The British Sundial Society

BULLETIN

VOLUME 19(ii) June 2007

GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics; and, by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.
2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis@btinternet.com*. Material can also be sent on CD or as a single-sided typescript, single- or double-spaced, A4 paper.
3. Figures: For photographs, colour or black-and-white prints as large as possible (up to A4). Slides and transparencies are also acceptable. Pictures can be sent electronically as jpg (do not over-compress) or tif files. For email attachments, do not exceed 10 Mbytes per message. Tables should be treated as figures and numbered as part of the same sequence. Drawings and diagrams should be in clear black lines on a white background. Each figure illustrating an article should carry on the back the author's name and a number indicating its relative position in the text (Fig. 1, Fig. 2 etc…). Captions for the figures should be written on a separate sheet in numerical order. They should be sufficiently informative to allow the reader to understand the figure without reference to the text.
4. Mathematics: symbols used for the common dialling parameters should follow the conventions given in the appendix section of the *BSS Glossary* (available online on the Society's website). Consult the editor if in doubt or for help in laying out equations.
5. The *Bulletin* does not use footnotes. Where additional information is required, notes should be numbered as a Reference with a superscript number. For very long notes, use an appendix.
6. References : Sources are referred to in the text by a superscript number. They are listed in numerical order under the heading 'References' (or 'References and Notes') at the end of the article. The *Bulletin*'s convention is as follows:

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

   Examples:

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

   If you simply wish to give a short list of books associated with the subject of the article, this may be given at the end of the article under the heading 'Bibliography', using the convention as given for 'Books' above.
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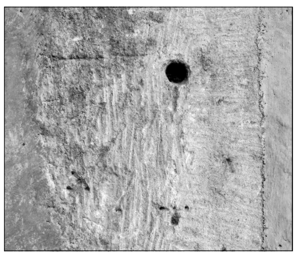
Front cover: *The 17-sided polyhedral dial at Cambridge University's Downing Site, seen on the tour during the recent BSS conference. The pedestal carries the inscription:* Soli Horisque Wilelmus et Uxor Lucia Ridgeway Postuerunt A[nno] S[alvationis] MCMXIII. (For the sun and the hours, William Ridgeway and his wife Lucy placed this in the year of our salvation 1913). *The gnomon for the horizontal dial is pierced to show a seated camel. Photo: John Davis.*

Back cover: *An Anglo-Saxon carving from Inglesham, Wiltshire, showing The Virgin and Child being blessed by the hand of God. Until 1910 it was mounted on the south wall of this fine early church it is now inside the south aisle. It is not certain if the dial also belongs to this period. Almost opposite on a south facing pillar are traces of a genuine Anglo-Saxon dial. Photos: Mike Cowham.*



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

BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

ISDN 0958-4315

VOLUME 19(ii) - June 2007

CONTENTS

EDITORIAL

This issue has a definite 'stained glass' feel to it, justifying our use of extra colour pages. Even the Photographic Competition had two entries featuring a stained glass dial though they did not make it to the top ten. When you have finished admiring the pictures, don't forget to read the AGM reports and the Accounts: the Society needs lots of active participation and involvement.

We also start a new series on astrolabes, from Tony Ashmore, written as a result of requests from the Readership Survey.

The feature on David Harber Sundials Ltd from Doug Bateman is, we hope, the first in an occasional series about the professional dial makers in our midst. Not too many people can make a living out of sundials so they deserve all the help they can get.

The Editor is always pleased to receive other suggestions for new topics in the Bulletin—we try to cater for all tastes!

The recent BSS Conference in Cambridge was a great success with wonderful sunshine to show off the many dials to their best advantage. It was pleasing to see some new faces amongst the many old friends. Also, it does seem that conferences at the major centres of dialling attract more than the average number of overseas attendees, to the benefit of everyone. Our thanks go to Doug Bateman and Mike Cowham for all their organisational efforts.

PRINTER'S ERROR

In the previous issue of the *Bulletin* (19(i), March 2007) there was an error at the bottom right of page 13 in the article by Theodossiou & Dakanalis. A computer problem after the final proofs had been checked transformed Greek characters into meaningless symbols. The correct reading should be:

On the formed ring is marked out the numbering of the hour-lines, which follow the ancient Greek method of using the capital letters of the Greek alphabet: Α, Β, Γ, Δ, Ε, F, (maybe Z but this is missing), Η, Θ, Ι, ΙΑ, ΙΒ.

We apologise to the authors and readers.

BRASS OR BRONZE?

JOHN DAVIS, TREVOR M BROWN* & IRENE BRIGHTMER*

* University of Derby

INTRODUCTION

Horizontal garden sundials from the 16th to 20th centuries are most often described in the BSS Register as being made of either brass or bronze. Both of these materials are alloys of copper with other metallic elements which, after several centuries exposed to weathering, show a bewildering variety of colours of patination. Thus the question which arises is how the reporters have identified the metal and whether they are in fact correct.

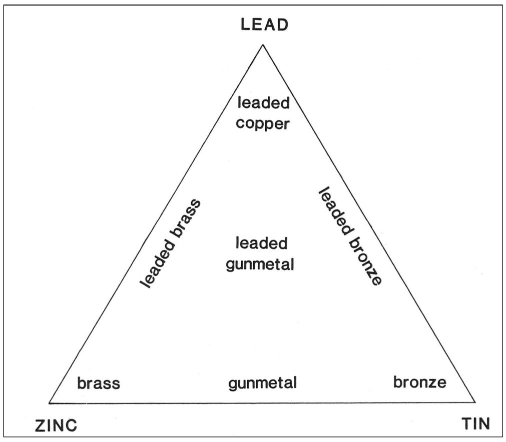


Fig. 1. Ternery diagram of copper alloys and their names.

By modern definitions, brass is an alloy of copper (Cu) with, predominantly, zinc (Zn). Bronze is similarly an alloy of copper and tin (Sn). Mixed alloys containing both zinc and tin are also possible and are known as gunmetals (see Fig. 1). Small amounts of other metals, frequently lead (Pb), are often added to improve machining or weathering properties. Historically, traces of many other metals such as silver (Ag), iron (Fe) and nickel (Ni) can sometimes be found as these were present in the mixed ores from which the metals were smelted. In the past, the terms bronze and brass did not have their precise modern meanings and were sometimes used interchangeably so that descriptions in contemporary literature are not a reliable guide to the alloys actually used. This literature has recently been reviewed by Manasek[1] who concluded that many 18th century dials traditionally described as brass may be of bronze. Pantalony et al[2] have considered the 1773 Heath & Wing horizontal dial at Dartmouth College, New Hampshire, variously described as brass and bronze, to be made of bronze. However, their assessment was solely on the basis of visual appearance which is notoriously unreliable after centuries of exposure to the atmosphere.

Name	Cu	Zn	Sn	Others
Common brass	63	37		
Free cutting (leaded, engraving etc) brass	61	36		3 Pb
Naval (marine, Admiralty etc) brass	61	38	1	
Yellow brass	66	34		
Gilding metal	80	20		
Nickel silver	62	5		33 Ni
Phosphor bronze	95		4	0.35 P
Bell metal	77		23	
Gunmetal	88	2	10	
Leaded phosphor bronze	87	1	7	3.1 Pb; 0.2 P

Fig. 2. Names of some individual copper-based alloys.

Different alloy compositions of both brass and bronze to optimise them for specific purposes are often named after the application for which they were developed. These often result in different colours of freshly-exposed metallic surfaces. Fig 2 shows some of these names.

Bronze is the oldest alloy known to mankind and has been available since prehistory (note 'The Bronze Age'). It can be prepared by melting metallic copper and tin together, both metals being extracted relatively easily from their respective ores. Today, it is quite expensive due to the price of tin. It is most commonly used for sculpture, where its abilities to flow accurately into fine moulds and to withstand weathering make it a natural choice. It is, perhaps, these perceived advantages that lead to the assumption that it is used for high quality sundials. Freshly prepared bronze surfaces have an attractive, slightly reddish-yellow colour.

Brass is a more recent alloy which was not widely known in Europe (although the Romans did have small amounts[3]) until the Middle Ages. This is due to the fact that metallic zinc was only identified and industrially available in the West in the early 19th century. The difficulty is that the temperatures at which zinc is released from its most common ore calamine[4] are above its boiling point and so the zinc comes off as a vapour and is lost. Early production was often known as 'colouring copper' as the resulting brass was much yellower that the original copper which had been heated together with the calamine – the 'cementation process'.[2] European production of brass in the medieval period centred on Meuse valley (around Liège) and in the vicinity of Aachen. Metal for use in the monumental 'brasses' found in English churches in the Middle Ages was usually imported from the Low Countries, often in the form of the mixed alloy 'latten' as ballast in the hold of ships working as part of the wool trade. The processes of mining, smelting and working metals was well known in 16^{th} century Europe through the books of Agricola[5] and Birringuccio[6]. It was not until the Elizabethan period that England had an indigenous source of brass. Calamine was discovered near Tintern on the River Wye with the first brass produced there in 1566 and later on at Bristol. The cementation process for producing brass in an enclosed retort limits the zinc content to less than around 32%.

Brass exists in two metallurgical phases, known as α-brass and β-brass, with different physical properties.[7] Below 32% Zn (by weight) only the alpha phase exists whereas above 45% Zn the material is all beta phase. In between, a mixed (α+β) phase exists. Thus brass produced by the cementation process is all in the alpha phase. The presence of the mixed (α+β) phase which, being harder, is preferred for very fine engraving, is indicative of the higher zinc concentrations resulting from co-melting zinc and copper. This co-melting technique was not developed in England until after the work of William Champion[3] in the mid-18^{th} century: James Emerson was granted a patent for the industrial process of producing brass from metallic zinc and copper in 1781.[8] However, 17^{th} century astrolabes from Lahore indicate the availability of high-zinc brasses in the near-East much earlier.[9]

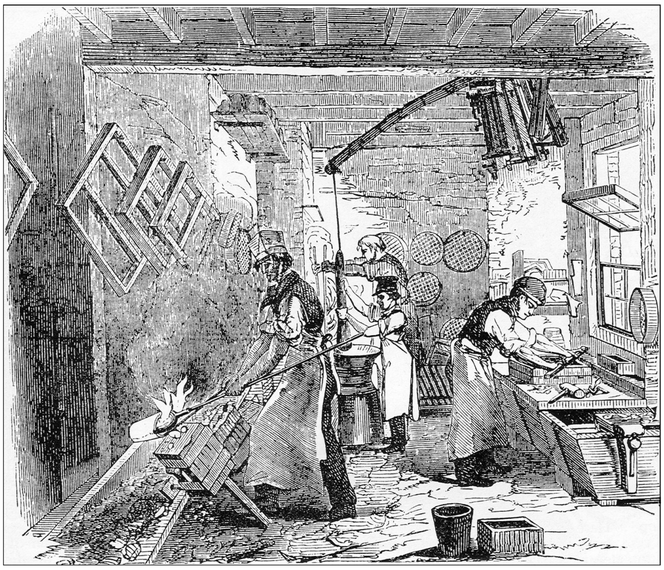


Fig. 3. Brass foundry work. This illustration from the London Illustrated News of 20 Sept 1851 shows the process at the clockmakers of J Smith & Sons, Clerkenwell. Brass ingots, smelted elsewhere, are melted and poured into moulds.

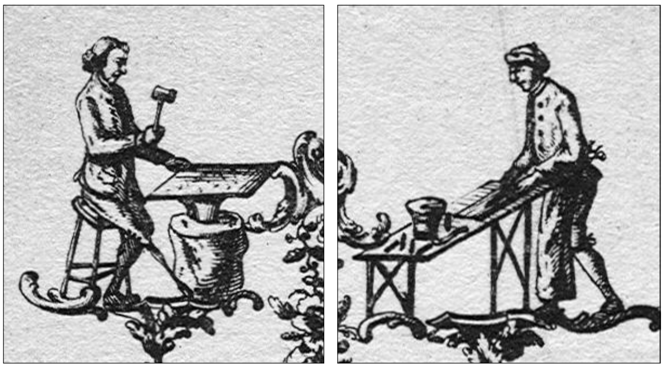


Fig. 4. Illustrations from the18th century tradecard of the platemaker Benjamin Whitton, Shoe Lane, Holborn, showing the process of hammering and scraping plates (copper for printing or brass for mathematical instruments). From the Ambrose Collection, courtesy of The Trustees of theBritish Museum.

Brass was an expensive material in the 17^{th} and 18^{th} centuries. It can be a hardwearing material, especially if it is work-hardened. It cuts very cleanly making it ideal for applications such as the gear wheels of clocks and for engraved mathematical instruments.

PLATE PREPARATION

Having produced ingots of the required alloy, sheets of the appropriate thickness and finish had to be prepared. Before the development of rolling mills, this was achieved by casting and then finishing. The preparation of the metal plates was a specialised craft skill and developed in 16^{th} and 17^{th} century London alongside the printing and mathematical instrument trades. In the 17^{th} century, brass foundries for melting brass ingots into usable shapes could be found in London, particularly in Chancery Lane which was also the centre of the instrument making activities and near to the clockmakers of Fleet Street. The Great Fire of 1666 caused the loss of some of these foundries: it is not clear how quickly the industry recovered.[10]

Rough plates of copper or brass were cast in the foundry (Fig. 3) and then the surfaces were prepared by a series of processes including hammering and scraping (Fig. 4). These processes also had the effect of altering the crystalline structure of the plates, particularly of the surface layer which became work-hardened.

ENGRAVING

The techniques of engraving metals with a sharpened steel burin or graver to produce printing plates was developed in the Low Countries, normally on copper plates. The same techniques can be used on the harder brass plates to produces scales for scientific instruments. The skills and techniques for engraving brass instruments developed markedly during the 16^{th} to 18^{th} centuries in London but will not be discussed here.

ANALYSIS METHOD

The method of compositional analysis used for this study was energy dispersive analysis of x-rays using a Leo 1450VP Scanning Electron Microscope (SEM) interfaced with an Oxford INCA energy dispersive X-ray analysis (EDXA) suite. The microscope has a backscatter electron detector to provide atomic number contrast as well as secondary electron detector to provide surface topography. Primary electron energies in the range 15-20keV were used. Using internal standards the instrument is capable of quantifying elements above oxygen in the Periodic Table. When used in this way the limit of detection is 0.1% by weight.

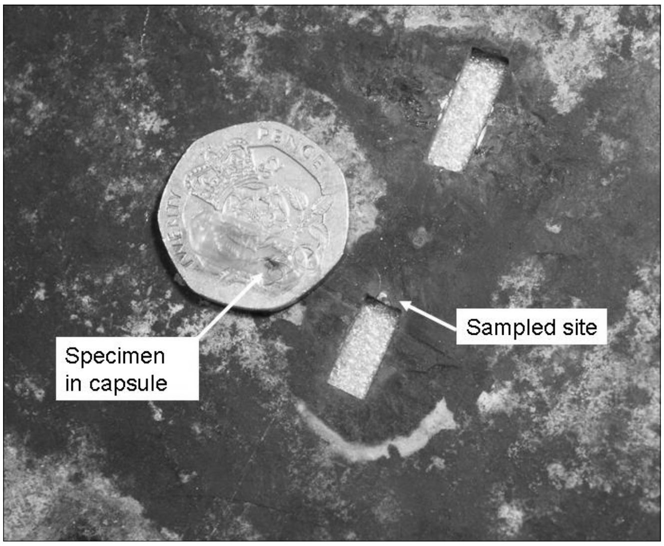


Fig. 5. Specimen taken from the back of an Elias Allen dial, inside a transparent capsule laying on a 20p piece.

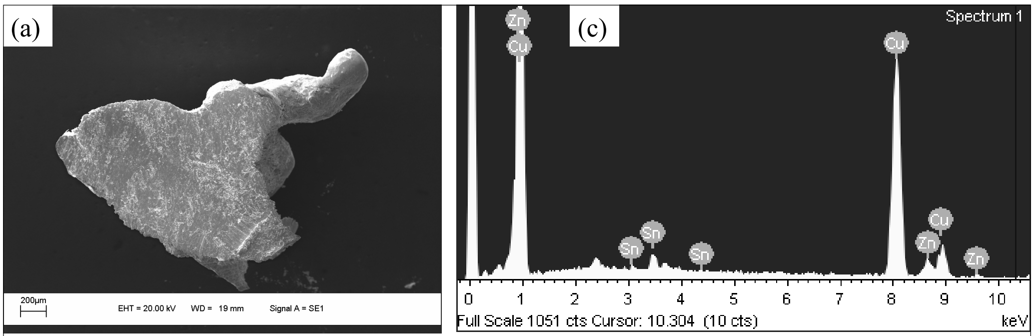
The analysis of alloys of copper, zinc, tin, lead and iron do not present problems in terms of overlapping peaks.
In principle, the x-ray analysis technique is non-destructive but the limited size of the specimen chamber meant that only samples removed from dials were used. The technique essentially probes the surface of the specimen to a depth of less than 3 microns (around a ten-thousandth of an inch). Since the dials examined were invariably covered with a patina with a thickness of much more than this, and because the surface regions of the dials could well have a different alloy composition to that in the bulk ('de-zincification' due to preferential loss of zinc at the surface), analysing the freshly-exposed surfaces of samples cut from the dials allowed reliable and representative results to be obtained.

