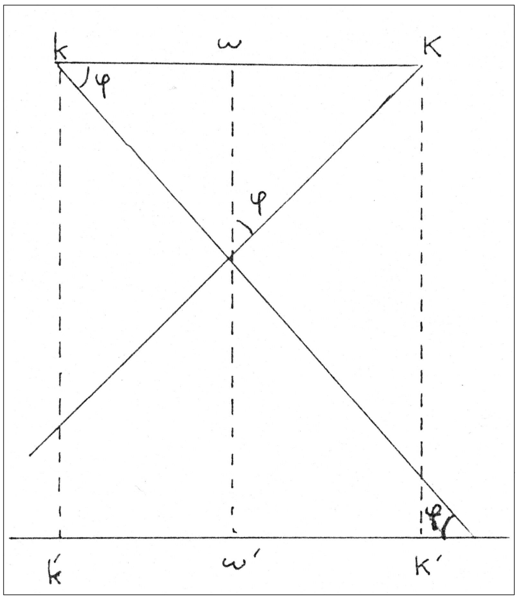

Fig. 4. Expansion of part of Fig. 3 in the horizontal plane kKk'K'.

The locus of the point *h* (or *k*) intersection of the parallels to the axes of *E* through *H* (or *K*) and *G* is then an ellipse E' on which it is easy to read the hours of sunrise or sunset, using a graduation deduced from the graduation of *E*. It is then possible to attach a rod to the foot of the style, parallel to the major axis of *E*, which will give times of sunrise and sunset on the ellipse E' (Fig. 2).

We obtain then an analemmatic sundial with two ellipses *E* and *E'*. For the lucky gnomonists of Bordeaux, Turin, Venice, Montreal, Minneapolis... $\phi = 45°$ and there is a single ellipse! In this case we have a special ellipse: the ellipse of Fagnano.[4] In the general case, the length of the axes of *E* are ($2a$, $2a\sin\phi$) and for E' they are

$$\left(2a, 2a\,{\cos^2\phi}/{\sin\phi}\right)$$

where *a* is a constant.

We shall show now that it is always possible to solve this problem using one analemmatic sundial with only one ellipse.

ANOTHER SOLUTION

Last year during the BSS Conference at Egham I was talking of this problem with Walter Hofmann of the Arbeitsgruppe Sonnenuhren of Austria and he asked me if I had a geometric solution of this problem. Some days later I found a more geometrical solution which gives other possibilities to obtain hours of sunrise and sunset.

We know that an analemmatic sundial is the orthogonal projection of an equatorial sundial with a circle $\overline{E}$ and its axis Δ (Fig. 3). The style cuts Δ in *G* and the shadows *H* and *K* on $\overline{E}$ for sunrise and sunset are the intersection of $\overline{E}$ with the horizontal plane containing *G*. Let *P* be a plane containing Δ and the horizontal direction East-West. If we project *H* and *K* in a horizontal North-South direction on *P* we obtain two points *h* and *k* (*G* belongs to *hk*) lying on an ellipse $\overline{E}'$ the projection of $\overline{E}$ on *P*. If we make an orthogonal projection of this figure on the plane of the sundial (Fig. 3), we obtain for the projection of the ellipse $\overline{E}'$ of the first part of this paper, and again we can solve (see Fig. 4) using the relation

$$\frac{w'K'}{w'k'} = \tan^2\phi$$

Many results of this problem can be found in the paper by Walter Hofmann.[5]

But it possible here, following Bruno Ernst[6], to find other directions for the projection of the equatorial sundial, thus obtaining an analemmatic sundial for which $\overline{E}$ and $\overline{E}'$ have the same projection. This can be achieved with a

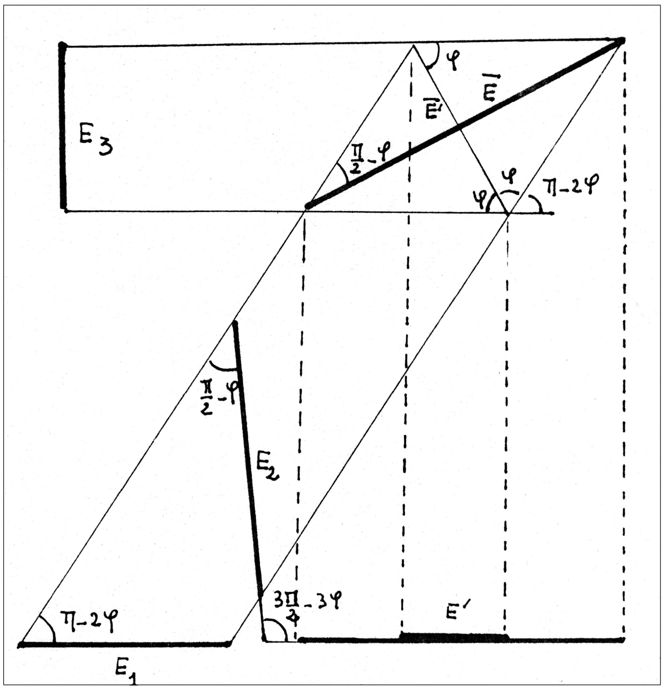

Fig. 5. A section through Fig. 3 in the vertical plane containing the polar direction Δ.

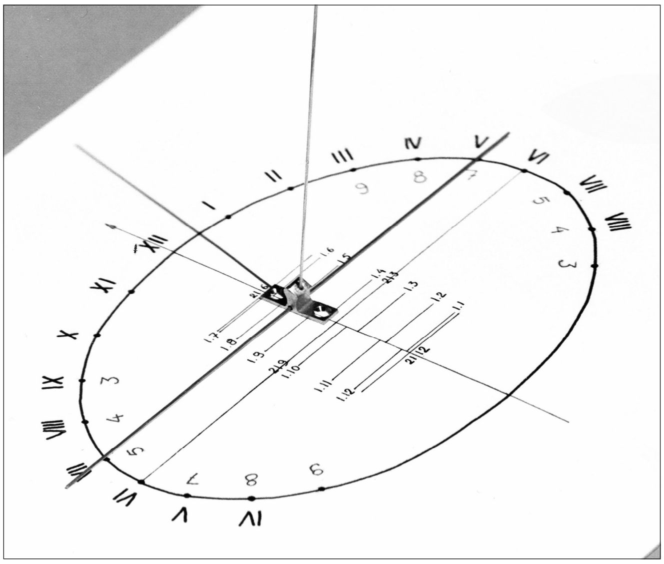

Fig. 6. An analemmatic sundial for latitude 48° with a non-vertical style and two scales on the single ellipse (Roman numerals for LAT and Arabic numerals for sunrise/sunset).

style in the meridian plane whose angle with the horizontal plane is 180° - 2ϕ (see Figs. 3 & 5). We obtain the sundial of Fig. 6. For this sundial the lengths of the axes of the ellipse are

$$\left(2R, {R}/{\sin\phi}\right)$$

where R is the radius of the equatorial sundial. For the dial of Fig. 6, $\phi = 48°$.

THE LAST SOLUTION

If we look at Fig. 3 and Fig. 5, we see that it is possible to obtain a circle instead of an ellipse by another choice of the plane of the sundial E_2 of Fig. 5. We obtain a Foster-Lambert sundial with hours of sunrise and sunset given by the horizontal moving rod, as shown in Fig. 7. The angle between the style and the vertical for the sundial of Fig. 7 (designed for latitude 48° N) is 6° and it is possible to turn the circle to account for the equation of time and longitude.

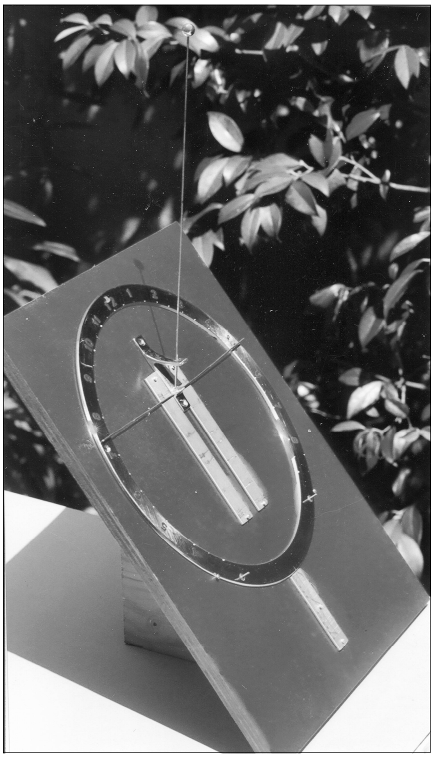

Fig. 7. An analemmatic dial with a circular scale (a Foster-Lambert dial) and a non-vertical style (for the same location as the Fig. 6).

In Fig. 5 we note also the possibility of the projection E_3, producing a vertical analemmatic dial.

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WREN’S DIAL REMOV’D

HARRIET JAMES

Fig. 1. Wren’s sundial on the Codrington Library at All Souls.

The vertical sundial at All Souls College, Oxford, has recently received some unusual attention.[1] In June 2006 the college refused a bequest from one of its Fellows, Dr John Simmons, a Slavonic scholar and Librarian, who died last year, aged 90. Simmons had been a leading voice in a long-running campaign to have the sundial moved from its present position on the Codrington Library building to its original position on the college Chapel.

Under the terms of Simmons’ will the college would have received part of his £888,000 estate if the sundial was moved. There seem to have been other conditions attached to the bequest, such as paving over gravel paths in one of the quads. *The Daily Telegraph* of 13 June 2006 reported a spokesman for the college as saying, “The college has decided to decline the bequest,” adding that the conditions were “too onerous”.

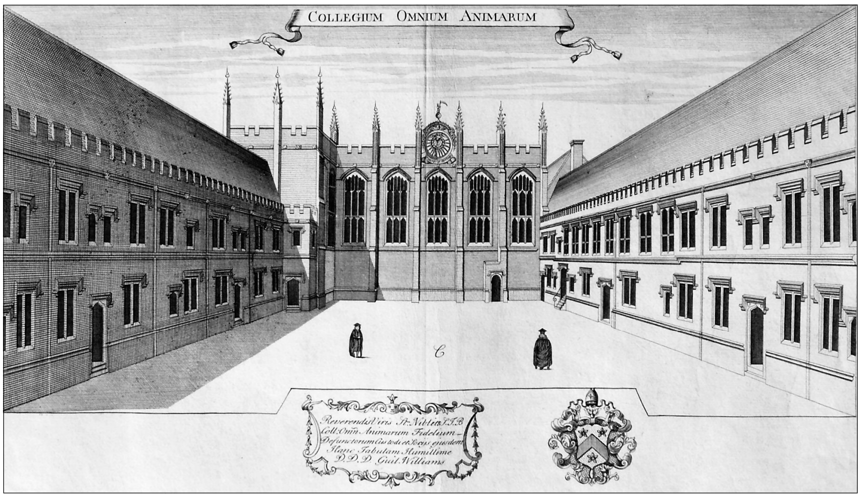
The sundial was made in about 1658 and is said to have been designed by Sir Christopher Wren (1632–1723) who became a Fellow of the college in 1653 at the age of 21, having been an undergraduate at nearby Wadham College.[2]

DESCRIPTION OF THE DIAL

The dial can be seen in Fig. 1 and in colour in Fig. 2 on page 155. The circular dial face is splendidly painted and gilded. With surrounding carved stonework of ornate garlands topped with a cherub, it was originally designed to fit between two pinnacles high up on the centre of the south-easterly façade of the chapel.

A circular blue chapter ring encloses black hour lines and an oval coat of arms of the college. Slanted Roman numerals in the chapter ring run from 6am to 5pm with intermediate half-hour spots. The chapter ring is enclosed by a band of black and red quarter-hour divisions. Surrounding that is a ‘sunburst’ of gilded rays, one for each hour and half-hour, the half-hour rays being shorter. The edge of each ray is outlined with thirty black minute marks “so that one may see to a minute what it is a clock, the minutes being depicted on the sides of the rays, viz., 15 on each side, and divided into fives by a different character from the rest.”[3] The marks for 5, 10, 20, 25, 35, 40, 50 and 55 minutes past the hour are short black lines, perpendicular to the outline of each ray and the intermediate minutes are black dots. These marks, otherwise known as ‘stepped’ or ‘interrupted’ transversals, are potentially more accurate than the normal ‘diagonals’ seen on horizontal dials, e.g. those by Tompion, Rowley and Thomas Wright.[4] They were unusual on large vertical sundials of the 17th century[5] and because of them the All Souls dial seems to have had a reputation for accuracy. The clock-makers of Oxford are said to have called at the college to regulate their time-pieces by it well into the reign of Queen Victoria.[2] The actual delineated timescale on the transversals runs from 5:15 am to 5:15 pm which suggests that the declination of the chapel wall for which the dial was made, is about 14° east of south.

Wren designed the proportions of the All Souls sundial very cleverly. The origin of the hour lines is offset to the east of centre to give a more even spread of hour lines around the circular face. The chapter ring is not centred on the dial face but is slightly above the centre so that the bottom of the elliptical coat of arms touches the centre of the dial stone and the rays at the bottom of the dial are longer than the others. Although the dial face is circular it appears to be elliptical from below. Wren was perhaps experimenting with the effects of distortion when placing an ellipse within concentric and non-concentric circles.



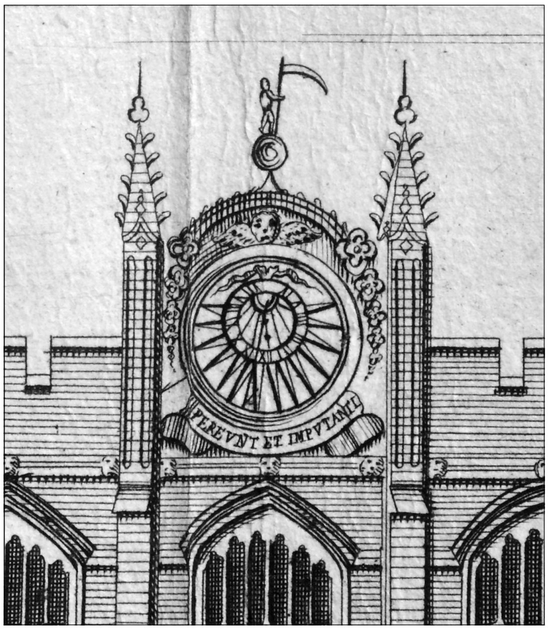
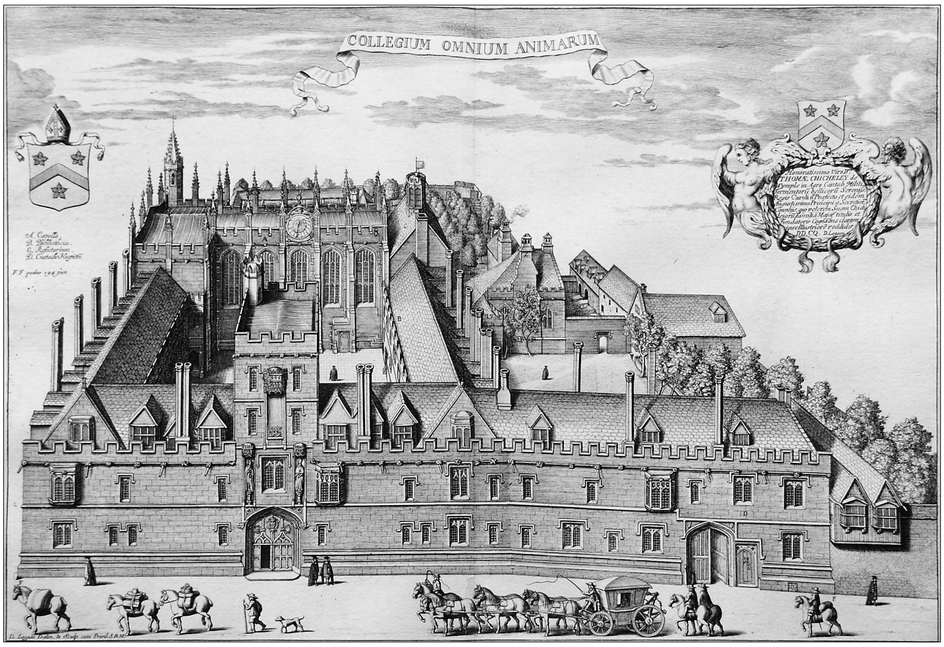
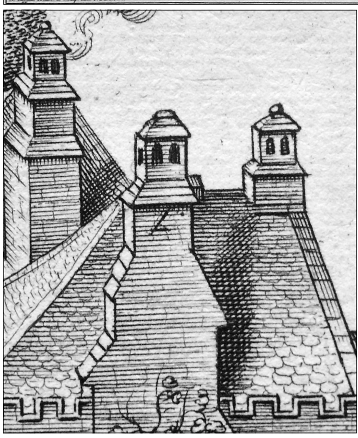


Fig. 4. An engraving of All Souls by William Williams (1733) with (right) an enlargement of the Wren dial.



The functional detail of the dial itself is shallowly-carved whereas the coat of arms, floral decorations and ribbon motto are more sculptural. The circular dial face is made of sections of a finer and whiter stone than the surrounding pinnacles, perhaps because it carved better for finer detail and because it shows a better shadow.

The gnomon is a simple rod with a ball finial and a forked support. The feet of the support are set into the stone below the dial face between it and the ribbon motto below. The style is made of a rod with a circular cross section suggesting that Wren intended the time to be read from the centre of its shadow rather than from its leading edge. The gnomon shadow seems thin but it is necessarily so if one is to read the finer divisions on the transversals.



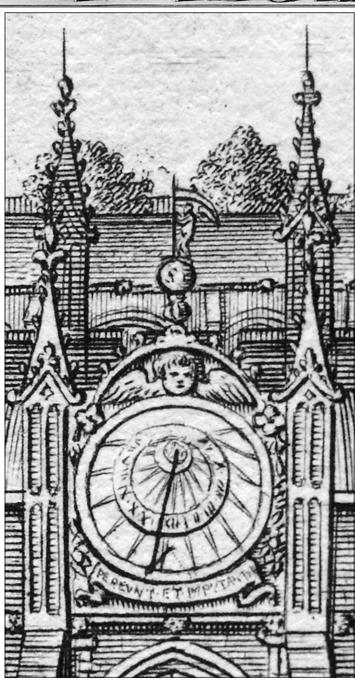


Fig. 3. Loggan's 1675 etching of All Souls showing the sundial in its original position. The enlarged sections show (right) the Wren dial and (above) another gnomon on a chimney.

The Latin motto 'Pereunt et imputantur' ('Our days/hours perish and are scored to our account') is taken from Martial's *Epigrammata* Vxx.[6] The relevant passage reads,

> "Bonosque soles effugere atque abire sentit
> Qui nobis pereunt et imputantur"

Which can be translated as "And he feels good days are flitting and passing away, Our days/hours perish and are scored to our account."[7] Another translation of the motto used in Oxford and mentioned by Gunter, is said to refer to the Fellows of All Souls: "They perish and are not thought of"![8] The same motto appears on seventeen recorded dials in the BSS register, the earliest dating from 1635.[9]

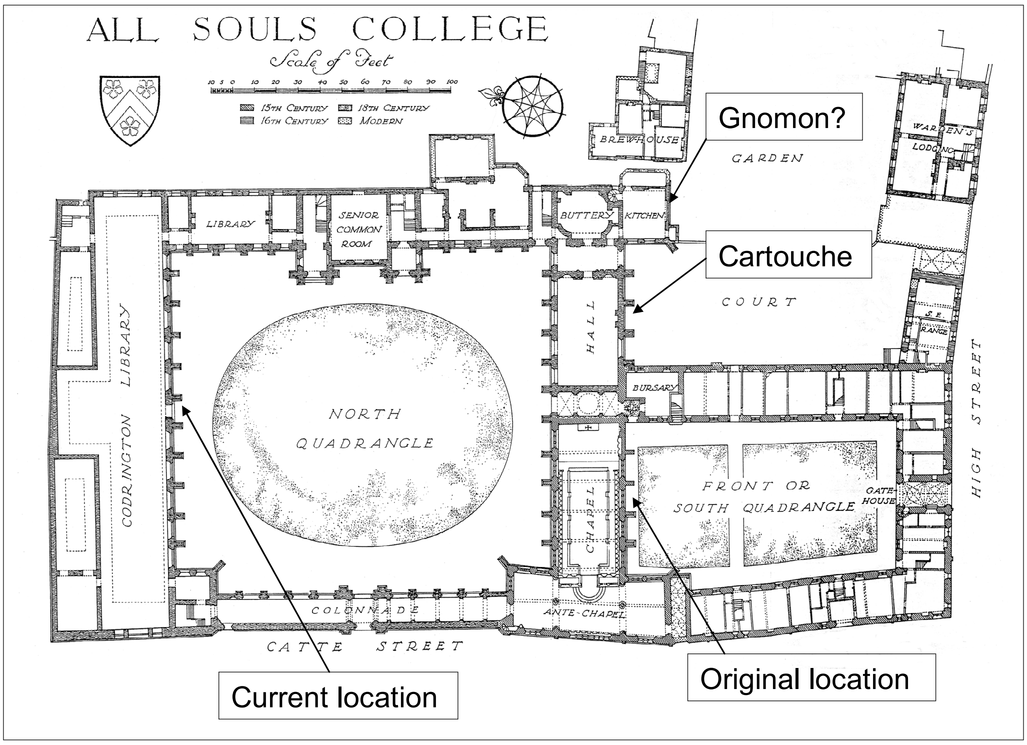


Fig. 5. Ground plan of the college showing the original and current locations of Wren's dial, the cartouche added by Hawksmoor, and the old gnomon shown on the Loggan print.

