BSS Bulletin 21(i)

The British Sundial Society

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March 2009

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GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics; and, by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.
2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis51@btopenworld.com*. Material can also be sent on CD or as a single-sided typescript, single- or double-spaced, A4 paper.
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   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 very large multiple dial Glamis Castle, Scotland (SRN 1489). The young lady giving the scale is a castle employee and wearing the Hunting Stewart tartan. See page 38 for the full story. Photo: David Gauld.*

Back cover: *A grand dial in a grand location: the Henry Wynne double horizontal dial at Wrest Park, Silsoe, Bedfordshire (SRN 5169). The dial itself is only a replica of the 1682 original, safe in an English Heritage storeroom, but the pedestal is thought to be original. Photo: John Davis.*

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

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EDITORIAL

New Author Award 2008

The third of our awards for the best *Bulletin* paper by a new author has just been judged and I am very pleased to announce that the prize will go to Robin M Catchpole for his article 'The Solar Pyramid' published in the June 2008 edition. Two of the four judges (John Lester, Jackie Jones, Mike Shaw and myself) placed this first and another had it in second place after assessing the 10 eligible papers for topics such as general interest, readability, illustrations, accuracy, and references. One of the judges described Robin's article as "a well-written explanation of an exciting project. Every aspect was covered in clear uncomplicated language". The prize, a certificate and a replica portable dial, will be presented at a later date.

Only 5 points (out of a total 400) behind Robin's paper was 'Sundials in Armenia' by Julian Lush (published in September) which was praised for breaking new ground and its illustrations. And not far behind that was Malcolm Barnfield's 'Timbouctou Sine Quadrant' in the December edition so it can be seen that there was plenty of variety. What next for 2009?

This issue contains two articles from Russian members of the Society. Considering that we only have two members in that country, this is a remarkable feat. I am very grateful to all the authors who write for the *Bulletin*, particularly those for whom English is a foreign language.

A NORTH-FACING POLARIZATION SUNDIAL OF VARYING HUE

ALLAN MILLS

Historically, the Sun is our prime timekeeper, fundamentally by measuring its apparent position in the celestial sphere. But it is far too bright for direct viewing – and there are no calibration marks in the blue sky – so long ago mankind discovered that shadows were the answer and the sundial was born. Over the centuries, the instrument has been developed and refined by many different cultures, and a remarkable range of designs testifies to the success of the basic idea.

It is interesting to enquire if any alternative methods are possible for measuring the position of the Sun against an agreed scale. For example, the Sun is a source of radio waves in the MHz to GHz regions, particularly when solar flares are present, so it is feasible to devise a radio sundial. However (even though it would work when the sky is completely covered with cloud) the size, complexity and cost of the equipment required has meant that solar radio astronomy has always been devoted to the study of the Sun as a star rather than to mundane terrestrial timekeeping.

Polarization of Light from the Sky

Linearly polarized light is a form of light where all the constituent waves vibrate in the same plane, rather than the random planes characterizing ordinary light from incandescent sources. This condition is induced by the molecular scattering that gives us the blue sky, with the content of polarized light being a maximum at right angles to the beams from the Sun. Apparently, it is never more than about 75% of the total sunlight, even in the clear skies above tropical deserts.[1-3] It will be considerably less in the hazy skies of the UK (even in the absence of obvious white clouds with their known depolarizing effects) but there appears to be little quantitative data for Europe as a whole. This matter will be examined in a companion paper.[3a] Meanwhile, it has been established that, if a conventional shadow sundial is working, then there is probably sufficient polarization in the light from the circumpolar sky for sundials based on the phenomenon to be effective.

Many years ago I presented in a sister journal[4] a lengthy account of how in 1848 Charles Wheatstone used this phenomenon to create a polarization sundial that was independent of shadows, and went on to show that a modern version reading to ±2 minutes of time was possible by using 'Sellotape' as a 'half-wave plate' and manually moving a disc to obtain a match across two fields. Patches of white cloud did not degrade this accuracy and it could even work for a short period after sunset!

Wheatstone also designed a simpler, non-mechanical device to demonstrate the principles used in his polarization dial. This employed a number of 15° sectors of mica or selenite arranged in a fan to face the northern celestial pole so that when the sky was mostly blue it was possible to estimate the relative brightness of each segment to give the time of day to ±30 minutes. I showed that 'Sellotape' could again be used instead of natural minerals, being readily available and easily cut without producing a ragged edge. An account was published in this journal.[5] It is urged that reference be made to these papers, for space does not allow the rather complex and lengthy technical explanations to be repeated here. Other authors have also presented accounts of modern polarization sundials.[6,7]

The Northern Equatorial Dial

The polarization dials described above face the northern celestial pole, a 'difficult' direction for the dial of a conventional shadow-based system. Polarization dials are also generally intended to be viewed from *below* the dial plane, in this respect resembling the much-admired stained glass sundials. I therefore decided to attempt to design and make an experimental dial taking the form of a translucent equatorial dial. Lacking any gnomon, time was to be estimated by visual comparison as in Wheatstone's demonstration dial. No great precision was expected so the equation of time was initially ignored, but it could be presented as the usual correction curve.

Arranging the numeration around the circumference is best for clarity and accuracy, and leads to an unoccupied central region that lends itself to any desired decorative motif. However, rather than using coloured glass, the natural polarization of the blue sky could again be used to produce colours by the interference of light. This carries the intriguing possibility of having the colours vary as the plane of polarization rotates about the pole in the course of the day.[5] It has already been mentioned that the intensity of the po-

Fig. 1. Cellophane strip at 45° between crossed polars.

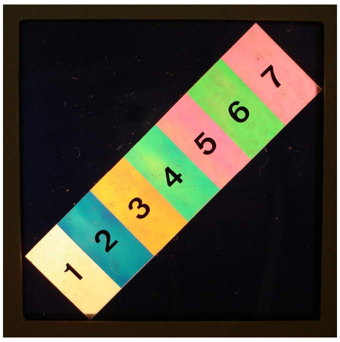


Fig. 2. 1 to 7 superimposed strips of cellophane at 45° between crossed polars.

Fig. 3. As figure 1, but between parallel polars.

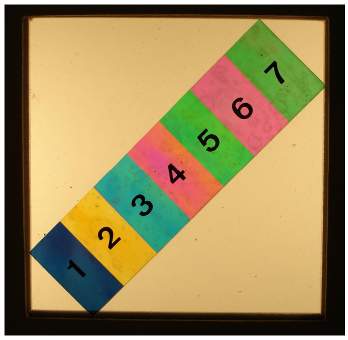


Fig. 4. As figure 2, but between parallel polars.

larized component of the light from the sky is generally considerably less than that of the ordinary unpolarized light, so the resulting interference colours are expected to be less saturated than stained glass or oil paints – more like water-colours.

Another factor to be considered is that in the ordinary sundial the shadow of the gnomon is thrown upon the plane bearing the hour lines and numerals, and has no 'thickness'. Therefore, it does not matter from what direction the dial is viewed: the position of the shadow with respect to the calibration pattern does not change. However, the axis of the polarization sundial is required to point at the celestial pole, so is sensitive to changes in the position of the eye away from a central viewpoint. In the instruments described in references 4 and 5, the eyepoint is located by the eyepiece, but in a 'window-like' design there is no such constraint. It would appear that a locating device (such as a ring supported by a rod or a wire tripod) might be advantageous. This must be investigated experimentally.

Control of Intensity in Polarized Light

Most crystals incorporate a directionality or 'grain' in their structure so that linearly polarized light passing through them moves more easily – and so faster – in one given direction than in another at right angles to it. The emerging orthogonal beams therefore differ in phase.

The transparent film known as 'cellophane' that is used in Sellotape is made from regenerated cellulose and is returning to popularity in packaging because, unlike its competitors, it is biodegradable. Manufacture of cellophane involves stretching, so it shares with crystals a strong directionality ('birefringence') to transmitted polarized light.[8] Faint striae along the stretch direction distinguish cellophane from more modern transparent films. Like the well-known polarizing sheet known as 'Polaroid'[9] it is 'length slow' but, lacking the preferentially absorbing dyestuff incorporated in the latter, beams moving in both orthogonal directions emerge from the film.

Normally these orthogonal beams cannot be distinguished by the eye, but interposing another piece of Polaroid at right angles to the first resolves both components in the plane of this second 'analyzing' Polaroid. If the 'slow' beam has been delayed by half a wavelength of light the net effect is to turn the resolved beam through 90°, so that it now passes through the second, crossed, Polaroid. The effect is at a maximum – and most dramatic – if a strip of the adhesive-coated cellophane known as Sellotape is inserted at 45° between crossed polars: it 'scrapes away the darkness' produced by the crossed polars and appears brightly illuminated against a black background (Fig.1). If the cellophane strip is then slowly turned between the crossed polars the intensity of light it transmits will diminish, until after 45° (then becoming parallel to one of the polars) it will almost disappear. Further rotation increases the transmitted light until after a total movement of 90° it lies along the opposite diagonal and intensity is again at a maximum. This cycle repeats to give maxima every 90°, separated by minima after a further 45°.

Interference Colours in Polarized Light

The word 'wavelength' in the above account is insufficiently defined. Visible light varies in wavelength between 400 nm in the violet to 750 nm in the red, and a single thickness of the 0.001 inch (25.4 µm) cellophane commonly used in adhesive tape acts as a half-wave plate only for a wavelength in the blue. This wavelength (and those nearby) are therefore subtracted, but the remainder of the incident light is transmitted. The Sellotape therefore appears a weak amber colour. Stacking layers of Sellotape or cellophane one on top of the other, all in a common direction, results in more intensive absorptions at a greater number of wavelengths.[10,11] This phenomenon leads to bright colours for a limited number of thicknesses, but gradually they are replaced by an alternation of faded pinks and greens (Fig. 2). The entire range of colours is known as Newton's scale of interference colours[12] and is illustrated by the Michel-Lévy chart.[13] The tint produced by a given number of thicknesses remains the same as the multiple stack is rotated between crossed polars but its intensity always reaches a maximum at 45° where the two components are equal. However, rotating the Polaroids from the 'crossed' to the 'parallel' orientation gives rise to the complementary colour against an illuminated background (Figs. 3 and 4).

The above phenomenon is related to the colours seen in oil films, soap bubbles and peacocks' feathers, all being parts of the extensive field of interference colours in white light. Thorough discussion would be much too long for an article such as this; it requires specialist textbooks. Nowadays, only a few physics students (or departments) study optics, so the application of interference colours in polarized light has mostly passed to the mineralogist. The reader seeking a more comprehensive explanation is therefore also referred to textbooks used by geologists.[13,14]

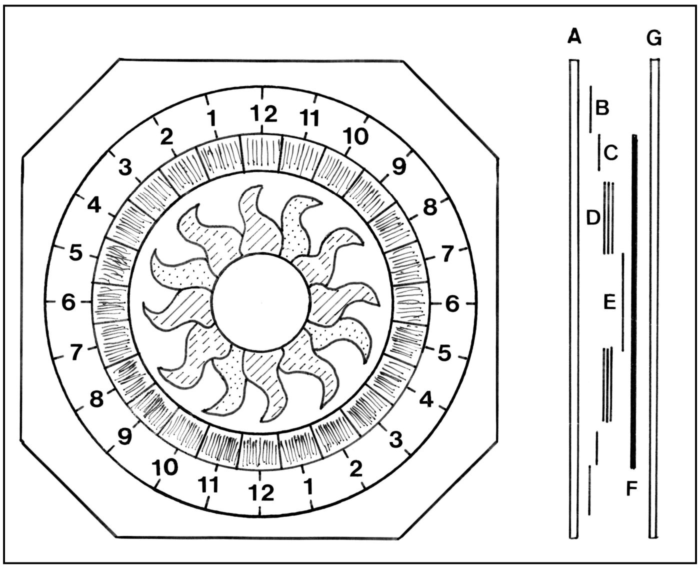


Fig. 5. Construction of the basic polarization dial. The exploded view on the right shows: A: Glass; B: Tracing film; C: Keystones of single thickness tape; D: Multiple layers of tape, all at 45°; E: Crumpled cellophane; F: Polaroid, polarizing in the vertical plane; G: Glass.

A Basic Polarization Dial

A dial intended to face the northern celestial pole and be viewed from the rear is shown in figure 5. The support consists of a 10 inch square of thin glass (nominal 1.5 mm, as used for pictures) with its corners removed. Upon this is mounted an annulus of tracing film secured with spray adhesive, carrying two sets of numerals 1–12. (The rub-down type are very convenient, but must nowadays be obtained from drawing office suppliers.) The dial is designed to be viewed from below, with this working face at the rear, so the numbers progress in an anti-clockwise direction.

Within the hour number annulus is the sundial proper. It consists of 24 keystone-shaped segments cut from 50 mm wide clear parcel tape (I used that retailed by Rylands Ltd) with its length direction arranged radially. This tape is based upon an identical gauge of cellophane to that used for Sellotape but has the considerable advantage over the latter of being waterproof and resistant to long-term oxidation. If the glass plate is first polished with wax polish and then placed over a full-size template, it will be found practicable to stick a length of tape across the centre, cut around opposite segments with a sharp craft knife, and then peel away the unwanted material.

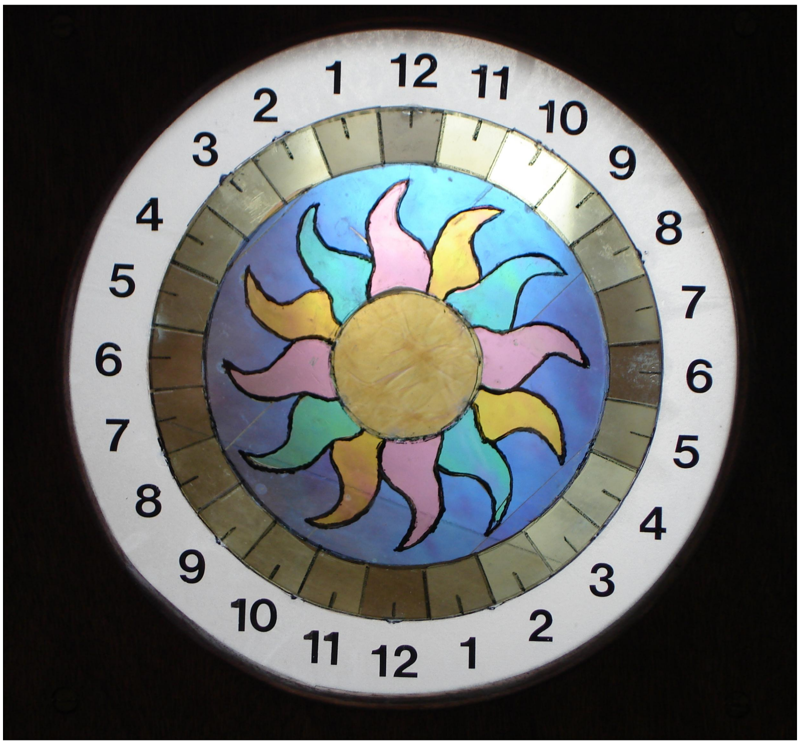
A disc of Polaroid[15] equal in diameter to the outer circumference of these wedges is in due course to be placed on top of the dial, but first hold it on temporarily and check that viewing a blue sky through the assembly gives rise to a ring of keystones of varying intensity. They will be arranged in a 90° cross, reflecting the behaviour described above for a single strip of cellophane. The assembly may be rotated to give the darkest segments opposite the '12's and '6's, and bright segments at the '3's and '9's. This demonstrates the timetelling function of the dial, with the opposing segments acting as a check on each other.

Fig. 6 (far left). Completed dial from the front, in ordinary light.

Fig. 7(left). Completed dial from the rear, in ordinary light.

Fig. 8 (above). Dial viewed indoors by light partially polarized horizontally.

Fig. 9 (right). Close-up of dial in figure 8.



Within the otherwise unused central portion of the disc, I placed artwork activated by the partially polarized light from the sky. I chose a stylized 'Aztec Sun' design, with areas containing up to six superimposed layers of parcel tape arranged at 45° to the horizontal. These multiple layers were found to be best produced by placing one length of tape upon a waxed piece of heavy plate glass, sticking up to five additional layers lengthwise upon it, and then peeling each stack as a whole from the plate. Placing the waxed dial over the pre-drawn design enables a chosen stack to be applied at 45°, cut around, and the surplus peeled away. Some prior experimentation between crossed polars will enable blue, yellow, magenta and green areas to be generated, remembering that in the final model, using only sky polarization on the incoming side, the colours will be much less intense. Complementary colours will appear as the analysing Polaroid is turned from 'crossed' to 'parallel' with respect to the incoming skylight. Cellophane discs that have been crumpled and then roughly flattened will give both colour and structure to the central region – try material from various sources. The junctions between differently-coloured areas may be painted with black household paint to hide the joins and give the impression of a stained glass window.

The dial was completed by fixing the disc of Polaroid on top with a few tiny drops of 'instant' adhesive around its circumference,[16] orienting it with its polarizing direction vertical to give 'crossed' colours at noon and the keystones then indicating the time where they were at minimum intensity – like shadows. A top sheet of glass, with a tape binding around the edge to keep out dust, completes the dial proper, but it should be mounted within a wooden protective frame. It may be convenient to suspend the latter between vertical wood pillars in the manner of an old-fashioned dressing table mirror, and to incorporate an altitude scale plus a magnetic compass and spherical level (Figs. 6 and 7). The polarizing dial may then be set to face north and finally angled upwards so that it faces the northern celestial pole with what was previously called the 'top' sheet of glass now on the underside. Raise and mount the dial while maintaining its orientation, so that it may be conveniently viewed from below.

This construction is obviously unsuitable for continuous exposure outdoors but might perhaps be adapted to a north-facing angled skylight. The long-term stability of Polaroid to sunlight is problematic so it would probably be wise to make the dial conveniently removable.

Appearance of the Dial in Polarized Light

Fig. 8 shows the dial viewed indoors by the partially polarized light reflected from a shiny table top. A measured content of 43% polarization parallel to the intercept of the incoming light with the plane of the table gave a situation comparable to a clear northern blue sky in the UK – but against a comparatively dark background. The outer ring indicates a time of about 12:15 local time (LAT) while the Aztec sun displays an amber disc with red, green and yellow rays against a blue sky (Fig. 9). This photograph may be compared with Fig. 10, where we are viewing the dial at noon against the blue sky. With a content of 33% horizontally polarized light, the colours are much less saturated.

Fig. 11 illustrates the situation three hours later, at 3pm LAT. As the polarization vector has moved through 45° it

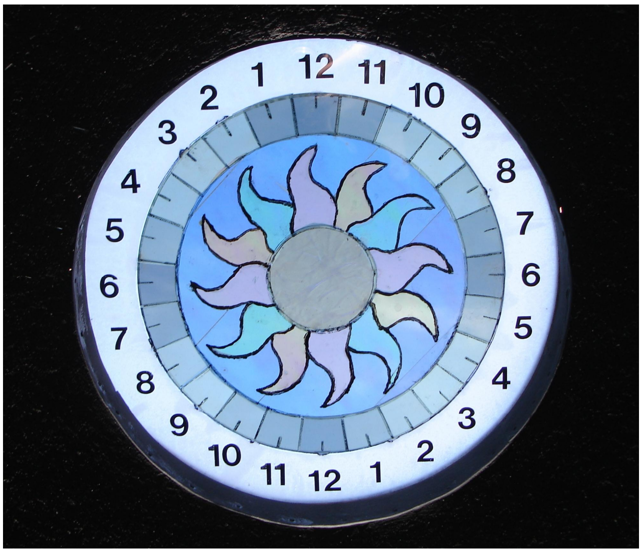


Fig. 10. Dial viewed outdoors at 12:15pm local time against the partially polarized light from a blue sky.

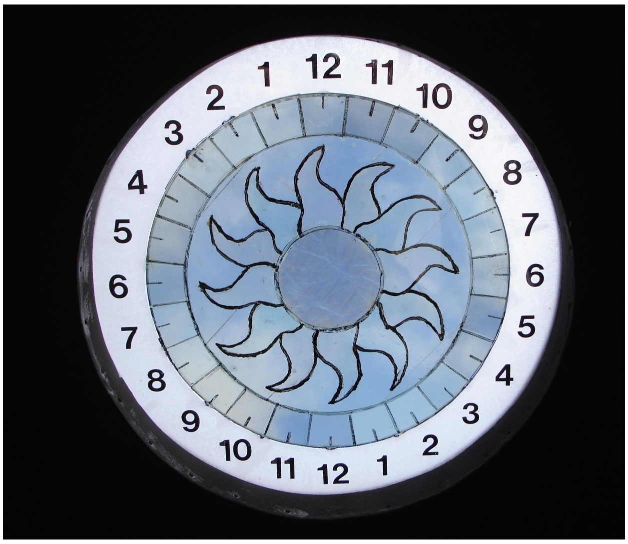


Fig. 11. View through the dial at 3pm local time.