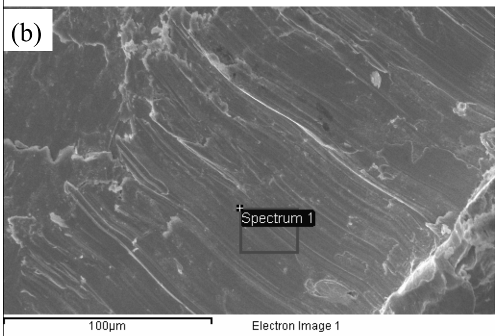
Conscious of the need not to introduce significant damage to valuable antiques, the specimens used were very small, typically 1×0.5×0.2mm. Small slivers were cut from the dials using a very sharp hardened steel lettering chisel and so that they did not cause any visible impairment to the dial, using locations on the back of the dialplate such as the insides of the tenon slots, the burrs around screwholes etc. In addition to analysing dialplates, the gnomons were also sampled wherever possible, usually from the hidden underside or the tenon. An optical photograph of a typical sample is shown in Fig. 5.

After x-ray analysis, some specimens were prepared for high-power optical examination by embedding, polishing and grain-boundary etching. The purpose of this study was to investigate if evidence of the plate preparation and ma-

No	Dial	Sampled region	Maker etc.	Date	Cu	Zn	Sn	Pb	Other	Comments
1	Modern	Brass sheet	CZ108	C20	57.4	42.6				Control specimen
2	Modern	Phos bronze	PB102	C20	94.2		5.8			Control specimen
3	Slate dial	gnomon	R Melville	c. 1850	63.7	36.3				
4	Weston Colville horiz	gnomon	T Soame	1665	73.7	9.8	6.2	10.2		
5	Irish slate	dial chapter ring	P Glasco, H Oldis	c. 1780 & 1822	47.9			47.3	P 1.3 Cl 1.7 Si 1.8	Re-used clock chapter ring Green patination
6	Sotherby's DH	dialplate	John Rowley	c. 1700	69.4	26.2		2.9	Fe 1.5	Brown patinated
7	"	gnomon	"	"	83.7	14			Si 2.3	Cast appearance, 'porous'
8	Hungerford DH	gnomon	Elias Allen	?C18 or 19	66.1	33.9				Replacement gnomon
9	"	dialplate	"	c. 1630	70.6	29.4				Green/black patina
10	Cardiff Sol horometer	dial spider	Pilkington & Gibbs	1918	88	8	4			Internal casting (machined)
11	"	pointer	"	"	85.9	9.8		4.3		Rolled sheet or casting?
12	"	screw	"	"	60.2	39.8				tip of machined screw

Fig. 7. Summary of analytical results. Elemental compositions are in weight %.





(d)

Element	Weight%	Atomic%
Cu K	88.03	89.90
Zn K	7.97	7.91
Sn L	4.01	2.19
Totals	100.00	

Fig. 6. Analysis of specimen 10 (Sol Horometer internal casting). (a) Overall electron micrograph of specimen, (b) close-up showing area analysyed, (c) resulting spectrum and (d) compositional analysis.

chining treatments could be observed in the microstructure of such small specimens. This study is ongoing and will be reported later.

RESULTS AND DISCUSSION

A typical set of results is shown in Fig. 6. The electron micrograph shows the region of the specimen sampled and the table gives the output from analysing the spectrum from the x-ray analyser.

A summary of all the specimens examined is shown in the table of Fig 7. The specimens are discussed below in the order in which the dials were made. There is no overall trend in the results: individual dials must be considered separately in relation to the development of metallurgy at the time.

Elias Allen double horizontal dial (c.1630-40). Elias Allen did not date his double horizontal dials but it is generally thought that they were made in the 1630s or 40s. The small dial examined here was fitted with a gnomon of a totally wrong type, probably in the 18th or 19th century. The dial had a mottled green/blue and black patina.

The analysis of the dialplate shows a brass with a zinc content of 30%, towards the upper end of the range achievable by the cementation process. The absence of detectable quantities of other elements shows that quite a high-purity ore was used. The gnomon, with its 34% zinc, is of more modern material, as expected.

Thomas Soame horizontal dial (1665). The 1665 dial signed Thomas Soame has been described before.[11] It was a provincial piece, not a London-made instrument like the Elias Allen or Rowley (below) dials. The specimen was actually taken from the gnomon rather than the dialplate; both had a very dark patina. It can be described as a leaded gunmetal. It is quite likely that this mixed composition has resulted from the smelting of a variety of brass and bronze scrap from different sources.

John Rowley double horizontal dial (c.1700). The double horizontal sun- and moon-dial (Fig. 8) examined was undated but thought to be early in Rowley's career on the basis of the engraving style of the signature. It is perhaps of significance that Rowley was working in London in the period after the Great Fire. The dial has been sold by Sotheby's at least twice in the last 30 years and is worn with a light brown colour, probably as a result of chemical

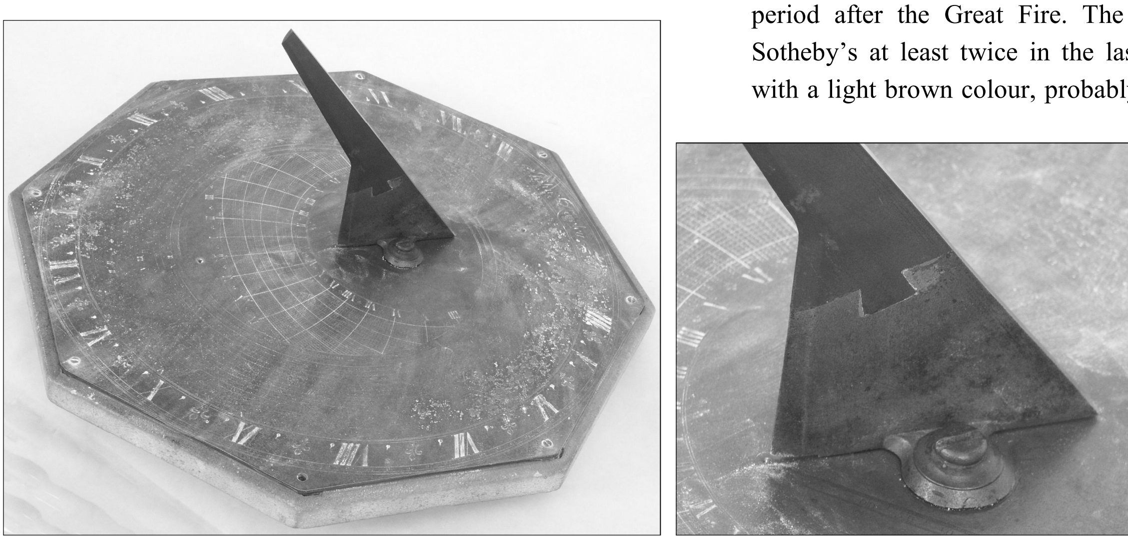


Fig. 8. Far left: a double horizontal dial and moondial by John Rowley. Left: Close-up of the repaired gnomon showing the original, slightly rough-textured, bottom section with integral feet.

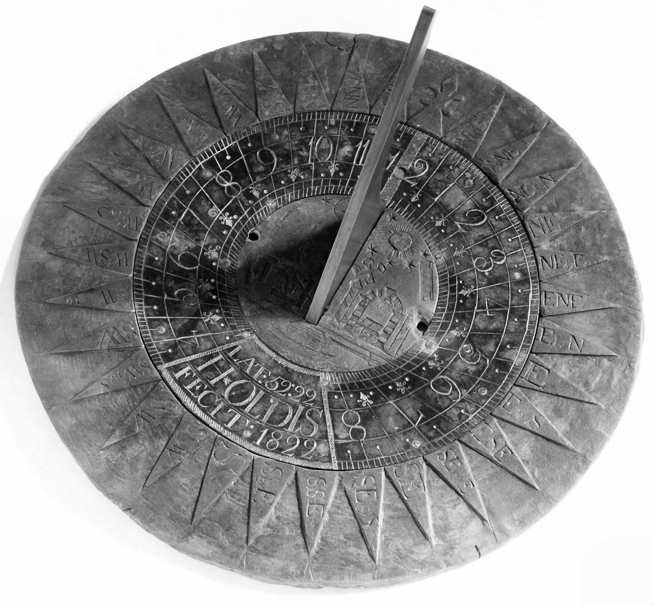


Fig. 9. Photograph of the slate sundial by H Oldis with an inset 'brass' chapter ring.

cleaning in the 20th century. It has an unusual gnomon which appears to be cast with integral mounting feet: examination of its fixing to the dialplate shows this to be original although the tip has been repaired. It appears to have a slightly porous surface texture. The compositional analysis shows the gnomon to have an unusually low concentration of zinc. This may have resulted from overheating of the melt during casting and a consequent loss of zinc by evaporation. The silicon content may have resulted from the sand (silica) used as the mould. The dialplate with its 26% zinc and presence of significant quantities of lead and iron, is more typical of a cementation-process brass.

Phil Glasco / H Oldis horizontal dial (late C18 & 1822). This Irish dial (Fig. 9) is of slate with an inset metallic chapter ring, originally thought to be brass. During restoration, it was found that the sundial had been engraved in 1822 by the amateur *H Oldis* on the back of the chapter ring of an earlier longcase clock which was signed *Phil Glasco Dublin*. The sundial face had an apple-green and black patina whereas the clock face, in contact with the slate and so protected from weathering, still had a brown oxidised copper colour. Analysis shows the plate not to be brass but of leaded copper. The lead content could come have come from the copper ores but was probably intentionally incorporated. It is possible that, since the ring was attached to the slate with lead rivets, there may have been some contamination despite efforts to prevent it.

Richard Melville multiple horizontal dial (c.1850). Melville made decorative multiple dials in slate with thin brass gnomons. On many dials the extant gnomons are clearly replacements but the ones on the dial examined were of the correct style with an appropriate rough finish and were still leaded in place with old iron pins so we are convinced of their originality. Care had to be taken to analyse an area of the sample that was not contaminated with remnants of the fixing lead. The analysis clearly shows that, with a 36% zinc content, the material is an (a+b) casting brass not easily distinguishable from a modern composition.

Pilkington & Gibbs heliochronometer (c. 1918). The specimens came from Sol Horometer Serial No. 12 which has spent its life in the Cardiff area. Most parts of this instrument, including the bowl, the support ring and the dial face show the appearance of being made from castings. The exceptions are the machine-made screws with B.A. threads and the flat pointer. The bowl of the device has blue/green patinas with the dial face showing a slightly more mottled green appearance.

The analysis shows that the cast parts of the dial are of a gunmetal. By contrast, the pointer is a leaded brass with unusually low zinc content (perhaps to allow it to be rolled) and the screw is a typical (a+b) brass.

Summary of results. The above results show that early horizontal dials were mainly made of brass, not bronze. The compositions may be compared with those of components from 17th and early 18th century lantern clocks also made in London.[10] In that study, brasses contained typically 20-25% zinc together with around 1.5% lead and 1% tin. These compositions are not unlike the ones we found for the London-made dials by Elias Allen and John Rowley although our small sampled areas do not seem to have detected the trace metals with sufficient sensitivity. Other investigations of the compositions of 'brass' instruments from the Oxford MHS[12] have shown similar results with one of the first English instruments to exhibit a zinc content in the 28-32% range being a 1568 compendium by Humphrey Cole. The closeness of this date to the beginning of brass working in England and Cole's position at the Mint may be significant here.

Only the provincial-made 'Thomas Soame' sundial of this early period could be described as a mixed alloy, probably having been produced from re-worked scrap.

In the 19th century, brasses used for English dials (e.g. Melville) show an increased zinc content and, into the early 20th century, there is evidence from the Pilkington & Gibbs dial of proper selection of metallurgical composition to suit the application (e.g. gunmetal for casting and weathering, high-zinc brasses for machining).

PATINAS

One of the delights of antique garden sundials is the range of patinas they develop after centuries of exposure. These can range from turquoise blues through apple greens and browns to completely black. The colours come mainly

Colour	Material	Compound
Olive green	Malachite (hydrated copper carbonate)	$Cu_2CO_3(OH)_2$
Blue	Azurite (copper carbonate)	$2CuCO_3.Cu(OH)_2$
Blue verdigris	Copper acetate	$Cu(CH_3COO)_2.CuO.6H_2O$
Green verdigris	Copper acetate	$2\ Cu(CH_3COO)_2.CuO.6H_2O$
Neutral verdigris	Copper acetate	$Cu(CH_3COO)_2.H_2O$
Black	Copper sulphide	CuS and Cu_2S
Brown	Cuprous/Cupric oxides	Cu_2O and CuO

Fig. 10. Table identifying some common copper patinas.

from the development of complex copper compounds which gradually develop on the surface although there is undoubtedly some influence from the other alloying metals. The influence of the atmospheric conditions and airborne contaminants is also likely to be significant but the authors have not found the detailed relationships described in the literature.

The development of verdigris on copper has been recognised for centuries and for a long period of time it was used to produce a pigment for green paint. Patinas can also be introduced artificially and the standard texts on the subject[13,14] give literally hundreds of recipes (chemical mixtures plus application methods) for producing interesting patinas on various metals, mainly for sculptures and decorative metalwork. Freshly-exposed brass and bronze surfaces take on a brown colouration after a few months of weathering and this darkens with time. The more interesting patina colours only develop naturally after many years of exposure.

Some of the likely constituents of patinas are listed in Fig. 10.[15] It can be seen that they are all copper compounds though it might be expected that the other metallic elements in the alloys could contribute to the colouring. For example, an early yellow paint pigment was lead stannate (Pb_2SnO_4). However, the limited range of specimens examined in this study has not produced an obvious correlation between alloy composition and patina colour. Atmospheric conditions probably contribute considerably to patination colours. For example, two similar and well-known early 19th century dials by Edward Troughton are at Trinity College Cambridge and St. Michael's Mount, Cornwall. The former, exposed to the sulphureous fumes of the college coal fires for two centuries, is black and heavily corroded. The latter, within feet of the sea for a similar period, is a fine blue-green colour.

NEXT STEPS

This paper is of the nature of a 'work in progress' report. The real value of the results will come as the size of the database is increased. Readers with interesting dials of known provenance are encouraged to contact the authors with a view to having them analysed. Further information on the variation of patination colours and their dependence on alloy composition and atmospheric conditions is also sought.

ACKNOWLEDGEMENTS

We are grateful to the owners of the dials examined for permitting them to be sampled. Susan Elliott and Graham Souch, SEM technicians at the Faculty of Education Health and Sciences at the University of Derby, are thanked for performing the analyses. Dr Dave Hulse, formerly of the University of Derby, provided valuable metallurgical advice.