On top of the All Souls sundial is a gilded weather vane in the shape of a beast-like Grim Reaper with a very large scythe, mounted on a stone ball. This weather vane appears to be as old as the sundial as it is shown in early etchings[10] (see Figs. 3 & 4). Perhaps the Grim Reaper is an allegorical reference to the full name of the college which is The College of All Souls of the Faithful Departed.

It is not known if the present colour scheme of the sundial is copied from the original. It is now in need of repainting.

HISTORY OF THE DIAL

In the year when Christopher Wren held the position of Bursar of Laws at All Souls, the accounts books record that a payment of £32.11.6d was authorized on 23 November 1658 to a "Mr Bird for the diall in the Quadrangle lately erected".[4] William Bird (or Byrd) was an Oxford stonemason.[11] Further payments to Mr Bird, Mr Wells "the Joyner" and Mr Hawkins for painting add up to a total outlay of £57 on the sundial, a sizeable sum in the mid-17th century.

The sundial seems to have stayed undisturbed for the next two hundred years despite major rebuilding of the college in the early 18th century by Nicholas Hawksmoor who added an extra quadrangle and the enormous 200-foot-long Codrington Library. (See Fig. 5 for the college ground plan.) Hawksmoor loved symmetry and because a new hall extended the façade on which the sundial was mounted, he balanced the sundial which was towards one end by adding a new cartouche (Fig. 6) towards the other. Like the sundial, the cartouche is set between two pinnacles. It carries the coats of arms of five major benefactors of the building of the hall. Although the cartouche is still there today, the sundial no longer balances it.

During repairs to the chapel in 1871 the sundial was found to be in a bad state of repair and was removed and stored until 1877. Then one of the Fellows proposed that the sundial be mounted on the Codrington library building in Hawksmoor's quad beyond the chapel and although he met with some opposition, his view prevailed. Simmons' objection to the repositioning of the sundial was one of aesthetics: "Thereafter, a sundial designed to crown a five-bay frontage but perched disproportionately over an eleven-bay one it [sic] has ever since shamelessly punctuated the harmonious 'compulsion of symmetry' that informs Hawksmoor's quadrangle."[2]

The wall of the Codrington library declines approximately 1.3° further East than the chapel wall so the sundial could be expected to be a few minutes slow. It is uncertain if the difference in declination is enough to account for the inaccuracy of 7½ minutes slow to local apparent time observed on 22 July 2006. The Victorian Fellows of All Souls may not have adequately supervised the repositioning of the sundial to account for the difference in declination. Subsequent repairs may have disturbed the setting of the gnomon. Either way, it should be possible to determine how the error arises and to realign either the dial, or the gnomon or both.

Fig. 6. The cartouche that used to balance the sundial.

Although the amount of Simmons' bequest is not known, it may not have been adequate to cover the costs of a major removal between buildings. However, it seems a shame that the present day authorities at All Souls will not at least ensure that the sundial tells the correct time even if they do not agree with Dr. Simmons' aesthetic sensibilities on its position.

Simmons himself once remarked: "We [the Fellows of All Souls] may elect cranks but we don't elect fools." He was well known in Oxford circles, not least for the tie he devised and gave to friends who shared his belief in the four Cs – conserve, consider, contribute, co-operate.[12] He seems to have come up against some opposition from amongst the Fellows and from the authorities responsible for the college buildings. In 2002 he wrote: "The battle for our sundial still rages, but I gather that English Heritage is getting a new boss. I'll give him a couple of weeks and then return to the charge. He can't possibly be as bloody-minded as his new colleagues [in English Heritage] are."[13]

Fig. 8. A modern bust of Sir Christopher Wren at the Guildhall, London.

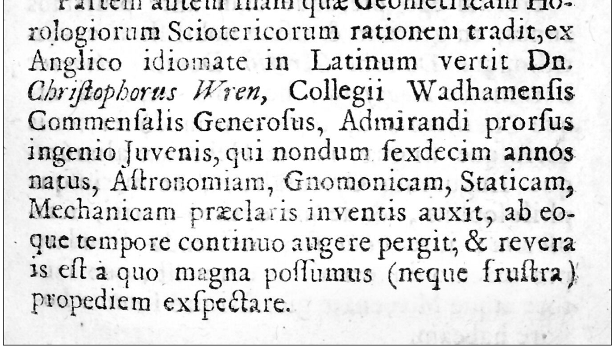
He met some BSS members at All Souls during a very wet afternoon sundial tour as part of the BSS Oxford Conference in 2004. Although then in his late 80s, he was vigorous in his determination to get something done about the sundial and from a damp plastic bag handed out postcards of a mock-up colour photograph showing Wren's sundial back on the chapel wall (Fig. 7 on p.155).

WREN'S DIALLING INTERESTS

Wren (Fig. 8) had a practical interest in dialling from a very young age. As a child he had lessons from his brother-in-law Dr William Holder who later published *A Discourse Concerning Time* (1694). While he was a schoolboy Wren designed an instrument for drawing lines on a sundial and at thirteen made an instrument which he called a *panorganum astronomicum* which could have been a kind of orrery. The diarist John Aubrey says that as a teenager Wren made "severall Curious Dialls, with his owne handes" in the grounds of William Holder's parsonage at Bletchingdon, Oxfordshire.[14,15]

Wren seems to have gone up to Wadham College, Oxford in 1646 at the tender age of 14.[16,17] In about 1647 he had a serious illness and was sent to recover in London with Charles Scarburgh, a physician friend of Holder's. Scarburgh had taught mathematics at Cambridge and had a fine collection of mathematical and scientific books. While staying with Scarburgh, Wren wrote a treatise on spherical trigonometry and impressed Scarburgh with his design for a weather-clock that recorded fluctuations in wind speed and temperature.[18]

Scarburgh knew William Oughtred and encouraged Wren to translate from English into Latin Oughtred's treatise on dialling written in 1598. Wren wrote, "The doctor promises, I may both gain an old man's favour, and at the same time win that of all those students of mathematics who acknowledge Oughtred as their father and teacher."[16] Oughtred was delighted with the translation and published *Horologiorum Sciotericorum in plano* as a supplement to the third and subsequent editions of *Clavis Mathematicae*. Oughtred presented Wren with an inscribed copy of the third edition (1652) and described him in the preface as "Christopher Wren, gentleman commoner of Wadham College, a youth generally admired for his talents, who, when not yet sixteen years old, enriched astronomy, gnomics, statics and mechanics, with brilliant inventions, and from that time has continued to enrich them, and in trust is one from whom I can, not vainly, look for great things." (Fig.9.)



Partem autem illam quæ Geometricam Ho-
rologiorum Sciotericorum rationem tradit,ex
Anglico idiomate in Latinum vertit Dn.
Chriſtophorus Wren, Collegii Wadhamenſis
Commenſalis Generoſus, Admirandi prorſus
ingenio Juvenis, qui nondum ſexdecim annos
natus, Aſtronomiam, Gnomonicam, Staticam,
Mechanicam præclaris inventis auxit, ab eo-
que tempore continuo augere pergit; & revera
is eſt à quo magna poſſumus (neque fruſtra)
propediem exſpectare.

Fig. 10 (right). Wren's clock at Wadham College.

Fig. 9 (left). Part of the preface of William Oughtred's Clavis Mathematicae, *third edition.*

Back in Oxford at the lodgings of John Wilkins, Warden at Wadham, Wren attended the early meetings of a group of natural philosophers which was to become the Royal Society. His wide range of interests included experiments on the circulation of the blood and intravenous injections using live dogs. Among other subjects he explored ciphers, fortifications, and the grinding of lenses. His interest in astronomy seems to have developed during the 1650s when an observatory was set up at Wadham. He found time to make a reflective ceiling dial (now lost) in his room at Wadham, with figures representing Astronomy and Geometry.[8] An inscription accompanying the ceiling dial read:

CHR. WREN.
Angustis satagens his laquearibus
Ad cœli methodum tempora pingere,
A Phœbo obtinuit luminis ut sui
Idæam, speculo, linqueret æmulam
Quæ cœlum hoc peragret luce vicariâ,
Cursûsque effigiem fingeret annui;
Post annos epochæ —
VIRG**I**NEO Q**VI**B**V**S
VERE FA**C**T**V**S HO**M**O EST E**X** **V**TERO **D**E**V**S
ETAT**I**SQ**V**E S**V**Æ N**V**PERÆ.

This can be translated as

"Chr. Wren, busying himself on this narrow fretted ceiling, was enabled by Phoebus in accord with the movement of the heavens to represent the times so that with the reflector he might leave an Idaean rival of his light to travel over this heaven with borrowed brightness and form a likeness of his annual course. 1648 years after the time when God was truly made man from the Virgin's womb and in the 16th year of his own youthful age."

The date 1648 and Wren's age are obtained from the chronogram in the last three lines of the Latin by adding up the values of the bold Roman numerals. The word 'Idaean' seems to be a reference to Ida, the nymph who was identified with the constellation of Ursa Minor by the ancient Greeks.[19] 'Idaean' could also be a pun on the word 'Wadham'.

When designing the All Souls dial Wren may have been inspired by the other sundials in Oxford at the time. The Turnball dial of 1581 at Corpus and the dial on the chapel at Merton of 1629 still survive. There were dials at Wadham College, too.[20] In the 1654 John Evelyn visited Warden Wilkins' lodgings at Wadham and saw many 'artificial, mathematical, Magical curiosities' which included "… Shadows, dyals, Perspectives…A Way-Wiser, A Thermometer; a monstrous Magnes, Conic & other Sections, a Balance on a demie Circle, most of them his [Wilkins'] own & that prodigious young Scholar, Mr. Chr: Wren." [21] Oughtred's son-in-law, Christopher Brookes, ran a successful instrument-making business from Wadham.

Engravings of the gardens at Wadham by Loggan and Williams, of 1675 and 1732 respectively, show Wilkins's statue of Atlas which held up a spherical sundial. Pointer describes it in his *History of Oxford* (1749): "The Globe is an entire Dial without a Gnomon." [22] None of these 'curiosities' has survived at Wadham today.

At All Souls there was another sundial of the same orientation as Wren's. It is shown in Loggan's engraving of 1675 high up on a chimney stack (See Fig. 3) and is mentioned by Gunther.[8] It seems to consist of a plain east-decliner gnomon without any visible hour lines. Perhaps it was already old and worn by the 1650s.

After Wren left All Souls in 1657 he became Professor of Astronomy at Gresham College, London. Part of his inaugural lecture was devoted to the biblical miracle of the retrocession of the shadow upon the sundial of Ahaz (2 Kings xx.11) when God is said to have caused the shadow on the sundial to move back by 10 degrees. Wren speculated that this effect might have been caused by the appearance of a parhelion (a luminous spot in the sky caused by refraction of sunlight through what he called "nitrous Vapours" but which are in fact ice crystals). Wren suggested that the sundial of Ahaz had been one like those which, according to Vitruvius[23], were introduced to Greece by Berosus the Chaldaean. He said that although the parhelion might explain the miracle, the explanation did not diminish it, adding that our knowledge of refraction makes the rainbow no less wondrous.[24] Peter Drinkwater would not agree with Wren's interpretation of the miracle (BSS Bulletin. Feb 1992.1). He says that the original Hebrew was mistranslated and that the shadow of two walls passed up and down the sundial which consisted of two back to back flights of stairs.

Wren's interest in dialling may have persisted throughout his life in spite of his eclectic interests and busy professional life in London. An engraving of 1700 by John Oliver shows Tring Manor, Hertfordshire, which is said to have been designed by Wren. There are two apparently north-facing vertical sundials on the front of the house.[25]

In about 1671 Wren presented Wadham with a pendulum clock. This clock had an early 'seconds' pendulum and the mechanism is said to have been designed by Wren.[26] The clock face is still in position on the chapel wall in the front quad at Wadham (Fig.10). The original mechanism is now kept in the Museum of the History of Science at Oxford. One of the spandrels in the top right corner of the clock face contains three crosses and a chevron, part of Wren's coat of arms (Fig. 11 on p. 155).[27]

The decorative carvings which surround of the clock face bear a remarkable resemblance to the carvings surrounding the dial at All Souls – a cherub, floral garlands and spiral volutes are common to both clock and dial.

VALUABLE BEQUESTS

The Codrington Library building, the cause of Simmons' disputed bequest, was itself bequeathed to All Souls. In 1710 Conrad Von Uffenbach wrote:

> "After lunch we saw the library in All Souls College, *Collegium Omnium Animarum.* This is a small poor room with an inconsiderable number of books. But as a Colonel Codrington has bequeathed ten thousand pounds sterling (an amazing sum of money, which could have been turned to better purpose than making a palace for these worthless Fellows, as they for the most part are) – as, I say, he has left this sum for the rebuilding of the college and added to it his fine collection of books worth three thousand pounds, a new library is to be built."[28]

Even if the present day Fellows feel they could not meet the challenge of Simmons' bequest, they should at least honour his and Wren's memory by trying to correct the error in the dial's time-keeping and by making sure this grandest of sundials is properly maintained.

ACKNOWLEDGEMENTS

It is a pleasure to thank the following people for their help in preparing this paper: A. Ashmore, A. Chapman, J. Davis, G.L. Huxley, J. Lester, E. Mizzi, N. Aubertin-Potter.

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2. J.S.G. Simmons: *Wren's Dial Remov'd*, *High Victorian Hubris,* self-published pamphlet (2000).
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6. Martial was born 40 AD and published in Rome 86-103 AD.
7. *Oxford Dictionary of Quotations.*
8. J. Elmes: *Memoirs of the Life and Works of Sir Christopher Wren* (1823), p.21 and R.T. Gunther: *Early Science in Oxford,* p.113 (1923).
9. SRN2180 Halton, Lancs. There are two from 18th century: at St. Mary, Payhembury, Devon SRN0540 and at St. Buryan, Cornwall (dated 1747).
10. e.g. William William's etching of the college dated 1732-3 and David Loggan's of 1675.
11. J.C. Cole: 'William Byrd, stonecutter and mason', *Oxoniensia*, xiv, p.63-64 (1949).
12. Quoted in the *Daily Telegraph* article 12.6.2006
13. Private communication 2 January2002.
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15. There are three dials recorded in the village (SRN1330, 1324 and 4772) but none of them are at the parsonage.
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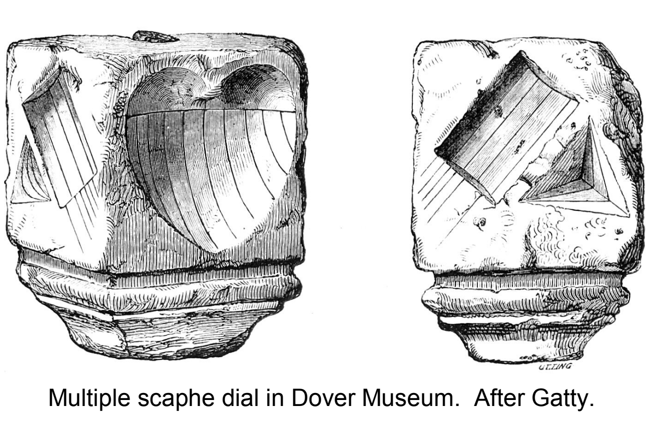
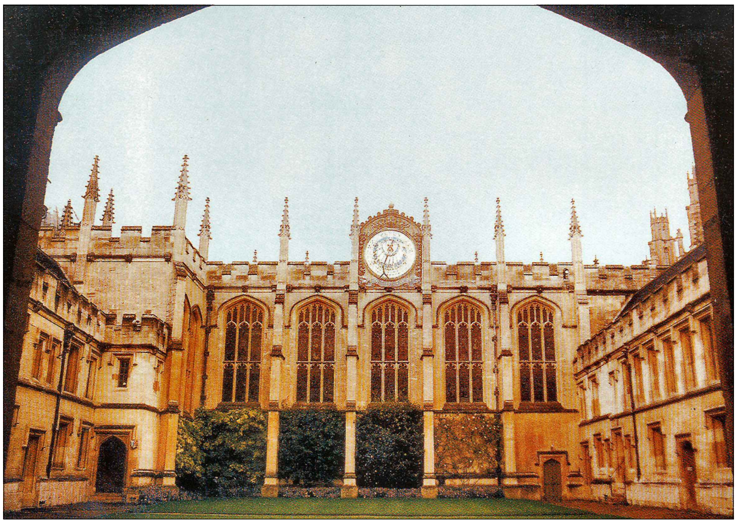


Multiple scaphe dial in Dover Museum. After Gatty.

Fig. 11. Wren's coat of arms in stained glass at the Museum of the History of Science, Oxford. Note the universal equinoctial ring dial on the left and the other mathematical instruments. Photo: J. Davis.

Fig. 2 (left). Wren's sundial on the Codrington Library at All Souls.

Fig. 7 (below). Simmons' mock-up postcard showing the sundial back on the chapel.



THE TAVISTOCK SQUARE BOMB MEMORIAL

Report from George White

The British Medical Association has privately unveiled a memorial set up to commemorate the bus-bomb victims of 7th July 2005 and to celebrate the contribution of the doctors and others, who set up a field hospital in the BMA court-yard immediately following the atrocity. The very moving ceremony took place in the garden designed by Edwin Lutyens, within the BMA's walls and in the presence of the relatives of those who had died, of many who had survived and of many who had assisted. It was not open to the media, who instead covered the unveiling of a small plaque in the Square itself, erected by Transport For London.

The sundial memorial was designed and made by BSS member Joanna Migdal. The Tavistock Square dial takes the form of a substantial hand-engraved bronze horizontal dial standing on a simple Portland Stone plinth. It took seven months to complete. The dial indicates both British Summer Time and Greenwich Mean Time and is equipped with an Equation of Time graph. It is pierced with the crest and mantling of the BMA and is adorned both with its motto "WITH HEAD AND HEART AND HAND" and with the words "REMEMBER SEVENTH JULY 2005".

Just as the roof of the bus was torn away by the blast, so a quarter of the circular dial has been torn back and is used to cast the shadow. This is to symbolise the fact that despite the disaster, time moves inexorably on and though life is changed irredeemably, the human spirit is not broken. Echoing the shape of the dial, the cylindrical plinth is also without a quarter section. This is a reminder of the 'broken pillar' of classical times, symbol of the fallen hero. But the break too serves a purpose. For each year on 7th July precisely, the shadow cast into it by the corner of the dial will run along a carved and gilded line as an annual remembrance of the tragedy. Similarly, the pillar has been devised so that the shadow of its edge, falling diagonally across its base will (at the exact time of the explosion each year) touch a second gilded line. For just a moment, that line will divide light from darkness, life from death.

Having watched the line at the unveiling on the first anniversary of the explosion, I cannot tell you what a powerful and moving experience it was. But for the present, the British Medical Association's sundial is the only substantial permanent reminder of the dreadful event to have been made.