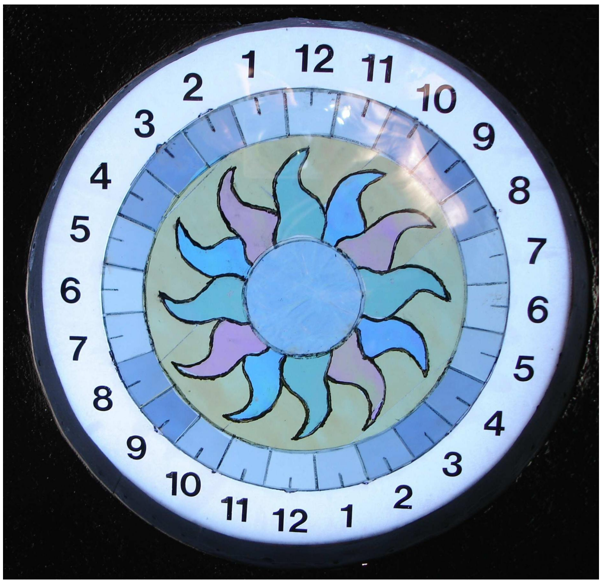


Fig. 12. View through the dial at 6pm local time.

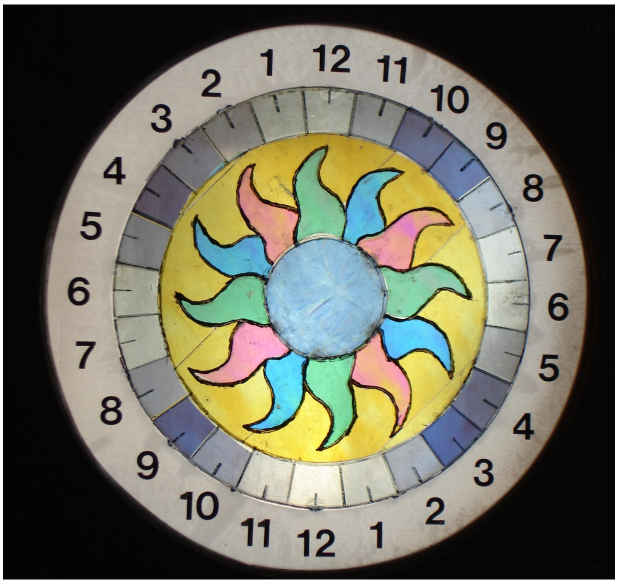


Fig. 13. Dial illuminated by light partially polarized in a vertical plane, indoors.

is now parallel to the axis of the cellophane design and we see very little colour against the blue sky. Compare Figs. 6 and 7, taken in ordinary unpolarized light.

Fig. 12 shows the result when at 6pm LAT the skylight is polarized vertically, parallel with the analyzing Polaroid. We see the complementary colours to the noon appearance. These colours are more intense in the polarized light reflected from a polished – and comparatively dark – table (Fig. 13).

Other Observations

(i) Observation of the ring of wedge-shaped segments gives a poor assessment of the time when the dominant eye is not obliged to look through a ring positioned around the axis aligned to the northern celestial pole.

(ii) The polarization of skylight proved to be low and/or anomalous towards the horizon,[2] resulting in poor performance by the dial. This would be the direction viewed by a vertical north-facing dial, so there appears to be little point in making such a thing.

Conclusions

The polarizing sundial might make an intriguing novelty for a sloping skylight that happened to face the celestial pole but, as a timeteller, it is no rival to the shadow dial with a conventional gnomon.

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3a. see page 14 of this issue.

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11. Jearl Walker: 'More about polarizers and how to use them, particularly for studying polarized sky light', *Scientific American,* **238,** pp.132-36 (Jan 1978).
12. 'Newton's scale of interference colours'. This name is used in all textbooks but is rather inappropriate because Newton could never have seen the phenomenon generated in polarized light and could not have accounted for it by his favoured corpuscular theory of light. What he did describe (*Opticks* Book II, Part I, 1704) were the coloured circular interference fringes that appear beneath a long-focus convex lens resting upon a plane glass support when the combination is viewed in white light. It appears that David Brewster (*A Treatise On Optics*, pp.103-4, 1831) was the first to apply this anomalous title to the related phenomena seen in polarized light, probably being influenced by his great admiration for Newton.
13. C D Gribble & A J Hall: *Optical Mineralogy: Principles and Practice* UCL Press, pp.215-231 (2001). A Michel-Lévy chart is reproduced in colour on the back cover. See also 'Michel-Lévy chart' on Google, especially the excellent explanatory text by J G Delly.
14. P Gay: *An Introduction to Crystal Optics,* Longmans, (1967). Ch. 9 and Appendix B.
15. Available from Edmund Optics (Europe) Ltd, Tudor House, Lysander Close, York YO30 4XB. e-mail for a catalogue and prices (including p&p and VAT) to *uksales@edmundoptics.co.uk.*
16. This was a mistake – cyanoacrylate evolves vapours leading to an unsightly white deposit around the point of application. Better to use tiny spots of old-fashioned cellulose acetate adhesive ('balsa cement').

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GÉRARD DESARGUES

This picture is the frontispiece of Abraham Bosse's 1643 book *La Maniere Universelle...pour poser l'essieu & placer des heures et autres chaoses aux cadrans au soleil*. ('The universal method to position the gnomon and draw the hours and other furniture on sundials'.)

Gérard Desargues

Abraham Bosse (1602-1676) is now best-known as an engraver but was also a teacher of perspective and a disciple of the mathematician Gérard (or Girard) Desargues (1591-1661) whose work the book showcases. Desargues' own book on sundials (1640) was rather dense in content and too theoretical for artisans. An English translation by Daniel King was published in 1659 as *Mr De Sargues Universal Way of Dyaling* with a preface by Sir Jonas Moore.

Descartes described Desargues, who worked mainly on conic projections and perspective, as "a geometer of profoundly original ideas whose work introduced the principal concepts of projective geometry". Lalande said was also an admirer of his work, saying that it included methods of laying out dials mechanically with set-square and wire (a form of trigon, perhaps?).

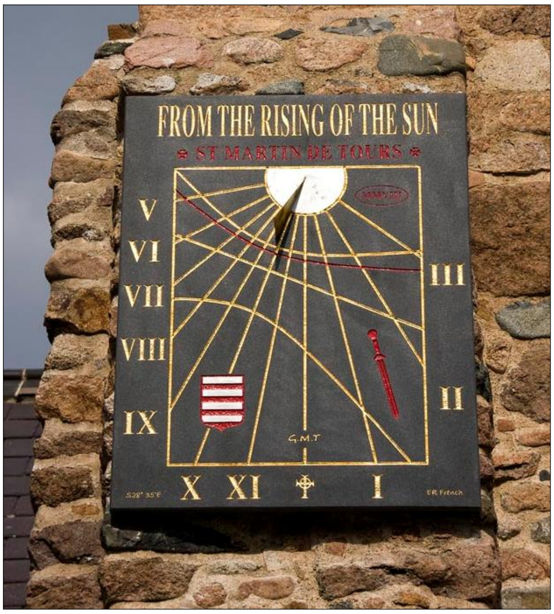
Picture courtesy of Leo Cadogan Rare Books, www.leocadogan.com.

JD

NEW DIALS

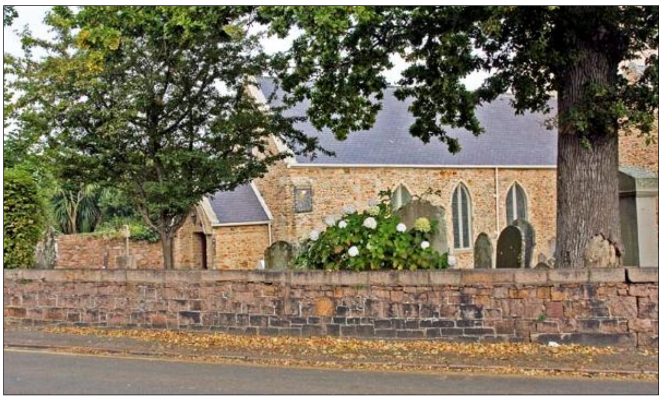
Grouville Church, Jersey, Channel Islands

My initial idea of designing a sundial for Grouville church began one bright Saturday morning in November 2006. As a relative novice to the art of designing sundials, I thought this might be an opportunity to try and understand the detail of designing a vertical declining sundial. What could be a better setting than this beautiful little church which lies on the east coast of Jersey.



After making a home-made device to measure the declination of a wall, I set out to test it with my watch set exactly to GMT. This first visit was simply an exercise for my own amusement. Two minutes after I arrived at the church, the sun was shining as I held my home-made device against the south-facing wall. With the instrument levelled, the shadow reading was 17.9° and my watch said 11:11:52 am. Back home, I transferred the data into my sundial computer program (*Shadows Pro*) which showed me that the wall was declining 28.35° east of south.

After several further visits, one at solar noon, I had a final reading: our church wall was S 28° 35' E. Within hours I had a basic design for a vertical declining sundial using *Adobe Illustrator*. Later, I realised that I needed information on the church history for some of the dial features. I phoned the Rector, Mike Lange-Smith, and was surprised to learn that that very day, 11 November, was the saint's day for St Martin of Tours, the patron saint of Grouville church. Mike told me the story of St Martin: on meeting a beggar on a cold night he took out his sword and cut his cloak in half, giving one half to the beggar. I decided that this story should be incorporated into the dial in some way. Thus the dial incorporates a Roman sword (St Martin had originally been a Roman soldier) and a cloak which is actually the crest of Grouville. After further discussion we agreed on a motto that Mike had suggested: *From the rising of the sun*. This is from Psalm 113:3. We decided that the anniversary date of 11 November would be our main declination line, in addition to lines for the equinoxes and solstices.



Instead of the more usual rod-and-nodus gnomon, I chose a triangle with the tip acting as the nodus. I cut the gnomon from a 300 × 300 mm sheet of stainless steel, having acquired some special blades from Germany for my scroll saw. It was a slow and tedious job but at least the accuracy was assured. The sundial was made in Jersey by F.J. Carter, monumental masons. We chose a honed dark grey granite, imported from India. The granite was sandblasted and all lines and numbers were gilded with 23.5 carat gold-leaf.

The dial was installed during September and officially blessed and dedicated by Mike Lange-Smith on Sunday, 12 October, with a reception at the Grouville Parish Hall afterwards. A big thank-you is due to our Constable Dan Murphy and his wife Dawn for their generous gift of the dial to the parish: Grouville is now the eighth parish church on Jersey with a dial. Thanks are also due to Mike Lange-Smith and Robin Dupre for their enthusiasm and to Mark of F.J. Carter Ltd for his expertise in the making and installation of the dial.

Eddie French

St Austell, Cornwall

The cemetery park sundial, St Austell, was commissioned by Cornwall County Council and Restormel Borough Council as part of the towns' regeneration scheme. St Austell had become a neglected area so it was due for a substantial grant from the European fund. When the money was transferred, a favourable exchange rate provided an unexpected bonus for the council and, to their credit, they directed this towards the sundial. At first I was asked to design and build a suitable sculpture depicting elements of the town's history and, since the park was still a cemetery—the gravestones having been moved to the perimeter some years previously—something in recognition of those buried there.

The idea of a sundial quickly gained momentum with suggestions and ideas coming from several sources. It was decided that granite stepping stones from a local quarry would be placed at each hour to encourage children to take an interest. A 'timeline' of historical events was also suggested. I developed the idea of a rotating nodus: a nodus with a 'nodule' on it which could be rotated every six months to mark out these events at their respective dates throughout the year. The event would be marked out on the dial face with an engraved stainless steel band. I also suggested carving the symbols of the zodiac along the dial face where it meets the gnomon, to correspond with the position of the nodus nodule. This idea was eventually rejected for two reasons; it was considered inappropriate to incorporate zodiac symbols because of their association with 'new age' ideals and the rotating nodus was rejected as being unnecessary. Besides, costs had begun to escalate and time was running out.

I used *Shadows Pro* for the dial layout and the position of the nodus and passed the information on to a chap called Mike Venner who did the CAD drawings. Mike had a passive interest in sundials and proved to be an astute and sensitive ally. This was his last job before retirement and from the start he gave it the benefit of a lifetimes experience and knowledge. He worked closely with the quarry, Ennstone Products of St. Breward, to make sure that the stones were cut in such a way that they didn't interfere with the hour lines, the EoT graph or the dedication.

I was invited to the quarry to choose the materials and their finish. I chose granite, polished and unpolished, and slate. The dial furniture is picked out with gold enamel. The dial is longitude corrected (St Austell is 5° west of Greenwich) and the square stepping stones have summertime hours on the top and wintertime hours on the front.

After much hesitation and discussion it was decided to make the gnomon from polished stainless steel. A lot of people, myself included, were sceptical of stainless steel as a material in a traditional setting. However, I discovered an obelisk at a National Trust property which blended perfectly with its surroundings. The various committees then decided to go along with the idea, having seen the photos. It proved a success. I have heard nothing but praise from all parties and from the general public. An added bonus of the gnomon's mirror finish is that it gives the illusion that you can see the whole of the dial face and stepping stones when viewed from one side.

My thanks go to M. Blateryon for his excellent website. The dial is very accurate and the official opening will take place in late January.

Bradley Dillon

Another St Petersburg Dial

Valery Dmitriev, who designed and made this dial, calls it simply "Angel, playing a harp". He sent his wishes that all BSS mem-bers will hear the music of the harp and that the angel will bring pleasant gifts! Note the time scale two hours ahead of local solar time, accounting for summer time in St Petersburg.

A MOONDIAL FOR THE NORTHERN HEMISPHERE

MICHAEL LEE

Retirement from a busy life offers relaxation, perhaps linked to a new hobby. In my case I decided model engineering would be a complete departure from anything I had done before. At three times the age of any fellow students, I enrolled on a mechanical engineering course for two years and so developed an absorbing interest.

By chance, an invitation in 2004 to see a sundial and have its mysteries explained to me, along with recommended reading on the subject, eventually lead me to an article by Norman Darwood in the Bulletin[2] which caught my interest. I considered his drawing, reproduced here as Fig. 1, could be re-designed and developed as a mechanical instrument and work with a high degree of accuracy.

Moving house from Cheshire to Wiltshire in 2007 placed me only a short distance from Norman who lives near Southampton. Conversations, meetings, sketches and permission from Norman to use his design for my moon dial plate produced the instrument described here.

Little achieved in life is the work of an individual. Many friends in model engineering and gnomonics societies became involved; applying their time, computer aided drawing skills, expertise and patience. I name them at the end of my article; without their help and skills the moon dial could not have been constructed.

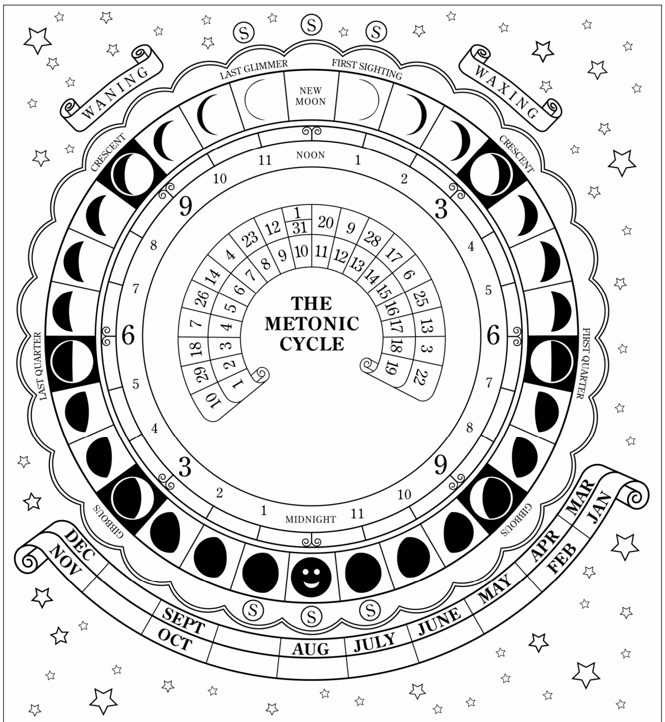


Fig. 1. Drawing of the moon dial face, reproduced from the original by N Darwood in ref. 2.

What features does the moondial comprise? First, a hardwood plinth is supported by three adjustable feet. Attached to the plinth is a 32-point compass rose indexed with 360° and to a traditional design. At the centre of the rose sits a large hexagonal hub. Four facets of the hub support:

* a finger screw to lock the hexagon hub
* a spirit level tube
* an arrow shaped pointer
* twin stainless steel shafts terminating at a hexagonal shaped hinge.

Between the shafts, a polar arm rises from the hinge centre. A locking lever on the end of the hinge secures it. For calibration, a quadrant is swung on one of the twin shafts. On top of the polar arm, a supporting frame provides a structure to seat the moondial which is secured by a threaded gnomon.

Dial Construction

The materials used were:

* variety of hardwoods for the plinth
* stainless steel of various diameters for shafts

J Davis

Fig. 2. The completed dial, as seen at the BSS Newbury Meeting in September 2008.

Fig. 3 (above). Close-up of the base unit.

Fig. 4 (right). The dial face (© M. Lee).

* brass hexagon various sizes for fittings
* brass tubing and round bar of various diameters
* sheet brass of a composition suitable for etching
* spirit level tube
* acid based patination fluid
* fine polishing abrasives
* wire wool
* beeswax polish for wood and metal

The overall structure is a freelance design requiring precision in its manufacture. It measures overall 35 cms wide × 40 cms high when calibrated to its highest position.

The wooden plinth is 40 mm deep × 35 cms in diameter and formed using a hand-held router fitted with a variety of shaped cutters to achieve the final design. Accurate placement of the holes on the upper surface for the centre hub, the eight retaining bolts to secure the compass rose and the three in the underside for the adjustable feet, were all achieved using a vertical milling machine.

Final finish of the plinth was by hand, using various grades of wire wool. Emphasizing the colour and grain of the hardwoods was achieved by treatment with a wax containing a high percentage of beeswax which was then buffed.

Drawings and sketches of the compass rose, quadrant and moon dial were recreated on an *AutoCad* computer program and loaded onto a disc. The disc was sent to a photographic specialist to produce high contrast photographic negatives at the scale required.

The process of etching is to use the negatives for transferring images onto sheets of brass suitable for etching, and which have previously been coated with a photopolymer layer. Ultra violet (UV) light transfers the images from the negative to the photopolymer. Dipping the brass sheet into a solution of ferric chloride enables a chemical milling of the unwanted material. This work was carried out professionally because of the high degree of detail required.

As my intention was to give an aged patination to all of the brass parts, I first scoured them with a household cleaning agent then rinsed them in water until the surface tension on the brass was minimal. Each item of brass was then immersed in a weak acidic solution to achieve a dark copper to steel-blue colour. Finally the items were rinsed, dried and wax polished.

Machining of the stainless steel round bar and shaping of the brass hexagon fittings were achieved using a *Myford* model engineering lathe and a *Wabeco* precision milling machine. All the screw threads were also made on the lathe. The project took one year of my leisure time.

The Moondial Plate

The plate contains the following information in a series of rings. Commencing with the inner circle:

* 19 Golden Numbers, the 19-year cycle of the moon
* Golden dates which follow the metonic cycle
* months of the year, January to December
* symbols of the daily phases of the moon during its monthly cycle
* description of the phases e.g. waxing, waning etc.
* 32 compass points labelled, for example, N by E, NNE, NE by N etc.
* 24-hour time ring.

Setting Up The Instrument

* remove the moondial plate by unscrewing the gnomon
* place the plinth on a level surface
* rotate the plinth, orientating the compass rose to true North

Fig. 5. The minor components unassembled.

* slacken the finger-screw on the central hub and rotate it until the arrow pointer is located over North on the compass rose
* observing the spirit level, adjust the feet beneath the plinth until the bubble sits between the site marks on the glass tube
* undo the knurled screw securing the quadrant and swing it into the vertical position; secure the knurled screw
* determine the latitude of your location and raise the polar arm to the co-latitude by rotating the locking lever on the hinge. Along the polar arm, an arrow is located to sight the degrees on the quadrant
* lock the lever and return the quadrant to its original position parallel to the compass rose
* refit the moon dial and re-thread the gnomon.

In countries with low light pollution, a moon shadow from the gnomon may be possible. In arid climates cloud will be minimal.

Fig. 6. The latitude arc and pivots without the plates.

Moon's Phase

To use the dial, it is necessary to know the phase of the moon. A simple (if not totally accurate) method for this is to use the *Golden Number*. The Golden Numbers are so called because in ancient Greece they were etched in gold on public buildings and monuments. See reference 1 for a fuller definition.