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2. D. Pantalony, R.L. Kremer & F.J. Manasek: *Study, Measure, Experiment – stories of scientific instruments at Dartmouth College*. pp.33-34, Terra Nova Press, Vermont (2005).
3. J. Day: 'Brass and Zinc in Europe from the Middle Ages until the nineteenth century', *2000 Years of Zinc and Brass*, P.T. Craddock (Ed.), British Museum Occasional Paper No.50 (1998).
4. Calamine is a mixture of zinc spar, $ZnCO_3$ (smithsonite in the US) and zinc silicate, $Zn_4Si_2O_7(OH)_2$ (hemimorphite).
5. Georgius Agricola: *De Re Metallica*. (1556). Translated into English by H.C. Hoover & L.H. Hoover, Dover Publications, New York (1950).
6. Vannoccio Biringuccio: *De La Pirochtechnia*. (c.1530). Translated into English by C.S. Smith & M.T. Gnudi, Dover Publications, New York (1990).
7. Alpha phase brass has a *face-centred cubic* lattice structure and beta phase brass is *body-centred cubic*.
8. Wikipedia at *www.wikipedia.org*.
9. B.D. Newbury, M.R. Notis, B. Stephenson, G.S. Cargill & G.B. Stephenson: 'The Astrolabe Craftsmen of Lahore and Early Brass Metallurgy', *Annals of Science*, 63(2), pp. 201-213, (April 2006).
10. G. White, *English Lantern Clocks*. Antique Collectors Club, Woodbridge (1989). See Appendix IV.
11. J. Davis: 'A 17th Century Churchyard Dial', *BSS Bulletin*, 15 (ii), pp 68-70, (2003).
12. C. Mortimer: 'X-ray fluorescence analysis of early scientific instruments'in Y. Maniatis (ed.), *Archaeometry: Procedings of the 25th Archeometry Conference, Athens, 1985*. Elsevier, Amsterdam, pp.311-317, (1989).
13. R. Hughes & M. Rowe: *The Colouring, Bronzing and Patination of Metals*. Thames and Hudson (1991).
14. A.L. McMullen: *Architectural metalwork in copper and its alloys*. Copper Development Association, London (1963).
15. M.V. Orna: 'Chemistry, color, and art', *J Chem Ed*, 78(10), p.1305 (October 2001).

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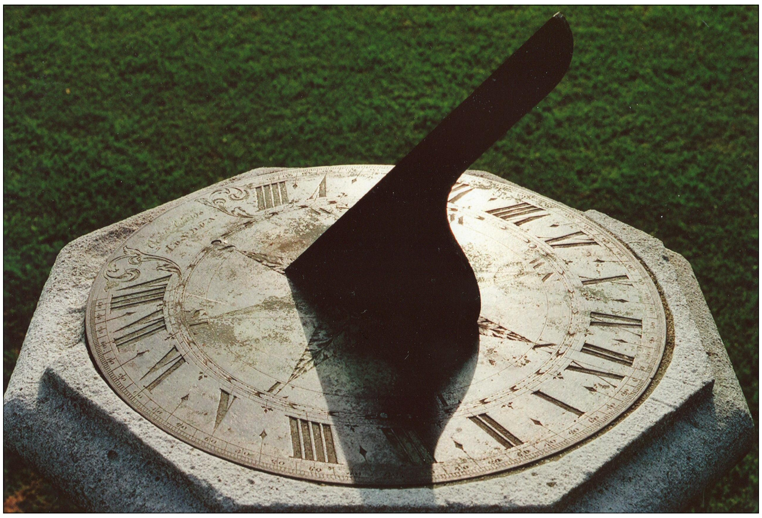
m.i.brightmer@derby.ac.uk

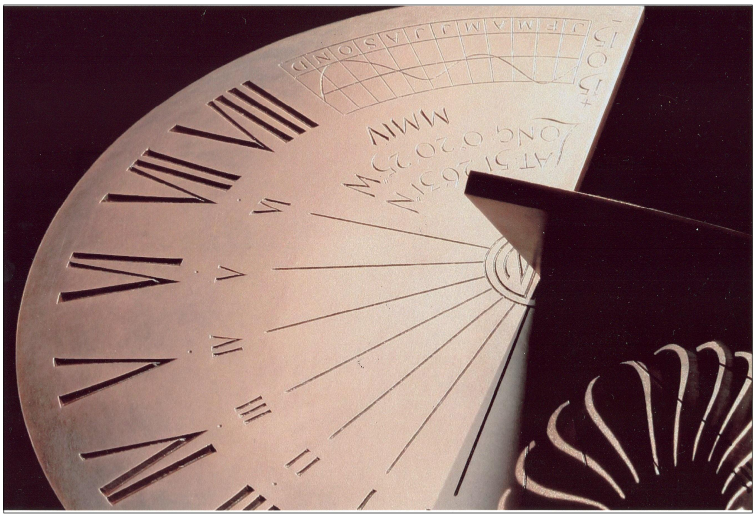
Redacted

Overall Winner
Paul Shaw - *The Answer is Blowing in the Wind*

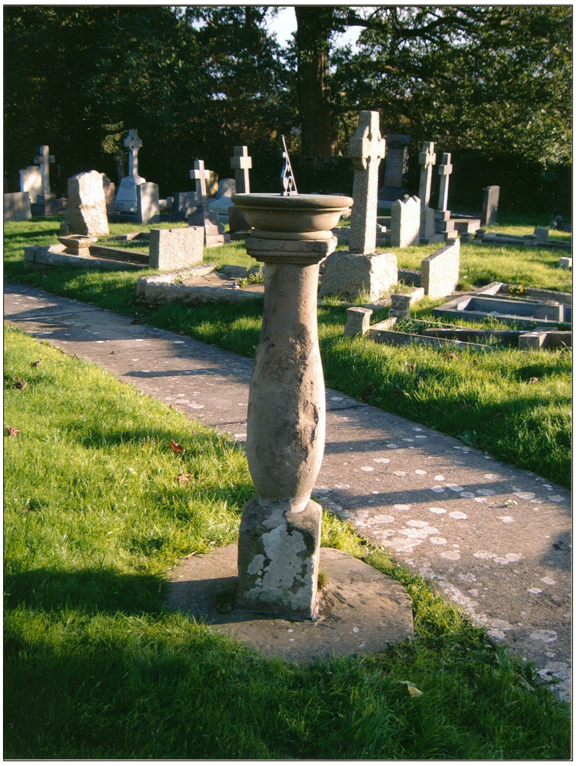
Third Place
David Hawker - *Fourth Cherub*



Second Place
Ian Butson - *Shadow from Sunlight*



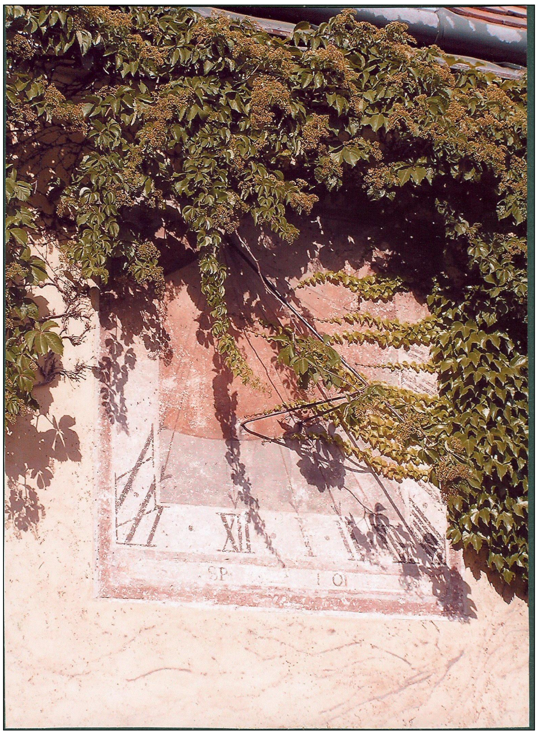
Sir George White - *The Shadow of St James*



Irene Brightmer

Evening Shadows in a Clwyd Churchyard

Robert Sylvester - *The Time of My Life*



Colin Davis - *The Tendrils of Time*

Mike Cowham

Phew! What a job in the Midday Sun! –

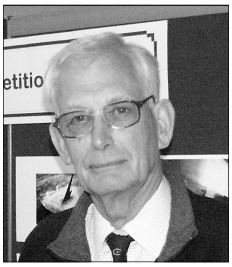
Ian Butson

Time and Tide Wait for No Man

Tony Wood - *Blue Slate*

MINUTES OF THE 18TH ANNUAL GENERAL MEETING
FITZWILLIAM COLLEGE, CAMBRIDGE,
15 APRIL 2007

1. The meeting was opened by the Chairman, Christopher St J H Daniel, at 12:47 pm. He remarked that it had been a marvellous Conference, with excellent speakers. He thanked all taking part, especially the many members from abroad. About 70 voting members were present.



2. Apologies were received from David Young, Andrew James, Michael Maltin, Michael Lowne, Wilf Dukes and Nick Nicholls.

3. The minutes of the 17th Annual General Meeting, held at the Collingwood Conference Centre, Durham on 23 April 2006, had been circulated in advance, were taken as read, and were approved by a show of hands. There were no matters arising and the minutes were adopted, and signed by the Chairman.

4. Council Members' Reports

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

Secretary: Doug Bateman

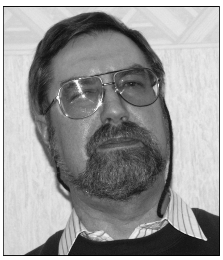
Liaison. Since the last AGM I have dealt with 17 enquiries by letter, quite a number by email, and a few by telephone. Many have sought advice about setting up dials or information about dials in their possession. Whilst we are helping to 'educate the public' as part of our charitable status, few of the enquiries have led to membership. The number of enquiries is fewer than those made in the previous year.

Unauthorised use of our logo. Last year we had a case on leaflets in garden centres. After giving advice we were informed that the logo had been removed. Similar instances have not been reported.

Conference 2007, 13-15 April. At the time of writing 110 have booked and we have a very good programme, entirely based on suggestions and offers from members.

Conference 2008, 28-30 March. The Latimer conference centre, Buckinghamshire, has been booked.

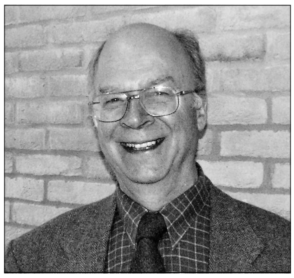
Editor: John Davis



Bulletin production has run smoothly: special thanks are due to Tony Ashmore for his careful proof-reading. Suggestions from the Readership Survey have started to be incorporated and more will follow. The New Authors Award had 11 authors to choose from and was won by the excellent paper on London stained glass dialmakers from Geoffrey Lane. The exercise is due to be repeated for more new authors in 2007. Some progress has been made in digitising *Bulletins* before 2004 and we will eventually have the complete set (from 1989) in a form that can be indexed.

No new BSS Monographs have been published but there are several in various stages of production. The nearest to completion is the second edition of Jill Wilson's *Biographical Index of British Sundial Makers*. Also, John Lester has done a great deal of research in preparation for the publishing of the dial drawings of Mrs Crowley, a joint undertaking between the BSS and the AHS.

Membership: John Foad

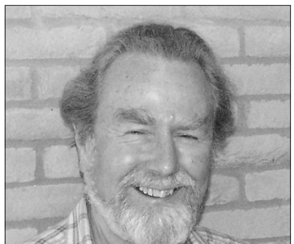


Membership stands now at a healthy 482, eleven up from this time last year. 71% are UK residents, with the rest being split about equally between Europe, where 27 countries are represented, and the rest of the world, including 41 members from the USA.

Advertising: Mike Cowham

In the last few issues we have carried adverts from Green Witch showing some of their range of affordable replica dials. They are paying for their adverts by giving us some of their dials which we are using for prizes for the Photo Competition and Best New Author awards. Other advertising has been at a low level but at least one new advert is in the pipeline.

Restoration: Graham Aldred



Several sundial restorations have been completed successfully in the last year. These are the Guisborough Market Cross, with three cardinal dials and a spherical dial, a vertical declining dial at Painswick, to which BSS contributed, a slate Melville sundial, a replica heliochronometer at Bromley House, Nottingham, a Helio-Chronometer in New Zealand and a Sol Horometer in Wales. It is quite probable that other restorations do occur that are not reported. About a dozen restoration advice enquiries have been received, many of these do not result in any follow up leading to a restoration but there are three that could be classified as optimistic with reasonable support from the custodian or owner. The most interesting of these is at Glasgow University, a complex multiple sundial based on a sphere, probably quite unique, thought to have been designed by Lord Kelvin and moved from his house to the University in 1971. Another is an interesting vertical declining dial, dated 1627, with nodus and declination lines in North Wales. The restoration of the Mansfield Market Cross with four vertical declining dials should proceed this year; it is in the final stages of tender with contractors. Unfortunately the fine polyhedral sundial at Nelson became a victim of vandals recently, it is badly damaged but repairable.

Reference Library at Nottingham: Graham Aldred. During the last year the first edition of the BSS Reference Library Catalogue has been produced and is now available. Full details of pricing and purchase options are given in the March newsletter. Recognition should be made of John Foad's considerable efforts in managing the production of this publication. It is hoped that this catalogue will reveal the extent of the BSS collection of dialling material and stimulate members to visit the attractive location at Bromley House. Copies will be available for sale at the annual conference or by post from Peter Lane the Sales representative. The Society has responded to the Bromley House Library 'Adopt a Book' appeal, which involves repair and conservation of some of the old books in the general library.

Fixed Dial Register: Patrick Powers. I am pleased to report that the number of errors in Register 2005 identified over the ensuing year has been rewardingly small. Data entry into the database has continued without much incident though the Society computer facility is showing its age. Tests are in hand (on a separate machine!) to establish the viability of future operation under the new MS operating system Vista. A little further work has been conducted into the ways in which Members might eventually be able to submit records and images electronically. Work on this is expected to increase in the coming year in order to accommodate the ever increasing use of digital photography.

The design of the mass dial database is now complete and Tony Wood is busy getting his and Edward Martin's backlog entered.

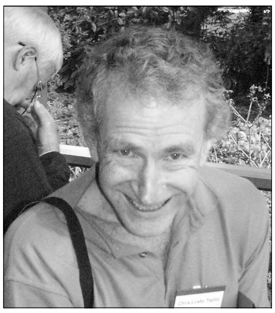
At this year's conference I shall have completed my tenth year as Registrar and shall be standing down from that role although I expect to remain involved as needed to provide support for the two databases I would like to thank all those who have helped over the years both with sending in dial sightings and in helping me resolve queries from time to time.

Mass Dial Group: Tony Wood There has been considerable activity with regard to mass dials: Chris Williams in Kent has made a statistical survey of all the English counties in respect of survival rates and distribution. This is a major achievement and the results are to be published shortly. The Mass Dial Register has been set up and data is being entered. To date the regions entered are the counties of Devon, Cornwall, Lancashire, Greater London, Rutland and West and South Yorkshire together with Scotland, Ireland and Wales. Printed versions have been distributed for comment. The layout follows on the Lincolnshire listing of Bob Adams but with metric measurements now being used. The reporting of new dials at a lively level has continued from a small group of experienced recorders and further information via NADFAS and our website has been received. Sadly, Edward Martin died at the end of February. He was the pioneer of computer recording of mass dials, being the first to gather together the data from disparate counties and create a database with pictures. His legacy is the existing database mentioned above. Special thanks to various members who have investigated reports of mass dials for me.

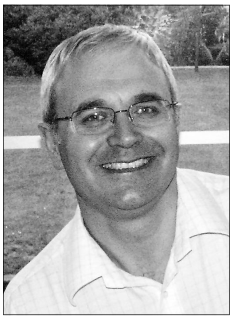
Saxon Dials: Tony Wood. Mike Cowham is undertaking an extensive survey of Saxon dials and has raised many questions over the status of currently recorded mass dials. He hopes to publish eventually.

Museums Survey: Tony Wood. The Museums Survey has reached its final phase and I am awaiting replies from the last batch of forms sent out. Prior to that I covered Ireland, both North and South, with a reasonable response and new dials can now be added to Michael Harley's existing Irish Register. It has been requested that the results be published and Ian Butson has said he will undertake this with some help initially from Jill Wilson. It seems to be agreed that it has been a worthwhile exercise and many dials of interest and indeed importance have been uncovered. Makers' names are passed on to Jill Wilson for the Biographical Index and other interested parties are informed about particular dials. It is also worthwhile mentioning that that the Society has been able to assist some museums on occasion

Exhibitions: David Young. A small team represented us at the British Horological Instute last summer. I am very grateful for the hard work, for little reward, that is entailed. I am also happy to continue archiving Society records.



BSS Website: Chris Lusby Taylor. There have been no significant changes to the BSS website in the past year. If any member has website experience and would be willing to help, the Webmaster would love to hear from them.



Publications Sales: Peter Lane

A flyer for publications was included with the December Bulletin and this led to a significant increase in orders. The exercise may be repeated for other sales items. In particular, the EoT monograph, the CD for Mass Dials of Lincolnshire and the old but trusty software 'Sundial Constructor' have sold quite well. Back issues of the Bulletin continue to sell, and I expect that the planned CD of the complete run of Bulletins will also sell well. On the other hand, there are a number of unsold hard-copy Registers. Overall, sales are a steady activity and bring revenue to the Society. Finally, due a career change I will have to relinquish the role of Sales and hope that a volunteer will come forward fairly soon.