THE DINMORE SUNDIAL

JOHN WALL

Some coincidences are so remarkable as to be not mere coincidences, but positively providential. Two weeks ago I was reviewing some photographs that I took in 1974 whilst researching my degree thesis under the rather pompous title 'The Ecclesiastical Organisation and Architecture of the Military Orders in Britain from the 12th to the 14th Century'. One which caught my eye was captioned 'Dinmore Sundial', (Fig. 1). The very next day I found the very same sundial featured on the back cover of the BSS *Bull* 18(i) for March 2006. However, the Bulletin caption calls for further consideration.

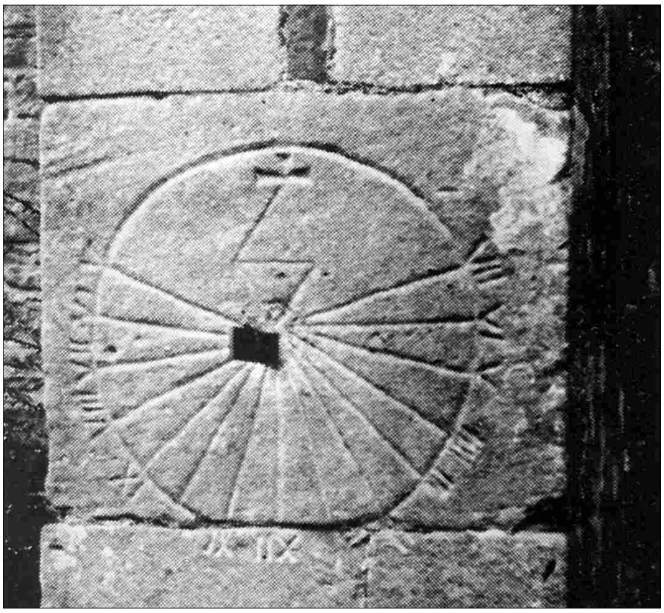


Fig. 1. The Dinmore dial.

First. Dinmore was not a foundation of the Knights Templars as stated, but a foundation of its brother military/monastic order the Knights Hospitallers, or to give them their full title the Knights Hospitallers of the Order of St John of Jerusalem, hence the dedication of the chapel at Dinmore to that saint. When the Templars were suppressed in 1312 some of their preceptories were transferred to the Hospitallers, but Dinmore was not one of these. Both the Templars and the Hospitallers were fully monastic orders, but exceptional in that their principal function was initially the protection of pilgrims en route to Jerusalem, and latterly to take part as 'military monks' in the Crusades. Their 'monasteries' were styled Preceptories, each under the supervision of a Preceptor in place of an Abbot or Prior.

Second. The date of the sundial is most probably contemporary with the chapel, as is evident from the fact that the lower part is clumsily carved so as to overlap onto the dressed ashlar block below. That is, it has not been relocated 'en bloc' from an earlier building. (It is as if the mason, in scribing his circle, misjudged his centre point and could find no other means of correcting his error.) The chapel on which the sundial is carved is of the early 14th century, as indicated by the reticulated tracery of the windows, (Fig. 2). The Preceptory was founded shortly before 1189 and was dissolved some time shortly before 1535.

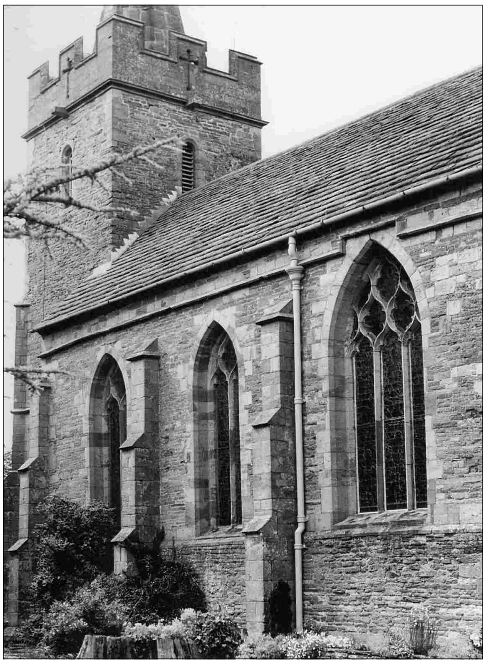


Fig. 2. Dinmore chapel, showing reticulated tracery.

Third. The unusual symbol in the upper half is almost certainly a roughly carved or eroded representation of the eight-pointed cross of St John. In the 19th directive of the Rule of the Hospitallers the brethren are bidden to wear this white cross on the breast of their black hassocks and mantles. This form later became known as the Maltese Cross when the headquarters of the Hospitallers was established in that island when they were expelled from the Holy Land.

Fourth. We may ask: 'What was the purpose of this sundial?' To my mind it is not a conventional scratch/mass dial as stated, since that is a much more basic time-teller from an earlier era. This is a rather more sophisticated dial. As a monastic order the Hospitallers were under obligation to observe the 'Horae Canonicae' or Canonical Hours – seven services in all, including Terce, Prime and None, with appropriate prayers and ritual throughout each 24 hour cycle. Nevertheless, I do not believe that this sundial was installed primarily for the benefit of the brethren. (Unlike the Anglo-Saxon sundial with inscription at Kirkdale in North Yorkshire, for example, where certain hour-lines in its octaval time-scale, which correspond to some of the canonical hours, are marked out with crosslets at their termination.) At Dinmore, as elsewhere, the military monks would have other internal means of ensuring punctual observance of the canonical hours.

There is one other function that could be assigned to the Dinmore sundial. Of the 50 Templar and 50 Hospitaller preceptory churches a number also served as parish churches for the local community and Dinmore was one of these. It was customary in parish churches for mass to be said daily. In a dual-purpose church such as Dinmore it is probable that both the enclosed brethren and the lay parishioners shared the same mass. However, Hospitaller legislation provided that the preceptor should not order the priest to say mass. In other words the former had no authority over the latter in spiritual matters. The priest having determined the time of mass, it would be convenient for his parishioners to have some means of 'telling the time', so as to turn up punctually for that service. It is only in this sense that the Dinmore sundial can properly be described as a 'mass dial'.

I have not come across any specific reference to sundials in the extensive MSS of the Military Orders in Britain. Neither have I noted any vertical sundials on the chapels of their 100 preceptories, apart from the one at Dinmore. The BSS Register does record one on the south wall of the parish church of St Mary and St John in Rothley, Leicestershire. This church was associated with the nearby Rothley Templar Preceptory which had its own chapel. Both buildings are still in use today. Curiously, in my photograph (Fig. 3) of Rothley Preceptory chapel there appears what looks suspiciously like a small horizontal sundial on a pedestal a few feet away from the south wall. If it is indeed a sundial it is not recorded in the Register.

In addition to their preceptory chapels the Templars and Hospitallers had 'appropriated' some 300 parish churches and dependent chapels. That is to say, they acquired the advowsons and revenues of these churches, usually as endowments from the lay founders of their Houses. In all other respects these parish churches were independent, and as with the generality of parish churches many would have sundials on their south-facing walls. However, there would be no reason to signify with a symbol or otherwise, as part of the furniture of the dial, that the church was 'owned' by the Templars or Hospitallers. It is therefore unlikely that the Maltese cross featured on the Dinmore sundial is repeated on any of the sundials on the Hospitallers appropriated churches. Nevertheless, when I have the time, I will collate my schedule of the 300-odd appropriated churches with the BSS Register to determine how many possess sundials, and if so how many feature Templar or Hospitaller symbols.

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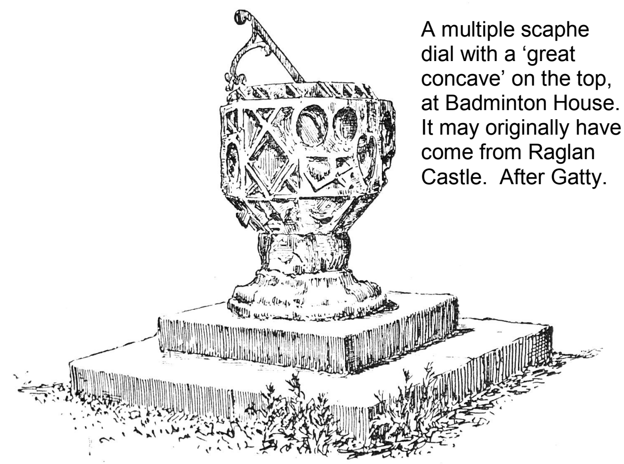
Fig. 3. Rothley Preceptory chapel with a possible horizontal sundial at bottom left.



A multiple scaphe dial with a 'great concave' on the top, at Badminton House. It may originally have come from Raglan Castle. After Gatty.

PRODUCTION-LINE MANUFACTURE OF PORTABLE DIALS

MIKE COWHAM

I had always thought that sundials were made individually, perhaps in a similar way that many of us still do today. However, dialmakers were in business to make a living and I am sure that they would, where possible, try to make several copies of any dial that they designed.

The delineation of a dial was, and still is (until the computer program), a major part in the dial's manufacturing process. Any delineation (for perhaps London) would still be valid for a future dial and they would have kept this in some form for later use. On occasion some makers would use a nearby latitude layout to avoid the time and cost of making a new delineation and would simply adjust the gnomon angle to suit the new location. This, of course, is incorrect but most dial owners would hardly be in a position to realise these relatively small errors. The better makers would not stoop to such 'low tactics' but in 2004 it was interesting to see the dial by Thomas Tompion that was sold by Sotheby's.[1] It appears that a 'stock' delineation had been used by him and this was corrected for the dial's new latitude by effectively tilting the dial plate, by making it tapered, as much as 20mm from south to north. This was obviously a deliberate act but the result would have given a correct dial for his customer. It would certainly have cost him a lot more to get such a thick dial plate and to fashion it with such a taper. Why Tompion did it this way is not known as he almost certainly knew how to delineate a dial correctly. His principle trade was as a clockmaker and he is only recorded as having made a few dials during his career. Therefore, it is possible that a colleague like John Flamsteed or Robert Hooke could have designed the original dial for Tompion, so he may just have re-used the 'professional' delineation and added the tilt to correct it for its new latitude. It was certainly an expensive solution to a simple problem.

It is very difficult to establish if any early dial was made on a form of production-line. Identical dials are likely to be many miles apart but comparison through photographs could possibly establish a link between two or more of them. Unfortunately many of these dials have suffered over the years from corrosion and the elements in general making a detailed study rather difficult. However, in the 19th and 20th centuries, we know that dials were made in quantity by manufacturing companies like Pearson-Page and by Barker & Sons, both of whom turned out many identical models.

Fig. 1. File marks crossing the hinge and dial plate of an Augsburg dial by Lorenz Grässl.

Portable dials too must have been made in quantities and there is some evidence of batch production from quite early times. Most Augsburg dials (e.g. Fig. 1) are marked so that the main dial plate, the hinge of the equatorial chapter ring and the latitude arc can all be matched together, so they must have been made in quantities but we do not have any records showing how large such batches would have been. We can only guess that a craftsman trying to assemble the two halves would not welcome too many options when matching the 'file' marks so batches were probably limited to perhaps 10 or 20 at a time.

The dial shown in Fig. 2 and thought to have been made around 1700 has recently been found in a shipwreck off the coast of Brazil. On its underside is scratched a Roman

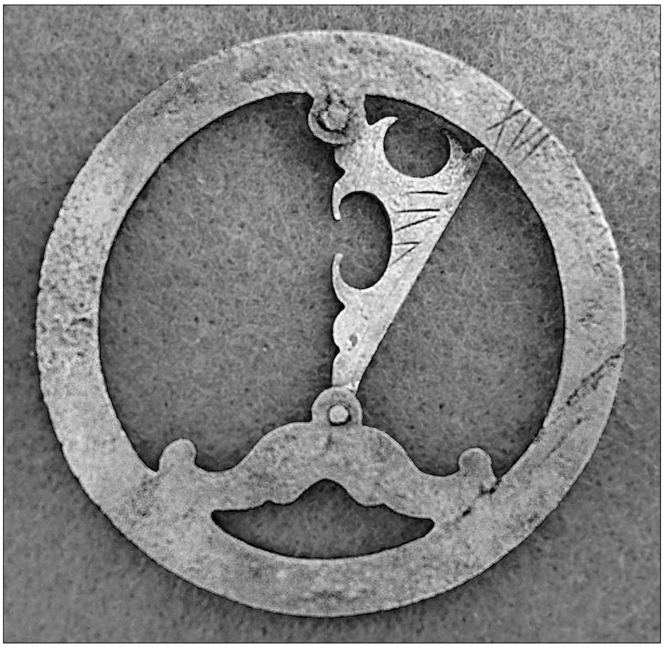


Fig. 2. Dial recovered from a Brazilian shipwreck showing the underside of the dial plate and one side of its gnomon, both marked with 'XVI'. (Photo from Francisco Noelli, Archaeologist, Projeto de Arqueologia Subaquática, Brazil.)

Fig. 3. Poke dial stamped 'TW'. Note the misalignment of the letters 'A', 'B' and 'C' which is identical on all known dials by 'TW'

numeral 'XVI' and the same numeral is scratched on one side of its gnomon, again clear evidence of batch manufacture. The origins of this dial are still being investigated but it may have come from Germany, probably Augsburg or Nuremberg. Normally with portable dials it is difficult to place two side-by-side that are really identical. In my experience I have never seen two exactly alike (until some mass-produced dials of the early 19th century). I have managed to compare, side by side, four simple ring (or 'poke') dials signed only with initials 'TW' – see Fig. 3. It appears that these rings have had their various scales stamped on them in blocks. This process would have been done before the rings were rolled into a hoop. Each block of numerals show the same misalignment with certain letters misplaced, being higher, lower or skewed the in the same way on each example.

Ivory dials from Nuremberg again do not normally come as identical items but the evidence of their delineation process can often be seen. How did they delineate these dials? They were certainly not going to do each individually but it appears that they were almost certainly marked out from a common template. The exact form of this template is unknown but it may have been nothing more than a piece of card or paper, the calibrations simply being pricked through onto the ivory.

These 'prick marks' can still be seen on some dials and give us an insight into their manufacturing process. In the case of the two dials by Paul Reinman and shown in Figs. 4 & 5 (made 10 years apart), the prick marks are identical in both angle and measurement suggesting that the same template was in use for quite a long time. Both, of course, would have been delineated for the latitude of Nuremberg. It seems that only the hour positions are pricked through and the sub-divisions of half and quarter hours were done simply by eye. This is very obvious from many dials because the sub-divisions often vary dramatically in width. Note that on both dials that the first half hour, running clockwise around the scale, is proportionately smaller than the second half of the same hour.

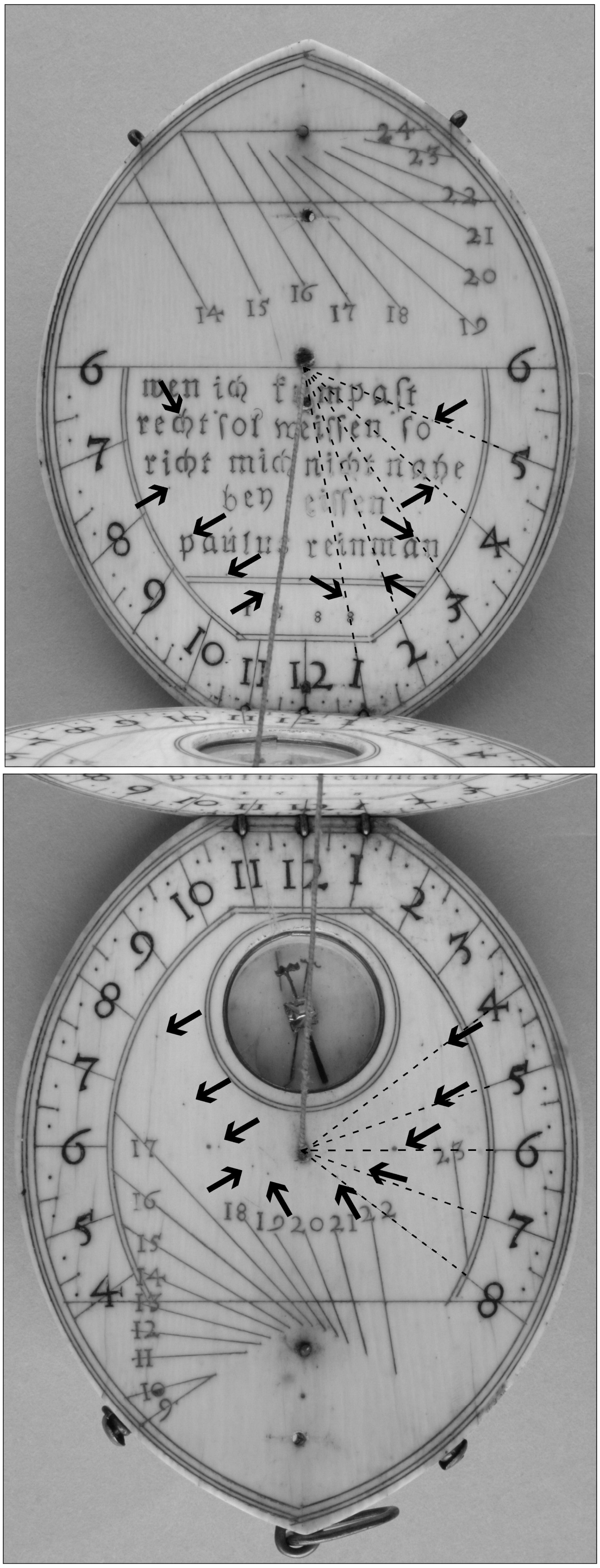


Fig. 4. The upper and lower leaves of an ivory diptych dial by Paul Reinman, dated 1588, showing the 'prick marks' in the ivory. Lines have been drawn through some of these to the outer scale. Evidence for 'hand division' of hours is shown by unequal divisions such as between 4am and 5am on the lower tablet.

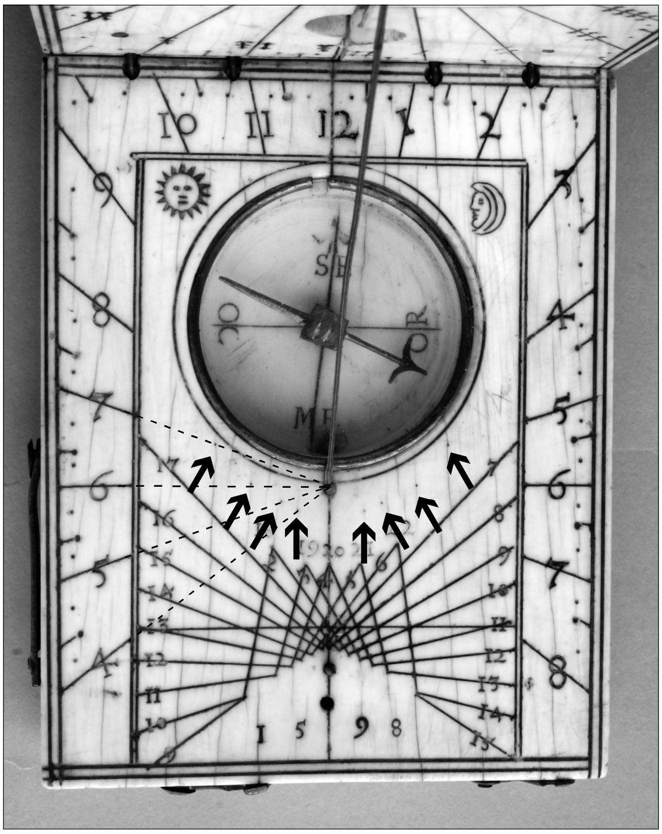


Fig. 5. *A further dial by Paul Reinman of 1598 showing identical 'prick marks'.*

In the case of the lower tablets of these dials we do not usually find all of the 'prick marks' so this may show that the dials may have been delineated before the compass bowl was bored out. It is understood, from contemporary records, that the ivory surface was softened, *by some secret process,* to allow it to take the punch marked characters without splitting and it would probably need to be allowed to re-harden before the compass bowls were finally bored out.