The Golden Number (GN) is defined as one more than the remainder resulting from dividing the year by 19. It is an integer number between 1 and 19. For example:

Year		GN
2005	2005/19 = 105, remainder 10	11
1983	1983/19 = 104, remainder 7	8
2013	2013/19 = 105, remainder 18	19

The Golden Numbers are shown in the central arc in the middle of the moon dial. Next to them are numbers which we can define here as the 'Golden Dates'. These numbers follow the *Metonic Cycle* and will remain correct until AD 2200. For example, a GN of 1 has a 'Golden Date' of the 10th and a GN of 2 has a date of the 29th. A GN of 10 has a date of either the 1st or the 31st.

Finally, to find the phase of the moon on any date:

* Start at the moon phase opposite the month name
* Begin counting with the Golden Date
* Count up (clockwise) or down (anticlockwise) to reach the day of interest. The symbol shows the moon's phase on that day.

Example 1: 2006, June 5th. The GN is 12. The Golden Date is the 9th. Starting at June (two days before full moon) on the 9th, count down (anticlockwise) to the 5th to arrive at one day after the first quarter.

Example 2: 2023, December 25th. The GN is 10. The Golden Date is the 1st or 31st. Starting at the gibbous moon on the 31st, count down (anticlockwise) to the 25th and arrive at two days before the full moon. Alternatively, count up (clockwise) from the 1st to arrive at the same answer.

The relationship used here between the GN and the 'Golden Date' will change over the centuries.

To Find The Time By The Moon

Rotate the dial so that today's moon phase is pointed to the south, i.e. the highest point. Then the moon's direction perpendicular to the plane of the dial indicates the current time. The outer ring of the moon dial gives hours, half hours and quarter hours. Note that the moon does not give enough light to cast a visible shadow for most of the month so this dial relies on estimating the moon's direction, rather than on a shadow.

The time indicated by the dial is related to the solar or local apparent time. However, variations in the moon's orbit will have a far greater influence of the closeness of the time indicated by the dial to clock time than the effects of the Equation of Time. The actual moon's phase can be one day (or occasionally two days) before or after that found by the GN method.

A further feature of the dial is the two sets of ringed 'S' near New and Full moons. These indicate the dates where Spring tides may be expected.

Historically, ships' captains were dependent on the Golden Number and Golden Date calculations described previously to determine high tide and when safe passage from port could occur.[3] Navigators knew that new and full moons cause the highest (Spring) tides and that the time of any high tide is linked to the moon's transit. The average daily delay of the moon's transit is 50 minutes so delay to each of the two daily tides is typically 12 hours 25 minutes. The time offset between the moon's transit and high tide at a particular location is commonly called 'the Establishment of the Port'.

With this knowledge and using the 32 points of a compass as a clock with each compass point representing a phase of the moon, the moon's transit could be calculated. By using the compass in this way, high tide was determined for the intended day of sailing from port.

Planting Crops By The Moon's Cycle

Today's scientists would be sceptical of the historical beliefs of Greeks and Romans regarding any influence a waxing or waning moon could have on agricultural methods and the appropriate dates in the moon's cycle to plant crops. Using the moon as a calendar would, it was thought, enable flower, fruit, leaf and root days to be established. Farmers and gardeners would choose a day corresponding to the part of the plant they wished to be most successful. This old method worked on a simple assumption: as the moon waxes, increased gravitational forces draw water and nutrients upwards. This would, they believed, help plants producing their valuable parts above ground, i.e. fruit trees and flowers. When the moon wanes, forces decrease so water and nutrients in the plant move downwards. This is an ideal time to plant root crops. These beliefs may finally have been put to rest by Christiaan Huygens in 1656 with the introduction of the pendulum clock, relying on the constancy of gravity.

Currently, any effect of a waxing or waning moon is being tested as an experiment in biodynamic sowing and planting. This is being carried out at Nymans in West Sussex. Whatever the reader may think, the influence of the moon has been an enjoyable pastime for me in constructing an interesting dial.

Acknowledgements

Thanks to Norman Darwood for permission to use his design, Barry Harrison and Tony Moss for computer aided drawing skills; Gordon Brooks for computer aided drawing and design skills; Frances Lee for typing and photography.

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READER'S LETTER

Keep it Simple

It was a great pleasure to receive here, in Brisbane, the December 2008 Bulletin, together with Chris Madden's particularly apt cartoon on p.165. For example, my UK radio-controlled clock will not work at all here, even as a simple quartz electric clock, whereas my universal equatorial 'coffee-time' sundial[1] continues to function faithfully and silently at latitude 27.5° S.

Additionally, my universal heliochronometer, adapted from my clever Kelvin-Hughes astro-compass[2] behaves equally well, certain of my hour markings merely being re-numbered.

Incidentally, concerning Noel Coward's 'mad dogs and Englishmen in the mid-day sun', in Brisbane 'high noon' can, in the late Spring, occur at 11:32am relative to the mean Eastern Standard Time with a zone meridian at 150° East.[3]

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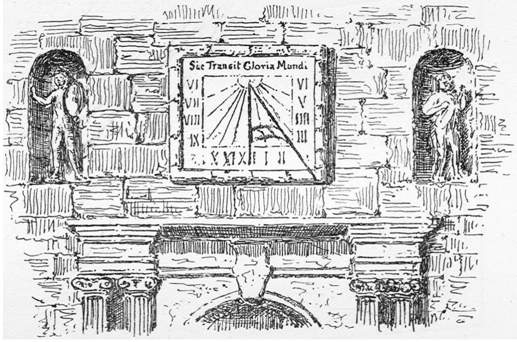
Maurice Kenn, Brisbane



Fountains Hall, Ripon (after *Gatty*).

AN ELECTRONIC POLARIZATION SUNDIAL AND PHOTOMETER

ALLAN MILLS

Molecules of air in the terrestrial atmosphere scatter a small fraction of the incident light from the Sun. This phenomenon is most intense towards the violet end of the spectrum and, when compounded with the emission curve of the Sun (peaking in the yellow) and the sensitivity curve of the human eye (peaking in the green), gives us the blue sky. Compared with the Sun itself, the light from the sky is not very intense but we view it against the blackness of space.

This scattered light is also quite strongly linearly polarized so it is well-known that viewing the blue sky through polarizing sunglasses causes an obvious variation in the depth of colour as the glasses are rotated. The axis of polarization of light from any point in the sky is, in general, perpendicular to a plane containing that point, the Sun and the observer.[1,2] The polarization is never 100% complete, but tends to be a maximum at a point 90° from the Sun.[1,2] As the latter moves across the southern sky it carries this polarization pattern with it, causing it to appear to rotate uniformly once per 24 hours about the northern celestial pole (NCP).[1, 2]

It will be apparent that if (like many insects) we had eyes sensitive to the direction of skylight polarization, then viewing the region of the NCP would enable us to determine the time of day from the orientation of this 'polarization sundial' with respect to the horizon. But our eyes possess only a trace of polarization sensitivity and, even when aided by looking through a piece of 'Polaroid' polarizing plastic, can detect a change in intensity only after a rotation of some ±20°. I have shown in previous papers[1,2,3] how sensitivity may be increased to about ±2° by visually comparing the intensities produced by the insertion of a 'half-wave wedges' of cellophane. Best of all is to arrange that one half of the modified visual field is presented alongside the unaltered original light. The human eye has evolved to be so good at matching adjacent fields that rotation may be measured to ± ½ degree of arc, equivalent to ±2 minutes of time.[1]

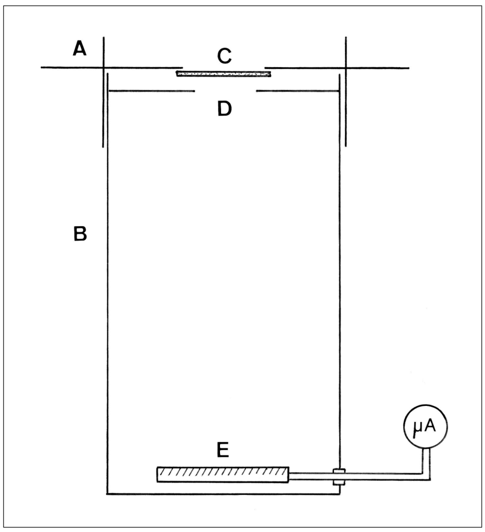


Fig. 1. Construction of the electronic polarization dial.
***A**: Removable/ rotatable drum;*
***B**: Body;*
***C**: Polaroid HN32;*
***D**: Aperture;*
***E**: Silicon photovoltaic cell.*

An Electronic Polarization Sundial

The fact that the eye is poor at assessing the absolute intensity of an illuminated field does not prevent instrumental methods accomplishing this task very well. Many forms of photocell are now available, one of the first to be developed being a layer of amorphous selenium deposited on a thin metal plate. When covered with a transparent electrode, the combination acts as a photovoltaic cell, generating a small current proportional to the intensity of light falling upon it. Many photographic exposure meters manufactured in the 1950s were based on such a cell, a few square centimetres in area, connected to a robust moving coil microammeter. I therefore decided to investigate the practicality of an instrument that viewed the blue sky around the NCP through a rotatable polar, and then measured the transmitted intensity electronically with a selenium photovoltaic cell. The availability of a cell that was used in a photometer intended to measure room illumination determined the design of the apparatus (Fig. 1). The sealed circular cell had an active diameter of 59 mm and was mounted in a metal can that, with a 25 mm diameter hole in its top, permitted the cell to view a circular zone 30° in diameter. All interior surfaces were painted matt black. The hole could be covered when required by a rotatable glued paper drum bearing a 35 mm diameter disc of Polaroid type HN32. An index on the drum moved against a scale of hours fixed to the body of the instrument. When required, the device could be quickly fixed in a pre-located mounting to point at the NCP and the electrical output of the photovoltaic cell measured with a digital microammeter.[4] (Fig. 2.) Lenses were avoided because it was feared that reflections from their glass surfaces might introduce spurious polarization.

It will be appreciated that the electrical output is at a maximum P_{max} when the polar is parallel to the natural polarization of the sky, and at a minimum P_{min} when (after a further rotation of 90°) the Polaroid is crossed with it. Detection of either point will enable the solar meridian to be located and it will be found to appear to rotate slowly anti-clockwise

Fig. 2. The polarization sundial/sky polarimeter.

around the pole. Time is then indicated by the position of the index against the hour scale. It was found that, using either the maximum or the minimum signal, the meridian could be located to ±2° (±8 minutes of time). This is superior to the eye but somewhat inferior to a common shadow-casting sundial of comparable size. However, it must be remembered that a north-facing dial of this nature is rarely in sunlight! Restriction of the field of view to a circle 10° in diameter centred on the NCP did not help, for the signal then became so small that accuracy was diminished. A more modern phototransistor of greater sensitivity might be advantageous.

It would of course be possible to arrange for two photocells to view and compare the split field produced by a half-wave plate but, as the eye is so good at this, there appears no reason to construct such an instrument unless an electronic output is required for some technological purpose.

Application as a Sky Photometer

There appears to be very little *quantitative* information on sky polarization from Europe: the few measurements reported in the literature[5-7] are mostly confined to continental USA. Complex all-sky polarimeters have been employed – in recent years complete with the obligatory computer!

Conditions	I	P_{max}	P_{min}	$P_{\%}$	I_{pol}
Exceptionally clear blue from zenith to horizon	52.0	24.5	5.7	62	32
Fine blue sky	63	29	8	57	36
Blue with high cirrus	70.5	31.1	10.7	49	34
Blue with extensive cirrus	84.5	34.2	15.0	39	33
Blue with scattered white cumulus	92	40	20	33	30
Blue patches through extensive cloud	160	67	56	9	14
Overcast	158	64	56	7	10

Table 1. Polarization values under various conditions.

The simple photoelectric polarizing 'sundial' described above is in fact well adapted to the quantitative assessment of the percentage of linear polarization $P_{\%}$ in the light from a selected 30° diameter area of the sky. The region centred on the NCP is both convenient in general and relevant to the operation of polarization sundials. Using the following symbols for the output in µA of the selenium photocell:

I Output with no polar in place
P_{max} Output with polar parallel to natural polarization
P_{min} Output with polar crossed with natural polarization

it may be shown[8] that the percentage of polarization $P_{\%}$ in the incoming light is given by:

$$P_{\%} = \frac{P_{max} - P_{min}}{P_{max} + P_{min}} \times 100$$

The intensity of the polarized illumination (I_{pol}) is given by:

$I_{pol} = I.P_{\%}$ in arbitrary units

Some representative figures obtained at a rural site in central England are shown in Table 1. It was found that:

a) The output current could only be recorded to 0.1 µA in very stable conditions.

b) A clear blue sky gave the greatest degree of polarization.

c) The presence of some white clouds could increase the general illumination, so the final intensity of polarized light might actually be enhanced.

d) Common values for the percent polarization in the light from the NCP in 'ordinary' sunlit UK blue skies were in the range 30–50%. These were adequate to operate a polarization sundial and give rise to interference colours.

The maximum degree of polarization given in the literature[9] is 75% at a point 90° to the Sun, but no source or location is given for this figure. It would be interesting to measure the famous blue skies of Italy and the south of France, as well as skies at high altitudes. In these places it might be possible to detect fine aerosols brought in by the jet stream, even if nothing was apparent to the eye.

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THE MASS DIALS OF CONTINENTAL EUROPE

CHRIS H.K. WILLIAMS

Early primitive sundials – the contemporaneous equivalent to what English diallists term Saxon or scratch dials – have long been recorded across the length and breadth of Europe. How do British and Continental dials compare and relate to one another? Two issues bedevil the literature. British and Continental students were not always aware of each other's efforts; and much work is based on limited evidence with little indication of how statistically representative it might be. In consequence, whilst it is obvious and indisputable British dials are part of a shared Europe-wide heritage, details of their co-evolution is ambiguous.[1] Definitive insight awaits a systematic appreciation of surviving dials.

Accordingly, this article reviews the status of Continental listing/recording. These have always been dwarfed by their English counterpart,[2] almost certainly a reflection of less intensive surveying. There is no Continental equivalent to Horne, Cole, or the Mass Dial Group (MDG). By the 1960s it was known that mass dials survived across the breadth of Europe.[3] The considered opinion of the MDG in 1991 was "that there were a great many in the north of France and in Germany".[4] In 1996 it was noted there were "about 250 known Continental examples".[5] Since then we have witnessed an apparent explosion in our awareness of surviving dials.[6] These include both published sources and unpublished BSS listings/recordings.

In contrast to the UK, the MDG does not have a systematic programme to record Continental dials. It has, however, over the last decade, filed reports of dials encountered by its recorders (when on holiday) or notified by (overseas) BSS members. Although the filings are essentially opportunistic they still total approaching 300 dials (Table 1).

Turning to published sources these include:

- Armenia: A two week survey concluded "some forty of the principal old churches were visited, over half of which carried sundials, and there are certainly as many more."[7]
- France: In recent years the number of listed dials has increased by about 150 annually and now totals in the region of 1000.[8]
- Germany: A local study listed 21 dials.[9]
- Greece: A series of articles discuss and record 9 dials.[10]
- Hungary: A series of articles discuss and record 7 dials.[11]
- Spain: Two major studies, one national and the other regional, list some 300 dials.[12]
- (Former) Yugoslavia: Two articles point to 7 dials.[13]

Country	No. Dials
Austria	4
Denmark	8
France	212
Germany	1
Norway	9
Poland	1
Spain	25
Sweden	1

Table 1. Continental mass dials in MDG Files.

Source: A.O. Wood, personal communication.

How should all this evidence be interpreted? Perhaps the most obvious and longstanding general feature is the sheer geographical spread of mass dials; a feature reinforced by more recent work. The 'extension' into south-east Europe is particularly noteworthy. It establishes the presence of mass dials on Orthodox, as well as Western, Christian churches. Recent sightings have even ventured beyond Europe. Two scratch dials have been recorded on the Armenian Church in Jerusalem.[14] Two dials have also been reported in Mexico, undoubtedly a Spanish colonial import.[15] All of this is consistent with a shared common heritage, and that such dials were in widespread and common usage.

There are strong reasons for believing the true number of surviving Continental dials to exceed, by a significant factor, this article's 2000 or so dials. Most obviously, because of linguistic and search constraints, not all actual listings have been included. More importantly, the listings indicate they are the product of incomplete surveying – both inter-country and intra-country regional variations in the density of listed dials imply significant geographical variations in the level of surveying: furthermore the large increment of recent listings, particularly in France and Spain, suggests survey rates well below saturation. Continental listings appear low because not all churches have been surveyed. The much higher English listings reflect the fact it is the first country to be (virtually) fully surveyed.

It has been established that only a small fraction of English scratch dials have survived the twin rigours of weathering and rebuilding into present times.[16] Although comparable conclusive Continental analysis is not yet feasible, anecdotal evidence abounds – the poor condition of many dials suggests many more have already succumbed to weathering; the frequent mention of repositioned dials attests to the impact of rebuilding. Whilst variant views might be held on the extent to which Continental conditions might have somewhat attenuated or compounded the English level of dial loss, there is no reason to doubt Continental dial loss has also been substantial.[17]

Whilst some robust general conclusions can be made at this stage, much remains to be done. A motivation for this preliminary review was the hope it might stimulate interest and assistance. The future agenda might fall into three parts:

- A comprehensive register of hitherto listed dials. The author is prepared to act as a post box to compile a full catalogue of sources.
- Extension of Continental surveying. As surviving evidence is constantly deteriorating, it is to be hoped accelerated progress will prove possible.
- Analysis of listed dial data. The author is undertaking a detailed analysis of England's database. Currently only France appears to have the statistical potential[18] to warrant similar analysis. The extent to which this might be possible is being assessed with the collaborative assistance of Denis Schneider.

We will only really understand mass dial evolution in a European context when we know the genuine similarities and differences – both in what survives and might once have existed – across Europe.

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17. We can be certain of one contributor to dial loss being relatively higher on the Continent – war damage, especially in Germany and east Europe. We should also be mindful of the impact of Ottoman occupation in south-east Europe.
18. This is a technical statistical matter of sufficient representative data. Only France has the 'feel' of potential adequacy-size of database, its rate of increase, and retrievable survey rates.

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CONSTRUCTION OF MY LAWN ANALEMMATIC SUNDIAL

KEN HEAD

Introduction

The theory and use of the analemmatic sundial have been covered in previous articles.[1-3] This paper literally comes down to earth by presenting practical details involved in the design and construction of my own dial of this type, which I hope will be useful to others.

Concept

When I first became interested in sundials about 10 years ago, I set out an analemmatic dial on my lawn. I used old square tiles for hour markers, just bedded into the grass. Unfortunately, after a few months the grass grew over them and they completely disappeared into the ground. The date scale was of cardboard, which I laid out when needed.

I wanted to make a dial that would not only be durable but also easy to make, using readily available materials. The hour markers needed to be firmly bedded at some depth below the surface, and set at exactly the right level – too low, and they will soon be covered by grass; too high, and they will interfere with the lawnmower. The way I tried to achieve this is described below.

I made the necessary calculations, planned the design details, and cut and made the markers, during the autumn and winter months ready for installation in the spring. A general view soon after completion is shown in Fig. 1, and the date scale is shown in Fig. 2.

Location

I chose a convenient position on the lawn where interference of sunlight by surrounding trees would be as little as possible. I established the north-south line by making use of my own shadow. I placed a marker peg at the point where the centre of the dial's ellipse would be. On several (rare) sunny days during late November and December, as noon approached, I stood upright, with feet together, so that the shadow of the middle of the top of my head fell on the marker. As the sun moved round I adjusted my position and at the instant of solar noon I inserted a peg in the ground between my heels. The distance of each peg increased on each occasion, and by the day of the winter solstice there were about eight such markers. A string stretched from the centre as a 'give and take' line through the points showed a maximum scatter of within 30 mm, so I considered I had obtained a reasonable average line.

Fig. 1. General view of the lawn sundial. The small white spots are the focus markers.

Location details:

Latitude: 51° 20' N; Longitude: 00° 24' W;
NGR TQ117597

Fig. 2. Date scale. Latitude and longitude data are included at the north end. The solid circles indicate the zodiac boundaries.

Dimensions

I decided that a semi-minor axis (b) for the ellipse of 2 m would be suitable. At this latitude, the corresponding semi-major axis (a) is 2562 mm. The overall length of the time scale is 1388 mm, the distance of the sunrise and sunset marker points, R and S, from the centre is 841 mm, and the distance to the foci is 1601 mm.