Foreign Tours 2006 & 2008: Mike Cowham.

Ludwig and Luise Engelhardt were our hosts as a group of 29 BSS Members visited Nuremberg in October. We were able to see many of the fine dials in the area and visit some of their best museums. In the Gernamisches National museum we were able to see a good selection of Nuremberg Ivory Dials and many fine works of art. A day tour to Rothenberg-ob-der-Tauber and another to Franconian Switzerland allowed us to see the surrounding area and some further interesting dials.

There will be no tour this year but one is being arranged for 2008 to the Alsace region of France. This area is rich in dials and we will be visiting Strasbourg, Colmar and Freiburg (Germany) as well as many mediaeval wine producing towns and villages. For more details contact Mike Cowham.

******

There were no comments from the floor on these reports, but Doug Bateman and Chris Daniel made the following points:

Patrick Powers, who has acted as Registrar for ten years, is looking for a successor. It is hoped that a volunteer will be found soon. Some computer experience is required, but Patrick will give a very full handover. The position is an opportunity to obtain a knowledge of the dials of the British Isles that is second to none. The workload is not intense, amounting to perhaps one hour a week, and there are no deadlines. There is also an opportunity to take the Register to the next stage, allowing Members to submit their photographs and reports in digital form.

Chris Lusby-Taylor, who manages the Society web site, would like some assistance in this task.

Any members willing to help in either respect should please contact Doug Bateman.

5. Treasurer: Graham Stapleton

In taking over the post of Treasurer from John Davis in June 2006, I inherited a very well maintained set of accounts with a spreadsheet system that ensures accurate monitoring of the Society's position. The accounts, kindly audited by Geoff Parsons, are shown separately. The headline figure shows an increase of almost £14k, but this is artificial in that Fitzwilliam College have charged the bulk of their fee much later than other venues have done. The underlying turnover is quite similar to last year, even though there was a 'safari' – it is greatly to the credit of Mike Cowham and the Durham Conference organisers that the balance has been so favourable.

Two other components of this buoyant figure have come through the work of John Foad in making a Gift Aid claim very close to last year's despite a lower membership roll. Peter Lane is likewise to be thanked for his proactive marketing and management of sales, which continue to bear fruit. Changes in the charities law have required Council to start examining how Society funds will be apportioned in future. This will allow us to know exactly how much is available for restoration grants and projects in future.

6. Election of Officers.

Nominations had already been proposed and seconded. There being no other nominations from the floor, the following were again proposed by John Lester and were approved by a show of hands, and the Chairman declared them duly elected.

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

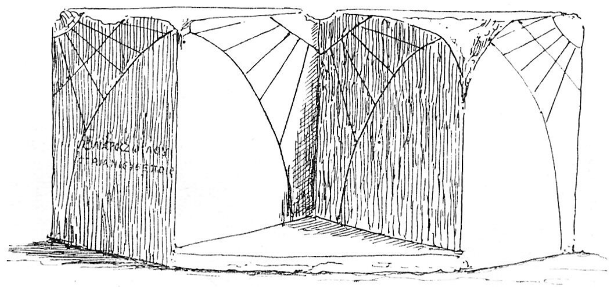
Members of Council. John Davis, Graham Aldred, Patrick Powers, Tony Wood and John Foad.

Audit. Geoff Parsons audited the accounts for 2006, and had kindly agreed to do so again for this year. His appointment was approved at the meeting by a show of hands.

7. Any Other Business

Maurice Kenn proposed a vote of thanks to the Chairman, which was strongly supported by applause from the meeting.

There being no other business, the Chairman closed the meeting at 12:54 pm.



A rather unusual Greek dial in white marble. It was brought from Athens by Lord Elgin and is now in the British Museum. One face bears the inscription:

ΦΑΙΔΡΟΣ : ΖΩΙΛΟΥ : ΠΑΙΑΝΙΕΥΣ : ΕΠΟΙΕΙ
(Phaidros son of Zoilos a Pæanian made this)

Phaidros is thought to have been an architect living in the second or third century AD. *After Gatty.*

BRITISH SUNDIAL SOCIETY
Accounts for 2006

Income and Expenditure

	INCOME			EXPENSES		
		2005	**2006**		2005	**2006**
General						
	Subscriptions (1)	£13,203.64	£12,715.89	Subscriptions	£52.00	£107.00
	Gift Aid	£1,819.79	£1,802.74	Bulletin (5)	£7,866.13	£7,892.88
				Publications (6)	£3,007.64	£399.45
				Officers (7)	£2,331.27	£3,049.46
Events						
	Holloway 2005	£13,513.70	£0.00	Holloway 2005	£14,515.13	£0.00
	Durham 2006 (8)	£4,567.00	£12,546.09	Durham 2006 (8)	£67.00	£12,147.72
	Nurnberg 2006	£0.00	£12,670.00	Nurnberg 2006	£0.00	£11,787.14
	Cambridge 2007	£0.00	£7,212.00	Cambridge 2007	£1,248.00	£1,248.00
Sales etc						
	Sales (9)	£5,149.60	£2,083.80	Sales (9)	£620.59	£366.52
	Auction (13)	£0.00	£1,082.00	Auction (13)	£0.00	£27.50
	Advertising (3)	£55.60	£50.00	Advertising (3)	£0.00	£70.00
	Donations (Somerville) (14)	£249.15	£777.86	Donations (Somerville) (14)	£0.00	£0.00
				Library (10)	£131.00	£100.00
				Internet (11)	£146.88	£193.88
Finance						
	Interest	£1,573.43	£2,138.94	Banks/Insurance (12)	£749.67	£817.74
Special						
	Awards 2005	£0.00	£0.00	Awards 2005	£2,198.05	£0.00
				Photo competition	£83.09	£126.51
Other						
	Offprints	£0.00	£0.00	Offprints	£0.00	£790.00
	Misc	£0.00	£137.83	Misc	£27.75	£129.70
	St. Katherine Cree Fund (4)	£0.00	£0.00	St. Katherine Cree Fund	£0.00	£0.00
TOTALS		£40,131.91	**£53,217.15**		£33,044.20	**£39,253.50**
Net income		£1,813.25	**£13,963.65**			

Notes for 2006

1. Balance held in the U.S.A. Amounts paid in US dollars have been converted to sterling at the exchange rate in force: on 31/12/2006, when notified of balance, or when sums were repatriated.
2. (Intentionally blank)
3. Advertising income for adverts in the Bulletin & Newsletter, expenses for Society publicity in other journals etc.
4. These donations held for the restoration of the St. Katherine Cree Sundial, are not part of the general assets.
5. Four editions paid for in the year. Includes postage costs.
6. Production of the BSS Register (CD version).
7. Includes postage, leaflets, travel, computing sundries, meeting room costs etc.
8. Advance deposit for the 2006 Conference and early payments from members.
9. Sales of booklets, sweatshirts, slides, ties etc by Margery Lovatt, Peter Lane, Jane Walker & David Young
10. Subscription to the Bromley House Library (Nottingham) and purchase of books.
11. Hosting of the BSS website and domain name costs.
12. Bank costs (inc international), credit card costs, Society liability insurance.
13. Proceeds of the auctions at Conferences are added to the Somerville Fund

14 The Andrew Somerville Memorial Fund contains all donations to the BSS and its reserves are part of the general BSS Assets. Expenses include the annual Somerville Lecture and grants.

15 The BSS Library valuation is based on the 2003 value by Rogers Turner Books.

General Notes.

A. The accounts are prepared on a payments and receipts basis. That is, money is booked when it is received or spent (i.e. when cheques are written, not presented). This is in line with the Charity Commission's guidance.

B. The year-end funds are held mainly in approved investment accounts as well as current accounts.

C. Events are priced not to make a loss, with contingencies plus a gross margin of 10%.

D. Stocks are valued at nil as they are unlikely to have any value if the Society were to be wound up. This does not impact our cash flow.

	2005	**2006**	**Delta**	
Current account balance	£1,771.33	£3,559.18	£1,787.85	
Deposit account balance	£16.51	£16.59	£0.08	
BSS USA current account balance (1)	£1,028.81	£1,904.76	£875.95	
Charities Office Investment Fund	£41,765.39	£52,840.25	£11,074.86	
TOTALS	**£44,582.04**	**£58,320.78**	£13,738.74	inc cheques not presented
			£13,717.74	excl cheques not presented
Change in funds from previous year	£7,510.27	£13,738.74		
Income received during the year	£40,131.91	£53,138.15		
Expenses incurred during the year	£33,044.20	£40,296.36		
Excess of income over expenditure	**£7,087.71**	**£12,841.79**		
Andrew Somerville Memorial Fund	£1,322.29	£3,182.15		Included in above amounts
St Katherine Cree Restoration Fund	£1,148.42	£1,148.42		Included in above amounts
Library Valuation	£16,635.00	£16,635.00		Not included in above amounts (note 15)

Auditor's Comments

1) The accounts have been well run using the spreadsheet developed by the previous Treasurer.

2) The ownership of the Katherine Cree Fund is not clearly stated: a strategy for managing this fund should be determined.

3) Greater clarity is desirable in the allocation and recording of the amounts to the Somerville Fund

4) The Council's proposal to retain up to 20% of the excess margin from events is considered appropriate.

NAME	**POST**	**SIGNATURE**	**DATE**
G Stapleton	Treasurer		12-IV-07
G Parsons	Auditor		12/4/07
C Daniel	Chairman		12/4/07

Redacted

MAKING BRASS DISCS THE EASY WAY

TONY MOSS

Long-time contributors to the internet Sundial Mailing List will recall a series of notes and pictures I distributed some years ago concerning the production of large brass discs in the workshop. At the time these ideas arose from the production of the plates for my LindiSol heliochronometer and involved 'sandwiching' the blanks between MDF discs fixed to a lathe faceplate. This worked very well but was somewhat laborious in that individual MDF discs had to be made and pre-prepared and, worst of all, stored for each plate diameter.

While pondering a similar problem recently a much easier solution occurred to me which seemed too simple to be feasible but experiment soon proved otherwise. This is so good and so useful that surely I can't have been the first to think of it….can I?

Having punch-marked the centre point and scribed a circle, the disc is first rough sawn to a slightly oversize multi-polygon for which I use a Taiwanese metal-cutting bandsaw. This amazing workhorse retails for less than £180 and, with a few simple modifications, quickly profiles brass and bronze up to 25mm thick while also serving as a narrow 'warding file' to generate intricate shapes with little effort. The centre-punch mark is now drilled with a 'centre-drill' or 'Slocum drill' to give a conical centre hole into which a revolving centre in the lathe tailstock will fit. (Fig. 1.) This 'live' centre is essential or too much wear would result with the pressure required for contact.

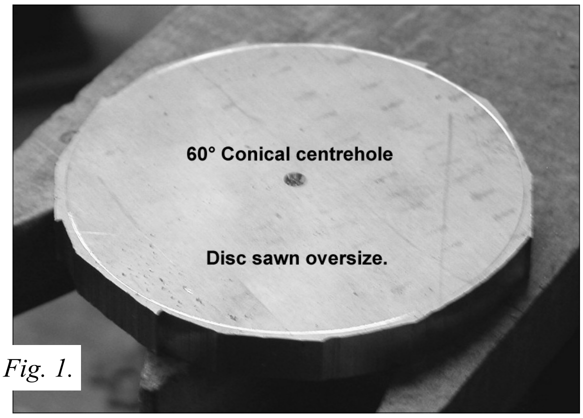


Fig. 1.

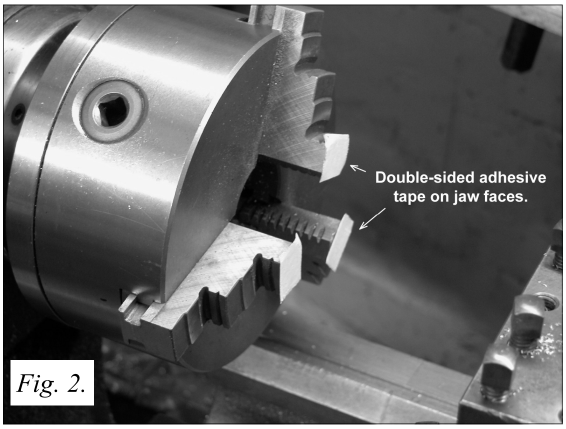


Fig. 2.

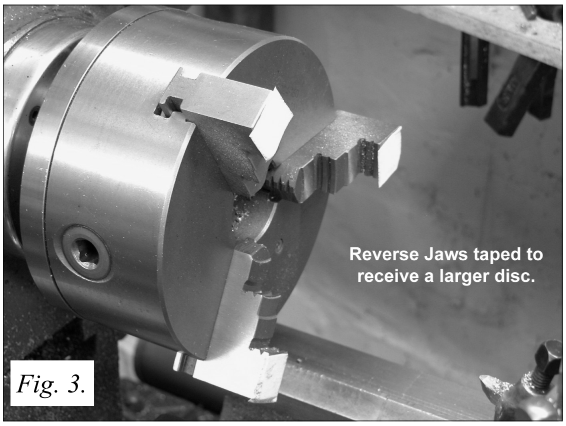


Fig. 3.

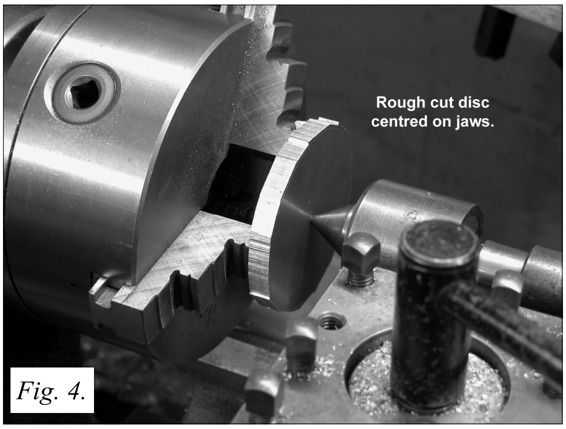


Fig. 4.

Now comes the clever bit! Open the jaws of the lathe 3-jaw self-centering chuck to fit within the size of the scribed circle with a few millimetres clearance. Either the normal or the 'reverse' jaws (Fig. 2) may be required to fit any particular disc size. Carefully clean the three jaw faces with a grease solvent and then apply a square of double-sided adhesive tape. (Fig. 3.) I use an industrial grade of tape made by TESA which has amazing strength. My 30-year-old roll is as active as ever it was! The disc is placed on the tailstock centre and carefully pressed against the taped chuck jaw faces before pressing firmly home by hand to ensure good adhesion. (Fig. 4.) The disc can now be turned to diameter and chamfered with a series of medium cuts. (Fig. 5.) The tape provides all the cutting torque required and the revolving centre maintains good contact and alignment.

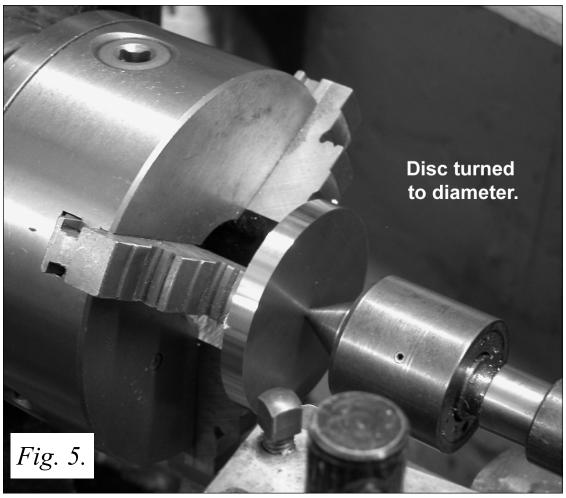


Fig. 5.

Perhaps the hardest bit is actually removing the finished disc from the chuck face where it will be found to have a very firm grip only overcome by an improvised wooden lever from behind. The advantage over my previous system is that the chuck jaws are instantly settable to suit any diameter of disc. So far only thick brass plate has been used for larger discs. Care must be taken to avoid thinner stock 'dishing' in the middle in larger sizes. This process is limited to the maximum size of disc which will rotate over the lathe bed. (Figs. 6 & 7.)

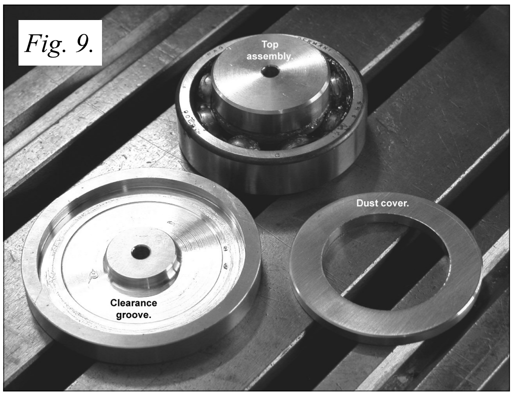


Fig. 9.