A French ivory diptych dial (Fig. 6) too shows similar 'prick marks', but this time in a perfect circle. It too has lost the marks that would have been where the compass bowl is now placed. Note that it is only the main dial (in this case the outer one for 48°) that corresponds to the prick marks and the two other scales for different latitudes have probably been offset from this by eye. This unknown maker appears to have done this quite well and it is difficult to find fault with the subdivisions of his dial.

Therefore, it seems likely that a simple form of template would have been employed to make quite large batches of ivory dials from both Nuremberg and France. The individual decoration and even the size of the ivory tablets may have varied considerably but the same templates could still have been utilised. Other portable dials must also have been made in a similar way but extensive study of these has so far failed to reveal similar 'prick marks'. However, these may have been marked in a different manner on the

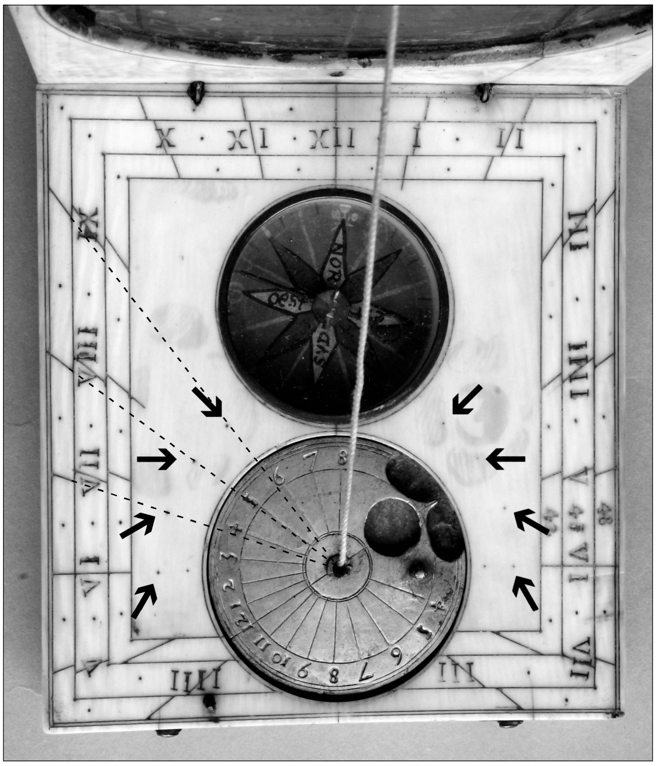


Fig. 6. *An early French ivory diptych dial showing 'prick marks' in a circle.*

metal surface and therefore could easily have been polished out before the dial was delivered.

Similar techniques, using a template, must also have been used for laying out many garden dials and we should search for this evidence, especially on the few dials that remain that are in excellent condition.

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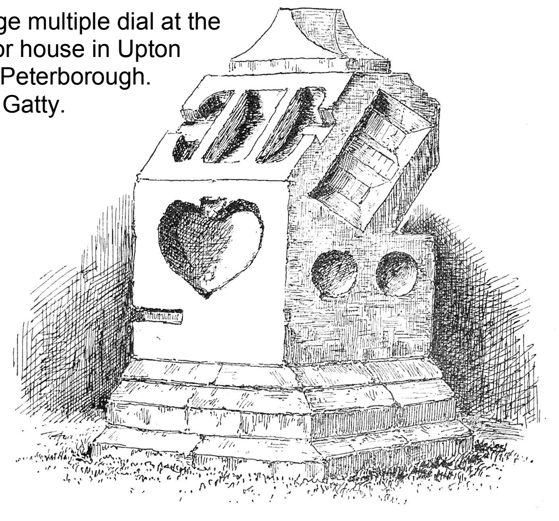
A large multiple dial at the manor house in Upton near Peterborough. After Gatty.



SOMETHING UNSUSPECTED, BUT NOT NEW, IN DARKEST SCOTLAND

K. ANDERSON

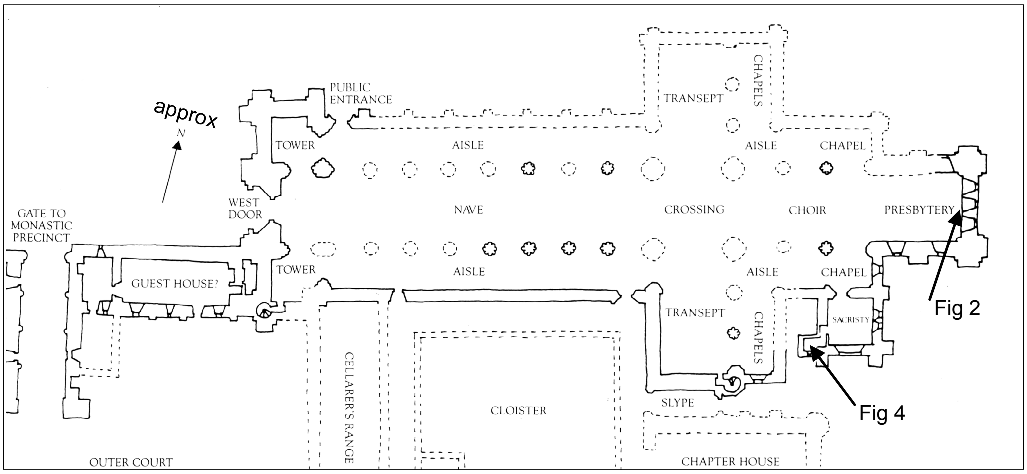


Fig. 1. Plan of part of Arbroath Abbey, showing direction of the meridian lightspot.

[*This article, contributed by a non-member who is researching ancient Scottish buildings, raises some interesting questions about the construction and orientation of medieval churches. Further comments are invited.—Ed*]

On a visit to the outstanding, partially ruined, Arbroath Abbey (Fig. 1) in mid-December 2005, three spots of sunlight were observed in adjacent arches of the applied arcade behind the site of the High Altar. These spots, seen in Fig. 2, occluded in turn and the centre one was particularly rounded and bright. Placing the head in the spot and looking back up the sun-ray, the very last edge of the sun could be seen disappearing behind the stonework of a window of the choir and the angle of the sacristy wall (Fig. 3). The window frame has been restored after early fire damage (accurately, according to the stonemasons) and was originally built around 1200. The sacristy was built around 1400. Further visits with watch and camera determined that the centre spot occludes at astronomical noon for Arbroath (Greenwich +10 minutes).

Fig. 2. Showing the noon light spots in the applied arcade (choir).

Subsequent visits for a series of photographs were so cold that the wretched observer took shelter in the sacristy between pictures. A strange light effect was visible there too. Through a little door high on the interior wall, a streak of sunlight can be seen on the underside of an arch and it moves off this edge of stonework at solar noon. This event too was photographed (having due regard to Health & Safety regulations!). It is shown in Fig. 4 and found to be due to a narrow lancet in an exterior wall, with original and remarkably un-eroded stonework frame. A later glass pane has been inserted, well within the area of the window.

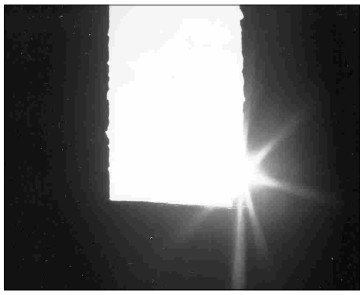


Fig. 3. Showing the view as the last edge of the sun's disk occludes, from the central light spot in the arcade.

The dating of these meridian arrangements is fairly early. The sacristy was built by Abbot Paniter in the early 1400s, the main part of the Abbey in the 1200s but the choir was probably built first and so might be late 1100s.

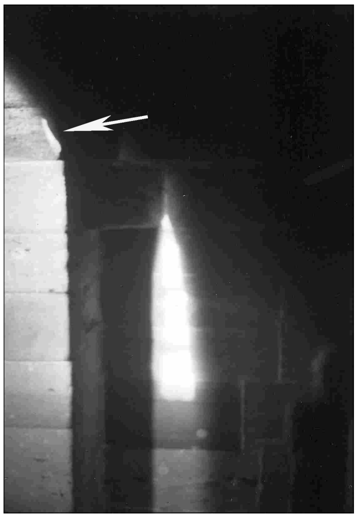


Fig. 4. Showing light pointer on the stonework approx. 1 minute before meridian transit (left hand of picture).

The Abbey buildings are now much reduced by fires, 'quarrying' and general demolition over the centuries so it is good that this corner still exists to show its meridional activity. There is likely to have been something elsewhere in the building, working from mid-March to mid-September but, as the central crossing tower, roof, north side and almost all the internal structures have gone, it would be mere guesswork to suggest what might have been. Arbroath was a very well endowed Benedictine (Tironensian) Abbey, in a small thriving port, and its bells must have been a feature of the life of both the clergy and townsfolk, keeping the hours in order.

Tribute must be paid here to the kindness and patience of all staff at the Abbey, who gradually came to realise that there might be something very special to be seen, but that only someone prepared to stand and watch was likely to puzzle it out! They are a busy group of people.

Arbroath Abbey is in the care of Historic Scotland, opening hours: (summer) 9:30 to 18:00; (winter) 9:30 to 16:00. A sunny day is advisable if you are thinking of visiting!

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SUNDIAL DELINEATION USING VECTOR METHODS

Part 6 - Equatorial Dials

TONY WOOD

[Readers are reminded that the meanings of symbols used in this paper do not follow the normal BSS convention. See the first part of the series (Bull. ***17****(iii) pp.121-127) for their definitions here. Ed.]*

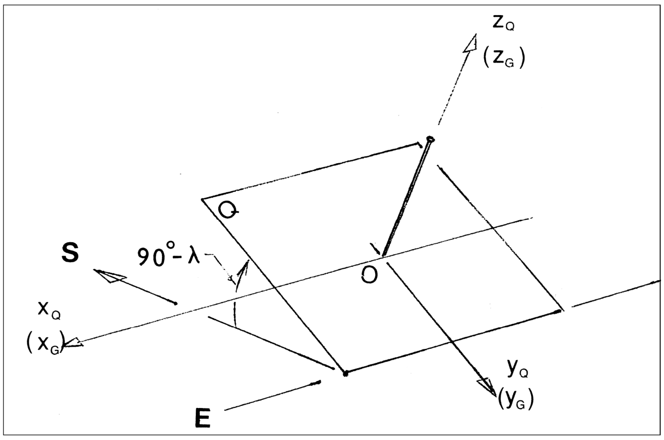

Fig. 20. Equatorial dial. Axis system.

Here, the dial plate (Fig. 20) is in the original gnomon axes. We have therefore the shadow plane components:

$$x_Q = x_G = p\cos\alpha \quad y_Q = y_G = p\sin\alpha \quad z_Q = z_G = q$$

The intersection with $(x, y, z)_Q = (s, t, 0)_Q$ gives the hour lines:

$$y_Q = x_Q \times \tan\alpha$$

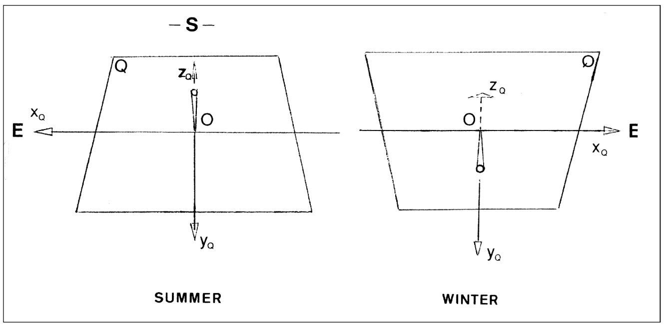

Fig. 21. Equatorial dial. Views in summer and winter.

It must be remembered that the axis system (Fig. 21) is viewed from north in summer ($\varepsilon > 0$) and so the axes as viewed are inverted, with Ox_Q off to the east, Oy_Q to the north (and downwards) and Oz_Q up out from the dial plate. In the winter ($\varepsilon < 0$) the 'underside' of the dial is viewed from the south (Fig. 21) and the axis system is Ox_Q off to the east, Oy_Q to north and downwards and Oz_Q is away on the upper side of the dial; the downward gnomon is therefore along the negative Oz_Q axis.

Declination lines

The ray line components are, in equatorial axes:

$$x_Q = p\cos\alpha \qquad y_Q = p\sin\alpha \qquad z_Q = n - p\sin\varepsilon$$

intersecting with dial plate components $(x, y, z)_Q = (s, t, 0)_Q$ to give

$$x_Q^2 + y_Q^2 = n^2/\sin^2\varepsilon \quad (= r^2)$$

i.e. a series of circles, radius $r = n/\sin\varepsilon$, centre $(0, 0)_Q$ with n and ε both positive in summer, both negative in winter. At the equinoxes ($\varepsilon = 0$) the circle is of infinite radius.

Sub-style angle

There is no sub-style angle as the gnomon is perpendicular ($\zeta_Q = 90°$) to the dial plate.

The sub-nodus co-ordinates are trivially: $(x_n, y_n)_Q = (0, 0)_Q$

And the nodus heights (distances from dial plate) are:

$(z_n)_Q = n$ in summer ($\varepsilon > 0$) (n positive)

$(z_n)_Q = -n$ in winter ($\varepsilon < 0$) (n negative)

Dial Illumination

If both sides of the dial are considered then there is no sun position limit, L_S; the upper surface is lit from sunrise to sunset in summer, the lower surface likewise in winter.

Summer is considered to run from the spring equinox (~March 20, $\varepsilon = 0$) through the summer solstice (~June 21, $\varepsilon = 23.5°$) to the autumn equinox (~September 22, $\varepsilon = 0$). Winter then commences and goes through the winter solstice (~December 21, $\varepsilon = -23.5°$) to the spring equinox.

SUMMARY AND CONCLUSION

1) The equations avoid sec, cosec and cot as they are not on our calculators.

2) So far, the plane of the ecliptic and celestial spheres have not been invoked.

3) A flat earth is implied through use of plane trigonometry.

4) No account is taken of atmospheric refraction in the consideration of the horizon limits for dial illumination.

5) Although some equations contain many terms, their evaluation is simply by substitution of appropriate values, usually using α, the shadow angle, as the variable; the dial orientation angles and sun's declination being constant (on a given day). Several terms in the equations will therefore remain fixed throughout.

6) All derived angles should be expressed in degrees if used in subsequent equations.

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UNDERSTANDING SUNDIALS

FARNCOMBE ESTATE, 18-20 August 2006

JILL WILSON

High on the Cotswold Edge above Broadway with stunning views over the Vale of Evesham towards the Malvern Hills is the Farncombe Estate Adult Learning Centre, which offers comfortable accommodation and good food. From 18th to 20th August this year it was the host to a weekend course on 'Understanding Sundials.' By no means all who had booked were BSS members, some had no prior knowledge but just a general interest, and two admitted to having come because they were curious as to how sundials could be the subject of an entire weekend. All left after Sunday lunch having enjoyed every minute and carrying away detailed tables and handouts for future use.

After a preliminary sherry and Friday dinner Christopher Daniel gave as introduction a masterly illustrated survey of the history of dialling and of dial types, many of the recent dials shown being of his own design. On Saturday morning Tony Belk explained theory and design from first principles, including taking account of the movement of the sun, dial furniture and the way of converting apparent local time to mean time. In the afternoon, joined by John Davis, practical dial delineation was the topic. All present had the opportunity to delineate two or more sundials, either simply with the aid of dialling scales or using a scientific calculator.

Sunday morning was devoted to materials and the practicalities of designing and installing dials, with especial attention being paid to wall declinations. Finally Tony Belk, taking over from John Davis, summarised the course. Members were reluctant to leave the display of models, materials specimens and folders of designs and pictures.

Having up to now been no more than an 'armchair diallist' I now feel more confident in my understanding of the design side. Those who started with more knowledge and experience gained much and the absolute beginners were heard to say they now had a new interest and would not look at a sundial as just a garden ornament again. Should BSS repeat a course of this type I heartily commend it to you.

READERS' LETTERS

IMAGES OF ENGLAND

Not long ago I came across a useful resource for members who enjoy seeking out new dials for the Register. In case it is not generally known, I thought I might mention it here, for the benefit of members who have access to the internet. There is a web site *www.ImagesOfEngland.org.uk,* operated by English Heritage, and its purpose is to build an 'Image Gallery' of Listed Buildings around the country. It is searchable by Who? – famous people or organisations involved with the structure; What? – the type of building; Where? – the geographical location; When? – the period that the structure was constructed. On your first visit to the site, you need to register, but there is no charge.

The important feature for us is that it also has a 'Free Text' search field. If, for example, you enter 'sundial' in the Free Text field, and select 'Durham' in the County field, you get a list of all the gallery's buildings in County Durham where the word 'sundial' appears in the description.

Ossington churchyard

It is remarkable how many are to be found in some counties. A large percentage are still unregistered, and many are of high quality. In Nottingham for example 60 dials were listed, of which only a few appeared in the Register of 2000. In a remote country churchyard I found a lovely pillar dial, dated 1742 and signed by William Arden, a new one for Jill's Biographical Index.

In Buckinghamshire, where the search came up with 30 dials, I found a curious dial hidden behind the thick growth of a magnolia tree on a town house in Beaconsfield.

Beaconsfield, Bucks.

In County Durham, the web site again showed 60 dials, including examples on the back walls of working farms, which would have been hard to locate by any other means. The dial illustrated here was on an abandoned Methodist Chapel of 1836, not easily seen by the casual passer by.

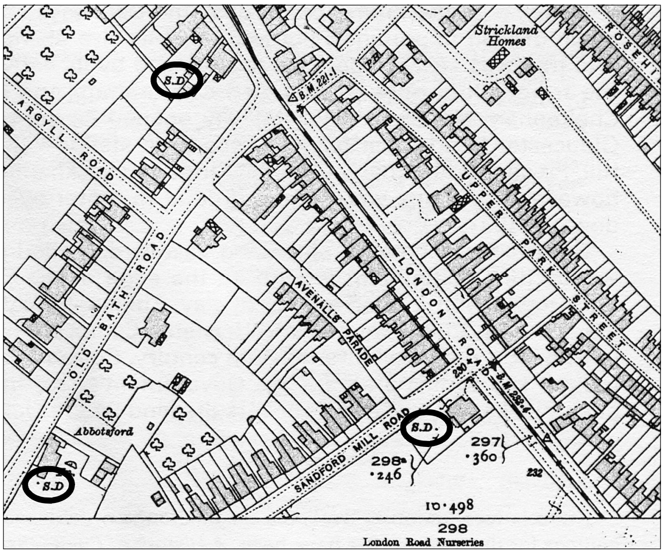
Wolsingham, Co. Durham

Across the country, the site has an amazing 2,705 references to either 'sundial' or 'sun dial'. Although a few of them may now have gone (entries date back to the 1950s), most remain. I can strongly recommend spending an hour or so on the web site to seek out dials in your area, or before a trip away.

John Foad
Ulcombe, Kent

CARTOGRAPHY

John Wall's article in the September Bulletin tells us of his using maps and gazetteers to track down possible sundials. It is perhaps a good moment to extend the information and reveal that some Ordnance Survey maps actually have sundials marked on them. Too good to be true? – well, there are snags.



The map I have is a reprint of the 1921 1:2500 mapping (the original article has dropped a zero from the scale and should be 1:25000) so any dial marked is over 80 years old. A sundial is marked by **S.D** – any dot after the D is the sundial position. The reprints don't appear to have any OS reference or lat/long but this is not a major problem: if you can't find the road 80 years later the dial will have gone as well.

The coverage of the reprints is very scattered and seems to be of urban areas. The attached bit of map has THREE dials marked and the current road layout (in Cheltenham) is much the same. I wonder if they are still there?

The maps are published by Alan Godfrey at the Prospect Business Park, Consett, DH8 7PW. The serious researcher might be able to find the original maps in a dusty archive. I know that the universities of Birmingham and Kent at Canterbury have such archives but can't be sure about the dust!

Tony Wood
Churchdown, Gloucs.

CHURCH ORIENTATIONS

I have read with interest the articles by John Wall[1] and Ian Hinton[2]. In recording sundials in Guernsey[3] I have noted the orientations of ancient churches and have related them to the orientations of megalithic tombs in the Channel Islands.[4] The vast majority of the tomb orientations, and all of the churches, fall between the directions of summer and winter solstice sunrises. Similar results have been found for megalithic tombs elsewhere[5], and Hinton's study confirms that the same is generally true for English churches.