Hour Markers

To make the hour markers I used lengths of tree-trunk, of about 160 to 180 mm diameter, from overgrown cypress trees which had been cut down the previous year, for cutting into 17 pieces about 200 mm long. Being coniferous, I felt that their natural resin would ensure reasonable durability in the ground. Four pieces of smaller diameter were cut

Fig. 3. A typical hour marker.

for the sunrise and sunset markers[1] and focus points. The ends selected to be the top faces were smoothed as far as practicable with a Surform tool and coarse sandpaper.

I decided to use very simple Roman numerals, for ease of marking and cutting – all straight lines. The numerals were marked out in pencil, incised with a marking knife, and slightly recessed using a ¼ inch mortise chisel. These preparations were carried out a little at a time during the autumn and winter months.

For preservation I used creosote, but I painted the numerals first, with white undercoat followed by gloss. Masking tape laid along the edges made this an easy task. When the gloss had hardened, I dipped both faces into a tray of dark brown creosote and almost immediately wiped the excess off the paint surface. This was repeated a few days later and it produced clear white numerals on a dark background. One completed marker is shown in Fig 3.

Date Scale

I used a 2 m length of 7 inch by 2 inch timber joist retrieved from a nearby house reconstruction site. I made one face reasonably smooth before marking the lines, months and other details. These were incised and painted as for the hour markers, before applying creosote. To make incision of the curved letters easier, I used a hand engraving tool fitted with a chisel point ground from a piece of 3 mm diameter steel rod.

Setting Out

The north-south line obtained as described above was extended in both directions and an east-west line through the centre point **O** was derived by means of 3,4,5 triangles. Using these lines as axes, careful measurements of the calculated *x* and *y* values[3] enabled the position of the centre of each hour marker to be determined and marked with a peg. As a further check, the distance *r* from the centre was also measured. But since these markers would disappear as soon as a hole was dug, additional reference markers were necessary. I used a template consisting of a piece of softwood about a metre long, with a 25 mm diameter hole at its mid-point. The hole was placed over the peg, the template was aligned towards the centre of the ellipse, and I inserted a reference peg at each end of the template. These pegs remained in place to facilitate setting the marker in its correct position.

The date scale was set out on the *y*-axis, with a similar reference marker at either end. The **R** and **S** points, and the foci, were similarly marked out on the *x*-axis.

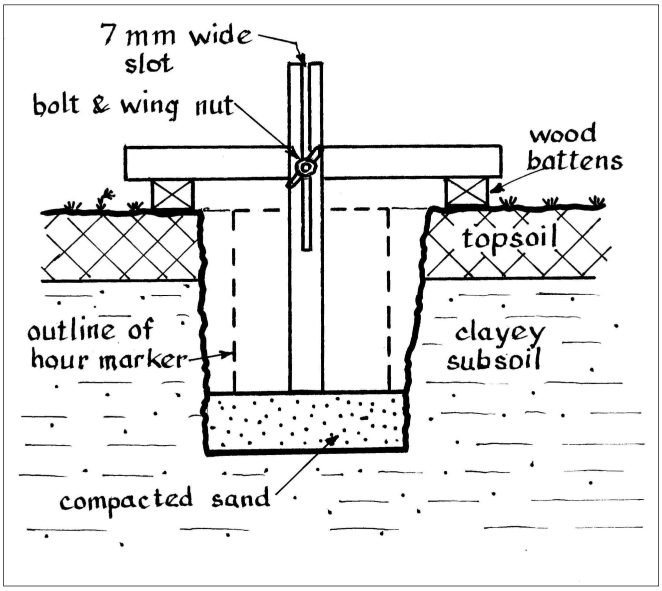

Fig. 4. Use of adjustable depth gauge to ensure that sand surface is at the correct level, made from 50 × 25 mm (nominal) softwood.

Construction

To ensure that the hour markers would be firmly supported, I dug holes to a depth of about 250 mm into the subsoil underlying the topsoil in which the grass grew. I placed a layer of sand in the hole and compacted it with a hand rammer. Using the purpose-made adjustable depth gauge shown in Fig 4, after setting it against the hour marker on the battens on a flat surface, I was able to obtain the correct level of the surface of the sand on which it sat. After placing in the hole, a drawing pin was inserted at the centre of the marker and, by laying the template between the two outer reference pegs, I could align the hour marker precisely by bringing the drawing pin under the centre of the hole in the template. The date scale was also positioned using the reference pegs and aligned with the north-south string line.

The cavity left around the markers and date scale was backfilled with compacted sand, then soil, and finished off with small pieces of turf.

Comments

The dial indicates solar time as accurately as can be expected from a dial of this type. After six months of use, the markers are still firm and level with the lawn surface and the lawnmower passes over them easily with only a slight bump. Occasional hand trimming of encroaching grass is needed. Rain keeps the white numerals and lettering clean and bright.

After installation I made a separate check. I tied a string of length equal to the major axis to a nail in the centre of each focus point and stretched it to each hour marker in turn. As I had hoped, the apex of the triangle formed by the string coincided nicely with the centre of every marker – all except one, the **I** o'clock marker, which I found was nearly 100 mm off its true position. This was the only correction needed.

About two weeks after installation, I noticed that the date scale board was rocking, because shrinkage had caused the board to curl across its width. I lifted the timber out, scooped out a shallow channel of the sand on which it was bedded along the centre-line, and replaced it. Since then the board has remained firm, with no further movement. From this experience my advice would be to use two lengths of board, placed on edge, with the line of contact forming the centre-line.

If the markers are still firm and clearly visible in about a years time, I will consider that my efforts have been worthwhile.

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SUNDIALS AND THE RISE AND DECLINE OF COSMOGRAPHY IN THE 'LONG' SIXTEENTH CENTURY

GIVEN BY

DR JIM BENNETT

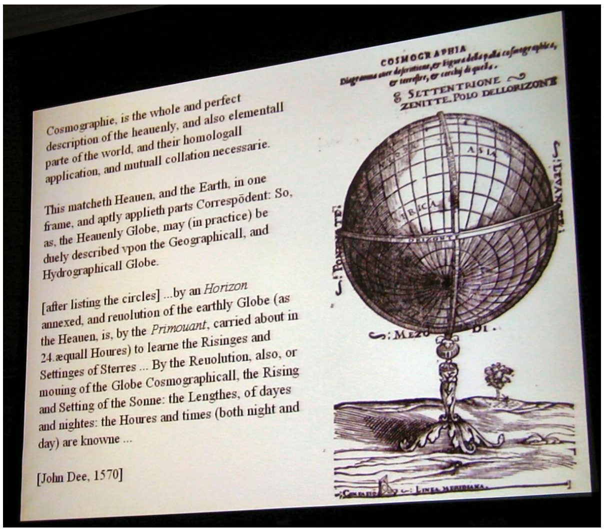
THE SCIENTIFIC INSTRUMENT SOCIETY'S 16TH ANNUAL INVITATION LECTURE
21 November 2008

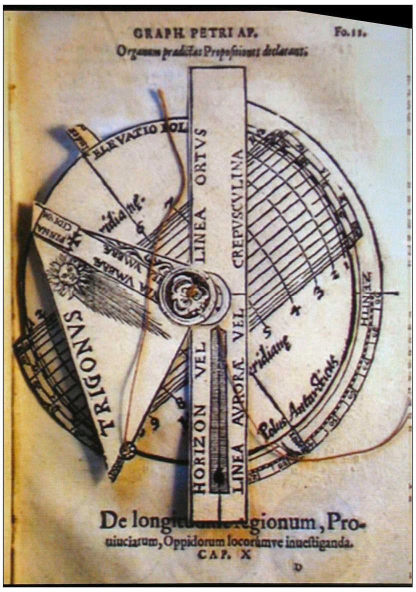
The SIS annual invitation lecture was of particular interest and relevance to the BSS this year. I counted seven members who had made use of the fact that the lecture was in the early evening to spend a day in London at various galleries, libraries and institutions before gathering at the Society of Antiquaries in Burlington Arcade for the meeting. The lecturer, Jim Bennett, is of course well-known to us both as our Somerville lecturer from 2001 and as the Director of the Oxford Museum of the History of Science where he was one of our hosts when we visited there during our 2004 Conference.

Jim started by saying that some enthusiasts for scientific instruments might think that sundials are rather boring (perish the thought!) and that early sundials just have a complicated way, or ways, of telling the time. But he said that sundials were much more than this and went on to explain why. Time was just one of many measures of the universe which a dial could show.

I was pleased to have the term 'cosmography' explained to me. Jim used John Dee's 1570 description to show that it encompassed a complete study of the universe as it was then known, at the beginning of the Renaissance. Thus as well as the measuring of the heavens, the detailed geography of the earth was included as part of a single system: this was shown by the models and drawings of a globe – itself a modern concept – in the centre of the celestial sphere.

The real start of the study of cosmography was assigned to the astronomers Georg Peurbach and Regiomontanus in the late 1400s, building on the *Almagest* of the great Ptolemy from the first and second centuries AD. One of the first sundials which was shown was the





The complicated organum Ptolemaei with moving paper volvelles in Peter Apian's book.

famous Regiomontanus 'universal' altitude or card dial, published by him in 1476. Jim pointed out that the latitude scale on the early examples usually ran from 39° to 54° N in steps of 3°, a rather strange division to modern eyes. Jim postulated that this could be traced back to Ptolemy who defined geographic latitudes in terms of 'climates', according to the maximum day-length in any region, and that 39° was taken as the latitude of Rome.

Jim took us through the instruments of the early workers, both in brass and ivory and also in paper in the form of book illustrations with moving paper volvelles. He showed examples from Peter Apian's *Cosmographia…* where the Oxford MHS was able to display both the paper and brass versions of the 'organum Ptolomaei'. Other contributors were discussed, particularly Stoeffler, who is known mainly for his astrolabes but also wrote on dialling, Oronce Fine, and Mercator and Gemma Frisius.

In England, the work of John Blagrave was picked out. Cosmography (and dialling) was a subject which was largely outside the universities but it was of increasing interest to the educated social world and had wide social, political and commercial aspects. For the latter, the demand for atlases, globes and, of course, dials was growing.

The decline of cosmography in the 17th century was not accompanied by a decline in dialling. In fact, dialling became more important as the more widely available, and used, clocks needed an instrument which would "give them the time which they could then keep". But the dials in this period tended to be simpler, single-purpose instruments just giving the time with less attention being paid to all the other features of the heavenly and earthly universe.

During the questions, it was pointed out that Ptolemy also wrote a book on astrology. Jim said that the influence of the heavens on the earth was clearly known and explainable during the Renaissance by examples such as the seasons. Thus it was not unnatural that mathematical astronomers would seek more subtle connections. Another point made was that the decline of cosmography approximately coincided with the growing acceptance of Copernicism. Jim said that it would have been possible to have constructed a coherent Copernican cosmography but the time for all-encompassing studies seemed to have passed.

At the close of the lecture, Jim was presented with the SIS Medal and he and the other officials all took a ceremonial drink from the 'loving cup' presented to the Society by the Honourable Company of Scientific Instrument Makers. Unfortunately, your reporter could not attend the following buffet as trains to East Anglia called.

John Davis

SUNDIALS OF ST PETERSBURG

VALERY DMITRIEV

[This article is based on the presentation made by the author at the 2008 BSS Annual Conference, Latimer. Ed.]

St Petersburg is a young city. It was founded by Peter the Great in 1703 at the mouth of the river Neva, on coast of Baltic Sea, and became for many years the capital of Russia. The geographical co-ordinates of the centre of St Petersburg are 60° N; 30° E. Sundials appeared in St Petersburg almost from the moment of its birth in the beginning of 18th century.

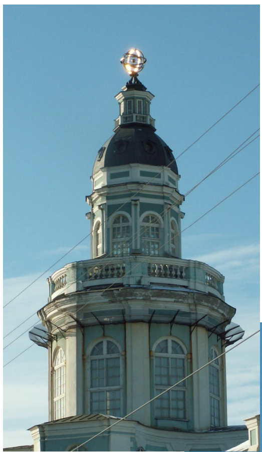


Fig. 1. Armillary sphere on the dome of Kunstkammer.

Armillary Sphere on the Dome of Kunstkammer

Among the sundials of St Petersburg, the first to be described must be the magnificent armillary sphere (model of the structure of the solar system) on the dome of Kunstkammer, made in the first third of the 18th century by the French mechanic Pierre Vinon at the creation of the first state astronomical observatory in Russia and still decorating the panorama of the central part of the city (Fig. 1). In Kunstkammer there is a science museum (Lomonosov Museum) with a collection of 18th century scientific instruments, including a sundial belonging to Peter the Great.

Cadran Solaire on the Menshikov Palace

Within two minutes walk of Kunstkammer, at the palace of the first governor of St Petersburg, Alexandr Menshikov, there is a double sundial, simple and graceful, as part of the architecture of this light-coloured building.[1] After Menshikov's disgrace in 1732, the palace was adapted as part of the military school – the First Cadet Corps.

Fig. 2. The sundials on the Menshikov Palace.

The sundial on the Cadet Corps building was established in the middle of the 18th century and has served townspeople more than two and a half centuries (Fig. 2). In one of the poems written shortly before the Second World War, the well-known Russian poetess Anna Akhmatova mentions this sundial (in French):

> *Cadran solaire on the Menshikov Palace.*
> *A steamship is passing, making waves.*
> *If there is something else in the world that I know better*
> *Than this shining spires and gleaming waters!...*
> *Salty smack – too it doesn't matter.*

Solar Milestones

The unusual milestones established at the end of the 18th century on two St Petersburg roads, connecting St Petersburg with the imperial country residences in Tsarskoe Selo and Peterhof, are directly connected with the sun. The first and last milestones of each road have sundials. Each milestone has two dials – on their southern and northern faces. This is extremely unusual as it is well-known that for

Fig. 3. Milestone with a sundial at the Orlovsky Gate in Tsarskoe Selo.

a north-facing surface, even at the latitude of St Petersburg and in the summer ('white nights') the sun shines for a very short time. The eastern faces of the milesones give the distance to St Petersburg but the western faces, which are not visible to passing travellers, have no inscriptions.

Work on the installation of these milestones began in 1772 and was completed in 1787. Of the four solar milestones, complete sundials remain only on two – at the Obuhovsky Bridge in St Petersburg and at the Orlovsky Gate in Tsarskoe Selo (Fig. 3). The designer of these 'verst pyramids' is currently not known[2] – it may be the Italian architect Antonio Rinaldi[3] or the French architect Jean Baptist Michel Vallen-Delamot.[4] [The verst is a pre-1918 Russian distance measurement, approximately equal to 1.1 km or 0.66 miles.]

In the Top Garden of Peterhof

The magnificent grounds of Peterhof, with the well-known fountains in the Bottom Garden, have a sundial in the Top Garden which is unnoticed by the majority of visitors. The first mention of a sundial in the Top Garden can be found in the album of Saint-Hilaire Pierre of 1772; on the axonometric image of the Top Garden, the sundial is clearly visible in its present position, at the end of the central avenue of the Top Garden near to the Great Palace.[5] The dial face was made from Russian marble with gilt Roman figures; the gnomon was of gilt copper and the whole sundial stood on a pedestal of Italian marble. The dial there carried an inscription:
"O. Richter, St.-Petersburg".[6]

A view of the original sundial comes from a photo of the beginning of the 20th century. It was destroyed during the Second World War, the remains being found in the anti-tank traps dug in 1944. In 1972, under V Matveev's leadership, the face was restored with some changes: thus, the dial's marble slab "has been dressed in a brass" (Fig. 4).

On the Parade-ground of the Gatchina Palace

On a parade-ground before the Gatchina Palace, near to the bastion wall, there is a monument to the Russian Emperor Paul I. Between the bastion wall and the monument pedestal there is a round pillar of a pink granite with the inscription engraved on the eaves "Peterhof 1770". This pillar is the pedestal of the sundial (Fig. 5). The earliest source on the sundial – an inventory of the Palace from 1796 – specifies "a sundial on a marble board".[7]

The sundial was erected during the time of Grigory Orlov, the favourite of Empress Catherine II who originally owned the palace and park. Initially, the sundial stood closer to the palace ramp but it was later transferred to the garden. In 1851 the dial was moved to its present position when the bronze monument to Paul I (by the sculptor I Vitali) was installed on the parade-ground. The actual sundial had been damaged during the Second World War and is not restored

Fig. 4. The sundial in the Top Garden of Peterhof; far left: modern view; left: view in 1930, courtesy of the archive of the State Museum 'Peterhof'.

Fig. 5. The sundial on the parade-ground of the Gatchina Palace at the monument to Paul I. Left: modern view with only the pedestal. Right: from an early 20th century photograph in the Archive of the State Museum 'Gatchina'.

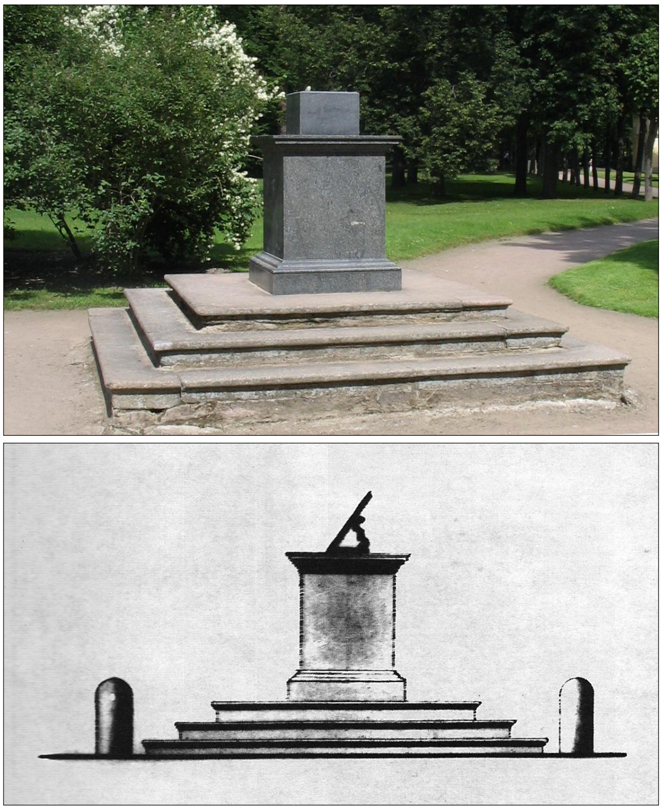


Fig. 6. (a) the pedestal of the sundial in Pavlovsk Park. (b) drawing of the complete dial from an album of 1803.

until now. Its shape was modelled from a photo dating to the beginning of the 20th century (Fig.5).

At the Open-air Cage of Pavlovsk Park

The sundial of Pavlovsk Park originally (1798) stood on a pedestal in the centre of the Smart courtyard. Later, before the installation of a monument to Paul I in 1872, it was transferred to the Open-air cage, between the palace and pavilion.[8] The pedestal of the sundial is made from grey-blue granite: a dial is on a gilded "marble board".

At the beginning of the 20th century, shortly before the First World War, the sundial was stolen by unknown persons but the pedestal remained upon which, in 1968, a stone vase was placed. By the end of the 20th century the vase had been broken and since then the pedestal remains with neither vase nor sundial (Fig. 6a). It is possible to see the sundial on a drawing of 1803[9] in which it is appears without connecting chains between the surrounding columns (Fig. 6b).

In a Shelter of the Lonely Muses

The manor of the president of the Russian Academy of Arts and the first director of the State Public Library, A Olenin, is in Priutino and was a favourite place of creativity for many Russian artists and poets, including great Russian poet Alexander Pushkin. The sundial in Priutino stood on a granite pedestal and had a marble dial under a glass cover – a rare way to protect a sundial from a bad weather.[10] The sundial was installed in the first third of the 19th century. The pedestal is in its original location (Fig. 7) but, unfortunately, the sundial no longer exists and no photographs are known.

Demidovsky Sundials

The manor of Ural mining industrialist A Demidov is in Taici and was constructed in last quarter of the 18th century. It has a marble sundial with the monogram of the owner of the manor and four dials – surprising in its beauty, grace and accuracy of calculation. The sundial is still there though it is separated from its pedestal.

Fig. 7. The pedestal of the sundial at the manor of Pritutino.

Fig. 8. The sundial in P Demidov's manor in Sivorici.

In Sivorici, the manor of the brother of A Demidov (P Demidov) also has a four-faced marble cube dial on a granite pedestal. It also has the monogram of its owner and it still exists, though it has lost its gnomons (Fig. 8). The Taici and Sivorici dials are rare variants of those remaining in vicinity of St Petersburg.[11]

Both the Demidov's manors were constructed during the 1770s by the same architect, I Starov. Since the dials at Taici and Sivorici are very similar in design, it is reasonable to assume that they were executed by one master whose name, unfortunately, is not known.