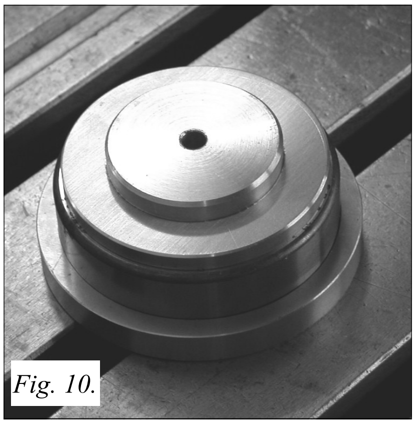


Fig. 10.

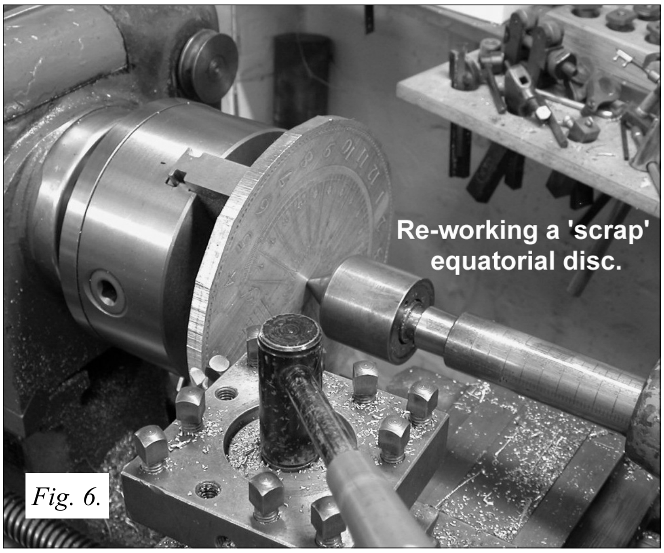


Fig. 6.

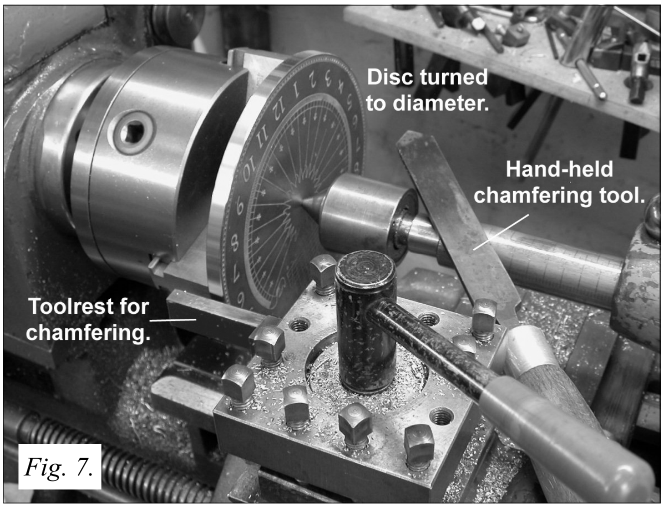


Fig. 7.

For larger discs a similar process can be applied to a rotary table on the milling machine. (Fig. 8.) If fixing holes or a gnomon slot occur in the metal disc, these can of then be used to bolt to tee-nuts in the rotary table slots. In contrast, a large plain disc with no fixing holes/slots raises problems because there is no tailstock on a milling machine to supply the closing pressure needed to maintain contact with the double-sided adhesive tape. My solution to this can be seen in Figs. 9 & 10. The tailstock is replaced by a ball-bearing pressure pad secured by a box-section steel 'bridge'. Double-sided tape equally spaced at six locations around the rim of the rotary table provide the driving force. It was the manufacture of this device using a surplus ball-race which led me to think of the quick lathe method of making brass discs.

Tony Moss
Lindisfarne Sundials
www.lindisun

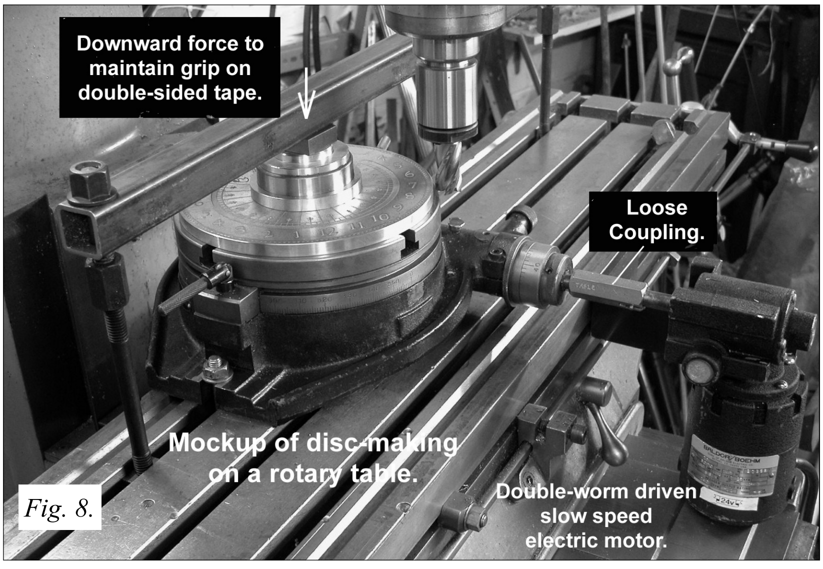
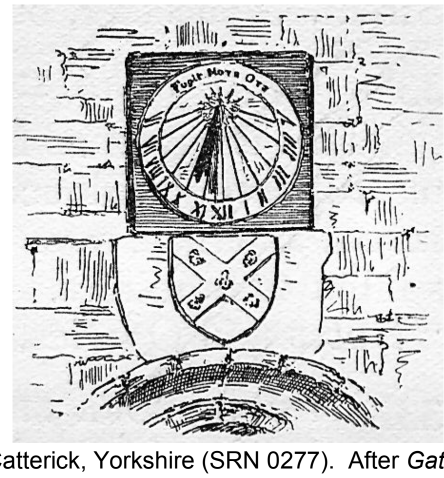


Fig. 8.


Catterick, Yorkshire (SRN 0277). After *Gatty.*

DAVID HARBER LTD - *A visit report by Douglas Bateman*

David and Sophie Harber with some of their numerous awards in the back-ground.

From a chance introduction to sundials by way of an antique dealer with a crude armillary sphere, David Harber Ltd. has grown into a well established business selling sundials, garden features and sculptural work, employing up to 8 people.

David's own background is almost as astonishing as the variety of his work. He left Dartington school, Devon, at the age of 15, and went to assist PhD students at a nature reserve, became an apprentice thatcher, an apprentice potter, and taught rock climbing in Dartmoor. At the age of 23 he persuaded the BBC to appoint him, on the strength of his climbing experience, to be the second cameraman on an expedition to Patagonia.

The office team: David and Rosemary Booth who now provide mathematical support, and Karen Fry, who has managed the office for eight years.

After this, and on a whim, he went to live in France and ended up running a small boatyard for 2 years, which gave enough experience to gamble on buying a 160t boat in Rotterdam which was taken back to France as a travelling art centre! It was whilst maintaining the boat that David had very quickly to learn welding and metalwork. The boat was eventually sailed to the UK, sold, and is now moored on the Thames near Kew Bridge.

For once David seemed down on his luck when, in 1991, the antique dealer showed him the armillary and he thought he could make one just as well, if not better. Whilst fabricating the dial on the steps of a rented cottage in the Hambledon valley, near Henley, a passer-by asked if he could buy it. David quoted "3 months' rent" as the price: without knowing how much this was, the stranger agreed. This person turned out to be the actor Jeremy Irons, who subsequently bought some more sundials. The next step was to rent a corner of some farm buildings for two years. As the business grew he moved to the current premises - more farm buildings with much more space. These have been occupied for 14 years and, to come up to date, during 2007 the business is to move to a workshop near to Didcot, this time as owners of the property.

Given my own staid background and steady career, I asked myself "would I have employed a man with such a CV?". The answer would probably have been no, yet one can see an artistic thread and a strong sense of self reliance coupled with a determination to succeed. The determination has been reinforced by his wife, Sophie, who has been equally firm about putting the business on a sound footing with professional marketing.

At the start of a commission, the context is always stressed and to this end a watercolour of the dial and its proposed location is shown to the client. The illustration may be supported by a mock-up, but almost invariably a good watercolour painting convinces the client. In my own limited associations with David, I have always been impressed by this approach, especially as the paintings themselves are very pleasing. Referring to the early days, David freely acknowledges generous support from Society members, in particular Ian Wootton and David Young.

A sound business philosophy is that the sundials must have a long life, and an example that David is proud to tell is that some of his early models were mild steel with an electroplating sequence to give a bronzed finish. He found that the plating company had omitted the intermediate stages so, rather than risk customers having dials that would eventually

The current workshop team: left to right - Marcin Mankowski, Ian Piggott, Andrew Esson, and Rory Elliott.

A couple of water colours - a valuable follow-up to initial enquiries.

rust, he replaced them all at considerable personal expense with versions made in brass and bronze. Although David Harber Ltd. will certainly use these traditional materials, it partly explains the preference for stainless steel in the majority of their products. Indeed, if there is one defining feature of the business, that is polished stainless steel.

However, that brings other problems. Stainless steel is not easy to work with and good welding techniques are required. In sheet form, locally applied heat can distort it to give warping that can be permanent and ruin the desired shape. (This is due in part to the low thermal conductivity compared with mild steel or brass.) It is therefore a credit that quite complex shapes such as obelisks with cut outs, curved surfaces and spherical forms can be made to a high degree of perfection.

....if there is one defining feature of the business, that is polished stainless steel.

Another problem is engraving. Stainless steel is tough and, although etching has been used to great effect by some makers, especially for fine detail, the armillary spheres and similar dials require large letters, hence the choice of machine engraving. Initially a pantograph engraver was used, but now a large flat bed machine with a computer controlled tungsten carbide cutter gives the clarity, speed of cut, and depth (up to 0.2mm) that is needed.

More traditional materials have not been neglected, in fact quite a number of commissions were vertical dials in stone and slate, although even here, the dramatic or unusual can appear. A good example is the massive 3t rough hewn block of limestone set up in the centre of Winchester. A vertical dial is on one face and the gnomon is part tubular to allow a gentle cascade of water descend into a grill below.

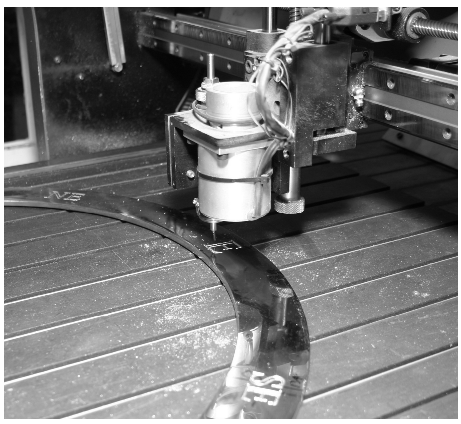
For 10 years David Harber Ltd has been exhibiting at the Chelsea Flower Show. The Royal Horticultural Society has given them several awards for the quality of the display so it is logical that there is a Harber dial at the RHS gardens in Wisley. Although such shows are expensive, it gives a good showcase. Of course, many professional landscape gardeners attend the show, both foreign and from the British Isles. Perhaps because of the shows and word of mouth, about 30% of the sales are overseas, including the Middle East, America and, so far, three dials in Russia.

Continuing the theme of the flower show, the business is embracing garden sculpture. Certainly not the classic maiden with an urn, but bright steel water features, rills and hemispheres. Some sculptures use more ‘native’ materials, but still responding to the fashion of architectural aspects of modern gardens where the owners and landscape designers look for strong statements.

The office is manned by Karen and nowadays mathematical support is provided by Rosemary and David Booth. Sophie Harber, in addition to looking after three small children, is the driving force for the business. To have four workshop staff is further evidence of a large output. In 2006 production was 76 armillary spheres, 31 other types, 9 sculptural features, and 2 water walls: a most impressive record.

A flat bed computer controlled engraver.

The engraver cutter working on a stainless steel armillary horizon ring.



An armillary sphere unveiled by Her Majesty the Queen at Goodenough College. The College has over 620 postgraduate students from more than seventy countries and is a leading residential centre for international postgraduate students in London.
Goodenough College is not the first academic institution to favour David Harber. More than ten Oxbridge colleges feature garden sundials from the company. St Paul's school in London and Stowe School in Buckinghamshire also have armillary spheres in their grounds. (Photo: Sophie Harber.)

To return to a personal note, whilst researching the mathematician and diallist John Blagrave (1561-1611), David unearthed the astonishing fact that this celebrated Elizabethan was a direct ancestor of his. John Blagrave was an esteemed Tudor mathematician and designer of astronomical instruments.

Within the British Isles and throughout the world there are sundial designers and makers of very long standing, but I am not aware of any other sundial manufacturing group that can claim to be such a large and successful enterprise. Further details and examples can be seen on their equally outstanding website www.davidharber.com.

An attractive modern dial made of clear blue or green glass; the hour lines cast a shadow on to the etched surface, which gives extra 'depth' to the dial. (Photo: David Harber.)

The Berossos type of dial is another favourite Harber design. Usually 50cm in diameter, it is available in verdigris copper or stainless steel.
(Photo: David Harber.)

SMALLEST DIAL PICTURE?

This representation of a sundial is only a few thousandths of an inch across and is to be found near the timing circuitry on a Hewlett-Packard PA-7300LC microprocessor. It was chosen by the designers because "it is much faster than any clock and does not move in discrete 'ticks'." The motto on the dial reads "VR fp 1995" (not in Gatty!). We are not sure of the design latitude.

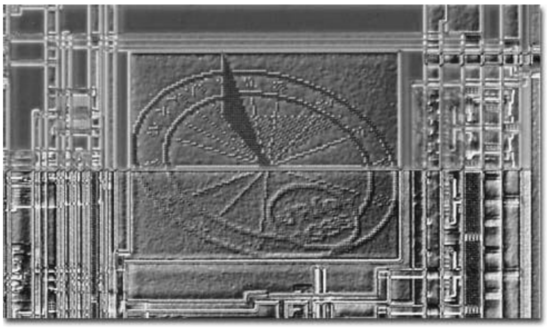


Photo © Michael W. Davidson & Florida State University, 1995– 2006 (with permission)

SHEDDING A GLORIOUS LIGHT

See p. 71 for text

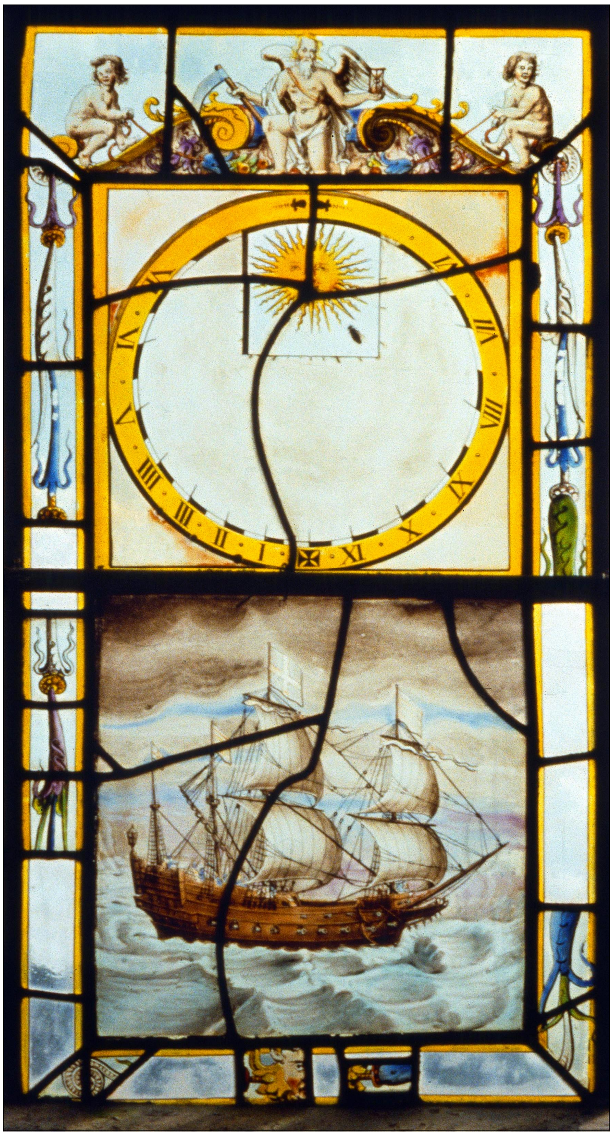


Fig. 1. 17th century, direct south-facing sundial, with a war-ship below. In St Botolph's church, Lullingstone, Kent.