These results are consistent with the hypothesis that the churches and tombs were usually laid out to face sunrise on the day construction began. It is reported that historical church records indicate that this is the case, and that measurement of the church axis enables the calculation of possible calendar dates for the beginning of construction.[6]

This conclusion is supported by Sir Henry Chauncy, who, in 1700, stated: "One end of every Church doth point to such a Place, where the Sun did rise at the time the Foundation thereof was laid, which is the Reason why all Churches do not directly point to the East; for if the Foundation was laid in *June*, it pointed to the North-East, where the Sun rises at that time of the Year; if it was laid in the Spring or Autumn, it was directed full East; if in Winter, South-east; and by the standing of these Churches, it is known at what time of the Year the Foundations of them were laid". [7]

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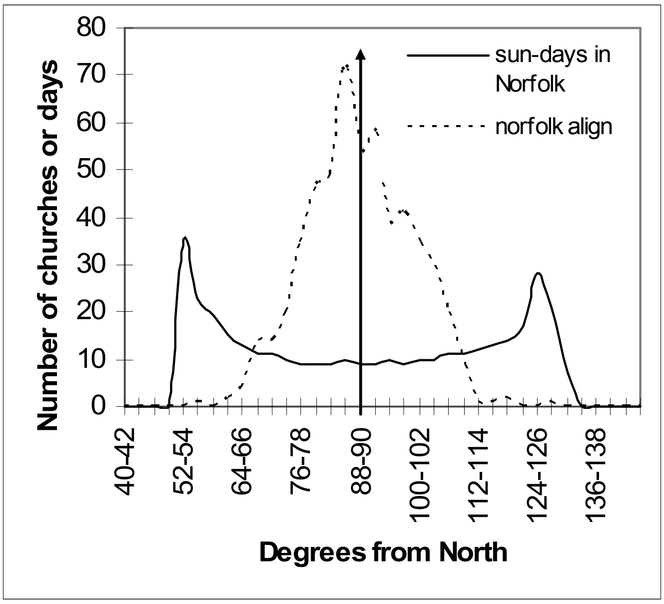
David Le Conte
Guernsey

Ian Hinton replies:

On the face of it, sunrise position seems to provide an opportunity to explain variations in church orientation. However, my large scale data do not bear this out at all. Space restrictions in the Bulletin prevented discussion of this issue. I refer Mr Le Conte to my forthcoming article in The Antiquaries Journal, Vol. 86, due for publication in December 06. In brief, if churches faced in the direction of sunrise on the day that their foundations were set out, then a set of orientations that followed sunrise would be expected. The chart below shows that this is definitely not the case among the 549 churches in Norfolk, neither is it amongst the other 1300 I have surveyed in other counties. Alternatively, if the date of digging the foundation or the date of the commencement of construction is used, different problems are introduced and I have also shown that neither of these can be used either. The issue of church alignment continues to exasperate, even after several years of study.



The solid line ("sun-days in Norfolk") shows the number of days a year that the visible sunrise has a specified azimuth for Norfolk churches. The dotted line shows the alignments of Norfolk churches.

continued on page 175

HOOKE'S JOINT, SUNDIALS AND THE SUNDIAL-CLOCK

ALLAN MILLS

[This article is based on a presentation to the British Sundial Society at the Durham Conference, 21-23 April 2006.]

Robert Hooke (1635-1703) was appointed the first Curator of Experiments for the Royal Society in 1662 and recognised for his many talents. However, the animosity of Isaac Newton, plus his own difficult personality and absence of family, led to him being rather neglected in his later years and overlooked after his death. This omission has been rectified in the past decade, with a number of biographies,[1] books,[2] and conferences[3,4] helping to restore Hooke's reputation as a pioneering scientist, inventive engineer, gifted artist,[5] and hard-working surveyor.

Hooke and Mechanisms

The quantitative study of technical mechanisms, and ideas for their application and improvement in novel scientific instruments, occupied a significant part of Hooke's early professional life. Horology, astronomy and microscopy were particular favourites,[6] but his name is now most commonly associated with the classic description of elasticity known as 'Hooke's law'.[7] The second item to which his name is familiarly attached is 'Hooke's joint', two of which are used in the transmission of almost every automobile. Surprisingly, no comprehensive account of the history of this important mechanism has been traced in the literature.

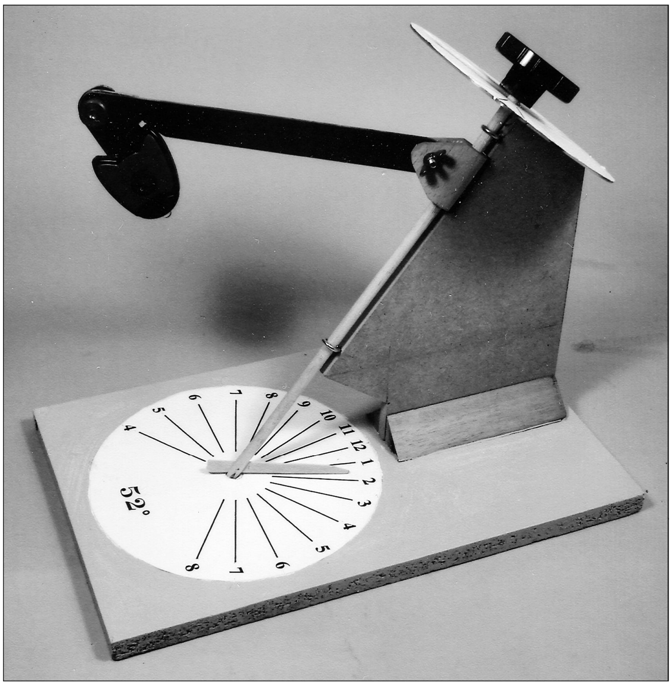


Fig. 1. Mechanical analogue to demonstrate motion of the shadow over a sundial.

A Mechanical Analogue of Sundials

Before studying Hooke's contributions to dialling it is helpful to consider a mechanical analogue of the equal-hour sundial devised by Chris Lusby-Taylor[8] and shown in Fig. 1. A thin shaft is supported at a chosen polar angle (here 52°) by a triangle of MDF, and is secured by screw-eyes that allow it to be rotated. This shaft simulates the polar axis, and a pointer inserted in a small hole drilled at right angles moves over a 'clock face' divided into 24 equal hours, with 12 noon at the top. A small spotlamp is also hinged to the inclined shaft, in line with the pointer. When illuminated, the shadow cast by the inclined shaft (also simulating the stile of a gnomon) falls upon a horizontal sheet of paper. It will be seen that the direction of the shadow is independent of the angle of the lamp with respect to the shaft, but turning the latter as a whole causes the shadow to progress in a non-linear manner around the paper 'sundial'.

A thin wooden pointer of rectangular section is freely pivoted within a slot cut in the lower end of the sloping shaft. A conical depression at the centre of the paper dial both supports the pointed shaft and allows the lower pointer to slide over its surface. If the two pointers are set parallel it will be found that the second pointer accurately follows the shadow over the face of the dial, automatically resolving the motion of the 'Sun' over the 'clock' (or equatorial) dial into the corresponding motion in the horizontal plane. It will be realised that a similar mechanism could mimic the motion of the shadow of a gnomon over the lower half of a vertical sundial. The polar axis must always be angled to match the latitude, whatever the orientation of the final sundial.

This demonstration model is not suitable for mechanization since the lower pointer is constrained by the plane of the paper dial and must necessarily scrape over it.

The 'Sundial Delineator'

Hooke frequently had difficulty in finding a place to publish his innovations. In 1675 he took the opportunity offered by some unused space in the plates accompanying the publication of his third Cutlerian Lecture[9] to illustrate an 'Instrument for describing all manner of Dials'. Shown here as Fig. 2, it was sufficiently unfamiliar a few years ago to be set as a quiz in the NASS *Compendium*.[10] Hooke's instrument was in fact an improved version of a lightly-built wooden device he made and demonstrated in 1667.[11] Both

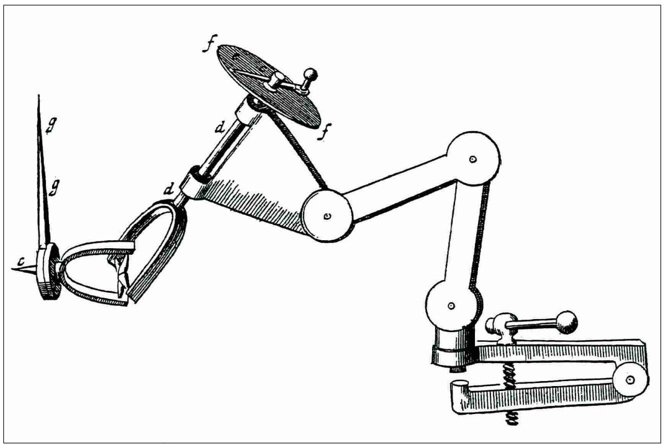


Fig. 2. Robert Hooke's refined instrument for delineating sundials (1675).

versions incorporated a cross-shaped interior member pivoted at opposite points between yokes fixed to input and output shafts, but the later instrument is shown as precision-made in metal with stirrup-shaped yokes to permit a greater inclination between the two shafts. Uniform rotation of the input shaft produces a nodding motion of the cross that gives rise to a variable output speed, accelerating over 45° and then decelerating over the next 45°.

Hooke appears to have realised intuitively, but subsequently proved by experiment, that this motion matches that of the shadow of a gnomon over the face of a sundial when the shafts of his delineator are set at an angle equal to the latitude of the dial's proposed location. The reason will be seen by examining Fig. 1, where the lower pointer and its pivot pin constitute the virtual 'cross'.

Hooke foresaw that driving the input shaft of his delineator with a 24^h clock would produce a 'sundial-clock' and also claimed that a similar mechanism could reproduce the equation of time. Like so many of Hooke's inventions, it appears that these more complex devices were never built.

The 'Universal Joint'

Hooke's 1667 instrument was far too light to have functioned as a flexible coupling to transmit significant torque through an angle, although he does say that it could "facilitate wheel-work and have other mechanical uses". By 1674 it had metamorphosed into the classic form utilised in Fig. 2, and Hooke was proposing its application in an altazimuth drive for an astronomical quadrant.[12,13] He called it a 'universal coupling'. It is recorded that blacksmith-made devices of this nature were already in use on the Continent to couple two rotating shafts meeting at an angle. Examples were apparently used in Dutch windmills for coupling the sails to an Archimedean screw for raising sediment-laden water from drainage ditches. In this application it would not matter (and probably was not appreciated) that the output velocity was not uniform. Seeing such a mechanism – or a drawing of it - Hooke would have realised that its 'cross' mechanism was identical in action with that in his sundial delineator, resulting in a varying output speed. Publication of his studies led to the universal coupling being identified with his name, at least in England.

Mathematical Analysis

Hooke was a competent mathematician, but the spherical trigonometry of his time was insufficiently developed to permit analysis of the kinematics of the universal joint. Not until 1845 did Poncelet[14] prove that:

$$\tan\beta = \tan\alpha \cos\gamma$$

Where α is the angular position of the input shaft,

β is the angular position of the output shaft and

γ is the inclination of one shaft to the other - the 'angle of articulation'.

The derivation is repeated in texts on automotive transmissions.[15] The 'angle of articulation' used by engineers is the complement of the corresponding 'angle of latitude' ϕ and, as the cosine of any angle is equal to the sine of its complement, we may write

$$\tan\beta = \tan\alpha \sin\phi$$

This expression is equivalent to the 'equation of the sundial' quoted in many books on their construction.[16]

Practical Verification

Models

Working examples of Hooke's joints were constructed to illustrate both the 'cross' and the 'disc' forms of interior member. They are shown in Fig. 3, along with commercial[17] examples in steel and acetal plastic. The last are free of backlash and considerably less expensive but, as the cross is reduced to a block buried within the yokes, it is much harder to demonstrate its motion.

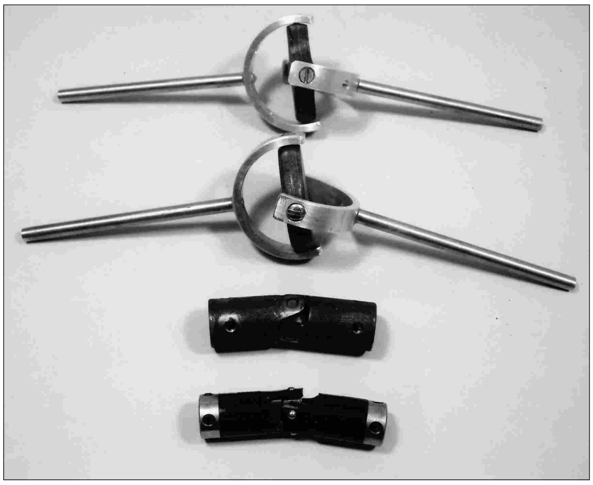


Fig. 3. Demonstration examples of 'single' Hooke's joints. Top to bottom:(a) with a cross-shaped interior member, (b) with a disc-shaped interior member, (c) two commercial versions.

Phase
Points at which the output velocity becomes maximal or minimal are 90° apart. Engineers say this denotes the *phase* of the Hooke's joint. It was found that the minimum velocity occurred when the cross was parallel with the wall of a vertical dial. When the shafts of the Hooke's joint, the 12-12 line on the dial, and the output pointer are all in the same vertical plane, then the yoke on the output shaft will be vertical. Numerals will be observed to bunch together around noon on any sundial to allow for the lower velocity of the shadow at this point.

Amplitude
The discrepancy from uniform spacing of the hour lines on a sundial decreases as latitude increases. This is reflected by the increasing amplitude of the departure from uniform motion as the articulation angle of Hooke's joint is increased from zero (where the two shafts are in line) to a maximum of 60°. (The plastic versions can only accommodate up to 53° with careful hand operation.)

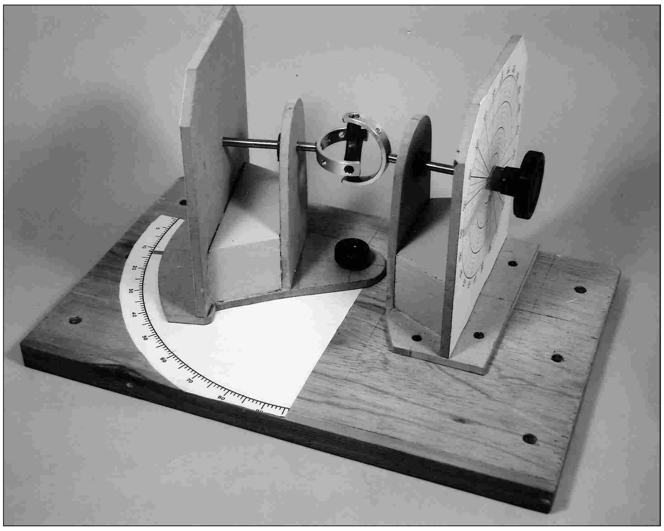


Fig.4. Apparatus for study of motion of single or double Hooke's joints at various angles of articulation.

Sundial Delineation
The commercial single Hooke's joint in acetal plastic was fixed in the measuring apparatus of Fig. 4, the phase and pointers set to zero, and the output yoke fixed vertically along the 12-12 line. The angle of articulation was set to a chosen latitude. It was then confirmed that moving the input shaft in equal 15° increments caused the pointer on the output shaft to agree with the positions of the hour lines on a direct vertical dial previously drawn by conventional methods[16] for the given latitude.

Horizontal dials may be delineated by setting the articulation angle to the co-latitude of the site and arranging the output shaft to be vertical. The yoke of the output shaft should be parallel to the 12-12 line.

In both cases the direction of the numeration must be appropriate for the hemisphere: in the northern hemisphere the shadow moves anticlockwise over a vertical dial, clockwise on a horizontal dial.

The Sundial-Clock

It has been noted above that Hooke himself first suggested, and later discussed quite extensively, the incorporation of a 'universal' to permit the relatively easy construction of a non-linear mechanical 'clock' that would track the motion of a gnomon's shadow over the face of a sundial and take over the time-telling function when clouds covered the Sun or at night. Nowadays, floodlighting would enable the clock to be read then, so the dial should embody the sundial 'night hours' drawn by extending the usual hour lines through the centre. Such a mechanism is more complicated than an ordinary clock because:

a) Its direction of rotation must be appropriate for the location and orientation. Some modern 24-hour time switches embody a suitable output spindle, but for large public sundial-clocks a somewhat larger and waterproof synchronous electric gearmotor might be advisable.

b) The angle of articulation of the Hooke's joint must be correct for the site and orientation. This will, in principle, require the input shaft to be set along the polar axis, but in cramped surroundings the motor and drive shaft may be rotated around the output shaft to best suit the conditions.

c) The phase must also be set to suit both dial and orientation of the drive by noting the position of the output yoke. Vertical dials will always have their 12-12 line vertical.

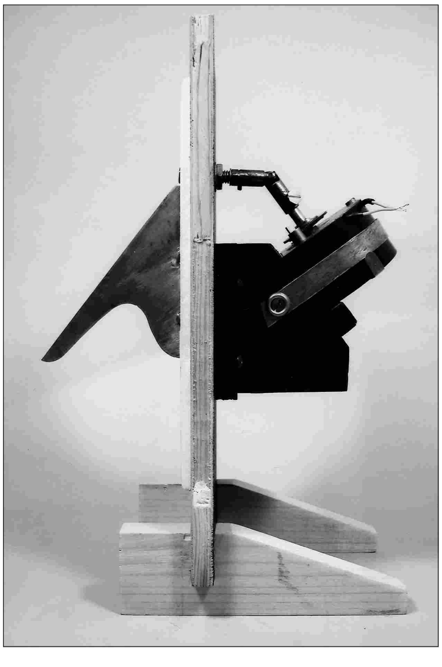


Fig. 5. Rear elevation of the drive for a sundial-clock on a vertical direct-south wall, showing the Hooke's joint.

d) 'The time' must be set after temporarily loosening the screw securing the rear portion of the universal to the 24^h clock drive. It is better to set on a convenient hour than to attempt interpolation in the non-linear spaces between numerals.

Fig. 5 shows the side view of a sundial-clock for a direct south vertical wall. It is driven via a single Hooke's joint. The fork on the

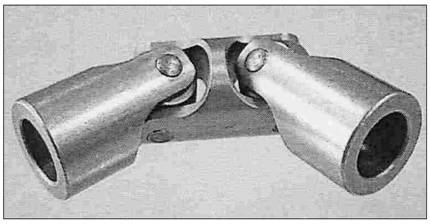


Fig. 6. A 'double' Hooke's joint with integral link.

output section of the latter was set to be parallel to the (necessarily vertical) 12-12 line on the dial.

The Double Hooke's Joint

Hooke himself realised that there could be circumstances where the periodic variation in speed characterising the standard form of coupling would be unwelcome. His solution was to employ *two* universals, one at each end of a common intermediate shaft, to give a 'double' joint.[18,19] Separate units may be assembled 'in phase', 90° out of phase, or in any intermediate position. The out-of-phase position, combined with parallel input and output shafts (or equal angles of inclination to the intermediate shaft) negates the variation, and the whole assembly is commonly known nowadays as a *constant velocity coupling* (Fig. 6). They are available commercially in a range of sizes.[17] The addition of a splined assembly in the intermediate shaft (to allow back and forth motion) has provided a coupling that, centuries after Hooke's time, has proved enormously successful in the automobile, for it allows power to be transmitted from engine to wheels even when their relative positions are changing as a result of going over bumps and hollows in the road. Millions are made every year.[15]

Sundial-clocks for declining vertical walls

The two shafts meeting at the centre of a single Hooke's joint must, by geometry, fall in one plane. When the input shaft is aligned with the pole, the output shaft will necessarily be in the same plane and must be arranged horizontally and pointing south to give an articulation equal to the latitude. This will be appropriate to drive a sundial-clock on a vertical wall facing due south, as shown above. What the mechanism is unable to do is subsequently move sideways out of that plane to pierce a wall declining east or west.