At the Konstantinovsky Palace

There was a sundial at the Konstantinovsky Palace in Strelna, currently the Sea Residence of the President of Russian Federation. The date of this sundial is not known. It is recorded that, until the middle of the 19th century, a sundial at the Strelna Palace, standing on the granite pedestal supported by four stone steps, had been shaded from the sun by trees and had lost its functional purpose.[12]

The sundial was restored under the orders of architect A Stakenschneider in 1850 and put in the middle of a special platform on an open meadow. Unfortunately, we have no the image of the sundial and when the Palace was restored more recently it was not mentioned.

Legend of the Polish King

In a diary of the Polish King S Ponjatovski, who visited Gatchina at the end of the 18th century, there is the first mention of a sundial in Konnetable Square:

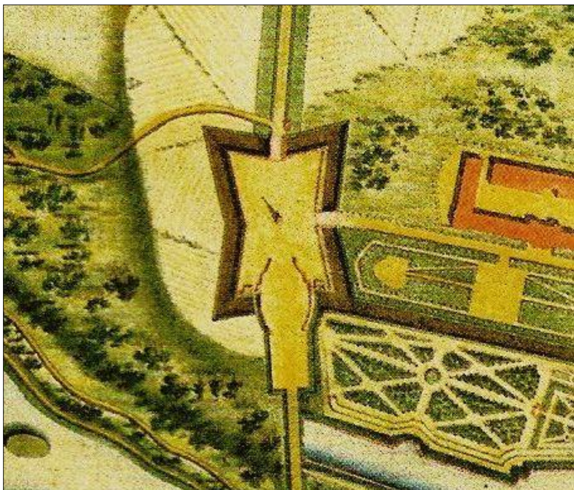
> "... on September, 6/17th, 1797. The king has gone to examine an obelisk from a stone, which Emperor has enjoined to construct on the main road to Gatchina. It is 40 feet high. Nearby there is a wall on which figures of day time are beaten out, the shadow from an obelisk serves gnomon. It reminds us of a similar gnomon, arranged by Augustus in Rome" [13]

This record has formed the basis for much recent speculation on the Konnetable sundial.

Recent surveys of the Konnetable Square and calculations by N Mishchik have shown that, with the known current height of the Konnetable obelisk and the size of the square, a sundial could only work in the spring and summer months and for a limited period each day (Fig. 9). It is probable that the sundial of Konnetable Square is just a beautiful legend of the Polish King.

The Sundial of Neptune

A monument was built in 1971 on the quay of the Moika River at the Dark Blue Bridge, showing the floods of St Petersburg. This obelisk has marks showing the waterlevels of the most catastrophic floods – in 1824, 1903, 1924, 1955 and 1967. It is topped by a decorative composition with a trident (the symbol of Neptune). Three faces of the obelisk have sundials (Fig. 10). The granite column (architect V Petrov; engineer P Panfilov) is a modern version of the 18th century marble milestones.



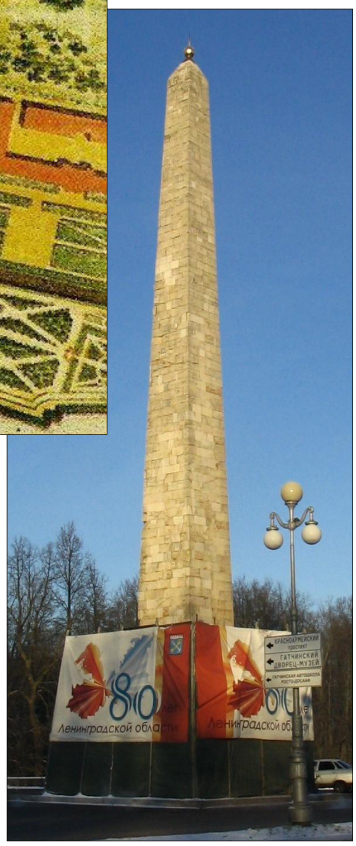


Fig. 9. Right: the obelisk in Konnetable Square, December 2007.
Above: a fragment of the general plan of the Gatchina Palace and Park. Kushelevsky album, 1798.

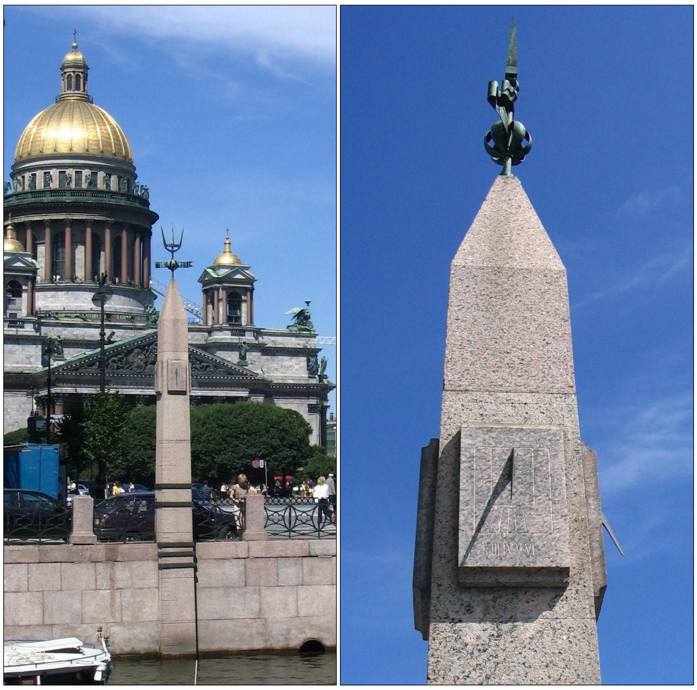


Fig. 10. The sundials on the flood monument at the Dark Blue Bridge.

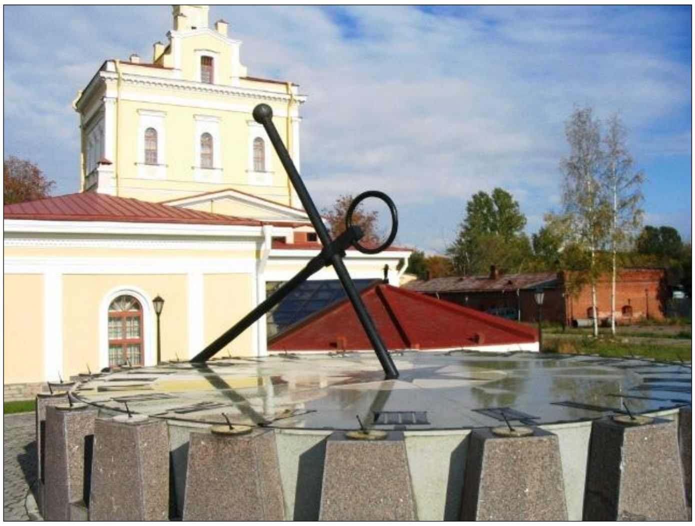


Fig. 11. The sundial in Kronstadt.

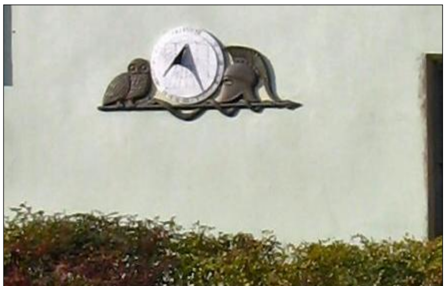


Fig. 12. The sundial in a courtyard of the philological faculty of St Petersburg State University.

The Kronstadt Sundial

Kronstadt is a former sea fortress on the Baltic Sea. The Kronstadt sundial (Fig. 11) was constructed in 2005. A former water tower was converted into a museum of the history of the city of Kronstadt and the sundial, designed by V Kahi, is adjacent to it. As well as the central dial with an anchor as its gnomon, there are twenty-four smaller dials each with a separate gnomon. These small dials have the names of various cities of the world.

"Together Forever"

In 2002, a park of modern sculpture was opened in a courtyard of the philological faculty of the St Petersburg State University. On the same day, 24 May, the philologists and orientalists established a small but graceful and symbolic sundial "МЫ НАВЕКИ" or *Together Forever* (Fig. 12). The designer of the sundial was G Postnikov.

The history of St Petersburg's sundials can be classified as: 18th century – gold; 19th century – bronze; 20th century – pig-iron, steel and destruction. It is difficult to predict what this century will bring. Time will tell.

All photographs are by the author, 2008, except where noted.

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IS THAT A DIAL? – BARCHESTON, WARWICKSHIRE

JILL WILSON and TONY WOOD

The churchyard cross occupies a marginal place in the sundial world, usually as a truncated column where it is convenient to put a sundial, perhaps post-Reformation. Very occasionally the cross-shaft bears vaguely mass-dial-like marks on its south side but so far no really good mass dial has been found. More importantly, the base of such crosses has been used for a horizontal mass dial. Nearly half a dozen have been found in Scotland[1] mainly in the Western Isles or Argyll regions. The sole example so far found in England, at Lolworth in Cambridgeshire, is well removed from Scotland and from the English mass dial tradition. It has survived because it is inside the church protected from the elements and footsteps.

Fig. 1. The stump of the Barcheston cross.

At Barcheston in Warwickshire, the churchyard cross and shaft early disappeared but the remaining base must have held a place in the regard of the parishioners as it was converted into a sundial (Fig. 1). One of us (JW) noticed that the stonework sloped at 52° and just happened to be carrying a protractor formed from a credit card cut to that angle. It confirmed that the stonework had been trimmed to the correct angle – *on the south side.* Further extensive stonework removal had made two recessed flat regions and, on close – very close – inspection, there were the traces of hour lines amongst a fair growth of moss and lichen (Figs. 2 & 3) but no numerals are visible.

Fig. 2 (left). The polar plane or thick gnomon, viewed from the SW. Note the credit-card protractor.

Fig.3 (right). The horizontal surface to the SE of the (very) thick gnomon.

There is no evidence of markings on the vertical surfaces. So we have a large dial with a gnomon 11½ inches wide casting morning and afternoon shadows onto widely separated horizontal surfaces. All of which raises the questions of when and why?

Barcheston has a few mass dials and one might have expected a vertical scientific to follow, carved into the wall. A horizontal church dial should be later than a vertical one but the transition from mass dial to scientific, whilst quite evident,[2] doesn't seem to have been universal and some early horizontals are known which owe nothing to mass dial tradition.[3] In classification terms it is a 'large horizontal in stone' but must have the widest gnomon yet recorded.

We were not the first to discover this sundial: Peter Drinkwater, author of *The Art of Sundial Construction,* mentions it in his book on old Cotswold paths[4] and adduces that the locals were prepared to convert the base into a sundial in the absence of a column. It seems that having a sundial was considered most important.

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A RUSSIAN ANALEMMATIC DIAL

ALEKSANDR M BOLDYREV

Shelkovo is a small town near Moscow. The river Kliazma flows steadily through it. A few years ago, Dmitry Barchenkov, a businessman from the town, concluded that the banks of this river should be improved as they did not match his ideas for the town development. Last year he built a very nice embankment along the riverside but was not satisfied with the result. It needed something unique and inviting that nobody had ever seen in this country.

I proposed to make an analemmatic sundial. I thought that nothing would be more unusual than an analemmatic sundial installed into the paving of the embankment and it became clear that this was the right idea. This article describes the way my friends and I made this sundial.

First of all, I made a drawing for coordinates 55° 55.504′ N; 37° 59.813′ E. I used the algorithm of Carl Sabanski published in the Internet.[1] By means of AutoCAD™, I drew the scale of dates and the ellipse with hour marks for standard time and for daylight saving time. AutoCAD is a very useful program for designing sundials. By using parametric designs, it produces high resolution pictures for showing to Council members who do not need mathematic details but who are responsible for the city's architectural appearance. During the period of discussion, the main difficulty was to come to an agreement with the customer about the inscription on the information board. We wasted a great deal of time trying to choose the best one. Finally the inscription *"Know the time and refrain from evil"* was accepted. It is a quotation from a medieval Christian philosopher, Jesus the Salach's son.

Making the Casting Models

Models may be made of any material. We made them of plaster-of-Paris (gypsum). We filled moulding boxes, specially made of plywood, with the gypsum mixture. Then, when it had set hard, we carved out the figures and the parts of the scale of dates with ordinary chisels (Fig. 1).

The next step was to turn the gypsum models into beeswax copies. We made wooden boxes, put the gypsum models into them (face up) and filled the box with a two-part silicone. This produced a silastic 3D mirror reflection of the model. Then we filled this silastic reflection with molten beeswax into which some aniline dye was added to show up blobs, scratches and imperfections clearly (Fig. 2). To each wax piece we welded a small wax funnel and one of two

Fig. 1. Sculptor Sergey Seriozhin shows the figure '20' that he just has carved. It is a precursor of the bronze numeral for the dial.

wax rods; the tip of the funnel cone and the end of rods being attached to the same edge of the detail. The former is a filling port for the molten bronze, the latter serves as an air hole.

Making the Ceramic Mould for Casting

We prepared a mixture containing, by weight, 60% of dry gypsum and 40 % of fireclay powder. Little by little we added water to this mixture and agitated it with a stirrer until a creamy consistency was achieved. We coated each wax piece carefully with this cream, put them into wooden boxes (the funnels and air holes are on the tops of the pieces) and filled the boxes up with the rest of the mixture.

Fig. 2. Sculptor Victor Ardyniev demonstrates a wax model of part of the date scale.

Fig. 3. The casting process. The relaxed-looking gentlemen in the background is in fact the main personage – sculptor Sergey.

Twenty-four hours later we put the boxes into a furnace and left them there until the melted wax had flowed out completely.

Casting and Finishing

We cast the details in Sergey's studio. It is well equipped but the capacity of the smelting furnace is rather small at 15 litres. We could have placed an order for casting in a larger foundry but we thought that it was a matter of honour to make everything with our own hands. So we had to repeat the melting process (Fig. 3) more than once. The 'bronze' used was actually a leaded gunmetal (85% Cu; 5% Zn; 5% Sn; 5% Pb), selected on cost grounds.

The pieces coming from the moulds looked very unattractive. They were covered with ridges resulting from cracks in the moulds produced by the high temperatures. We removed these ridges with sandpaper and polished the surfaces with abrasive paste.

The thickness of the bronze plates is about 10 mm. This means that any criminally-minded person could break an installed piece off with a simple crowbar. To complicate the 'work' of such persons, we welded bronze rings to the backs of the pieces, put 15 mm diameter steel reinforcement bars through them, and cast reinforced concrete plates around them. Thus the resulting weight of the dial numerals and the date scale had risen from 50 kg to 300 kg. Six strong and healthy workers could barely carry the scale of dates (Fig. 4). So let vandals just try.

Building the Foundations

While we were carrying out our studio experiments, workers had divided off the elliptical area of the embankment paving and excavated the foundation trench. The bottom of the trench was at a depth of 1 metre. They put in a 60 cm thick layer of sand with, above it, a layer of crushed stone (15 cm) and then poured a 15 cm thick concrete raft. They

Fig. 4 (top). The date scale weighs about 300 kg.
Fig. 5 (centre). Reinforcing the concrete foundation.
Fig. 6 (bottom). Stone paving in the rain.

reinforced the raft with a mesh of steel bars 15 mm in diameter. A home of average size might be safely built on such foundations (Fig. 5). The reliability of this design leads us to hope that the sundial will not be in need of repair for at least a few centuries.

Installation

We had very fine weather for all the preliminary work. But it was spoiled on the very day we started the installation. Downpours alternated with thunderstorms and prevented us from laying the granite setts onto the makeup cement-sand pad. Our building yard had turned into a sort of morass and there was a danger for all of us to get bogged down in it

(Fig. 6). It was already June 17. A grand opening ceremony set the deadline on the summer solstice. Mrs Ershova, the Head of City Administration, came to see us twice a day to insist that we should finish the work on time at all costs as the cosmonauts, popular actors, a brass band, local clergy, leaders of local political parties and other honourable guests, including the rest of the city population, were already invited and must not be disappointed. Dmitry Barchrnkov, the main sponsor and one of the authors, saved the situation. In a few hours, a team of his house-builders built a complete cover over our building yard. It was made of corrugated steel and was supplied with roof, door and even windows.

Fig. 7. Rubble infill of the information plate stand.

A important matter was to make a base for the inscription plate. We made it of granite slabs forming a kind of prism with a rubble-work infill. The jointed edges of the granite parts were carefully adjusted to each other. The joints were invisible to the naked eye (Fig. 7). So we hope that algae and other micro-organisms never settle and destroy them. The final result is shown in Figs. 8 and 9.

Fig. 9. The inscription plate.

The Great Opening

Everything that the Head of City Administration told us became a gospel truth. There was a brass band, passionate speeches, honourable guests, girls' choral singing, and even anthems. The only thing missing was the sun: the day brought foggy cold weather. But who we are to grumble about this?

Two months later I happened to meet Mrs Ershova again. The window of her office opens onto the embankment just opposite the sundial. She told me that, according to her observations, the most inquisitive citizens of the town of Shelkovo try to use our sundial even at night. I feel that something is right here.

A detailed photo report can be found at:
http://www.sundials.ru/shelkovo-mounting.html.

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1. Carl Sabanski's website 'The Sundial Primer' is at www.mysundial.ca/

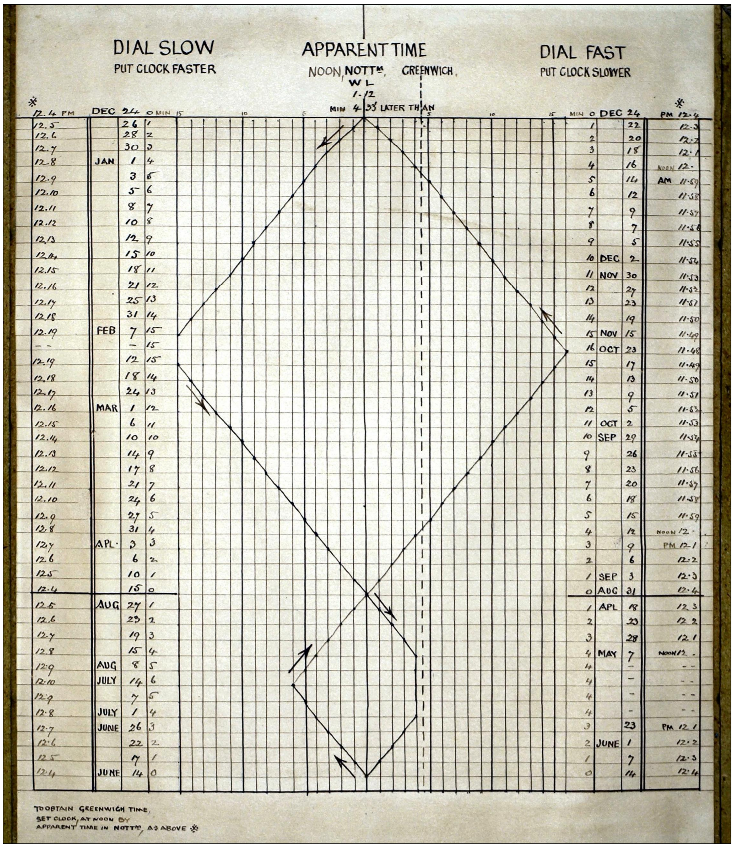
Fig. 8. A general view of the final result.

AN UNUSUAL EQUATION OF TIME DISPLAY

JOHN DAVIS

The drawing shown here was found in a cupboard by the librarian of the Bromley House Subscription Library, Nottingham, where the BSS has its library. It is neatly drawn in pen on the inside cover of a large notebook, though the rest of the notebook is now lost. The librarian thought the drawing might be related to the meridian line which is on the floor of the library,[1] or perhaps associated with one of the longcase clocks there. She showed it to BSS Council members at our recent meeting there and, although it was obviously some form of Equation of Time (EoT) chart, the exact format was unfamiliar.

The drawing looks rather like an analemma, though with straight lines rather than the normal figure-eight curves. Was this just a gross approximation or was it some form of experimental observation? A little thought clarified things. The vertical axis is not the sun's declination, as it would be for an analemma, but the calendar date. The dots, which all lie on the straight lines, show the EoT in whole minutes. This is only possible because the date scale is highly non-linear: in fact, the dates have been carefully and individually chosen to give the required integer values. Thus it is the converse of the curved 'Watch Faster / Watch Slower' scales seen on many high-quality 18th century horizontal dials. These have equi-spaced date scales matched to a non-linear EoT scale, usually of minutes but sometimes also including half-minutes.



The chart is not dated. With only the coarse 1-minute steps of EoT, it is not easy to identify the source of the data-set by matching it with published tables, available in a database.[2,3] One of the best clues is that a peak value is shown as 15 minutes (dial slow) from 7 Feb to 12 Feb. By a modern table, the maximum value in February is 14m 21s and so would round down to 14 minutes. One has to look back into the 19th century for the peak to exceed 14m 30s and so round up to 15 minutes. In fact, it is in the 1830s or 1840s when the EoT was ≥14m 30s for 5 days in February. Of course, the chart may not have been drawn at this date, it may merely have been using data published then. However, as the meridian line dates to 1836,[1] it seems likely that the chart is contemporary with it.