Fig. 2. Sundial, upside down, high on a window-sill in Ledbury church, Herefordshire.

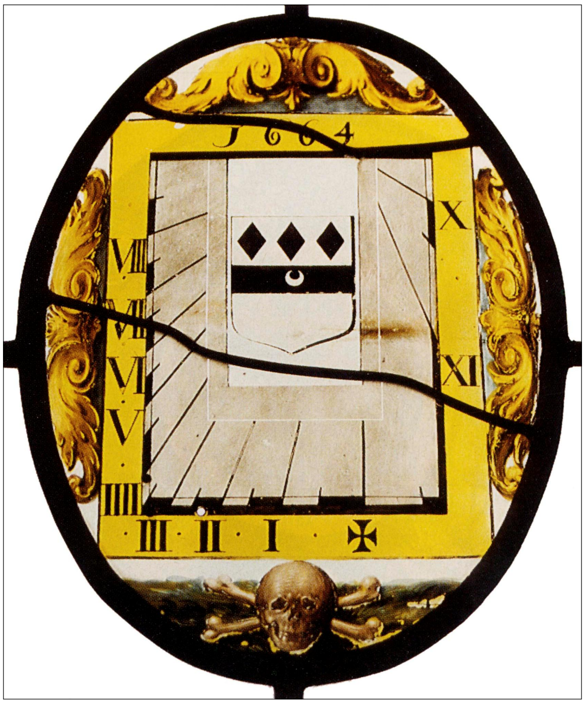


Fig. 4 (above). Declining sundial, 1664. In Leigh Park Hall, Staffordshire. Sundial construction was a popular pastime for 17th century gentlemen.

Fig. 3 (left). Earliest known stained-glass sundial in England. By Bernard Dininckoff, 1585. In Gilling Castle, North Yorkshire.

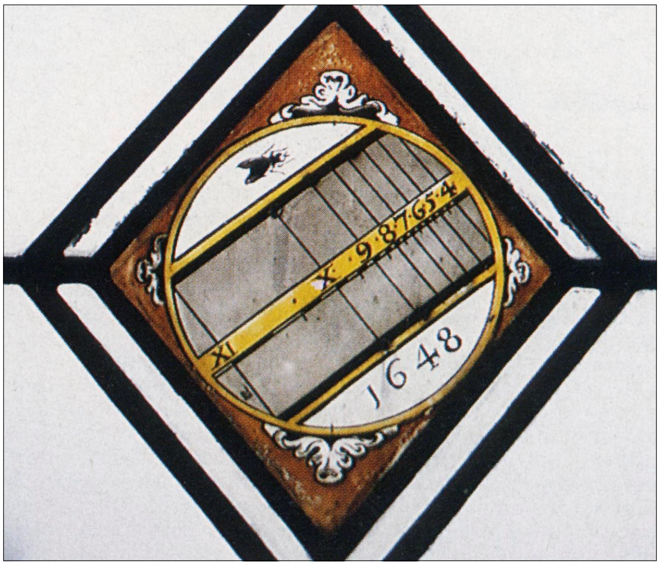
Fig. 5 (above). Sundial and the Seasons, by Henry Gyles, 1670. Nun Appleton Hall, Yorkshire.

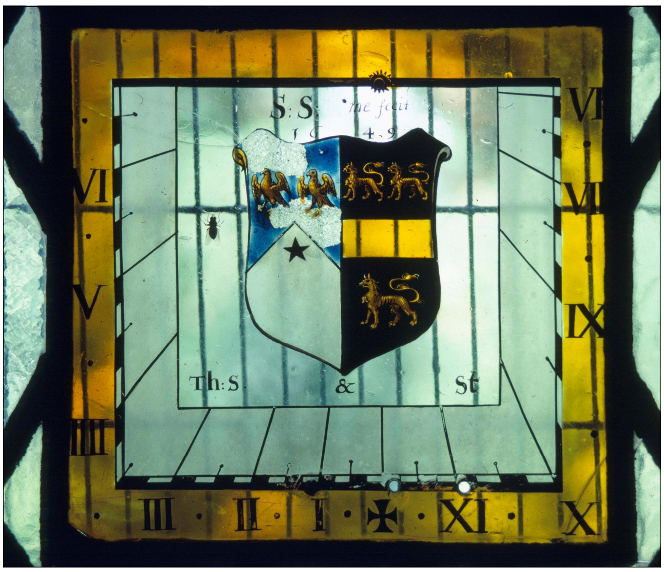
Fig. 6 (top right). 17th century glass dial at Grey's Court College, York.

Fig. 9 (right). Sundial of 1648 in the Museum of the History of Science, Oxford.

Fig. 8 (bottom right). Heraldic glass dial, 1649, in Bucklebury church, Berkshire. A south-facing sundial, it has been restored in a north-facing window. Excluding those in collections, there are some 32 painted or stained-glass sundials surviving in-situ (or almost in-situ) in Britain today.

Fig. 7 (below) South-west declining sundial by Gay Ogg, 1981. In Dulwich, south-east London.





SHEDDING A GLORIOUS LIGHT
Stained-Glass Window Sundials

CHRISTOPHER ST J. H. DANIEL

The following article was first published in *Country Life* Magazine twenty years ago (26 February, 1987). Since then, the author has written various articles on the subject of stained-glass sundials, mostly for *Clocks* Magazine. He has also re-discovered a number of 'lost' glass dials, designed the means of restoring one such dial, and designed two notable modern stained-glass sundials for historic buildings. During this time, he has endeavoured to encourage others in this particularly beautiful aspect of the art of dialling.

Whilst it is not the normal policy of the Society to republish an article, in this instance it is perhaps apt to do so *verbatim*, after exactly two decades, particularly as personal circumstances prevented the author from completing the work that was intended for publication on this occasion. Consequently, the article has not been updated and contains some minor errors (see Postscript).

Vertical sundials were once common on the walls of principal buildings throughout the country. They were set up both to indicate the time of day and to regulate public clocks, not noted for their accuracy much before the 19th century. A less common form of vertical sundial, but one that was popular during the 17th century, was the painted-glass or stained-glass sundial set in a window, which could be viewed from inside and was decorative as well as functional.

Stained-glass sundials usually took the form of an oblong or oval glass panel, with the gnomon (the indicator that casts the shadow) fixed to the outside of the windowpane. The glass was backed with a coat of white matt or coloured semi-opaque pigment, upon which the hour-lines and numerals would be painted in black (reversed to be read from inside). The surrounding decorations were usually in matt and stain with some enamel washes, occasionally in flashed glass or, more rarely, pot metals.

During the 16th and 17th centuries, the practice of constructing sundials grew and flourished. It was a popular pastime for gentlemen and an important part of a commercial mathematical instrument-making industry. Anyone well educated was expected to have more than a passing interest in the subject, which was regarded as both a science, gnomonics, and a mathematical art, that of dialling. Newton, Wren and Flamsteed recorded their study of this art, which, in clear weather, determined the time from the position of the sun by day and from the moon and stars by night.

With the improvement in clock movements in the late 17th and early 18th centuries, tables for the equation of time were often provided on sundials, to correct observed sundial time (apparent solar time), and enable 'clock' time, local mean time, to be deduced. This allowed the sundial to continue its role of keeping clocks and watches properly regulated.

Vertical sundials that face directly north, south, east, or west are termed direct-facing dials. However, most buildings have walls that face away at some angle between these points. Such walls are regarded as declining and sundials situated on them are termed vertical declining dials, measured in degrees from south or north towards the east or west cardinal points of the compass.

Glass-window sundials conform to the same principles that apply to vertical wall dials. More often than not, the surviving examples of this beautiful mathematical art are found to be declining, if only by a few degrees.

The earliest recorded window sundial seems to have been one dated 1518 in the castle of Kurfursten von Sachsen in Altenburg. The earliest surviving example, dated 1535, is in the collection of the Kunstgewerbemuseum in Berlin. In the 16th century Germany already had a reputation for instrument-making and sundial construction, particularly in Nuremburg and Augsburg.

It is not known when or by whom the first painted or stained-glass window sundial was introduced to Britain. The earliest known example is the exquisite little roundel, only 2¾in. in diameter, set into the magnificent heraldic window in the Great Chamber at Gilling Castle in Yorkshire. [Fig. 3.] In 1571 Sir William Fairfax succeeded to this property, which he held until 1597, and he rebuilt the 14th century house, including the Great Chamber.

To this day it is almost unaltered, a very fine example of a late-Elizabethan interior richly panelled in English oak. Its windows portray in painted glass the genealogy and heraldry of the Fairfax family.

The main, south-facing bay windows are the work of Bernard Dininckoff, whose signature, with the date 1585 and a tiny portrait of himself, appears just below the sundial in the bottom right-hand light. Dininckoff was possibly a member of a refugee family from Bohemia, which had been annexed in 1526 as part of the Austrian Empire. Many of the European scholars and craftsmen who came to England in the 16th century were fleeing war, plague or religious intolerance, although some, such as Nicolas Kratzer, horologer to Henry VIII, were enticed over. Thus the established English centres of learning and craftsmanship were enriched with fresh ideas and new skills.

Dininckoff appears to have become a member of the York school of glass-painting and much respected, since he was made a freeman of the city of York in 1586. The small circular sundial is the final embellishment to his glass masterpiece for Sir William. It is fortunate that it has survived, escaping 18th century renovations and 20th century commercial interests. After this branch of the Fairfax family had become extinct, the vendor of the property in 1929 removed the wooden panelling and the glass, and sold them off separately. Fortunately, with the help of the Pilgrim Trust and many friends, it was recovered for Gilling and restored to its proper place in 1952.

A glass sundial, by its very nature, is a fragile instrument, particularly since the glass must normally be drilled with two or more holes to allow the gnomon to be fastened in place. As this is normally made of brass, sometimes of iron or lead, the strain upon the glass must contribute to damage and loss.

However, neglect, vandalism, accidental damage (particularly from tennis balls) and the misguided notion that a glass sundial is valuable for its own sake have caused a large number of these sundials to disappear without trace. Sometimes a painted-glass dial will turn up in a public or private collection, usually without a provenance and therefore open to speculation.

The real value of the glass sundial is that each dial, as with other ordinary vertical sundials, was calculated and made for a particular window, in a particular building, for a given latitude and for the declination of the wall and window in question. Such a dial would be useless if removed and placed in a different window. Indeed, if every glass dial were properly recorded, it would take very little effort to trace it to its proper location, should it have been removed for any reason. The delineation of the hour-lines on the glass provides the details already mentioned, and almost every painted-glass dial differs in decorative subject, quality and style.

Excluding those in collections, such as the 18th century dial in the British Museum, which is thought to be German, there are some 32 painted or stained-glass sundials surviving *in situ* (or almost *in situ*) in Britain today. It is true that the dial in Ledbury church [Fig. 2] is upside down, high on a west-facing window-sill, and that in Bucklebury church [Fig. 8] is in a north window, despite its being a south-facing dial; but these are better fates than losing their glory altogether. It would be preferable, of course, to have them restored to their original windows.

Most of these surviving sundials are the product of the latter half of the 17th century. Puritan views against the use of ornate, colourful windows in churches obliged the glass-painter to look towards secular and domestic buildings for his livelihood. As a result, a number of beautiful examples of the glass-painter's art can be found in castles, country houses and colleges.

Probably the finest complete glass sundial, with the gnomon intact and undamaged, is the dial at Tong Hall, near Bradford, West Yorkshire, [not illustrated] attributed to and wholly typical of the work of the well-known glass-painter Henry Gyles of York (1645-1709). As Gyles was a friend of Sir George Tempest, who was building the hall in 1702, it is improbable that Sir George would have had any other glass-painter to carry out this work.

However, the sundial has been removed from its original lead and placed in a wooden framework, which has probably destroyed the proof that Gyles was the maker. Gyles was known to have used a glazier's vice, the wheels of which would have impressed his name and possibly the date onto the leadwork. The dial bears the inscriptions "Lat:54" and "Declines 14 deg: East". For the most part, Gyles signed on the glass itself and it is surprising, perhaps, that he did not do so in this case.

Henry Gyles was noted for his glass sundials, which he would sometimes include gratis when given a commission for a large window. A prime example is the dial made for University College, Oxford, depicting the figure of Christ (believed to be the first known portrayal of Christ in this context since the Reformation).

The Nun Appleton Hall glass sundial is fine, too. [Fig. 5.] Signed and dated 1670, it is the earliest known work by Gyles. It portrays the four seasons and has certain characteristics in common with the dial made for Tong Hall, some 32 years later.

Such was Gyles's reputation in this art that many unsigned 17th century, painted-glass sundials around the country are attributed to him. Some of these may have been the work of another prominent glass-painter of the period, John Oliver (1616-1701), a member of the London Company of Glaziers and Painters on Glass. Oliver seems to have received many commissions following the Great Fire of London in 1666.

Like Gyles, Oliver had a reputation as a skilled maker of glass sundials. His regular inclusion of a fly is often supposed to be an allusion to the warning 'tempus fugit', but flies were very common in domestic glass of that period. Not only were flies depicted on the glass, but sometimes bees, spiders and even their webs. Oliver appears to have included these life-like features on most of his dials.

Unfortunately, almost all of Oliver's sundials have been destroyed or removed to private collections. However, very recently, a glass-painted dial was discovered in a store belonging to the Weavers' Company [not illustrated]. It was removed from the Company's old hall when the building was pulled down in 1856, and may have been displayed elsewhere for a number of years. In 1916 it was boxed up and sent out of the City for safe keeping during the Zeppelin bombing raids on London. The sundial is almost certainly the work of John Oliver, and probably dates from about 1669, since Oliver was employed by the Weavers' Company at about that time in reconstructing their hall.

The dial is contained in a vertical, oblong panel with D-shaped ends, the uppermost semi-circle of which depicts a winged hour-glass; the lower semi-circle, the Company's arms. The dial itself has a plain yellow-stained border with the motto *Dum Spectas Fugio*. At the centre of the dial, a spider advances from its web to seize an unsuspecting fly. One hopes that the Weavers' Company will soon place the dial in a suitable window in their London office, to serve a decorative if not a useful purpose.

Fewer glass dials were produced in the 18th than the 17th century, but a fine one by John Rowell of Wycombe is still set in its original south window at Purley Hall. Another very fine glass dial by Rowell is to be seen at Arbury Hall in Warwickshire, dated 1733. In the 19th century, Charles Kempe revived interest in the art of constructing glass sundials and produced some charming examples, but most of these have also disappeared.

Despite indifference and neglect, glass-painted sundials are very much a part of our heritage. Sadly, the number has been reduced by nearly half since the turn of the century. One small delightful modern glass sundial by Gay Ogg has been added in recent years to a house in Dulwich [Fig. 7]; and one has been replaced in Blackheath by a modern copy after the original was broken by a tennis ball.

It is to be hoped that the known examples of this beautiful art will be preserved *in situ*, and that unknown sundials will be brought to light, wherever they may be.

POSTSCRIPT

The following updates to the above text should be noted:

* The earliest extant glass dial, which is dated 1529, is in the Adler Planetarium & Museum, not in Berlin.

* The Weavers' Company dial was restored and set up, to my design with a new gnomon, in a specially made bay window, in their almshouses in Wanstead.

* There are now more than 32 such dials still extant.

* I don't now think that "almost all Oliver's dials have been destroyed".