Hooke proposed[19] that the remedy was to use his 'double universal'. An assembly for a vertical wall at latitude 52° N declining 20° E is shown isolated in Fig. 7. It utilises two separate couplings but a unit with an integral intermediate shaft would be more compact and could not be mis-aligned in error. The input shaft must be held at the latitude angle to an intermediate shaft maintained in a horizontal position. The assembly was checked experimentally to match the graduations on a pre-drawn dial computed[16] for these conditions. Again, the fork of the final shaft must parallel the vertical 12-12 line on the dial.

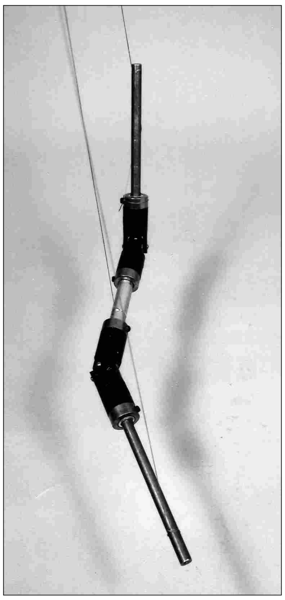


Fig. 7. Arrangement of two Hooke's joints and three shafts required for a sundial clock on a vertical wall declining 20° E.

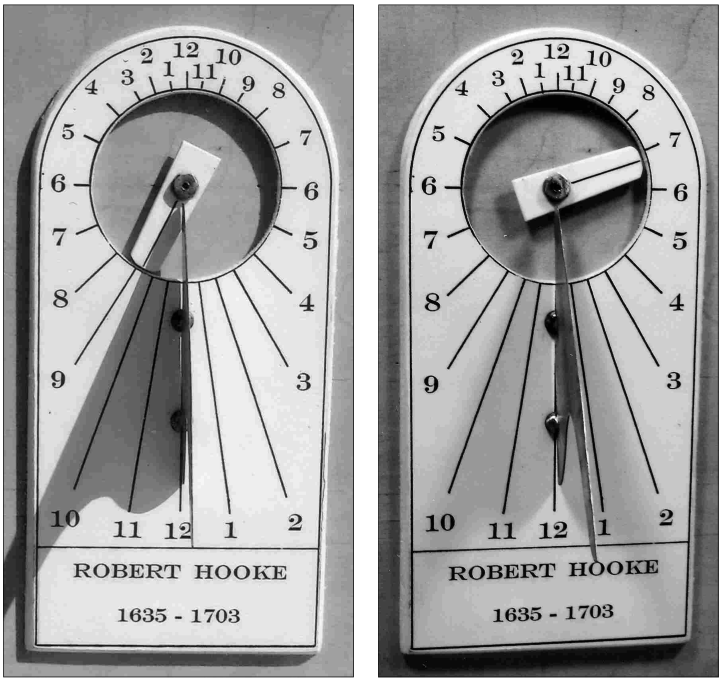


Fig. 8. Tentative design for a Hooke memorial sundial-clock: (left) in sunlight, with shadow and (anti-clockwise) clock registering 9:40 am, (right) by diffused daylight and/or flood-light, with the clock registering 6:45 pm.

Hooke Memorial Sundial-Clock

It is thought that a public sundial-clock would be an appropriate memorial to Robert Hooke. A possible design is shown in Fig. 8 and a suitable location is being sought.

ACKNOWLEDGEMENTS

I am grateful for the advice and encouragement of Dominic Statham and Chris Lusby-Taylor.

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12. Robert Hooke; 'Animadversions on the Machina Coelestis of Johannes Hevelius' London, 1674. Reprinted in R.T.Gunther, *Early Science in Oxford, Vol.VIII,* Oxford, 1931. Plate 2, Fig. 22.

13. For tracking celestial objects in general (including the real Sun) Hooke designed a universal with infinitely-variable unequal arms. This was to be adjusted to the declination of the object being followed. See reference 9, plate following p.119 and text on pp. 133-137.

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Postcard Potpourri 2 – Marrington Hall

Unlike the last sundial postcard, this sundial does feature in the Register. It can be found under Chirbury in the Shropshire section, where the latest of three sightings was by Roger Bowling in 1996. That reference tells me there are 11 component dials and it is sited at SJ272975 though it is not open to the public.

A search on the internet found the following at http://www.cpat.org.uk/projects/longer/histland/montgom/1074.htm

> "The estate was probably based on one of the two manors at Marrington mentioned in the Domesday Book, the present hall being a small mid-Victorian Elizabethan-style half-timbered country house incorporating a late 16th century timber-framed house, the earliest building perhaps associated with a sundial of 1595 erected by Richard Lloyd and inscribed 'From Dai To Dai These Shades Do Flee And So This Life Passeth Awaie', originally set within its gardens."

On the card one can see an Elizabethan gentleman underneath a motto that perhaps once said '… SIC VITA'. On the west face is a scaphe dial above an anchor. Is it a horizontal dial on the top? It looks like an equatorial dial on the inclined face. I wouldn't mind this dial in my garden, but will settle for the postcard!

pransom@btinternet.com

A VERY PUBLIC SUNDIAL

PETER BAXANDALL

Blandford Forum's fine early Georgian parish church of St Peter and St Paul dominates the centre of the town from the eastern end of the market place. Until the recent restoration few people would have been aware of the large 18th century triangular sundial within the pediment over the church's south porch looking down on them as they passed along the main road through the town. Two or three hour lines were visible (but only in strong sunlight), the prominent Aries symbol in the bottom right hand corner could easily have been mistaken for a stonemason's mark, the beautifully crafted iron bar gnomon looked something like a rusty relic of wall reinforcement. An early recorder wrote of the gnomon "Scalloping is probably caused by rust since it applies only to the outer end. It might just have been intentional and possibly even a nodus." (SRN2009).[1]

It *was* a little better known that the elegant stone vase above the sundial, familiar from old prints, had been taken down in the 1980s when it was found to be unsafe. The three parts and the rusted iron core were then left on the church roof.

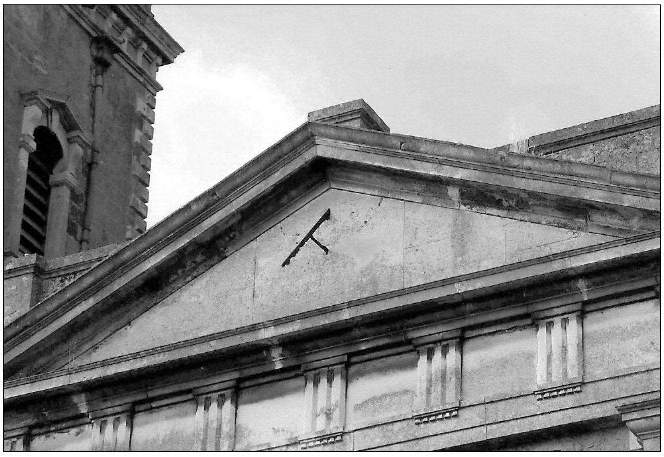

Fig. 1. The Blandford Forum dial before restoration.

The sundial (Fig. 1) was (and can again be seen as) exceptional in its prominence, its size, its shape and its simplicity. It forms an approximately symmetrical triangle 20' 3" wide and 4' 6" high with true declination S 2º11' E, able to show local solar time from 7 o'sun in the morning to 5 o'sun in the evening. It is painted on a tympanum recessed by about 12" within a layered pediment.

Beautiful though so many of them are, vertical dials do not always deliver what they seem to promise. A south facing wall receives (at best) 12 hours of sunlight on only two days a year (the spring and autumn equinoxes). Accordingly, a south facing vertical sundial only makes use of the full range of hours from 6am to 6pm on those two days. On a sunny summer solstice a south facing Blandford wall (50º52' N, 2º10' S) would only be in direct sunlight from 7.23 am until 4.37 pm (local time).[2]

Even if the pediment had not been there the Blandford dial would, in 2006, theoretically (ignoring refraction) only have used its full range (7am to 5pm) over two periods, 16th February to 29th April and 13th August to 25th October. But the pediment *is* there and through many spring and summer days its shadow allows just a sunlit triangle to move across the dial face (Fig. 2), the apex of the pediment acting as a nodus for the upper vertex of the triangle. The effectiveness of the sundial is limited by that movement because the time will only show on the face when the style (the leading edge of the gnomon) casts a shadow within the triangle. On 29th June 2006 that only happened between 8.50 am and 2.45 pm (sundial time). Converting to British Summer Time we find that, on that bright mid-summer day, the sundial did not wake up until after 10 o'clock in the morning and went back to sleep before 4 o'clock in the afternoon. In fairness the pediment shadow does not interfere between late summer and early spring when the lower sun shines more directly into the face.

There seems little doubt that, in the 1730s, the church's architect William Bastard chose the angle of the pediment

Fig. 2. Top to bottom: photos taken am, noon and pm on 29th July 2006 to show the track of the sunlit triangle across the face, and to capture the morning moment when the gnomon shadow just begins to show the time and the afternoon moment when it is just about to switch off.

(132º) to match the angle between the outer hour-lines (134º). In consequence, the sundial numerals all lie along the base of the triangle, a very unusual (indeed perhaps unique) feature until modern times, see for example the 1986 dial in Grouville, Jersey (SRN4615). Equally striking to me is the simplicity of the design. It is a bold (almost monumental) statement of the time for everyone, having none of the subtleties that require close inspection and an educated eye.

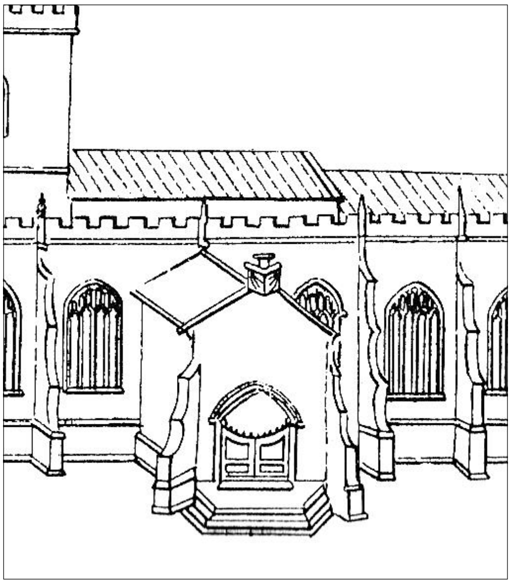

Fig. 3. A detail from a drawing of the pre-fire church by William Bastard the architect of the 1730s church.

His 1731 drawing of the proposed new church included a spire but no sundial![8]

The church was built by William Bastard and his brother John, replacing a church lost in the 'great fire' of Blandford in 1731; that earlier church had a two-faced sundial over its south porch (Fig. 3). The new church was consecrated in 1739, the tower and a cupola (controversially not a spire) being added later. It is not known when the sundial was installed but there seems no reason, given the care taken with the angle of the pediment, why it should not have been in place by 1740. Nor is it known with any certainty who designed it. In the inventory of what they lost in the 1731 fire[3] the brothers list "a large Sun dial just finished 3 10 0" (£3.50) and five dozen books on architecture, geometry and philosophy (science) including "*Liborns Dialling"* (surely one of the editions of *The Art of Dialling* first published by R&W Leybourn[4] in the middle of the 17th century) and also a copy of John Harris' *Lexicon Technicum* of 1708[5] which contained Flamsteed's Equation of Time tables. Their younger brother Benjamin designed and painted a rectangular sundial on a gable end of Sherborne Abbey in 1724 (SRN2013) and he might have been involved in Blandford. If the Bastard brothers did set up the ensemble we are grateful that they found the sensitivity to crown it with a delightfully understated and elegant stone vase rather than one of their lumpy funereal urns (four of them on the church tower alone) that were such a feature of their other designs around the market place and elsewhere.

On 15th November 1605 Blandford Forum was granted a Charter of Incorporation by James 1st of England (just a few days after the failure of the gunpowder plot). To commemorate the 400th anniversary of the charter Blandford and District Civic Society was easily persuaded to undertake the restoration of the sundial and the stone vase. They wisely commissioned Harriet James to report on the sundial's condition and history[6] and then, once a Faculty had been served by Salisbury Diocese, to undertake the restoration. At the same time the stone vase was cleaned up and reassembled around a stainless steel core by a Salisbury Cathedral stonemason, Andy Pullen of Romsey.

Once scaffolding was in place it was found that the sundial had been painted, with some scouring to the outline, on the Purbeck stone triangular tympanum. The surviving features are 2-3 mm or so proud of the surface, having been protected from weathering for many years by paint. A conservator (Lisa Oestreicher) reported that the paint had been lead based, that under several layers the original undercoats were white, and that on top of the undercoats the paints used were black and the more expensive vermilion. The lines were repainted accordingly, again using lead paints. There was however no trace of paint on the numerals, suggesting that a different and shorter wearing colour had been used. Harriet chose Prussian Blue, a Georgian favourite.

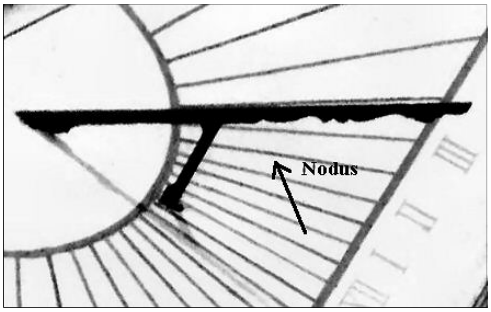

Fig. 4. The gnomon on the restored dial, showing the feature which perhaps acts as a nodus.

Fortunately the gnomon had been placed remarkably accurately, as had the hour and half-hour lines. The gnomon itself is a simple 50" long wrought iron bar with a single support and a very attractive scalloping or fimbriation along the bottom half of the lower edge – a typical example we have been told of 18th century ironwork.

The horizontal line above the numerals has an Aries symbol (Fig. 5) at both ends and one cannot help but look for a nodus. John and William Bastard in rebuilding much of Blandford after the fire were not immune from the Georgian concern for 'appearances' and it may be that the Aries symbols were just an added conceit. Living as they did in the house across the main road (East Street) from the church and looking directly at the sundial through the windows of their 'front parlour' every day, they perhaps enjoyed some wishful thinking (see Fig. 6).

Fig. 5. The Aries symbols on (left) the unrestored E side of the dial and (right) on the restored W side.

Fig. 6. The view of the restored sundial from the Bastard brothers' front parlour.

Photo: Phillip Ledwith.

On the other hand, although the horizontal line above the numerals cannot be an equinox line (the tympanum does not face due south) it is a near miss! A straight line drawn from a nodus (Fig. 4) at the top of the fimbriation to the noon mark on that putative 'equinox line' is at right angles to the style. The true equinox line on the dial for that nodus would pass through that noon mark but be inclined at 1.8 degrees to the horizontal and would have upset the balance of the design. However, provided one accepts some confusion around the equinoxes, in autumn and winter the shadow of the fimbriation crosses the horizontal line whereas in spring and summer it is thrown below onto the porch itself. The fimbriation seems (if it is indeed more than decoration) to have been designed to indicate the seasons rather than as a way of marking the precise dates of the equinoxes.

The Civic Society raised money from a number of sources; individuals, groups and trusts. A booklet describing the sundial and listing donors is to be available in the church. Three of the earliest (and for me the most encouraging) donations were from The Dorset Clock Society, The Wimborne and Blandford Decorative and Fine Arts Society[9], and splendid Sir John Smith's Manifold Trust. We had lots of advice and support from members of the British Sundial Society, from Harriet of course and from John Davis and Andrew James. Andrew in particular never quite let us forget in our enthusiasm that when the Blandford dial was made there was already a (1720) vertical triangular sundial on a church 'south' porch in nearby Ellingham, Hampshire (SN2916), a vivid dial celebrated by Arthur Mee and John Betjeman and several other authors (see Fig. 7). Andrew also gently expressed some doubts about our 'equinox line'. The was invaluable help from Polly Legg who knows so much about the Bastard family, and from Ken Lindon-Travers who perceptively played the rôle of 'everyman' throughout.

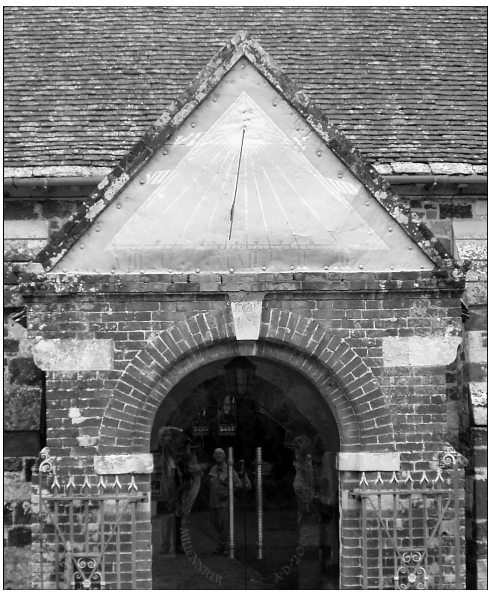

Fig. 7. The blue and gold triangular tin sundial over the porch of Ellingham church (1720).

We all managed to survive the heart-ache and unkind shocks that local politics is heir to. Harriet unfortunately was not able to be there when the Duke of Gloucester visited the town on 15th November 2005, the anniversary of the granting of the town's 'royal' charter (Fig. 8). As an honorary freeman of the Grocers' Company (which had such strong links with instrument making in the 18th century)[10] it seemed doubly appropriate that the Duke should examine the sundial and vase and then unveil a plaque that commemorates the restoration and shows a graph of the equation of time adjusted for Blandford's longitude. The plaque has been mounted on a wall of the Bastards' house just across East Street from the church's south porch where it can be read while keeping the sundial in view. The picture of the Duke's inspection that appeared in the Western Gazette might well have had the Batman sub-title "Is it a bird? Is it a plane? No, it's..." I particularly enjoy the poster in the video shop behind us.

In Blandford Forum market place, described by Nicholas Pevsner[7] as "one of the most satisfying Georgian ensembles

Photo: Western Gazette.

Fig. 8. The opening of the restored dial with (l to r) Tony Adams (Civ. Soc., casting a quizzical eye on the ring of photographers), John Barnes (Chairman, Civ Soc), Duke of Gloucester, an anonymous security officer, Peter Baxandall.

anywhere in England", there are enlivening quotations chosen by 'East Street Poets' carved into the pavements. One of them (from Oscar Wilde's 1891 essay *The Critic as Artist*) reads "We are all lying in the gutter but some of us are looking at the stars". We hope that increasingly Blandford residents and visitors to the town's centre will look up at the sundial and vase as they pass the church. They lift the spirits.

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READERS' LETTERS **(cont. from p.166)**

TURNSTILE DIAL

I was inspired by the Turnstile article (*BSS Bull* 18(iii), June 2006) to study the topic of equal hour divisions on a horizontal dial. This problem was tackled by Robin Holliday in 'Umkhonto We Langa Sundials' (*BSS Bull 97.1*, January 1997). He showed that, even for a normal horizontal dial, the equally-spaced hours contour is not an ellipse. In fact it comes to a point at noon, hence his 'Spear of the Sun' title.

In the case of the Turnstile dial, it is more difficult to determine a contour for equally-spaced hours. Also, such contours are not easy on the eye due to the lack of symmetry about the N-S line. A good reason not to pursue the subject any further and to congratulate Len Burge on going for an ellipse as the boundary of the dial.

John Singleton
Newbury

POETIC INTERLUDE

TONY WOOD

Farringford, on the Isle of Wight, was the home of Alfred, Lord Tennyson (1809-1892) and would seem a good bet for a decent sundial. The dial plate itself has long gone but the pedestal remains and so is filed under 'dead dials'. It is, however, of some interest as it has *two* mottoes carved round it and on each of the four faces is a sculpture of 'timekeeping'. Working backwards in time, we have: a clock, an hourglass, a sundial and 'something Egyptian'.

The representations of the first two are conventional enough but the 'sundial' (Fig. 1) appears to be an attempt at a scaphe dial by an artist unfamiliar with such dials. The 'something Egyptian' which features both the sun and moon is so far unidentified and may just be a scribe compiling a calendar.