One other difference between the presentation on this chart and the 'Watch Faster' scales is that here, the EoT is shown rounded to whole minutes on each day whereas for the Watch Faster scales a day is chosen for the value to be exactly a whole number of minutes. The effect is subtle but does mean that there is a slight displacement in the dates chosen for a given value.

The chart carries the initials "W L" near the top. It was initially thought that these might be the initials of the chart's author: Christopher Daniel jocularly suggested it might be William Leybourn – a nice thought but almost certainly not right! It is more likely that they stand for West Longitude.

The longitude value for Nottingham is given on the chart as 1° 12' [W] and the time offset from Greenwich as 4m 33s. Although this longitude actually translates to an offset of 4m 48s, the true longitude is nearer to 1° 9.1' W so the quoted time difference is very nearly right. It is the same time difference from Greenwich as the value engraved on brass plates on both the longcase clocks in the Library.[1]

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DIAL DEALINGS 2008

MIKE COWHAM

I seem to complain each year about the lack of good dials in sales but then I manage to find a few exceptional examples that are worth talking about. This year is no different and a few really good dials were seen, but it sometimes takes a lot of searching. Unless otherwise stated, prices quoted below include the buyer's premium.

Fig. 1. Small horizontal dial by Richard Hintonn.

15 January 2008. Bonhams 'The Gentleman's Library Sale' was, as it suggests, mainly books but it included a few instruments and other collectables. Of the two dials offered, I liked the small 11.7 cm horizontal dial, Fig. 1, signed by the unrecorded maker, *Richard Hintonn*. Bonhams date the dial as 18th century and it sold for just £396.

30 January 2008. In Salisbury, Woolley & Wallis had one of their regular sales of silver. This is not normally the place to find a sundial, but in this sale was a French string gnomon dial in silver. It did not at first sight look particularly interesting but I was determined to check it out, just in case, and was quite surprised with what I found. As it happens, I have not seen a dial like this (Fig. 2) before so it is worth detailing some of its features. The dial is unsigned, quite unusual for a dial of this quality. The string gnomon is fixed at the top of the spring-loaded arm and on the dial plate. To change the latitude setting a small slider moves up and down the arm, and as it moves down to a lower latitude the arm has to fold towards the dial plate see Fig. 3). Although a very simple concept is involved, the string length is critical so that the correct angle is achieved. Any stretching or shrinkage will reduce the dial's accuracy. It is very difficult to calculate this angle and it was almost certainly done by the maker empirically. Furthermore, around noon the vertical gnomon support gets in the way of the shadow on the outer scale but this in not a problem as the other two scales can still be used as there is little difference between the calibrations so close to noon. The dial was complete with its wooden box. It sold for £950 plus buyer's premium.

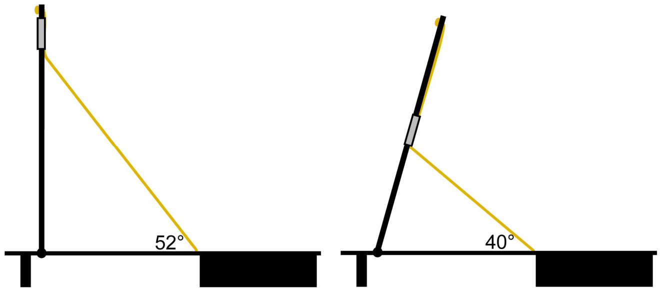


Fig. 2. Unsigned French string gnomon dial
Fig. 3. How the arm moves for a change of latitude.

23 April 2008. Christies South Kensington's sale of 'Travel, Science and Natural History' contained a selection of dials, from which I have picked just two. The first is a good inclining dial in gilt brass signed *CHAPOTOT A PARIS* (Fig. 4). These inclining dials are usually octagonal, like the more common 'Butterfield' dials, but they cover a more useful range of latitudes, generally from the Equator to 60° north. On the fixed dial plate are engraved the latitudes of 18 French towns and a further 18 non-French towns are on its underside. This dial was sold for £4000.

The other dial that I have selected from this sale was a real rarity. It is described by Christie's as a 'Star shaped

Fig. 4. Gilt inclining dial by Chapotot.

Fig. 5. Star-shaped polyhedral dial.

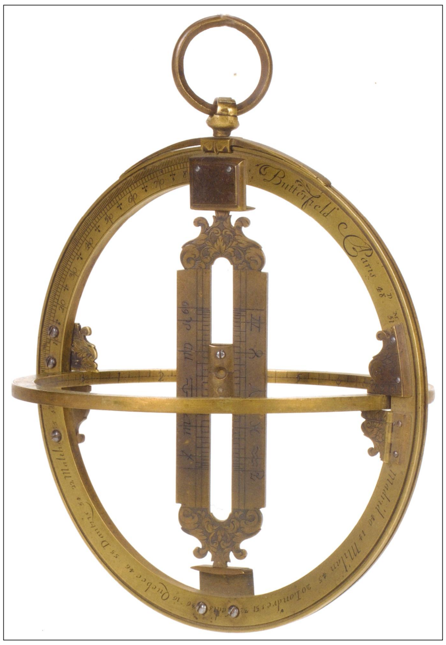
polyhedral dial' (Fig. 5). One of these is in the Germanisches Nationalmuseum in Nuremberg and others are in the British Museum and MHS Oxford. The dial is made from gilt brass and measures only 5 cm in length. It was probably made in Nuremberg in the 16th century. Each of the points of the star throws its shadow onto one of 16 faces. The dial is propped up by a support arm that may be set at latitudes from 32° to 60°. In its centre is a cover for the compass, whose bowl should be mounted on gimbals but it was missing on this dial. The hole on the lower arm of the star is probably so that the dial can be hung on a cord or chain around the neck. When I examined this dial carefully it was seen to be in need of some restoration, being slightly twisted but nothing seriously wrong. At the sale it made a very healthy £26,900.

18 November 2008. At Bonhams final sale of instruments for the year were three dials that I would like to highlight.

The first was a fine example of an ivory diptych dial signed by *LIENHART MILLER 1622* of Nuremberg (Fig. 6). It was also stamped twice, on the upper face next to the hinges, with his initials *L* and *M* separated by a crown. As with many of these Nuremberg dials, it is covered on all four faces with scales. The upper face has a wind rose with a small pointer at the centre of a 32-point compass, then surrounding this are the names of eight winds *TRAMANTAM, GRECO, LEVANTE, SIROCHO, OSTRO, LONENTE, PONENTE* and *MASTRO.* In the pocket to the side of the dial was a wind vane but it was probably not the original. It is very rare to find original wind vanes or pin gnomons for these dials, most having been lost over the years. Its vertical face, under the lid, has holes to tie the top of the string gnomon from 39°-54°, a list of 33 towns with

Fig. 6. Ivory diptych dial by Lienhart Miller of Nuremberg dated 1622.

their latitudes and a small pin gnomon dial showing the zodiac signs and day lengths. The horizontal face of the lower tablet carries the main dial with six separate rings for the range of latitudes and two small pin gnomon dials for Nuremberg hours and Babylonian hours. On its underside is a lunar calendar volvelle with the four quarters marked including Moon symbols - *DER NEYMAN, DAS ERST VIERTL* (sic)*, VOLMAN* and *DAS LECZT VIERTEL.* An interesting feature of the dial is that where the numeral **I** (1) has been placed on a calibration line it has been skewed by about 30° so that it is not lost in the line itself. This can be



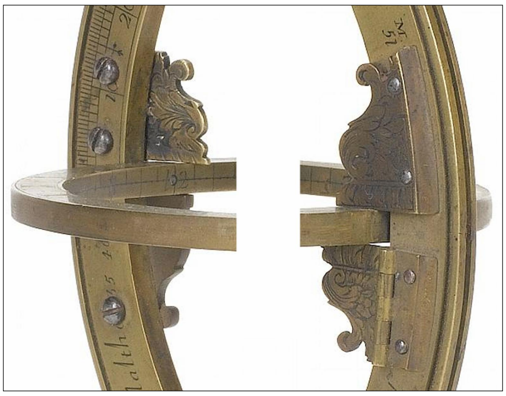
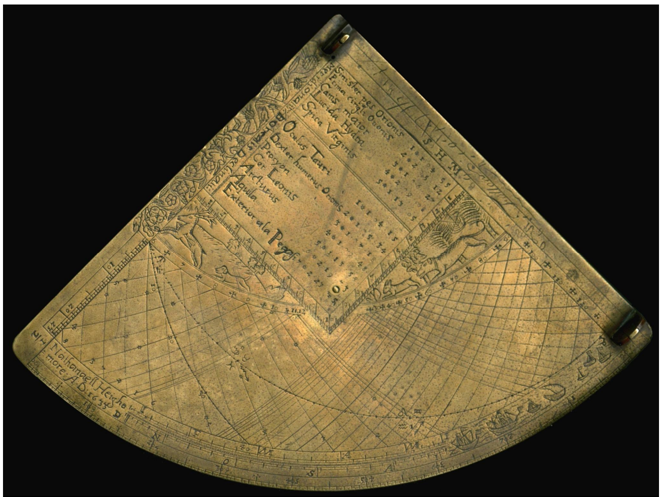


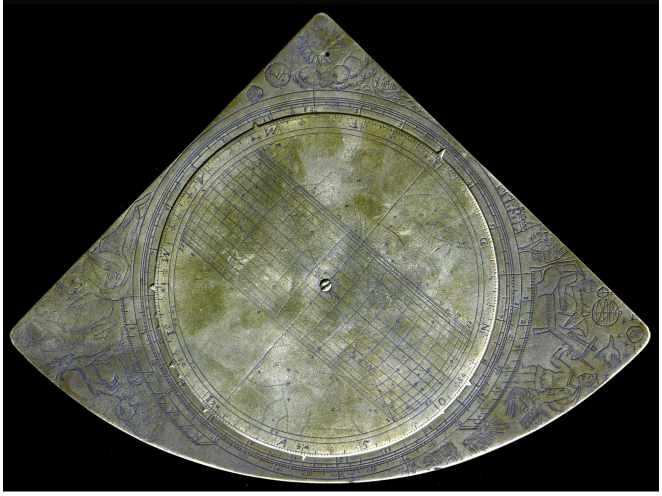
Fig. 7. (left) Universal equinoctial ring dial by Michael Butterfield.
Fig. 8. (above) Detail of the hinged locks on the Butterfield ring dial.

Below and below left:

Figs. 9 & 10. Gunter quadrant by Nathanaell Heighemore, 1633, showing some of its fine engraved scenes.

Figs. 11 & 12. Detail engraving on the Heighemore quadrant.

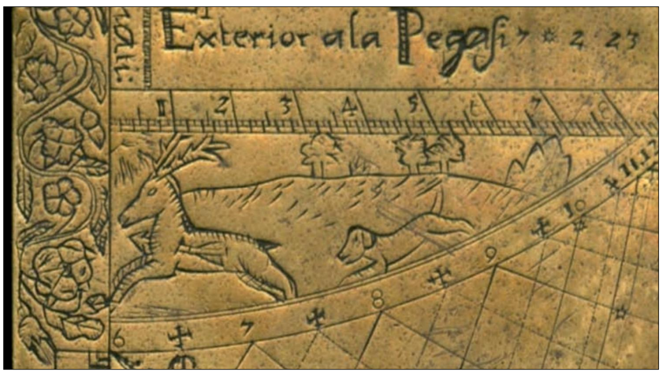




seen in the photograph with the **I** on the main dial and that on the Babylonian dial, bottom right. This fine diptych dial sold for £9000.

The following lot was a brass universal equinoctial ring dial (Fig. 7) by *Butterfield AParis*. Ring dials by Butterfield are uncommon as he seemed to concentrate most of his efforts into making his well-famed 'Butterfield' dials. This larger-than-average 16.5 cm diameter ring dial was made just for the northern hemisphere and was engraved with 35 towns and their latitudes. One unusual feature of this dial were two decorated hinged stops that could be folded out, to lock the chapter ring at right angles for use. These can be seen in the two detailed pictures of Fig. 8, the left one above and the right one below the ring. When not being used they fold flat against the outer ring. It sold for £6600.

The final lot in this sale was my favourite being a brass Gunter quadrant, 11.5 cm radius, signed and dated *Nathanaell Heighemore A:D: 1633* (Figs. 9-12). It was somewhat naïvely made by this provincial maker but it was beautifully decorated with flowers, ships and hunting scenes. One scene on the front shows a stag with an arrow through it being chased by a dog. On the reverse was an Organum Ptolomei or Rojas projection on a rotating disc, the surrounding plate with further scenes of the Sun, a ship,



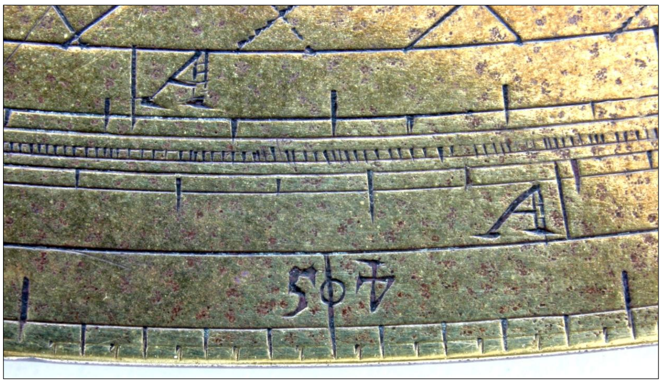


Fig. 13. Outer degree scale of the quadrant showing 50° and the inverted 40° using a common 0.

a mathematical instrument workshop and a scene with a mermaid playing a lute being watched by another woman plus a stag, a lion and an elephant; a strange combination of creatures! An unusual feature of this quadrant (Fig. 13) is the way that the degree scale was marked, from 0-90 from left to right and from 0-90 from right to left, this time inverted, but with both sets of degrees sharing the same 0. This most individual quadrant also made £6600.

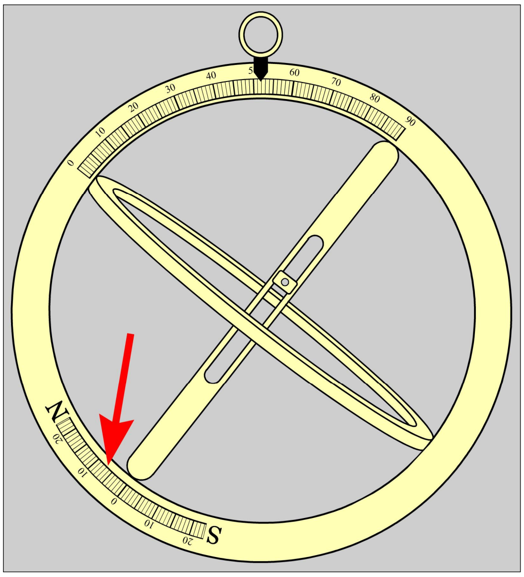
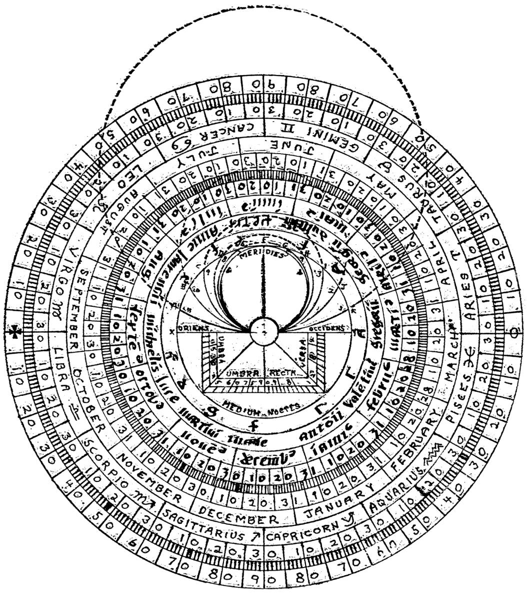


Fig. 14. Mystery scale on ring dial.

2 November 2008. The Scientific and Medical Instruments Fair in London is always a good place for dial hunting and at this Fair were several good dials. One that attracted my attention was a universal equinoctial ring dial, unsigned, but with an unusual declination scale on it. I have been trying to work out how this scale could be used in practice. It is placed at the position of the South Pole. I have made a sketch of it in Fig. 14 and would welcome any ideas as to how this scale is to be used on this dial. I feel that it has to be something to do with measuring the Sun's altitude to determine latitude or to find the exact time of noon (which is normally hidden by the vertical ring on these dials).

The other object that particularly interested me was a printing block showing the back plate of an astrolabe. For the few pounds that it cost it was worth having and I have since been trying to determine all of the scales on it, some quite unusual. Such things are difficult to date and I have not been able to find the book that it was used to print, but my guess is that it dates from the late 19th to early 20th century. However, the astrolabe depicted is much earlier. In particular, the central part is in Gothic script, showing the Julian calendar. This probably dates to around 1500 but the outer scales in English are more recent additions using the Gregorian calendar. The most unusual part for me was the



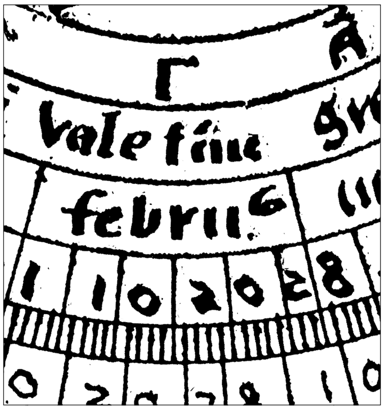


Fig. 15. (top) Printing block of astrolabe.

Fig. 16. (above) Detail of astrolabe print.

Fig. 17. (left) St Valentine's day identified by the Greek letter **Γ** *exactly above the 14 on the* ***febru***[6] *scale.*

listing of 12 saints' days, one for each month, but the actual day of the month for each saint is shown only by a letter positioned exactly in line with this date. This letter is the dominical letter giving the exact date and day of the week for each year. The apparent use of Greek letters for January and February are probably to show that these letters may differ in those two months due to the possibility of there being a Leap Year. Another unusual aspect is the shadow square where the left half is calibrated in degrees and the right, as usual, divided into 12. The extension of the circles (dotted) for planetary hours is unexplained unless this was an illustration to show how these circles were constructed.

ACKNOWLEDGEMENTS

I would like to thank the following for allowing me to use their photographs.

Bonhams, London for Figs. 1, 6, 7, 8, 9, 10, 11 & 12 with particular thanks to Jon Baddeley who supplied detailed pictures of the Heighemore quadrant.

Christie's for Figs. 4 & 5.

These pictures remain their copyright and may not be reproduced without their permission.

Mike Cowham
PO Box 970, Haslingfield,
Cambridge CB3 7FL

Postcard Potpourri 11 – All Saints' Church, Hillesden, Buckinghamshire

Peter Ransom

This is my only example of a scaphe dial on a postcard. It is recorded in the BSS Register, SRN 5016, and the description there mentions that it is a half sphere (surely this is but a quarter sphere?) with the motto 'Sic transit Gloria Mundi' around the lower semi-circle and '1601 Georg De Fraisne' across the top, the S being written backwards. The postcard is unused, but has the date 12/11/37 written in pencil on it.

The dial is carved into the buttress near the priest's door and shows the full hours drawn from the lower gnomon attachment, with half hour divisions strategically placed on the arc that runs along the dial. There is a nice picture of the dial at http://www.wishful-thinking.org.uk/genuki/BKM/Hillesden/AllSaints4.html
The internet picture shows that the stone above '1601 Georg' has been replaced since the postcard was printed.

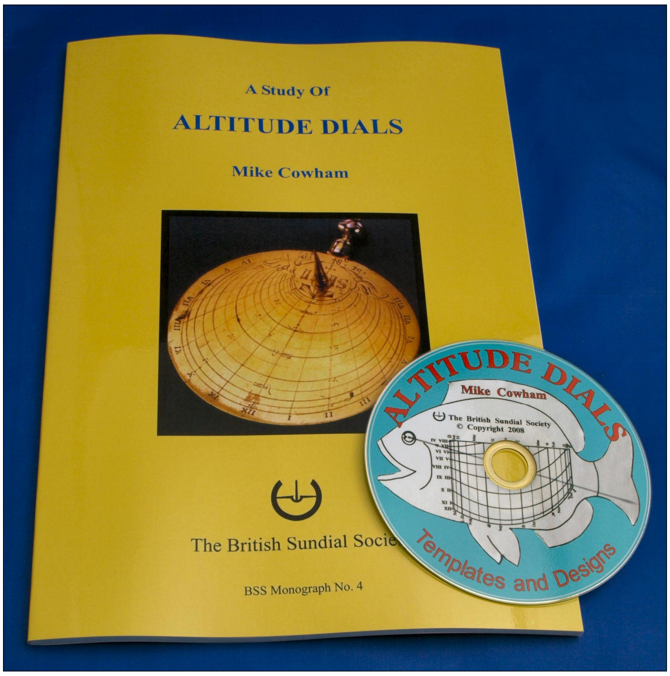
The church is of 15th century origin and was restored in 1493. It stands on the site of an earlier 12th century church and incorporates 12th century masonry in its foundations. The famous architect Sir George Gilbert-Scott restored it in 1874.

pransom@btinternet.com

Many thanks to Michael Lowne for the information he provided on the Wimborne Minster dial in the last Bulletin.