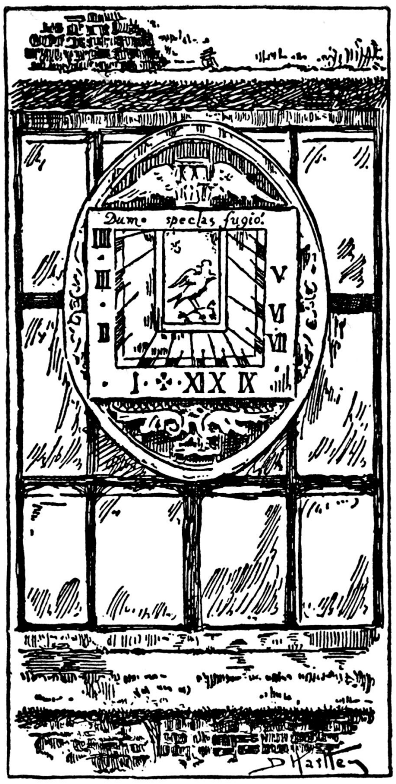
BIRD IN HAND

CHRISTOPHER St J. H. DANIEL

[This article was originally published in *CLOCKS* magazine, 'The Sundial Page', October 2001.]

Probably the best known stained-glass sundial of all is the one which, for many years, adorned a south-facing window in Nailsea Court in Somerset, now the county of Avon, until it was stolen about the turn of the 20th century. Its familiarity is no doubt due to the fact that it was copied and re-copied on many occasions by various hands from the late 19th century until the present time. Perhaps this is because, as its principal decoration, it features a bird, identified as a skylark, that, with wings outstretched, appears to have just alighted on the frail upper branch of a tree; but which has its beady eyes firmly fixed on a nearby fly!

The sundial takes the form of a rectangular panel set in the leaded framework of a painted and stained glass oval, measuring 10¼" (261mm) by 7⅜" (187mm) overall. The dial-plate is delineated with black hour-lines and half-hour marks on a white matt background, edged with a narrow black-and-white segmented border, highlighting the graduated divisions. A broad border in yellow stain, marked out with bold black-painted Roman numerals, denoting the hours, and small circular spots, marking the half-hours, provides a surrounding frame. A small heraldic cross within this border denotes the hour-line of 12 o'clock (noon). Across the upper horizontal length of the border, the inscription *Dum Spectas Fugio* ('Whilst you watch, I fly') proclaims the passing of time and life.



Derby, 1888. After Henslow.

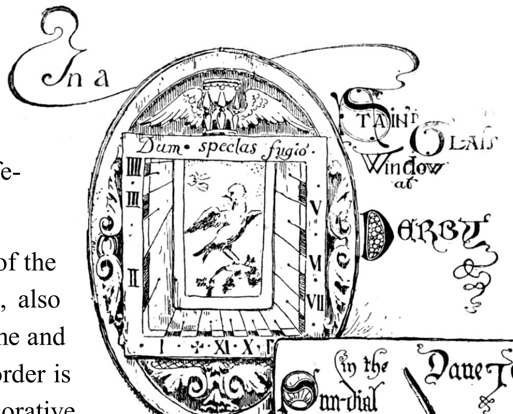
Within the area of the dial-plate, there is a central rectangular panel containing the scene of the bird, eyeing the fly. The bird is delicately painted, clearly depicting the crest and the fluffed-up layering of the feathers in various shades of brown. The fly, often included on such stained-glass dials as a pun on 'time flys', is also delicately painted, but is perhaps nearer life-size than the bird.

In the space above the yellow-stain border of the dial there is depicted a winged hour-glass, also symbolically representing the passage of time and the inevitable passing of life. This outer border is in a red 'float' stain, offsetting the decorative foliage or ornamental cartouche. There is no visible signature or date; but the sundial is undoubtedly a fine example of the glass-painter's art of the 17th century.

Probably more is known about this sundial because of the copy that was made of it by Frederick Drake in 1888 for a gentleman in Derby. In the *Strand Magazine* (Volume III, January-June, 1892, pp 607-612), there is an article entitled *Sundials* by Warrington Hogg, in which there is a sketch of a sundial "in a stained-glass window at Derby". The text states that "The dial in the stained-glass window in the private office of E S Johnson, Esq, at Derby, is a modern but very fine one; it is an exact copy, painted in 1888, by Frederick Drake, of the Close, Exeter, the glazier to the Cathedral, who painted it from one taken out of an old manor house in Devonshire, dated 1660."

It would indeed appear to have been an exact copy in almost all respects, except in style and in fine detail. Whether it was commissioned as an ornament or as a working sundial is unknown; but, in any case, Frederick Drake appears to have signed and dated this copy since, in his *Ye Sundial Book* (first published in 1914) T Geoffffrey W Henslow illustrates the dial with a sketch, with the caption 'Sundial in a window in Derby – dated 1888'. Glass-painter he may have been; but diallist Frederick Drake was not, since his Derby sundial could only have been accurate for the latitude of the manor house in Devon, for which the original was made, and for the declination of the window in which it had been situated.

In 1888, as a thriving commercial centre, Derby would have been abundantly furnished with well-regulated public clocks, those at the post office and railway station being linked to the Royal Observatory at Greenwich by the electric telegraph, keeping accurate Greenwich Mean Time. Thus, Mr E S Johnson could hardly have had any real need of a stained-glass sundial in his office for the determination of the time; but more likely for his own pleasure and perhaps a little for show! However, the fact that he had the original copied from a known source, which was recorded at that time, provides evidence of the provenance of the Nailsea Court sundial.



In 1912 there was published a work by Frederick Drake's son, Maurice Drake, entitled *A History Of English Glass-Painting*, in which there is an illustration by W. Drake of "A Jacobean Sundial, c.1620, from Mr Radford's Collection." A noted antiquary, Mr A L Radford FSA, is recorded as having lived at Bovey House in Devon. Evidently he had a fine collection of stained-glass works and it is more than likely that he acquired the sundial that later found its way to Nailsea Court. It is probable, at that time, that he would have had a good idea of its provenance, if not its date. Thus, originally in "an old manor house in Devonshire, dated 1660" it would have been constructed for the nearest degree of latitude, namely 51° North, establishing, from the delineation of the dial-plate, a declination from South of 34½° East. Apart from the style, the illustration in Maurice Drake's book confirms that the Derby sundial and the Nailsea Court dial are exactly the same.

In 1914, Warrington Hogg produced a delightful little work, *A Book Of Sundials*, that ran to many editions and reprints, which also featured his sketch of the dial at Derby. However, more recently, in 1969, the dial was copied again by 'the Glass Masters' of New York, presumably from the plate in Maurice Drake's book. It is claimed that it is a replica of one executed by the English glass-painter Henry Gyles of York (1645-1709). If anything, the original sundial – the Nailsea Court dial – is stylistically closer to the work of John Oliver (1616-1701); but, at present, the maker is unknown and the date is uncertain. In the case of the so-called 'replica' by 'the Glass Masters' of New York, the date is undoubtedly known and the style is closer to the work of Walt Disney. Fortunately, the new Nailsea Court sundial by Carol Arnold conforms to the original style!

(Left) The original Nailsea dial (photo: C. Daniel).

(Above) The 1969 New York representation of the Nailsea dial.

NAILSEA REPLACEMENT SUNDIAL

CAROL ARNOLD

[The author is a professional stained glass artist working in north Somerset – Ed.]

I first found out about stained glass sundials when I came across the 'Stained Glass Sundials of the World' website.[1] Looking through the site I found a picture of the beautiful Nailsea dial (reputedly made by John Oliver in the 17th century) famously copied, recopied and finally stolen after a fire at Nailsea Court in North Somerset. It transpired that the current owners of the house wanted a replacement dial to be made, hence I became involved.

Chris Daniel sent me an actual size photograph of the original dial from which to work. (See previous article for a colour photograph of the original dial.) John Carmichael and his 'diallers' gave me lots of encouragement, and advice about declination measurements and hour line calculations. To find the declination of the window I used the setup illustrated in Fig. 1 from a window sill inside the house. The spirit level ensured that the blade of the square was perfectly vertical. The sun angle to the window was measured from the angle which the shadow made, with the horizontal line perpendicular to the window. A piece of graph paper was fixed to the board to enable the accurate

Fig. 2. The author soldering the gnomon into position with the aid of a temporary plywood jig.

Fig. 4. The dial viewed from outside the building, showing the gnomon supports. The colours look quite different from this side.

Fig. 3. The completed replica dial by Carol Arnold.

Fig. 5. Close-up of part of the dial. Note the discreet signature (CA 06) in the leaf to the left identifying this as a replica.

Fig. 6. The dial resplendent in position with other stained glass at Nailsea Court

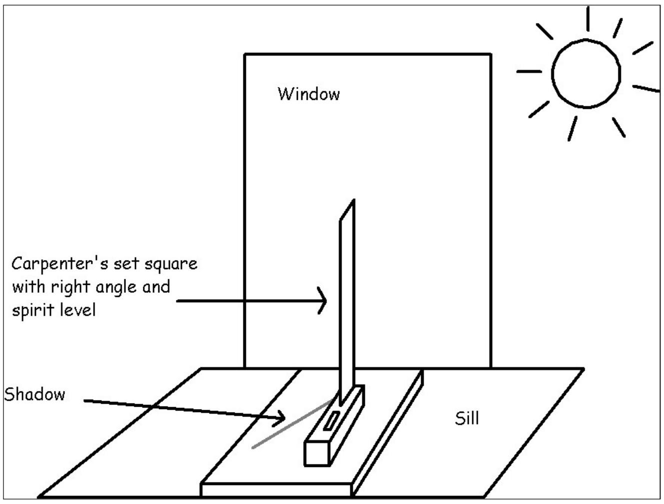


Fig. 1. The arrangement used to find the window declination.

angle to be calculated. Several measurements were taken over a few hours. The declination of the window was then calculated from this angle and the azimuth of the sun. The average declination calculation was 9° 0' 14" East of South.

A reverse-engineering calculation using the photograph of the original dial gave an approximate declination of 35° East of South. It is known that the original dial was not made for Nailsea Court but brought there at the beginning of the 20th century "from an old manor house in Devon". So it would never have given the correct time in its location at Nailsea.

The original dial had cracked – the gnomon and two horizontal stays had been fixed by drilling through the glass. I decided to fix the rods to the lead work to avoid any strain on the glass. The centre of the dial was therefore positioned at a point in the hourglass to allow the gnomon to be fixed to a horizontal brass rod just above the writing.

I used a program called 'Shadows'[2] which draws out hour lines for a particular latitude and window declination. I traced these onto my working 'cartoon'. Other calculations were necessary to pinpoint the centre of the dial, taking into account the thickness of the glass, positions and thicknesses of the brass rods.

The oval dial was first cut out of plain 4mm window glass. It measured 10¼" by 7¾" which was the exact size of the original. There were then many stages of etching, painting, enamelling, silver staining, and firing which I can briefly describe:

* The central rectangle was etched with acid paste to give a frosted appearance.
* The white rectangle and wings, hours glass and scrolls were enamelled and fired.
* The red area was painted with 'rouge' glass paint and fired.
* The black lines, lettering, and details on wings and scrolls were painted with a mixture of black and brown glass paint requiring several firings.
* The bird, fly, and branch were painted using black and brown paint and then fired.
* The leaves painted with green enamel and fired.
* Yellow areas painted with yellow silver stain on the reverse of the glass and fired.

The sundial was then leaded into a new leaded window to replace the old one. Once leaded in, a brass rod was used for the gnomon, held in place by two horizontal stays and a horizontal bar soldered onto the lead at the reverse of the window (Fig. 2). No brass rods were touching the glass.

The window was then installed *in situ*, and the sun came out just as it was in position. (See Figs. 3-6.) We had local solar time, accurate to within a few minutes.

ACKNOWLEDGEMENTS

With particular thanks to John Carmichael for his invaluable help and encouragement, Chris Daniel for information and photographs, David Brown for advice about declination measurements.

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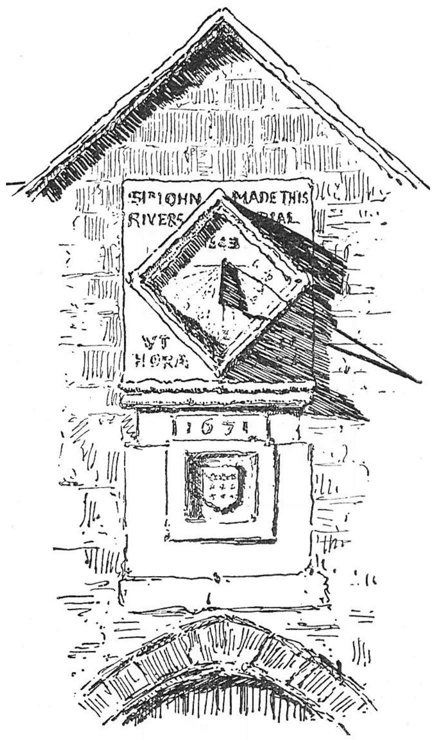

The vertical dial above the porch of Ashurst church, Kent. Ashurst is believed to be the birthplace of the great dial maker Elias Allen (d.1654). He made a brass horizontal dial for the churchyard but it was stolen a few years ago. It had the inscription:

ELIAS ALLEN MADE THIS DIALL AND GAVE IT TO THE PARISH OF ASHHVST AÑO DOMINI 1634

A replica is now in its place. After *Gatty* (who is wrong about the date).

SUNRISE AND SUNSET HOURS ON A GARDEN ANALEMMATIC SUNDIAL

K H HEAD

INTRODUCTION

Following the recent article by Bernard Rouxel,[1] I would like to make a few comments about the determination of the direction and time of sunrise and sunset from a garden analemmatic dial. But first I will try to summarise the properties and function of analemmatic dials, mainly for the benefit of newcomers to this subject.

I first came across the concept of sunrise and sunset markers nearly two years ago, after Margaret Stanier referred me to the article by John Carmichael[2] in 2002. I wrote to John for further details and he very kindly responded[3] by sending copies of e-mails from several experts in this matter across the world. More recently, John Davis very kindly sent me copies of articles published in previous years. I learnt a lot from this mass of information, for which I was very grateful, although I have not yet verified all the mathematics. But it set me thinking about how to incorporate the sunrise and sunset markers into the (unfinished) dial that I marked out on my lawn some years ago.

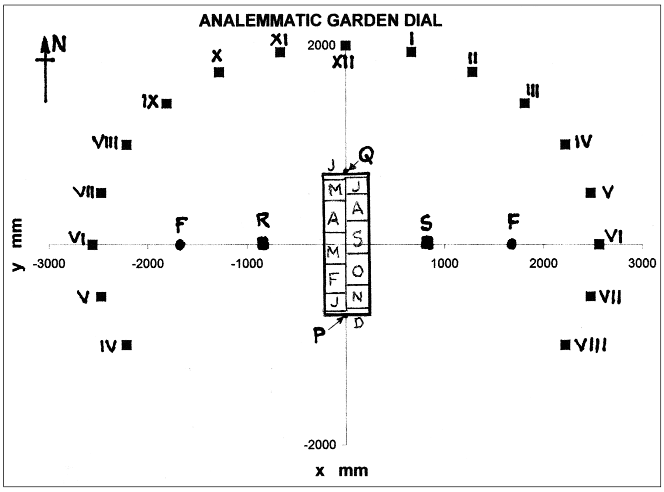

Fig. 1. Layout of analemmatic dial for latitude 51.33° N.

GENERAL DESCRIPTION

The **analemma**[4] was originally a graphical or geometric construction, in the form of an orthographic projection of the circles of the celestial sphere on to the plane of the meridian. This device was employed in antiquity for the delineation of sundials in which the gnomons were <u>perpendicular</u> to the 'dial-plate'. With the introduction of the 'scientific' sundial, having an inclined gnomon lying parallel to the polar axis of the earth, this type of instrument fell out of favour. However, in the 17th century, the term again came into use with the geometric construction of the 'analemmatic' sundial, as it is called today, in which the gnomon is perpendicular to the dial-plate.

The other meaning of **analemma**[5] (not discussed here) is the figure-of-eight graphical plot of the Equation of Time against declination of the sun throughout the year. The double meaning of this word is unfortunate and can cause confusion.

A feature of the analemmatic dial is that the vertical gnomon is not fixed, but its position has to be moved in relation to the declination of the sun. Solar time is indicated by the shadow of the gnomon related to hour markers set out on an ellipse. The gnomon is positioned on the line of the minor axis of the ellipse, on a scale which is usually marked in calendar months. The dial is delineated as outlined below (based on the method given by Waugh [6]).

The proportions of the ellipse are defined by the lengths of the major and minor axes. The semi-axes are denoted here by a and b, and are related by the equation

$$b = a \sin \phi$$

in which ϕ is the latitude of the location.

The coordinates (x, y) of each hour marker are calculated from the equations

$$x = a \sin t \qquad y = a \sin \phi \cos t = b \cos t$$

where x and y are measured from the centre O and t is the hour angle.