The two mottoes run:

AND UNTO MEETING
WHEN WE MEET
DELIGHT A
HUNDREDFOLD ACCRUE

and

FOR EVERY GRAIN OF SAND THAT RUNS
AND EVERY SPAN OF SHADE THAT STEALS
AND EVERY KISS OF TOOTHED WHEELS
AND ALL THE COURSES OF THE SUNS

The first quotation starts 90° after the second and may imply that the mount stone, bearing the second, has been reset.

Enquiries of The Tennyson Society confirmed that the 'mottoes' were indeed by Tennyson himself and taken directly from the 1850 poem 'In Memoriam' canto cxvii and make some reference back to two of Shakespeare's sonnets. There is also a reference in the annotations provided to Tennyson's 'The sun-dial' which perhaps a cultured reader may know. The mottoes are not listed by Gatty[1] but she quotes the relevant two verses whilst writing about the motto 'FUGIT HORA, ORA' – the connection being by no means obvious.

The Tennyson Society also kindly sent a 1951 photograph of the dial in its complete state, almost hidden by flowers but showing a horizontal dial. The location was slightly different to the present position by a pool. I suspect that Tennyson may be our most illustrious motto author yet. The pedestal is in none too good a state and would make a good 'restoration project' with a distinguished provenance.

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ACKNOWLEDGEMENTS

Kathleen Jefferson of The Tennyson Society.

Farringford Hotel, Isle of Wight.

Fig. 5. Close-up of the 'sundial' face.

Fig. 1. The 'sundial' face.

Fig. 2. The 'Egyptian face'.

Fig. 3. The 'clock' face.

Fig. 4. The 'hourglass' face.

MAKING REPLACEMENT SPRINGS FOR A PILKINGTON & GIBBS HELIO-CHRONOMETER

TONY MOSS

While successful replacement springs for Pilkington & Gibbs Helio-chronometers *can* be made by hand, the bending often results in an ugly item which performs less than perfectly. To make springs which work correctly first time and every time, a simple rolling jig is required as described below. The basic details of construction, dimensions and operation are covered in a series of captioned pictures that should be self-explanatory.

The original springs were made from brass which, besides being resistant to corrosion, has a useful additional property, common to many metals and utilised by craftsmen throughout the history of metalworking. When brass is first cast it is soft and malleable but, if shaped by rolling or hammering, it 'work-hardens' to form a spring. This effect is progressive so that extreme work will make a very stiff spring that may break easily if over extended.

Nowadays, sheet brass is commonly sold as 'half-hard' which is an intermediate state produced by cold rolling. In earlier times it would have been easily available as hard-rolled strip for spring making but today this has been replaced by beryllium copper, a specialised spring alloy used in applications from aerospace components to key springs in flutes and clarinets etc. The original P&G springs were probably rolled to shape from metal that was already hard and this additional working may account for some breakages.

Springs rolled from half-hard brass might perform satisfactorily with just the work-hardening gained from rolling to shape but I prefer to enhance this by some localised hardening produced by 'planishing'. This process, used by silversmiths and related trades over the ages, involves light overlapping blows which squeeze the brass between a polished hammer face and a steel 'stake'. This distorts the grain structure producing internal tensions that stiffen the metal. For P&G springs, just a short length of polished steel rod, slightly smaller than the spring 'eyes', is used. Only the part of the spring subjected to flexing needs this treatment with the remainder left half-hard and therefore adjustable in shape to fit the mechanism properly.

Author's address:
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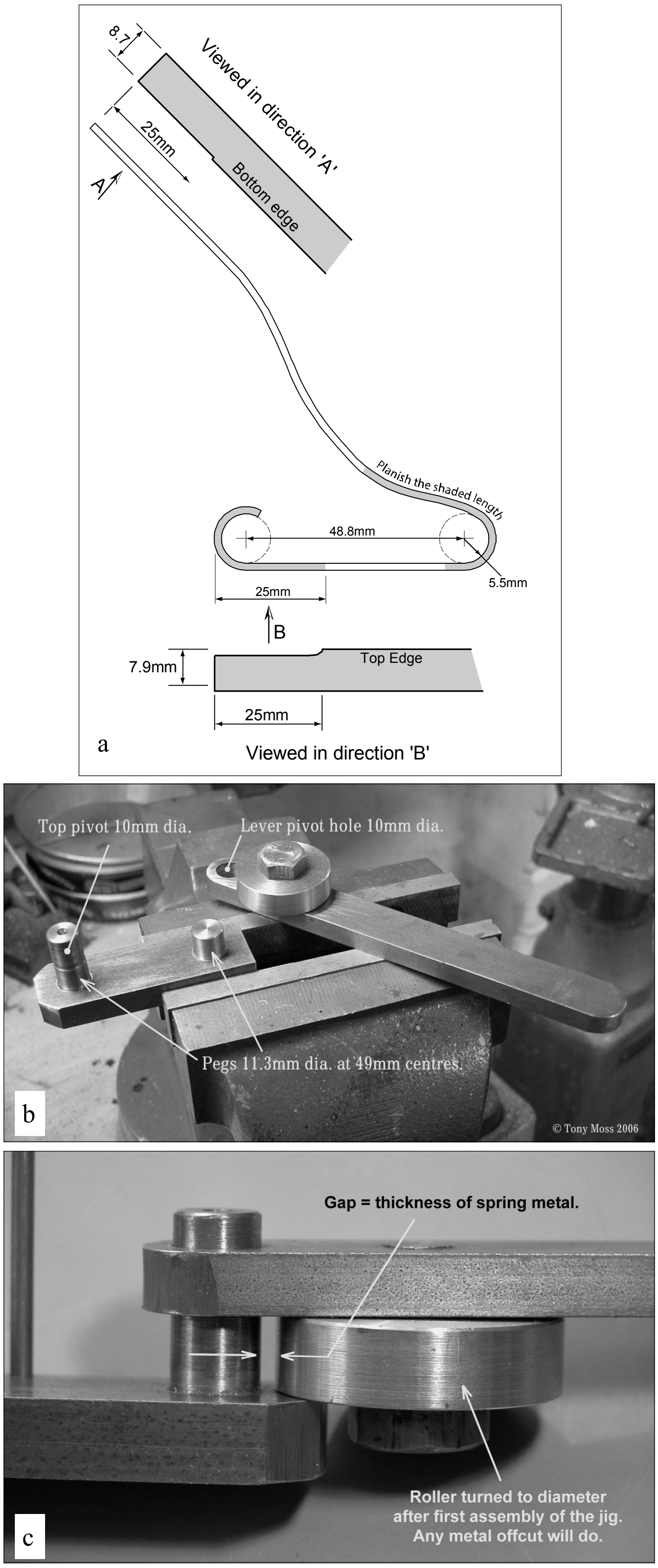
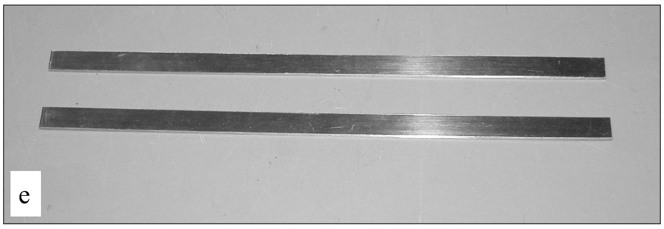
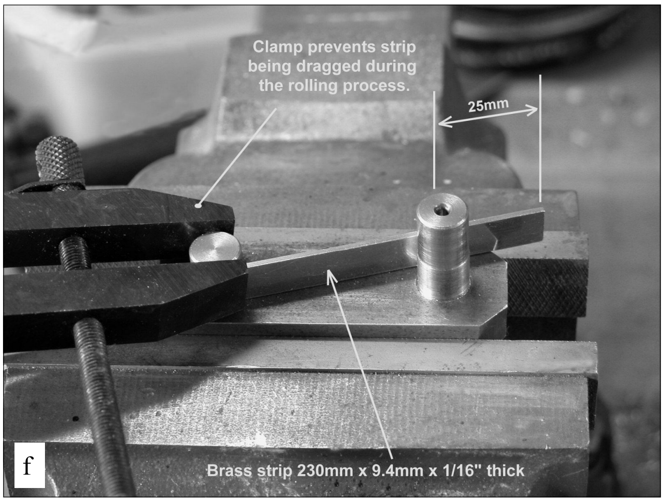
NE22 5SY



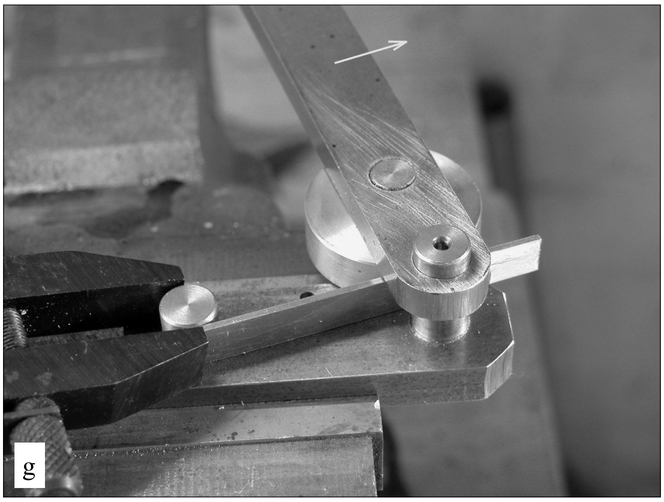
Top to bottom:
a) Drawing of the P&G spring
b) Jig parts
c) Roller gap


d

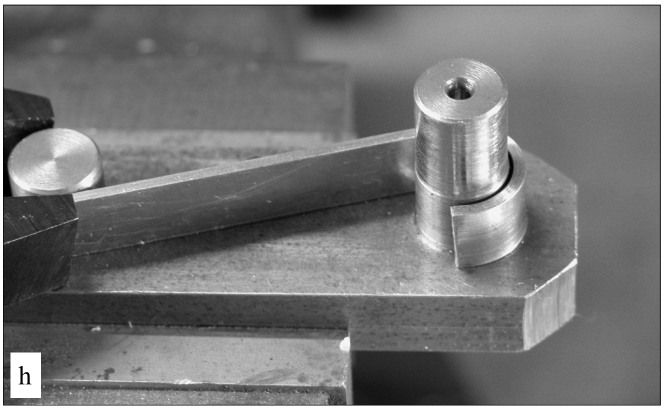

e

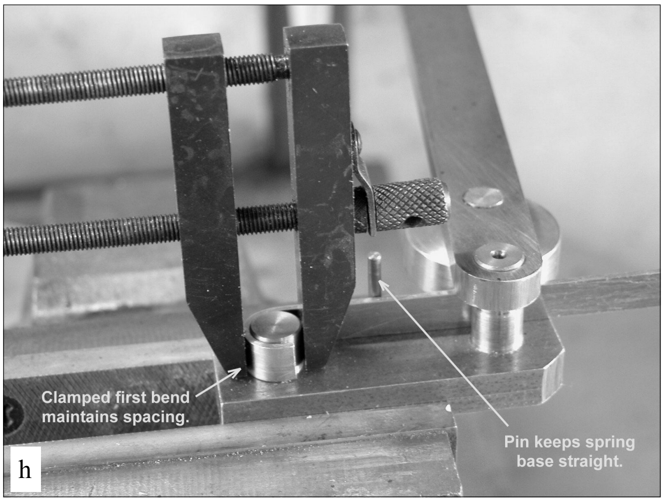


f

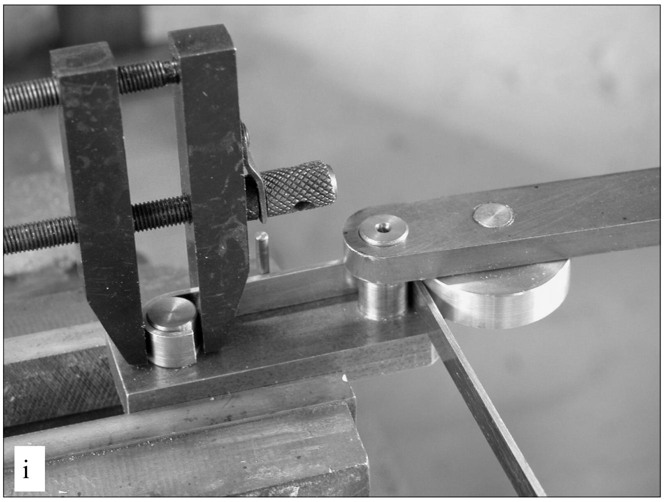

g

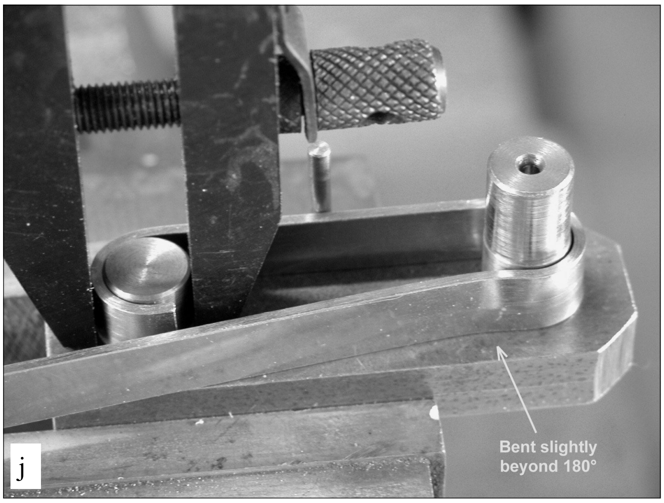
Above, top to bottom:
d) Bandsawing strips
e) Ready for bending
f) Stage 1
g) Beginning 1st bend


h

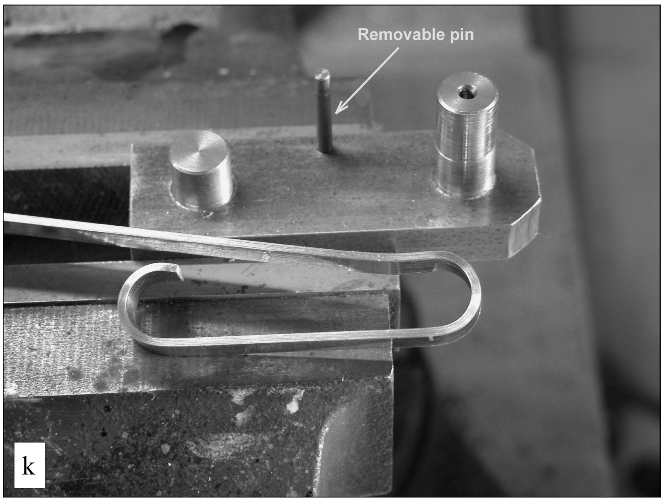


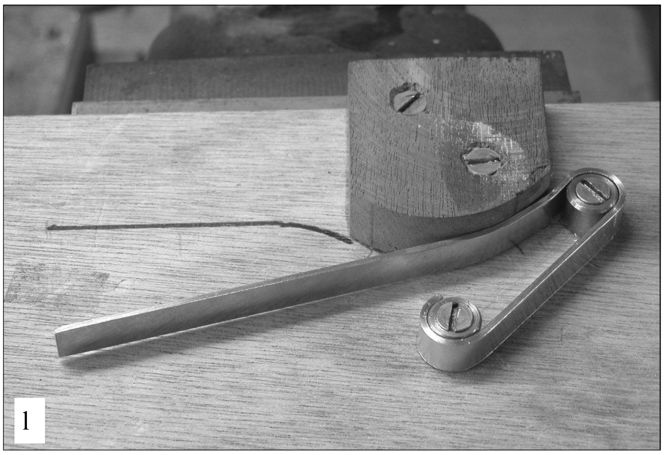
h

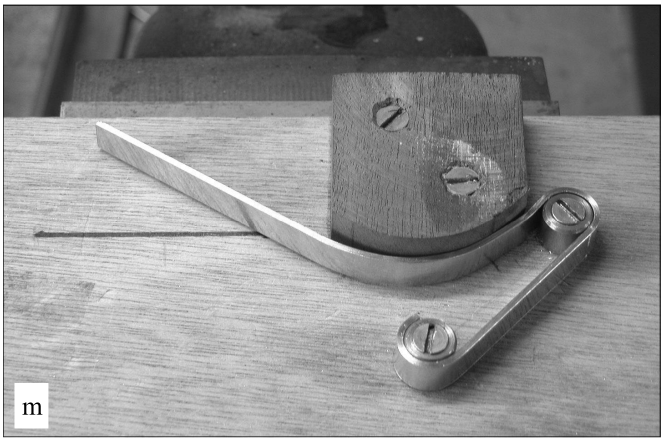

i



j

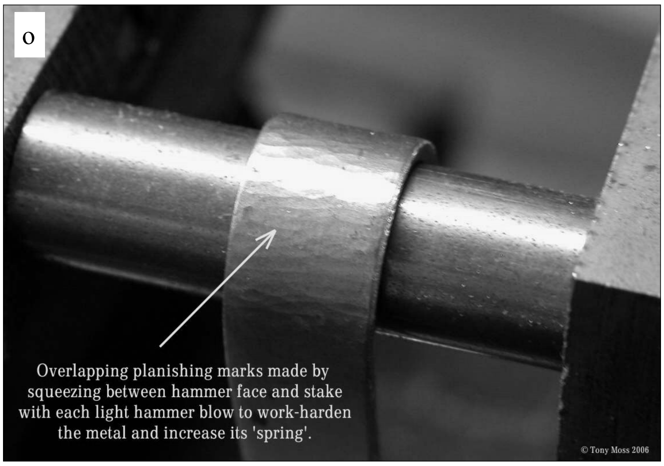


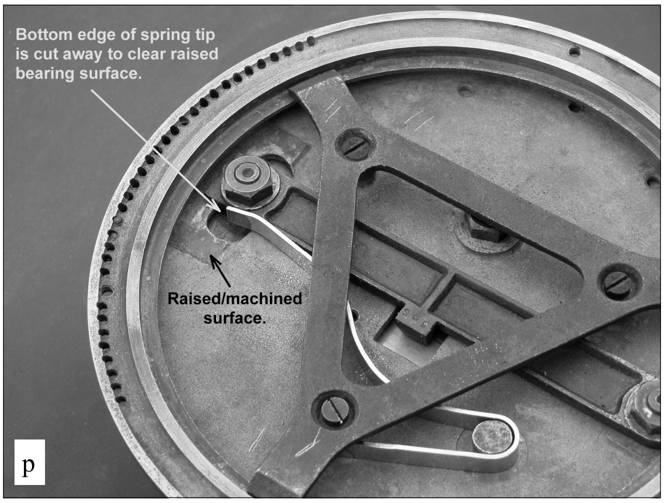




Left, top to bottom:
h) Bend 1 completed
i) Setup for 2nd bend
j) Bend 2 half completed

Above, top to bottom:
k) Bend 2 complete
l) Bend 4 half done
m) Bend 4 completed





n) Planishing
o) Planished surface
p) Spring fitted

WREST PARK—again

Contrary to what was written in the September Bulletin, English Heritage have now decided that it is uneconomical to keep the gardens at Wrest Park open during weekdays and have reverted to weekend opening only. (We are grateful to Ian Butson for this information.) It remains well worth a visit.

BSS TRIP TO NÜRNBERG
29 September - 5 October 2006

Saturday 31 September (Leonard Honey)
Our guide Anne, daughter of Ludwig and Luise Englehardt, took us for a tour of the 1950-year-old Nürnberg. The city wall was completed in 1415. Close to our hotel was the Craftsmen Courtyard where local traditional hand-crafted artifacts (from pewterers, leather workers, glass cutters, gingerbread bakers, etc.) could be purchased in charming surroundings. In the past there were some 130 small towers but now only 60 remain. Similarly, there were once 150 sundials in the city, but now the total is 60.

The first stop on our walk was St Lawrence church, on the front of which is a sundial from 1502 (Fig. 1) showing Nuremburg hours (Ludwig tried to explain this but the writer is still unclear!). The dial gives Babylonian hours on the left side and day length on the edges with a Latin inscription.

The highlight of the Main Market Square is the 'Beautiful Fountain' (Schöner Brunnen). There are figures underneath the Main Clock; the most important to us is at the bottom left showing a man holding a diptych, (Fig. 2) and, to his right, a figure holding bells originally a sandglass. There is a sundial on the side of the 1487 church, marked in the old style.