BOOK REVIEW

A Study of Altitude Dials by Mike Cowham
BSS Monograph No 4. A4, soft covers, viii + 63 pages, colour and b&w illustrations throughout, includes CD-Rom, ISBN 978-0-9558872-0-8. Price £14.50 inc UK postage from BSS Sales.



A Study of Altitude Dials by Mike Cowham has been issued by the BSS as Monograph No 4. There is a forward by Dr Ilse Fabian of the Sundials Group of the Austrian Association of Astronomy.

In his preface to the monograph, Mike tells us that this study was prompted when he came across a most unusual dial by Erasmus Habermel which appeared to be neither a vertical dial nor what he thought was an altitude dial. Having solved this particular problematic dial, he embarked upon the self imposed task of constructing many other types of altitude dial, each constructed for the latitude of Cambridge, 52º N.

We are all familiar with the so called 'direction dials' which rely on the sun's daily passage from east to west using a gnomon parallel to the earth's axis. These generally have to be in a fixed position or have a compass included to find north – care being needed to allow for magnetic variation. Altitude dials, in contrast, are designed to be portable, relying solely on the height of the sun in the sky to give the time. Clearly, this height is dependent on the latitude of the user and the time of year and these variables have to be built into the design. Their accuracy is generally less good than directional dials and they are more accurate towards equatorial latitudes as the sun's altitude is substantially constant at the poles!

The Introduction to the monograph gives a comprehensive foreward to the construction, accuracy and ease of use of this type of dial, together with explanations concerning shadow lines and an analysis of dial calibrations.

There then follows an explanation and classification of the various types: fixed latitude dials such as pillar or flag dials, chalice dials, circular plate dials, 'Ham' and vertical disc dials, ring or poke dials, quadrant dials and 'others' (Capuchin, planispheric astrolabe). There are also details of a number of universal dials. In all, 38 different types are described in detail with copious diagrams, illustrations and colour photographs.

There then follows a detailed section showing how the models were, and can be, constructed. Mike used a general drawing package to produce his replica dials, most were made to fit onto an A4 sheet. He makes the point that the techniques described also apply to conventionally drawn dials, but suggests that the use of templates can assist greatly. Where slightly different construction techniques are required, descriptions are given together with tips on the most suitable materials. Finally, there is a step-by-step photographic guide showing how the whole thing is put together onto substantial backing card after printing.

Mike stresses the enjoyment to be had from making your own altitude dials for your own latitude but, just in case the reader finds that too daunting, the monograph includes a CD-Rom which contains high resolution images of 38 different types of altitude dials, each delineated for 52º N, which can be printed off directly. It also has a full set of templates to aid construction for those who wish to take up the challenge.

This is an excellent addition to the prestigious series of BSS monographs. I'm sure it will fire the enthusiasm of members to try their hand at making and using a type of dial that they may not, as yet, be overly familiar with using. I was lucky enough to get my copy in late December – I treated it as a very welcome early Christmas present.

Mike Shaw

THE SUNDIAL AT GLAMIS CASTLE

DAVID GAULD

[The author is an amateur historian and a tour guide at the Castle. Ed.]

You *may* have heard of Glamis Castle. It is a tourist attraction open to the public for most of the year. The seat of the Earls of Strathmore and Kinghorne, it was the childhood home of Her Late Majesty Queen Elizabeth the Queen Mother, and the birthplace of the late Princess Margaret. Shakespeare mentions "Thane of Glamis" in his play, Macbeth, and the castle is pictured on the £10 notes issued by the Royal Bank of Scotland

You may *not* have heard that the Castle has a magnificent sundial! (See Fig. 1 and the front cover.) The literature[1-5] gives architectural descriptions, but it may be worth expanding in order to detail some of the more mathematical features.

Fig. 1. The sundial at Glamis Castle (SRN 1489).

It was fashionable in Scotland between about 1620 and 1730 to erect obelisk dials with other types of dial incorporated within the pillar.[4] The Glamis sundial is a particularly fine example of this, ingeniously including the Earl's coat-of-arms and coronet with 84 time-recording faces. It is one of the largest sundials in Scotland. The art of the designer, the skill of the stonemason, the genius of the mathematician and the pride of the earldom are all exuberantly displayed in this extraordinary celebration of geometrical shape and aristocratic confidence. The carving, sometimes described as 'baroque', is superbly and delicately executed. The dial may be tentatively dated to about 1683 because the Third Earl of Kinghorne (1643-1695) confided to his diary[6] the tantalisingly brief statement, "*There is in the garden a fine dial erected*" sometime between the years 1678 and 1684. However, Slade[5] dates it to before 1660.

The dial to a certain extent looks as if it might consist of *two* dials, each originally intended to be ground mounted, with one placed on top of the other. However, that hypothesis is not mooted in any literature we have seen, so we shall continue to assume that it was always intended to be as it now is, and so may be described in three parts: the obelisk, the lion dial and the pineapple.

The Obelisk

The whole structure stands 21 feet (6.5 m) high. It is mounted on an octagonal plinth situated in the lawn to the south of the castle and to the east of the main drive at a latitude of approximately 56½° North and a longitude of approximately 3° West.

The top consists of an eleven-point coronet standing on a fleur-de-lys supported by what could possibly be described as four modified logarithmic spirals. One corner of the plinth points due north (see Fig. 2). Local apparent noon may be determined when the shadow of the whole obelisk falls in the direction of that north-facing plinth corner.

Fig. 2. One corner of the octagonal sundial plinth points north. When the shadow of the obelisk falls on this corner it is local apparent noon. This photograph was taken in the early afternoon when the shadow had moved past the noon point.

The Lion Dial

The lion dial consists of four vertical dial faces carved in stone – one for each cardinal point of the compass (Figs. 3 (a-d)). Each of these faces is supported by a carved lion sitting on a tree stump. They are reminiscent of the lion rampant in the earl's coat-of-arms and also in the royal

Fig. 3. The lion dials: (a) north, (b) south, (c) east (d) west.

standard of Scotland (Fig 4). The south face (meridional) is elliptical in shape measuring 19 inches by 14 inches (48 cm by 35.5 cm), the east face (oriental) is 13½ inches (34 cm) square, the west face (occidental) is rectangular measuring 15½ inches by 13½ inches (39.5 cm by 34 cm) and the north face (septentrional) is circular measuring 16 inches (40.5 cm) in diameter.

The hours marked are:

South face	6am – 6pm
North face	4am – 6am and 6pm – 8pm
East face	6am – 11am
West face	1pm – 6pm

The hours are numbered using Roman numerals.

Above the lions is a stone canopy supported by an octagonal central pillar and four beautifully carved helical columns. This arrangement means that the lions are adjustable. They may be rotated on a vertical axis to ensure that the gnomons on each face lie exactly in the meridian, thus eliminating any errors introduced in construction.

The sundial lions are similar, but not identical, to the wooden lions in the castle dining room (Fig. 5). Slade[5] attributes the carving of the dining room lions to Jan van Santvoort, which would date them to about 1683. It seems possible that the dining room lions were used as a pattern for the sundial lions, or vice versa.

Fig. 4 (left). The lion rampant in the royal coat-of-arms and the arms of the Earl of Strathmore and Kinghorne.

Fig. 5 (right). One of the lions in the Drawing Room at Glamis Castle, attributed to Jan van Santvoort in 1683.

At latitude 56½º N, the theoretical angle between the noon line and each of the seven o'clock am and five o'clock pm lines on a South face is 64º. The measured angle at Glamis is 64º, showing that the dial was designed for the latitude of 56½º N and so was almost certainly designed specifically to be erected at Glamis. The gnomons sit at an angle of 56½°, further confirming that the dial was designed for its present latitude. (The north face gnomon was replaced in 1985.)

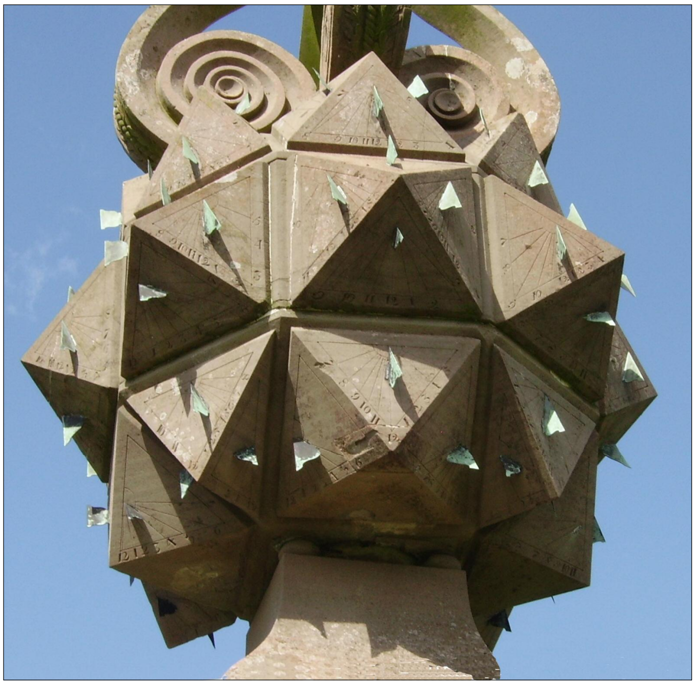


Fig. 6. The pineapple.

The Pineapple (or Stellar Rhombicuboctahedron)

'Pineapple' is not a geometrical term but it is a colloquial name used at Glamis to refer to the complex figure with many faces situated within the sundial structure.

The pineapple at Glamis Castle (Fig. 6) is based on an Archimedean solid known as a rhombicuboctahedron. Such a figure has 8 triangular faces and 18 square faces. (Fig. 7.) At Glamis, each square face (except the top and bottom ones) has a regular square pyramid surmounted on it, and each triangular face has an irregular triangular pyramid surmounted on it. The square faces measure 16 inches (40.5 cm) square. The angles of the pyramids are set such that four triangular vertical, direct faces are presented to each of north, south, east and west. These triangles are isosceles.

The intermediate compass points of north-east, south-east, south-west and north-west similarly each have four triangular vertical, declining faces. In addition, each of these eight compass points is presented with six other faces which variously recline and procline.

Each of these 80 faces is furnished with a gnomon set at an angle compatible with their being designed for the latitude of Glamis. The faces are scribed with the relevant hour lines for the angles at which they face, marked with Arabic numerals.

The pineapple sits on a short cylindrical pedestal above its square plinth, again making it adjustable so that the whole pineapple may be correctly aligned with the meridian.

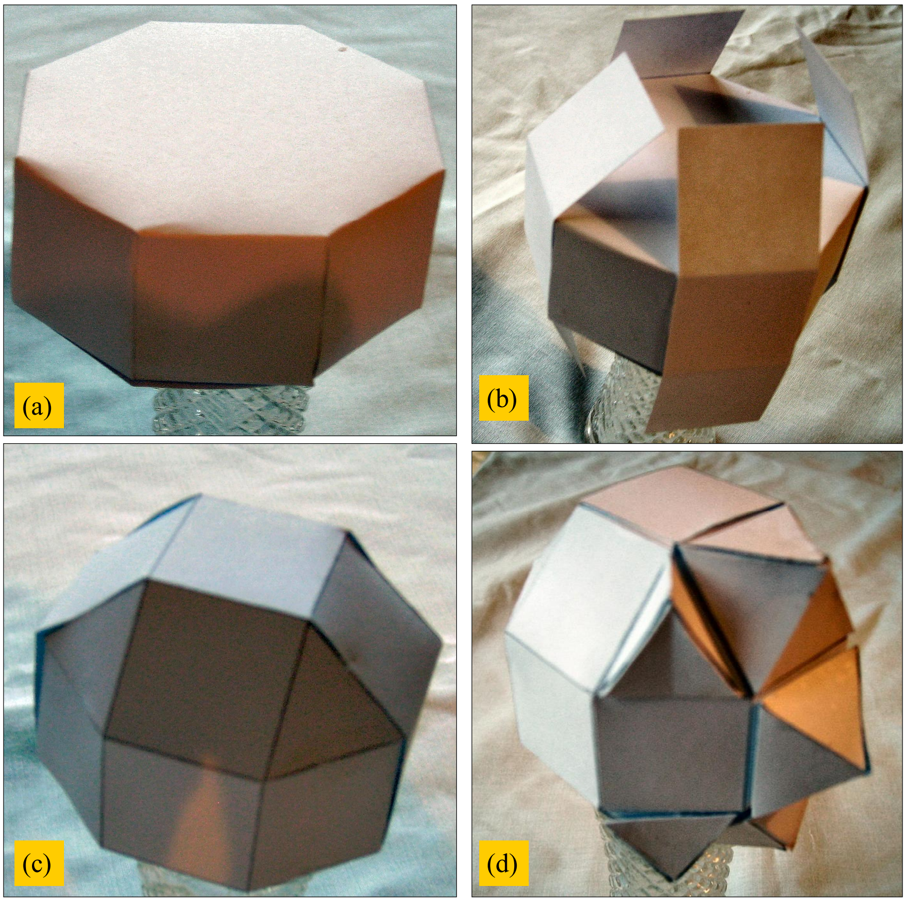


Fig. 7. To make a pineapple:

(a) take an octagonal prism with square faces;

(b) paste a piece of paper on four of the faces as shown;

(c) fold the paper and fill in the holes to make a solid figure with square and triangular faces. This figure is called a rhombicuboctahedron;

(d) place a square pyramid on each square face and a triangular pyramid on each triangular face. It is now a stellar rhombicuboctahedron.

Fig. 8. *The EoT table engraved on the base of the sundial.*

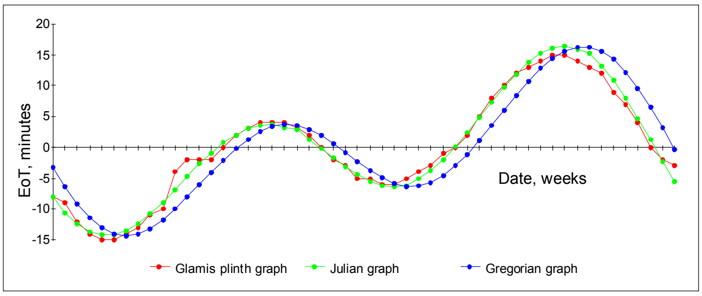


Fig. 9. Graphs of theoretical EoT for the Julian and Gregorian calendars and for the Glamis values.

The Equation of Time

The Glamis sundial is a contender for having the oldest inscription of the Equation of Time in the British Isles.[7] It is engraved on the plinth of the Glamis sundial (Fig. 8) and has been transcribed in Table 1. The line below the names of the months shows the dates of the first days of each week counting from 1 January. Below each date is the equation of time for that date in minutes. Below that again is an indication of whether the sun is fast or slow of mean time.

In Fig. 9, the graph shows the theoretical equation of time in blue for the present day Gregorian calendar. The green graph shows the equation of time had the eleven days not been removed in 1752. The red line shows the equation of time as engraved on the plinth of the Glamis sundial. The Glamis line closely follows the theoretical line for the Old Style calendar, apparently showing that the equation of time at Glamis was engraved before 1752. The x-axis shows a division for each week of the year from January to December. The y-axis shows the correction factor in minutes.

Mathematics

Calculating the hour lines for those 80 declining and reclining faces was quite a tour-de-force for a mathematician at that time.[8] But the mathematics of the practical time recording part of the structure is only part of the expression of mathematical imagery. The following mathematical terms have already been mentioned, but bringing them together emphasises just how much mathematical thought has gone into the construction: line, angle, triangle, square, rectangle, octagon, circle, ellipse, isosceles, face, logarithmic spiral, helix, Roman numeral, Arabic numeral, prism, rhombicuboctahedron, pyramid, cylinder.

It is also of note that the Equation of Time values on the Glamis sundial do not fit precisely with any of the early published tables.[7] This leads to the suspicion that the Glamis table was composed independently, perhaps by an astronomer with a good longcase clock and making comparisons with sidereal time.[7]

Who could the mathematician have been? The finger of possibility points to James Gregory, Professor of Mathematics at the University of St Andrews from 1669 to 1674 (Fig. 10). It must be said that the evidence for Gregory being involved rests entirely on his being a mathematician about the right time, fairly nearby (Glamis is about 20 miles from St Andrews) and his known possession of a

January					February				March				April				
1	8	15	22	29	5	12	19	26	5	12	19	26	1	8	15	22	29
4	7	12	14	15	15	14	13	11	10	4	2	2	2	0	2	3	4
SUN					SLOW				SLOW					*		FAST	

May				June				July				August				
7	14	21	28	4	11	18	25	2	9	16	24	1	8	15	22	29
4	4	3	2	0	2	3	5	5	6	6	5	4	3	1	0	2
FAST				*		SUN		SLOW							*	

September				October					November				December			
5	12	19	26	3	10	17	24	31	7	14	21	28	5	12	19	26
5	8	10	12	13	14	15	15	14	13	12	9	7	4	0	2	3
SUN				FAST					FAST					*		SLOW

Table 1. Transcription of the Equation of Time table carved around the pedestal of the Glamis dial.

Fig. 10. Were they friends? Left, Patrick, Third Earl of Kinghorne (1643–1695); right, Professor James Gregory (1638–1675) (picture courtesy The Marischal Museum, Aberdeen).

Fig. 11. This split second clock by Joseph Knibb was commissioned in 1673 by James Gregory. It still has pride of place in the Senate Room at the University of St Andrews.

clock! Checks with archivists at both St Andrews University and Glamis Castle have revealed nothing to connect the Third Earl with Gregory. Nevertheless, we *do* know that the Earl was familiar with both the town and university of St Andrews. We know, for example, from his own diary[6] that when a teenager, he had been a student at the university himself and that, in later life, he bought his carriage wheels in St Andrews. So the Gregory connection is possible, if not proven. We also know that the Earl had master craftsmen on site carrying out extensive elaborate carving and building work. It is possible that Gregory was given access to the skills of these craftsmen in exchange for providing the Castle with a fine sundial.

The Bad News

Unfortunately, we cannot easily use the Glamis sundial to set our watches today. Not one of the lion dials faces exactly in its correct direction and the whole pineapple is about 6° out of alignment. Also, the equation of time carved on the plinth is not correct for our modern calendar. We can, however, continue to admire it!

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Jane Austen and a "small astronomical Instrument"

On Tuesday 20 January 1805 the author Jane Austen wrote a letter to her brother, Captain (and later Admiral of the Fleet) Francis-William Austen (1774-1865). It read:

> My dearest Frank
>
> My Mother has found among our dear Father's little personal property, a small astronomical Instrument which she hopes you will accept for his sake. It is I beleive *(sic)* a Compass & Sun-dial, & is in a Black Chagreen Case. Would You have it sent to you now, & with what direction? – There is also a pair of Scissors for you. – We hope these are articles that may be useful to you, but we are sure they will be valuable. – I have not time for more.
>
> Yours very affec[ly], JA.

Jane Austen Memorial Trust

Rev. George Austen

The letter is now in the British Library, MSS 42,180 fols 5-6, and has been published as no. 42 in Deirdre Le Faye's book *Jane Austen's Letters (New Edition)*, p.98, OUP, (1997). After Francis-William died at Portsdown near Portsmouth, some of Jane Austen's letters and other memorabilia were preserved and passed on to his family. Where is the sundial now – it certainly would "be valuable"? We do not know what type of sundial it was—possibly a Butterfield or even a universal equinoctial dial, like the BSS logo.

John Baxandall

GRAVEYARD AND OTHER MEMORIAL SUNDIALS

JOHN WALL

Recently I enjoyed reading a book by Nigel Reece, a *Catalogue of Graveyard Epitaphs*.[1] There I came across this epitaph for William Caxton, 'the Father of printing':

> Thy prayer was 'Light – more Light – While Time shall last'.
> Thou sawest a glory glowing on the night,
> But not the shadows which that Light would cast,
> Till shadows vanish in the Light of Light.

The verse is by Tennyson and alludes to Caxton's motto *Fiat lux* (a couplet that itself appears on many a sundial). It is to be found on a wall tablet still in place beneath the East door window of St Margaret's Church, Westminster, where Caxton is buried. That is appropriate since he established the first printing press in England near St Margaret's in 1477. He died in 1491.