A second sundial we now came across was a modern polar dial where we stopped for a group picture (Fig. 8, p.182). Next, we visited the DGC Library: on the first floor of this grand building were old antique clocks in glass cabinets and lovely wooden decorations with sundial and clock books.

We wound our way back to the hotel browsing at the handicrafts and souvenirs courtyard on the way. After supper, we had the lovely experience of seeing a picture show given by Ludwig. We learned that important men had associations with the town, such as Kepler (born here in 1501), Dürer, Regiomontanus, the Tucher family (see Fig. 3), David Beringer etc, etc.

Sunday 1 October (Kevin Karney)
We walked, to the sound of harvest festival bells, to Albrecht Dürer's house on an overcast day. We passed by a fine dial high on the stepped gables of a typical baroque Nürnberg house (Fig. 4), the hangman's house, the first electric street light and the first steel suspension bridge. Dürer's dwelling house, where he lived many years with his wife Agnes, is a fine example of medieval architecture, now a tourist attraction. Beautiful prints are to be seen but no original paintings.

We sampled the wares of a small old Nürnberg brewery – where beer was made during the winter months and stored in the excavated cellars below. At this stage, Tony Moss broke into song, *Cushie Butterfield*. Our chairman was eventually discovered lost in the cellars and your correspondent's notes became indecipherable.

St Seobald's church yielded the exquisite relics of the saint, together with the cross made from nails from the roof of Coventry cathedral. In the streets, one sees private chapels suspended from the domestic house walls. By law, nothing could be built under the chapel.

Fembo House, the city museum, had its own dial (Fig. 5) together with superb wood and plasterwork and an interesting exhibit of mediaeval artisan's tools – those needed for making compasses, lenses, drawing wire, making chain mail. The wartime bunkers deep beneath Nürnberg castle revealed how the treasures of the city were preserved during the war. Dinner of bratwurst, sauerkraut and beer in the Mauthalle - with its own dial - finished the day.

Monday 2 October (David Hindle)
Day 1 of 2 days travelling by coach in the area. First just out of the city centre, parking by the "Stuff Corner" second-hand shop, to visit a graveyard, Old Johannes Friedhof, where the graves are beautifully decorated both with flowers and with bronzes often depicting family trades or wives and progeny (not sure about the skull with the movable jaw). Oh, and there was a dial on the chapel wall…

Next to the nearby Hesperidengarten, a recreation of Baroque garden as described in a book written in 1708 by Johann Volkamer of Nürnberg, including a horizontal dial of box hedges. Then back to the centre, to the gothic/ renaissance Rathaus (Town Hall), reconstructed like most of Nürnberg after the war (the Rathaus wasn't finished till some time in the 60s) to meet the "2nd Mayor" (he thought we were a horological group – several members undertook to correct him) and a drinks and snacks reception.

Back into the bus and off to Rothenberg ob der Tauber, another city retaining much of its medieval past. Even more than Nurnberg, its main industry seems to be tourism (what we didn't buy in Rothenberg: coffee (no time); a kilt (in the Scottish Wool shop); snowballs (a local pastry); table linen for christmas; a model of Nottingham Fairground ferris wheel; sausages packed as cigars; a derelict house for sale with a sundial). We met up with German BSS founder member Anton Schmidt and his wife, well known to several of the party. We were very efficiently led around the centre by a local guide, who showed us several dials, including a triple wall dial on an old school, and a quadruple dial over a garden entrance, ending up at St Jakobs Kirche to see Tilman Riemanschneider's Holy Blood Altar.

Tuesday, 3rd October (Claus Jensen)
Today we split up in various groups visiting the Castle, the Toy Museum, and the Transport Museum. One group – consisting of Mike Cowham and myself, only – went to St. Rochus Cemetery with graves of some of the famous Nürnberg sundial makers. Directed by Ludwig Engelhardt's article 'Sonnenuhren in Nürnberg', *Bürgerverein St. Johannis*, 49/2001, pp. 30–33, we succeeded in finding four graves each having an interesting epitaph showing a classical diptych dial (Fig. 6).

Tony Moss

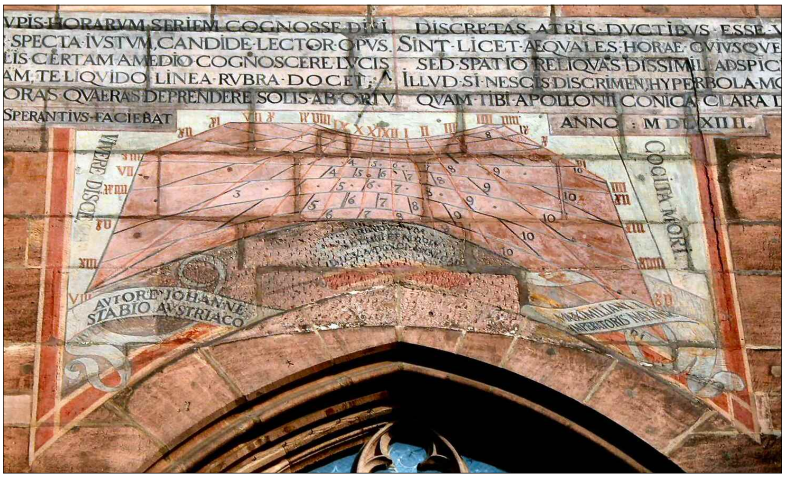


Fig. 1. St Lorentzkirche dial, 1502.

Kevin Karney

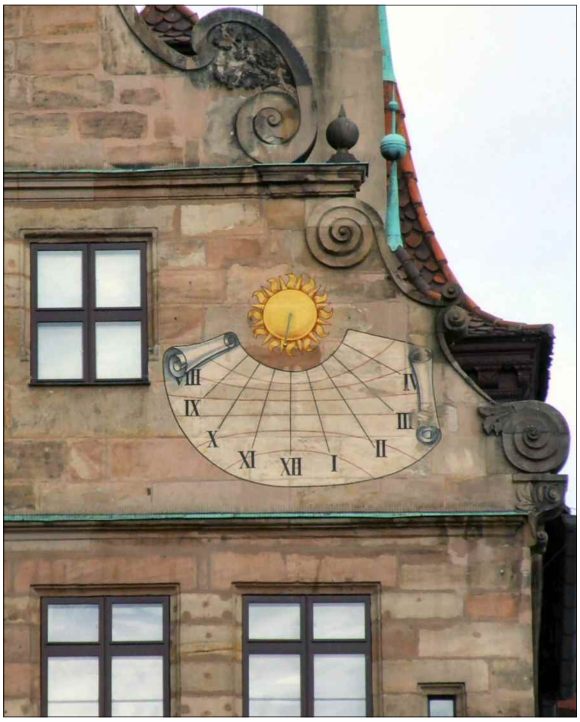


Fig.5. The dial on the side of Fembo House.

Leonard Honey

Fig. 2. The clock in the main square of Nürnberg. The man near 7 o'clock is holding a diptych!

Claus Jensen

Fig. 6. Gravestone of a dialmaker in St Rochus cemetery, showing a diptych dial.

Leonard Honey

Fig.3. Carved wooden panel in the Tucher house, featuring various dials and tools.

Kevin Karney

Fig. 4. A typical painted dial on the stepped gable of a Nürnberg house.

Tony Moss

Fig. 8. Group. The BSS group standing on a meridian line, part of an (expensive!) modern polar dial on the first day of the trip.

Tony Moss

Fig 10. A sundial in mosaics on a chemist's shop.

Tony Moss

Fig. 7. One of the dials seen on Wednesday's coach tour.

Fig. 9. A multiple dial in Rothenburg.

Tony Moss

Fig. 11. A triple dial in Rothenburg.

NEWBURY MEETING 2006

Above, left: The obligatory group picture in the afternoon sunshine.
Above right: Pat Briggs explains one of his marvellous Meccano models, this one an astronomical clock.
Below left: Jackie Jones, Janet Jenkins and Martin Hinchcliffe refracted in a sunshine recorder.
Below centre: Piers Nicholson's noon cannon in action.
Below right: Our guest speaker, Polly Vacher.

Photo: Ian Maddocks

Photo: Ian Maddocks

After this life-affirming experience the group proceeded to Germanisches Nationalmuseum, which among other things has a wonderful collection of scientific instruments several of which are described in the lavishly illustrated catalogue *Focus Behaim Globus*, vols. I-II, Germanisches Nationalmuseum, 1992. Unfortunately the instrument section of the museum has been closed for some time due to technical reasons, but even so we managed to spot a few fine specimens scattered in the remaining parts of the buildings: an Islamic astrolabe of 1079/80 A.D., a book cover by Erasmus Habermel equipped with a sundial and various other instruments, the famous Behaim Globe, and last but not least 19 most beautiful ivory diptych dials kindly exhibited especially for the BSS group in a showcase close to the entrance. Photos of each of these 19 dials and all the others seen on the Nürnberg visit will be available on the CD being produced and edited by Mike Cowham.

In the afternoon the subgroups of the morning met in the Germanisches Nationalmuseum where we had a most interesting guided tour through the collections with competent and inspiring introductions to several marvellous highlights of German cultural history.

Wednesday 4 October (Brian Moss)

By coach to Fränkische Schweiz the picturesque area between Bamberg, Bayreuth and Nuremberg. Fränkische Schweiz, or the *Franconian Switzerland*, was given its name by Romantic artists and poets who were captivated by its charm. (Fig. 7.)

Our first stop was Forchheim, the *Gate to Franconian Switzerland*. Once the court of Franconian kings, the town was the strongest fortress in Germany. A mid-morning breakfast awaited us in one of the most important secular buildings in Franconia, the '*Kaiserpfalz*'. The building housed some wonderful examples of art and craft, which included 14th century wall paintings and an exhibition of Bavarian State Art. A stroll through the town brought us to an attractive dial on the wall of the church of Saint Martin, and, close-by, were the faint remains of what could have been a scratch dial.

Back aboard we drove on past a modern dial on a chemist's shop in Ebermannstadt before leaving the town to drive through Franconia's mountains and valleys. The journey was made more interesting by our guide's informative commentary about the geology of the surrounding landscape. Stopping in the village of Tiefenpolz, we walked up a hill to the somewhat solemn tolling of the church bell, but our inspection of the dial there was cut short by the arrival of a funeral party.

A highlight of the day was a visit to Brennerei Kormann where we tucked-in to a tasty *Mittagessen*. We also sampled a variety of schnaps and liqueurs while listening to our host's description of how they were made. Our return journey took us through gently rolling hills scored with deep gorges and craggy dolomitic outcrops; arriving at Hotel Victoria in time for the final evening meal. This occasion was made all the more memorable by delightful little speeches (in both English and German) and the traditional offerings from the floor.

NEWBURY MEETING

23 September 2006

See page 182 for photos.

It almost goes without saying that the sun shone again for this year's BSS meeting at Newbury, ably organised by David Pawley and Peter Ransom at the congenial location of the Mary Hare School. It was pleasing to see some newcomers present as well as to be able to greet old friends.

The key speaker of the day was Polly Vacher who has flown single-handed (and in a single-engined plane) around the world in both the equatorial and polar directions, raising money for the Flying Scholarships for the Disabled Charity. As well as interesting tales of survival training and dealing with bureaucracy, Polly told us how she had used an Astrocompass Mk II as back-up to a GPS system when flying over the North Pole. Obviously this wasn't designed for the cockpit of a light aircraft so she had to use a dental mirror to see the key scale!

Other speakers included Peter Ransom on two analemmatic dials in France, including the famous one at Brou where there was also a rather nice stone multiple scaphe dial in the cloisters. Mike Shaw showed us some of the worst examples of garden-centre dials and his five golden rules for judging a dial. There was also a discussion of the various uses of the GPS system for diallists and how to get the optimum performance from the domestic versions as opposed to the expensive ones that surveyors use.

Newbury always makes use of its sunshine by allowing a variety of dials to be seen in their natural environment. This year we had a live demonstration of a noon cannon, now the proud possession of Piers Nicholson. The gunpowder-substitute was persuaded to go off under the influence of the sun and magnifying lens, though the sharp retort at exactly noon has still to be achieved. Also outside was a modern Aten heliochronometer brought along by Geoff Parsons and some model dials by David Young.

Inside, the highlight was undoubtedly another set of complex Meccano models with astronomical and horological functions by Pat Briggs. They really need extensive study to understand and appreciate fully the ingenuity required to achieve better than 1% precision with the limited range of Meccano gearwheels. Elsewhere, there was David Pawley's extensive collection of astrocompasses, dials by Melville and George Adams, books and photographs galore, not to mention several models of dials to be built or bright ideas for future development and refinement.

The event is now very firmly fixed in the BSS calendar as the ideal way to celebrate the autumnal equinox – see you there next year!

JD

THE ROMAN SUNDIAL AT DION
THE FAMOUS ANCIENT MACEDONIAN SANCTUARY

E. THEODOSSIOU

INTRODUCTION

Dion is a village in Pieria, 17 kilometers south of Katerini, the capital of Pieria prefecture in Macedonia, 440km from Athens and 85km from Thessaloniki. The present Municipality of Dion was named after Dion, the famous ancient Macedonian sanctuary. Among the ancient gods worshipped at Dion, the most important was Zeus. So, this ancient city was closely associated to Zeus (Jupiter = Zeus + pater) as its name implies – in Greek Zeus is also called Dias – with the genitive of Zeus being Dios.

During a summer excursion in Pieria we discovered an interesting spherical Greco-Roman sundial in the Archaeological Museum of Dion, which opened in 1993 in a newly constructed two-storey building. It displays finds mainly from the Dion area, but also from Olympus and the wider area of Pieria on the first floor. There are a number of exhibits from the Necropolis of Dion, mainly wooden figurines, and other votive offerings found in Macedonian tombs. Among them with the number 35 (Figure 1), is the Roman sundial mentioned above, found in the ruins of the archaeological site of Dion. This sundial is of the spherical type as defined by Gibbs[1] (although it was discovered after the publication of Gibbs' work). This type of sundial was very famous in Ancient Greece because it was invented by the famous Babylonian astronomer Berossus, who lived and worked from 356 to 326 BC on the Greek island of Kos.

Fig. 1. The Greco-Roman sundial at Dion.

THE GRECO-ROMAN SUNDIAL

The excavation of the Dion territory commenced in 1928 and is continued now by Prof Demetrios Pandermalis[2] (University of Thessaloniki). With his collaborators, he unearthed a precious statue of Zeus during recent excavations (July 2003). The excavation brought to light, among other items, a virtually complete portable sundial made of white marble which has been quarried locally from the excellent white marbles of Macedonia.

Fig. 2. The Latin inscription on the sundial.

This Greco-Roman sundial (Figure 1) unearthed in the remains of a wealthy private house that was dubbed by the excavators-archaeologists as the 'luxurious house' at Dion ($\varphi = 40° 10'$, $\lambda = 22° 30' = -1^h 30'$). Its dimensions are 35cm high, 30cm width and 15cm maximum thickness. It was dated by the archaeologists to the 1st century AD. The sundial is well preserved with just a minor break on its upper left side and more serious damage to the right edge of its base. It carries eleven engraved hour lines radiating from a small engraved circular arc near the gnomon hole to the lower edge of the spherical surface, dividing the bowl into twelve equal sectors. In other words the eleven engraved hour lines extend from the engraved winter solstice line to the summer solstice one and are crossed by the equinoctial day curve. The summer solstice curve coincides with the lower edge.

The sundial is very well and professionally made. The styling and carvings are also very good and precise. It is similar – but bigger – to the Jerusalem portable sundials.[3] This type of sundial was well known in the Roman World around the Mediterranean Sea.

The sundial bears no numerals or lettering marking the hours or any other – Greek or Latin – symbols or any special decoration. However, two rectangular inscriptions separate the dial face from the base (Figure 2). They are in Latin and although some letters are destroyed it appears to read:

I. GRANIUS FE [LIX]
AEDI [LIS] BARII
TH [??] IAQI

Usually, the front face of dials carried the names of the dial makers or the donors' name. On this dial the Latin inscriptions remind us of the donor by writing:

I. Granius Felix
Market inspector from Bari
dedicated

This sundial is unique; it is the only Greco-Roman sundial excavated at Dion and in the whole territory of Ancient Macedonia. It is one of the most beautiful ancient sundials that have been found in Greece and it is now on display on the ground floor at Dion Archaeological Museum.

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ACKNOWLEDGEMENTS

The author express his thanks to the University of Athens for finacial support through the Special Account for Research Grants (Programm 70/4/7691).

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SOLAR DATA 2007

	January		February		March		
Day	Declination	Transit	Declination	Transit	Declination	Transit	Day
1	-23°00'38"	12:03:26	-17°07'40"	12:13:32	-7°37'25"	12:12:24	1
2	-22°55'30"	12:03:54	-16°50'29"	12:13:40	-7°14'35"	12:12:12	2
3	-22°49'55"	12:04:22	-16°33'00"	12:13:47	-6°51'39"	12:12:00	3
4	-22°43'53"	12:04:49	-16°15'14"	12:13:53	-6°28'37"	12:11:47	4
5	-22°37'24"	12:05:16	-15°57'11"	12:13:58	-6°05'29"	12:11:34	5
6	-22°30'28"	12:05:43	-15°38'52"	12:14:03	-5°42'17"	12:11:20	6
7	-22°23'05"	12:06:09	-15°20'16"	12:14:07	-5°19'00"	12:11:06	7
8	-22°15'16"	12:06:35	-15°01'25"	12:14:10	-4°55'38"	12:10:52	8
9	-22°07'01"	12:07:00	-14°42'19"	12:14:12	-4°32'13"	12:10:37	9
10	-21°58'19"	12:07:24	-14°22'57"	12:14:13	-4°08'44"	12:10:22	10
11	-21°49'12"	12:07:48	-14°03'21"	12:14:14	-3°45'12"	12:10:06	11
12	-21°39'40"	12:08:12	-13°43'31"	12:14:13	-3°21'36"	12:09:50	12
13	-21°29'42"	12:08:35	-13°23'28"	12:14:12	-2°57'59"	12:09:34	13
14	-21°19'19"	12:08:57	-13°03'11"	12:14:11	-2°34'19"	12:09:18	14
15	-21°08'31"	12:09:19	-12°42'41"	12:14:08	-2°10'38"	12:09:01	15
16	-20°57'19"	12:09:40	-12°21'59"	12:14:05	-1°46'55"	12:08:44	16
17	-20°45'43"	12:10:00	-12°01'05"	12:14:01	-1°23'11"	12:08:27	17
18	-20°33'43"	12:10:19	-11°39'59"	12:13:57	-0°59'27"	12:08:10	18
19	-20°21'20"	12:10:38	-11°18'43"	12:13:51	-0°35'43"	12:07:52	19
20	-20°08'34"	12:10:56	-10°57'16"	12:13:45	-0°11'59"	12:07:35	20
21	-19°55'25"	12:11:14	-10°35'38"	12:13:39	0°11'44"	12:07:17	21
22	-19°41'54"	12:11:30	-10°13'51"	12:13:31	0°35'26"	12:06:59	22
23	-19°28'00"	12:11:46	-9°51'55"	12:13:24	0°59'07"	12:06:41	23
24	-19°13'46"	12:12:01	-9°29'50"	12:13:15	1°22'46"	12:06:23	24
25	-18°59'10"	12:12:15	-9°07'36"	12:13:06	1°46'23"	12:06:05	25
26	-18°44'13"	12:12:29	-8°45'14"	12:12:56	2°09'57"	12:05:47	26
27	-18°28'56"	12:12:41	-8°22'45"	12:12:46	2°33'29"	12:05:29	27
28	-18°13'19"	12:12:53	-8°00'08"	12:12:35	2°56'57"	12:05:10	28
29	-17°57'23"	12:13:04			3°20'22"	12:04:52	29
30	-17°41'07"	12:13:14			3°43'42"	12:04:34	30
31	-17°24'32"	12:13:24			4°06'58"	12:04:16	31

Tables of the sun's declination and the time of transit (UT) at Greenwich for the first quarter of 2007.

The daily Equation of Time can be obtained from the transit time by subtracting 12h from the transit time.

Data supplied by Fiona Vincent, using the software package EphemerisTool

Redacted

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