In truth this verse is a perfect commentary on a sundial and its function, especially the last two lines. Regrettably, it is not accompanied by a sundial itself at St Margaret's. The whereabouts of Caxton's grave here are not known.

(1) This entry prompted me to realise that a sundial would be a most appropriate ornament for a tombstone, since both stone and dial signify the passage of time and mortality. To begin with I could recall only one instance, in the Remembrance Garden of St Mawnan's Parish Church at Mawnan Smith, three miles south-west of Falmouth in Cornwall. (Not to be confused with Mawnan, one mile to the south.) It is recorded by Carolyn Martin in the BSS Fixed Dial Register. The original sundial, SRN 2268, was stolen in 1997 and replaced by SRN 4263 in 1999. (In passing, although it is not unusual for sundials to be stolen, this theft of a sundial from a Remembrance Garden must surely mark the depth of depravity.)

J Lester

Fig. 1. Tombstone, St Mawnan's church, Mawnan Smith.

(2) The replacement dial (Fig. 1) sits, as did the original, on top of an oblong granite block or pedestal that serves as a tombstone, with the following inscription:

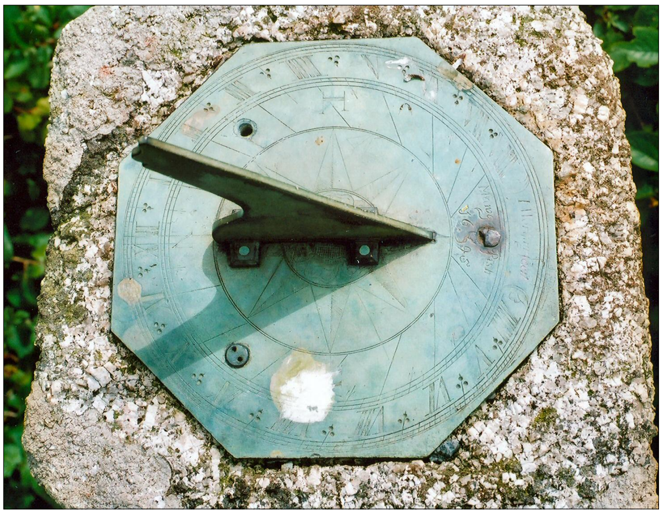
> (In memory of)
> THOMAS KEITH HUGH DAVIES
> A DEAR HUSBAND AND FATHER 1925-1971
> SAY NOT GOODNIGHT
> BUT IN SOME BRIGHTER CLIME
> BID ME GOOD MORNING

I wish I knew the author of these sublime lines which would be a fitting epitaph on the tombstone of any maker or lover of sundials. It did occur to me that an additional line of the inscription might name the author:

> THOMAS ANTHONY MOSELEY MA 1924-1997

but I cannot find any poet with this name in my anthologies. I can only conclude that, notwithstanding the surname, he was a member of the family buried here. The date of his death coincides with the date of the theft of the sundial.

(3) Five miles south-west of Mawnan Smith as the crow flies, across the Helford River estuary, lies the village of Mawnan in Meneage. In the graveyard of St Mawgan's church there was an octagonal brass dial plate with the date 1695, also recorded by Carolyn Martin, SRN 2687. Again, regrettably, the sundial was reported stolen on 5th December 1996. The furniture included a compass rose and the name of the maker, I, for Ioannes, that is John, Worgan. He was a well-known maker of instruments working at the Seven Dials in London. Whether or not the family had Cornish roots, there were Worgans in Cornwall later on. Some



L Burge

Fig. 2. Sundial by John Worgan at St Mawgan's church, Mawgan in Meneage (now stolen).

Worgan descendants are living in Cornwall today. The points of the compass depart from a finely wrought ‘rose’ in the centre below the gnomon.

Five close-up photographs of the dial plate are reproduced in Len Burge’s book on *Cornish Church Sundials,*[2] together with one of the upper half of a cylindrical granite pillar and capital (Fig. 2) and the stolen sundial on top. The pillar still remains *in situ* but the sundial itself has not been replaced. There are two photographs of the stolen sundial in the Register, and two more reproduced from Len Burge’s book, in *Mrs Crowley’s Sundial Sketchbooks*.[3] Unfortunately, they are accompanied by another photograph of the pedestal and inscription, and sundial, that rightly belong to dial number (1) above, at St Mawnan’s church, Mawnan Smith, near Falmouth. The Register number for that sundial, SRN 2668, is also erroneously repeated here. The confusion may have arisen because of the similarity of the names – Mawgan in Meneage and Mawnan Smith. The original spelling of the church dedication at Mawnan Smith is to St Mawnanas.

If we make a distinction between sundials situated above a grave, whether on a tombstone or a pillar, and sundials on a pillar near a grave, this sundial belongs to the second category.

(4) So, are there any other such sundials extant? There was a notable example at Dryburgh Abbey in the Scottish Border country. It stood near the grave of the novelist Sir Walter Scott in the North transept. Sir Walter requested that he be buried here by right of his ancestor Thomas Haliburton, into whose hands the Abbey passed in 1700. (Only three families have the right of burial at Dryburgh Abbey Church: The Earls of Buchan (Erskine), the Haliburtons of Bemersyde, and the Scotts of Abbotsford.) The sundial was illustrated and recorded by Mrs Gatty in her *Book of Sundials* as No. 1639:[4]

> “A very graceful cubic dial, having four faces to different points of the compass, stands on a small column, and surmounted by a pyramid and ball... placed in a little shrubbery near the arch of the ruined Abbey. It is supposed that the date of the dial is 1640. The Haliburton arms and the initials ‘TH’ are carved on the Eastern slope of the dial stone, and a corresponding shield with ‘I.C.’ on the other. At the back is the motto *Fiducia constante*.”

If Mrs Gatty is correct about the date of the dial, it pre-dates the life of Sir Walter Scott (1771-1832). It also pre-dates the acquisition of Dryburgh by the Haliburtons. How then are we to account for their arms and initials inscribed on the dial? Either it was formerly sited at some other of their properties, or these inscriptions were added after it was removed to Dryburgh. Both seem unlikely, and we can only

Laurence Furlong

Fig. 3. Sir Walter Scott’s sundial, Abbotsford.

conclude that Mrs Gatty was mistaken in her dates. It is much more probable that the dial dates from shortly after 1700 and was erected in Dryburgh Abbey to celebrate the acquisition of the property by the Haliburtons. It is also probable that the inscription WATCH WEEL, being the paternal heraldic motto of Sir Walter Scott, was added to the sundial after his death.

The remains of the dial first came to rest at Nenthorn House, from which they were presented to Abbotsford, Sir Walter Scott’s home, in 1987. They have been set up in the South Court in front of the house (Fig. 3). Mrs Gatty herself was responsible for the drawing of the dial that appears in her work – “sketched on the 10th August 1839”. [Mrs Gatty’s illustration was reproduced in *BSS Bulletin* 19(iii), p.117 (September 2007). Ed.] This sundial is not to be confused with another ‘Sir Walter Scott sundial’ in the East Court.

Having introduced evidence from Mrs Gatty, we continue for a while with her other contributions to our theme, including two tombstone sundials and several graveyard sundials.

(5) No. 838 describes and illustrates a cubical dial dated 1710 that rests on a flat table tombstone in St Andrew’s, Greystoke, churchyard, Cumbria. (SRN 0213; Fig. 4). On the west face is the motto NOX VENIT, (Night Cometh); on the south face REDIME, (Redeem [the time]); and on the east face LUX ES, (Thou art light). On the north side is engraved “Graystock. Lat. 56° 46'. J.G. MDCCX”. There are gnomons on three of the faces. Although the Register refers to it as an Altar Table, I prefer to regard this as a ‘tombstone table’, which accounts for its inclusion here.

Fig. 4. Table tombstone sundial, Greystoke. Far left, east face; left, south face with the E and W gnomons visible.

(6) No less affecting than a human memorial can be that of an animal – a pet, to be precise. Mrs Gatty records just such a memorial, not in a graveyard but in the garden of Vicarage House at Borden in Kent (No. 804). There a sundial surmounts a pedestal over the grave of a favourite Newfoundland watch-dog called Neptune – Neppie for short. On the east and west sides of the pedestal are two verses of an epitaph, one of which (the most relevant) reads:

> NEAR TO THIS TIME-RECORDING PILLAR'S BASE
> ENTOMB'D, AND, AS BECAME HIS MERITS, MOURN'D -
> POOR NEPPIE LIES: THE GENEROUS AND THE FOND -
> THE BRAVE AND VIGILANT - IN WHOSE NATURE SHONE
> UNITED, ALL THE VIRTUES OF HIS RACE:
> NOR GRUDGING BE THIS MEMORIAL, IF IT'S TRUTH
> ENFORCE THE CHARGE, BE FAITHFULL UNTO DEATH.
> OBIT, SEPTEMBER 9TH, 1839, ANNO AETATE DECIMAM.

Of course, gravestones for family pets are not uncommon. (Mrs Gatty adds that the above lines recall Lord Byron's *Inscription on the monument of a Newfoundland Dog*, dated Newstead Abbey, October 30, 1808). What is unusual is the addition of a sundial.

(7) Mrs Gatty records four more sundial memorials. I have no means of knowing whether the first, No. 805, although proposed, was carried into effect. She quotes from *The Gentleman's Magazine*, vol. xiv, p.332, 1744, an "Inscription on a dial to be erected by his desire on the grave of Edward Bond, of Bondvil, in the County of Armagh, Esq.". (The dial does not appear in the Register.) The epitaph contains a line particularly appropriate to a sundial: 'The stealing steps of never-standing time'.

(8) The second example, No. 474, is a polar sundial in the form of a cross set on a pillar in St John the Baptist churchyard at Shenstone near Lichfield in Staffordshire in 1848. (This replaced an earlier dial that was lost.) This dial was copied from a cross dial at Highlands, near Colne, in Wiltshire. It was put in place by the Rev. R.W. Essington who also composed the epitaph inscribed on the dial shaft as follows:

> IF O'ER THE DIAL GLIDES A SHADE, REDEEM
> THE TIME; FOR LO IT PASSES LIKE A DREAM.
> BUT IF TIS ALL A BLANK, THEN MARK THE LOSS
> OF HOURS UNBLEST BY SHADOWS FROM THE CROSS.

Unfortunately, as the Register records (SRN 2768), the dial is in a bad condition and no visible markings remain. It also states that according to the Internet the dial shaft was erected by one Rowland Fryth.[2]

(9) The third example, also recorded by Mrs Gatty under No. 474, was a "beautiful little white marble cross-dial mounted on a red sandstone pillar which was poignantly placed over a child's grave in the churchyard at North Collaton, Devonshire, about the year 1857". It carried the same verse as No. 6 above, with slight variations.

(10) The final example, No. 1394, seems to be the sepulchral monument of Richard Lloyd, of Marrington Hall, Shropshire – "either erected during his lifetime or placed over his remains" on the lawn in front of Marrington Hall, Shropshire. It was a curious old four-sided dial set on a pillar, round which are inscribed the words of an epitaph:

> THESE SHADES DO FLEET
> FROM DAY TO DAY
> AND SO THIS LIFE
> PASSETH AWAIE

The pillar was set on a solid square stone base round the chamfer of which was inscribed another epitaph:

> FOR CHARITI BID ME ADW [ADIEU?] WHO WROUGHT
> THIS STONE FOR THEE TOMB OF R.L.L.

These letters are the initials of Richard Lloyd. Mrs Gatty adds details of various heraldic bearings on the sides of the shaft showing the arms of families who have owned the property. Among these are those of Newton, to which family it is believed that Sir Isaac Newton belonged. "In out of the way corners of the stone there are many dials curiously inserted."

The practice of erecting sundials on tombs is of very ancient origin. Mrs Gatty in her Introduction (p.11) states that

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Fig. 5. Sundial, Salcombe Regis.

Fig. 6. Sundial, Dalbury.

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Fig. 7. Ash Family Memorial Sundial, Packwood House.

"dials were set up on (Roman) tombs in order to draw attention to the epitaph which recorded the names and virtues of the deceased. It was hoped that passers by would read these when they paused to note the time!"

I am greatly indebted to Dr John P. Lester for his detailed descriptions and photographs of the following memorial sundials, five of which are situated on pillars and one on a gravestone.

(11) In the churchyard of St Mary and St Peter at Salcombe Regis in Devon, on a tombstone, beneath a brass cross, is inscribed the epitaph: (Fig. 5)

> IN MEMORY OF RICHARD PEELE MOSSOP BORN AT SUTTON LINCOLNSHIRE 13TH DECEMBER 1844 DIED 25TH MAY 1935. On the step are inscribed the words: ALSO HIS WIFE DIED OCT 30TH 1955 AGED 91 YEARS

The gnomon supporter is cut out in the graceful outline of a swan.

(12) In the south-west corner of All Saints' churchyard in Dalbury near Etwall in Derbyshire there is a particularly fine bronze round sundial surmounting a pillar. (SRN 4092; Fig. 6). Inscribed round the perimeter are the words of an epitaph:

> REST ETERNAL GRANT UNTO THEM OH LORD, MAKE LIGHT PERPETUAL SHINE UPON THEM

The gnomon supporter makes use of the Greek letters alpha and omega. The gnomon is positioned unusually far south on the dial plate, so limiting the hours. The sundial is sited over the grave of Nina Bishop (1889- 1945).

(13) This memorial to the Ash family of Packwood House, Warwickshire (gifted to the National Trust by Baron Ash) is situated in the graveyard of St Giles' church nearby. (SRN 3986; Fig. 7). A memorial plaque on the plinth reads:

> IN LOVING MEMORY OF EMILY HANNAH ASH. DEARLY BELOVED WIFE OF ARTHUR JAMES ASH OF PACKWOOD HOUSE. BORN AUG 18TH 1857 DIED JAN 8TH 1918. ALSO OF ARTHUR JAMES ASH BORN OCT. 27TH 1858 - DIED JULY 19TH 1920.
>
> On the top step below a similar plaque records the death of their son.

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Figs. 8 & 9. Sundial, All Saints' church, Baschurch.

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Left to Right:

Fig. 10. Sundial, Sts Mary and Bartholemew's church, Hampton in Arden.

Fig. 13. War memorial sundial, Hockley Heath.

Fig. 14. War memorial sundial, Droitwich.

(14) This memorial dial is situated in the north-east corner of the graveyard of All Saints' church, Baschurch in Shropshire. (Figs. 8 & 9; SRN 3429). It is inscribed on a octagonal slab of marble, on the sides of which are the words:

IN MEMORIAM W.M.S. AETAT 31 1912.

The dial itself carries the motto WATCH FOR YE KNOW NOT THE HOUR; a cartouche bearing the words: "J. Barker and Sons. Scientific Instrument Makers. 17 Clerkenwell Rd, London"; an eight point compass rose; and acanthus and other decorative engraving.

(15) This precarious dial is situated south of the tower of Sts Mary and Bartholomew's church in Hampton in Arden, West Midlands. (Fig.10; SRN 4420). At the head of the plot on which it stands is a tombstone bearing details of the deceased: IN LOVING MEMORY OF E. GARDON PARRY M.R.C.S. L.R.C.P. JUNE 24 1890 - AUG. 30 1932 (the date of the sundial). The dial carries a motto that reads TYME FLYES, and an eight point compass rose. It is made of copper, has lost its gnomon, and is in poor condition.

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Figs. 11 & 12. Sundial, St Mary's church, Selattyn.

(16) In the south-east corner of the graveyard of St Mary's church at Selattyn in Shropshire, a memorial sundial stands beside the path. (Figs. 11 & 12; SRN 4376). Although there is no nearby grave to which this sundial relates, it is included here because it was erected in memory of Ivy Hilda Thomas who died in 1985. Inscribed on the capital round the dial are the words: FRIEND OF ALL. IN THANKSGIVING FROM THE PEOPLE OF SELATTYN. Also, inscribed on the dial plate, is the motto:

LET OTHERS TELL OF STORMS AND SHOWERS
I'LL ONLY COUNT YOUR SUNNY HOURS

There is also a rudimentary eight point compass rose and a spurious date, 1767, since this is clearly a modern dial dated 1986. 1767 may refer to an earlier sundial here, now lost.

John Lester has also drawn my attention to what might be called a sub-category of memorial dials - on war memorials. He has kindly provided details and photographs of those that have been recorded to date.

(17) At Hockley Heath, near Solihull in Warwickshire, there is a splendid pillar sundial (Fig. 13; SRN 1842) in the centre of the village. It is in excellent condition, was made by Bateman and Bateman of Birmingham, and was erected in 1921. All three faces of the sundial block are carved, unusually, on a vertical equilateral prism, enabling passers by to tell the time from sunrise to sunset throughout the year. All three faces have declining sundials - the 'south' face for example declines 10° E. A motto across all three faces reads:

THE DAYS WERE SHORT, THEIR WORK GREAT, THEIR TIME PASSED AWAY LIKE A SHADOW.

John Lester points out that the decision to construct this type of sundial may have been influenced by the Ash family who lived nearby at Packwood House and clearly were sundial enthusiasts.

Fig. 15. War memorial sundial, Warwickshire College, Henley in Arden.

(18) This imposing war memorial sundial (Fig.14; SRN 5235) stands in Victoria Square, Droitwich, Hereford and Worcester. The solid back-cut gnomon with full-length side supports is described and illustrated in *Sundials of the British Isles*.[6] The chapter author writes "it is uncluttered and the whole dial is a good workmanlike instrument worthy of the men it commemorates".

(19) The third and final war memorial sundial is found in the grounds of Warwickshire College, Henley-in-Arden, Warwickshire. The names of the fallen, Old Boys of the former College, are recorded on brass plaques inset on opposite sides of the plinth (Fig. 15).

In conclusion, John Lester and I have certainly not exhausted the number of graveyard and other memorial sundials. We would welcome details of other instances that readers may have observed in their travels. To date I have not come across a tombstone with a representation of a sundial as an indication of the deceased's occupation as a sundial maker.

On a personal note, I will require a sundial to be set up on top of my own gravestone, and a representation of one above my name as, if not a maker of sundials, certainly a lover of this infallible recorder of the passage of time.

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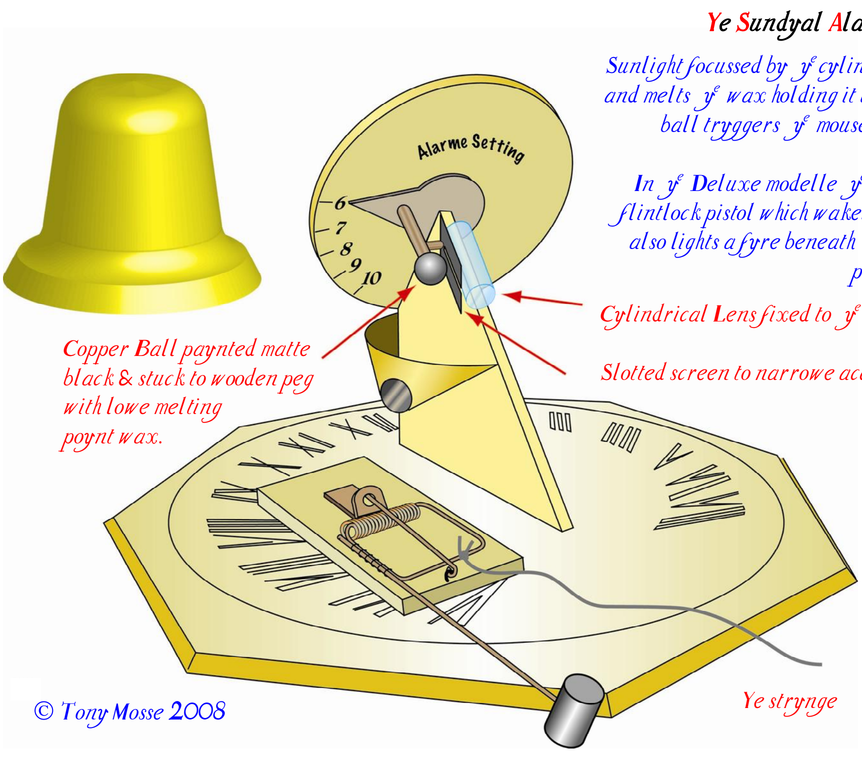
THE SUNDIAL ALARM



A member of the public mentioned to our Secretary, Doug Bateman, that she had seen Rowan Atkinson's *Blackadder* consult a sundial alarm after oversleeping before the Battle of Bosworth Field in episode one of the eponymous TV series. That sounded an interesting idea but we didn't know of any such device. But we did know a man with an inventive mind who could come up with something—Tony Moss duly obliged!

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