The scale of dates is derived from the equation

$$z = a \tan \delta \cos \phi$$

in which z is measured from O along the semi-minor axis (northwards positive) and δ is the declination of the sun on the date in question. If the declination on the 1st of each month is used, the scale can be divided into blocks corresponding to calendar months.

A dial of this type for my latitude of 51.33° N is shown diagrammatically in Fig. 1.

Indication of Sunrise and Sunset Data

In addition to showing solar time, an analemmatic dial can also provide an indication of the directions of sunrise and sunset on a particular day, and their times. An early suggestion was to mark a series of dates around the periphery of the ellipse, against corresponding sunrise or sunset times. However, it was shown by Roger Bailey[7] that two markers, the 'sunrise' point and the 'sunset' point, both on the major

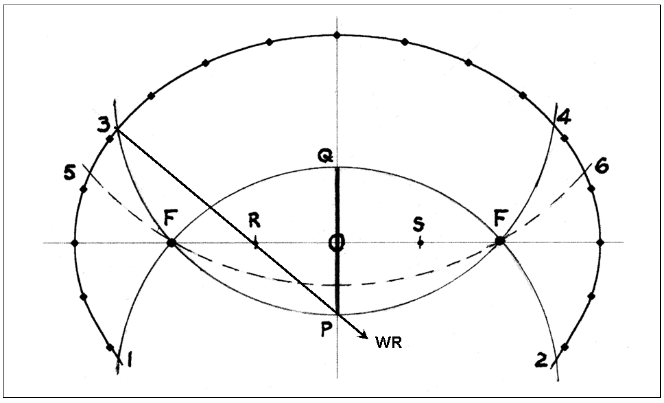

Fig. 2. Lambert circles for the solstices and (dashed) for an intermediate spring or autumn date. Intersection point times: 1 Summer sunrise; 2 Summer sunset; 3 Winter sunrise; 4 Winter sunset; 5 Intermediate date sunrise; 6 Intermediate date sunset. PQ represents the date marker scale. WR indicates the the direction of sunrise at the winter solstice (see also Fig. 3).

axis of the ellipse and equidistant from the origin, could provide these data geometrically. They are sometimes referred to as the 'Bailey points' and are denoted by R and S in Fig. 1. This concept was further discussed by Sonderegger,[8] and both authors also discussed their general accuracy. The derivation of these points, their use, and their validity, are discussed below.

These marker points, referred to as the 'seasonal markers', are not the foci of the ellipse (marked F in Fig. 1). But both Bailey and Sonderegger demonstrated that the foci can provide a geometric way of finding the times of sunrise and sunset – a procedure that is mathematically correct, but not very practicable to carry out. A circle centred on the minor axis and drawn through the two foci and the date point on the scale will intersect the ellipse at points corresponding to the times of sunrise and sunset on that day. Three such circles are shown in Fig. 2, those for the solstices and one intermediate date. Circles of this kind have been called the 'Lambert Circles'. They are only of theoretical interest and will not be pursued here.

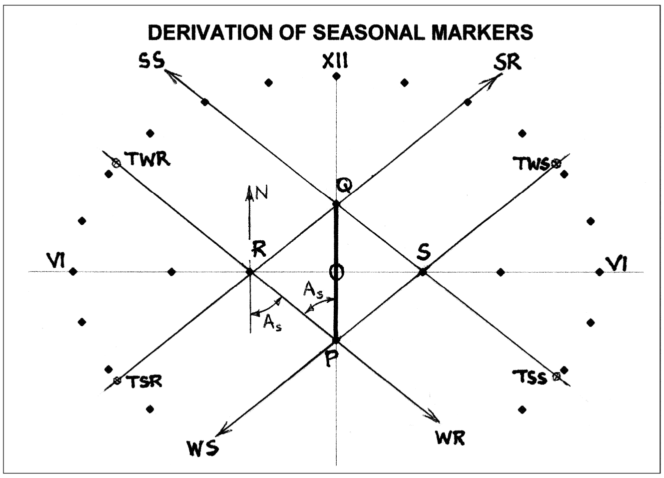

Fig. 3. Derivation of seasonal markers at solstices and directions of sunrise and sunset. SS Summer sunset; SR Summer sunrise; WS Winter sunset; WR Winter sunrise. Prefix T indicates corresponding solar time.

Derivation of Sunrise and Sunset Markers

The positions of the seasonal markers are derived from the directions of sunrise and sunset on the days of the solstices. The sunrise marker at winter solstice is obtained as follows, and derivation of the sunset marker is similar. Reference is made to the dial represented in Fig. 3, in which the date marker scale is indicated by POQ.

The overall length of each half of the date scale (OP = OQ = z at the solstices) is found by putting $\delta = \varepsilon$ in the above equation, giving

$$OP = OQ = a \tan\varepsilon \cos\phi$$

The sun's azimuth at theoretical sunrise, A_s , on a particular day is given by the equation [5]

$$\cos A_s = -\sin\delta / \cos\phi$$

On the day of the winter solstice, $\delta = -\varepsilon$, so the value of A_s is given by

$$\cos A_s = -\sin(-\varepsilon) / \cos\phi$$

By definition, the location of R is such that the line PR is in line with the rising sun, so angle RPO is equal to A_s. Hence the length OR is equal to OP tan A_s .

This defines the location of the sunrise marker, R, at the winter solstice. The sunset marker point S is obtained in a similar manner. The same procedures to find R and S could be used at the summer solstice instead, using the date point Q.

To summarise, the line from R extended through P gives the direction of sunrise at the winter solstice. Producing the line backwards intersects the time scale ellipse at the time corresponding to sunrise. Similarly, the line SP gives the same data for sunset. Lines RQ and SQ provide similar data for sunrise and sunset at the summer solstice. These lines are drawn on Fig. 3.

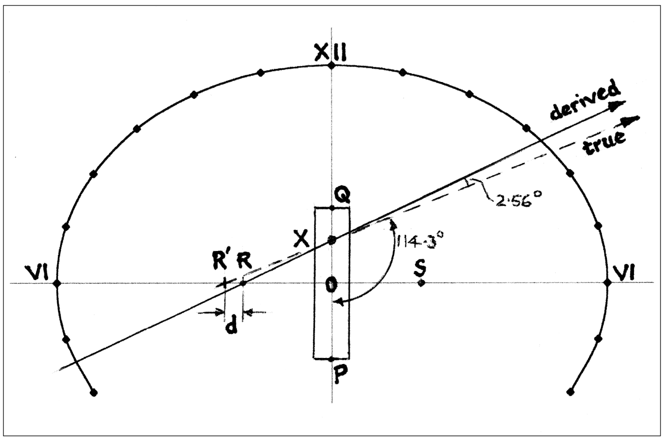

Fig. 4. Derivation of sunrise on 1 May. The intersection point R' of the actual sunrise direction does not coincide with R.

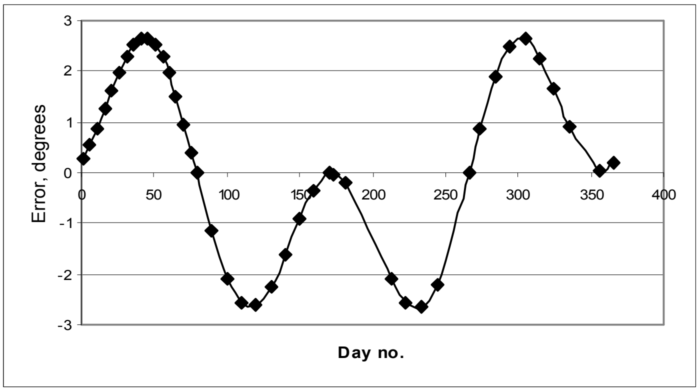

Fig. 5. Variation of alignment error throughout the year.

General Validity of Markers

The question that arises is whether the same is true for any other date point during the year. It is obviously true at the equinoxes, when the date points lie on the E-W axis and the sun rises and sets due east and west. But it does not follow that it holds good on dates between solstices and equinoxes. The mathematics becomes cumbersome but it is easier to demonstrate that there is a discrepancy by means of an example, as follows, using data for 1 May at my latitude.

At my latitude of 51.33° N, the sun's azimuth at sunrise at winter solstice is given by

$\cos A_s = -\sin(-23.44°)/\cos 51.33°$

hence $A_s = 50.46°$.

The length OR = $a \tan 23.44° \cos 51.33° = 0.2709a$ so the distance OR = $0.2709\, a \tan A_s$.

The point X in Fig 4 is the date marker for 1 May, when the sun's declination is +14.9°. The distance OX is equal to $a \tan\delta \cos\phi = a \tan 14.9° \cos 51.33° = 0.1663a$

Angle ORX is derived from the relationship

$\tan \text{ORX} = \text{OX/OR} = 0.1663\, a/0.2709\, a \tan 50.46° = 0.5068$,

hence angle ORX = 26.87°.

Since the sun's azimuth is measured from the south, the azimuth derived in this way (which I call A') for sunrise on 1 May is

-90° - 26.87° = -116.87°.

The actual azimuth of theoretical sunrise, A_s, on that day is given by the equation

$\cos A_s = -(\sin\delta/\cos\phi) = -(\sin 14.9°/\cos 51.33°)$

hence $A_s = -114.30°$.

So there is a discrepancy of 2.56° between the derived and the true angles.

I made my computer calculate values of A_s and A' for selected days throughout the year, and the differences between A_s and A' were plotted against day number (starting from 1 Jan as day 1). The relationship is shown in Fig. 5,

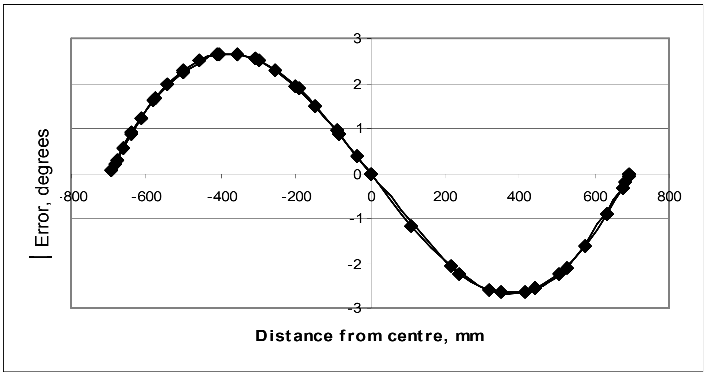

Fig. 6. Alignment error related to date marker.

where it can be seen that the maximum discrepancy (for this latitude) is about 2.7°. Plotting (A_s - A') on the scale of dates used for the date marker of the sundial gives the sinusoidal curve shown in Fig. 6. The June–December portion retraces the plot from January to June. This plot shows that the maximum discrepancies occur at the mid-point of each half of the date scale, between equinox and solstice. These maxima become smaller at lower latitudes, and greater at higher latitudes.

Another approach is to draw a line at the correct angle of sunrise through the date point and measure the distance (d) of its intersection with the major axis (R' in Fig. 4) from the solstice marker R. This is the method described by Bailey.[7] The maximum displacement d, corresponding to the greatest angular discrepancy of 2.56°, works out at 0.0621 a.

Application to a Table Top Dial

With a table-top or pedestal-mounted dial of the type described by Carmichael,[2] the approximate time and direction of sunrise and sunset is determined by laying a straight-edge or stretching a cord in line with the date marker and the R or S point. The angular error can be calculated as described above and depends only on the latitude. If a typical dial has an elliptical time scale with a semi-major axis of the order of 400mm, the range of error in the position of the R and S points would be 0.0621 × 400 = 24.8mm, i.e. about an inch in traditional measurements. A discrepancy of this magnitude would be unacceptable in a precision dial such as those described by Carmichael and Rouxel, but the marker points could be displaced to the mean position so as to halve the maximum error. Alternatively, the zone of discrepancy could be marked and perhaps calibrated with suitable date markers. Bailey devised a 'correction epicycle' to take this into account.

Application to a Garden Dial

About nine years ago I marked out an analemmatic sundial on my lawn. The 'temporary' markers are still in place, although they have to be re-exposed occasionally from underneath the grass which inevitably grows over them. In order to use my own shadow as the indicator, I considered that a semi-minor axis (b) of 2 metres would be suitable, which at this latitude (51.33° N) gives a semi-major axis (*a*) of 2.562m. The layout is as shown in Fig. 1, in which the ends of the date marker scale (P and Q) are at 694mm from the centre O, and the seasonal marker points (R and S) are 841mm from O.

On the day of the winter solstice, if you stand at P, and if the sun at the moment of rising could cast a shadow, it would fall across the marker R and would indicate the time of sunrise (just after 8am solar time in Fig. 3). Conversely, if you stand at R and look across the point P, you would be facing the direction of sunrise. At any other time of year, the same applies (with varying degrees of approximation) if you stand at the appropriate date point on the date scale.

From the relationships derived above, the maximum error in the position of the R and S points is 0.0621 x 2562 = 159mm, i.e. about 6 inches. Markers for this type of dial are slabs of stone or concrete, typically not less than 9 inches square, so the error lies within a single marker. Since we use a 'human' gnomon and all we need to know is that the direction of sunrise was 'over there' indicated by a wave of the hand, an error of this magnitude, and a discrepancy in direction of up to 3°, is not significant.

Therefore it can be concluded that, at this latitude, the seasonal markers R and S on a garden analemmatic dial provide acceptable means of indicating the approximate directions and times of sunrise and sunset throughout the year.

SYMBOLS

The symbols used are those given in the BSS Glossary, unless otherwise defined.

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Postcard Potpourri 4 – Haulfre Gardens, Llandudno

Peter Ransom

This postcard, with a postmark dated 8 August 1935, shows a floral sundial at Haulfre Gardens, Llandudno. These gardens follow a path which stretches from Llandudno's West Shore, over part of the Great Orme and down into the old town at its North Shore. They were first laid out in the 1870s by Henry Davis Pochin, a Victorian industrial chemist who was the inventor of white soap and the founder of Bodnant Gardens. The gardens were opened to the public in 1929.

The motto round the top of the dial is 'I count the bright hours only' and 'Tempus fugit' lies below the dial. Although the dial looks pretty accurate (the gnomon appears substantial), I think one of the afternoon hour lines has been omitted since the hours are numbered from 4 to 12 in the morning, yet the afternoon hours finish at 7. The 6am line goes straight through the gnomon root and emerges at 5pm.

Does the dial still exist? Any information about the dial would be most welcome.

Pictures of Haulfre Gardens can be seen at http://www.flickr.com/photos/davellandudno/sets/72157594203849512/

READERS' LETTERS

Dual Sundials

I would like to offer a correction to an historical comment made by Michael Lowne in his interesting article *The self-setting property of dual sundials* which appeared in the March issue of the Bulletin. Michael refers to the combination of "a polar-gnomon dial and an analemmatic dial" as a dual sundial; he then notes that "The dual dial was apparently first proposed by Thomas Tuttell and published by him in 1698" – referring here to Tuttell's *The Description and Uses of a New Contriv'd Elliptical Double Dial*. However, in fact Tuttell was neither the first to make such dials nor the first to publish a description of them.

The first author to recognize the self-setting property of this dial combination was evidently Vaulezard, who wrote the following in his 1640 introduction of the analemmatic sundial (*Traicté ou usage du quadrant analématique,* 1640, trans. by F. Sawyer):

> <u>Proposition I.</u>
>
> *Being given the day with an analemmatic clock made for the elevation of the pole of the place, to find in a moment the meridian line and the hour.*
>
> *To satisfy this proposition, there are a few things required: The first is to position the stile of the horizontal clock according to the elevation of the pole, and that of the azimuthal clock according to the proposed day, that is, the degree of the sign that the sun occupies this day in the zodiac. The second is to arrange the clock in the sunshine so that, being horizontal, the two clocks horizontal and azimuthal mark at the same time the same hour each by their particular stile, at which time the clock will be positioned according to the cardinal points and its meridian line will be the meridian line of the place; the hour will be that which the two clocks mark.*
>
> *For example, if the hour marked by the horizontal clock is nine o'clock, & if the azimuthal also marks nine o'clock, the instrument resting in this orientation will have the meridian line in the plane of the meridian of the place, and at that time it will be 9 o'clock.*
>
> <u>NOTE</u>
>
> *It must be noted that these hours can be doubly marked from one same height of the sun; namely by those before noon or after, being equally distant from noon, since one can, by turning the clock circle, mark three o'clock when it is nine, and two o'clock when it is ten; And this is why one must judge on which side is the north, so that the point on the horizontal dial that marks twelve o'clock can be placed towards this side, or else without this precaution having arranged the clocks so that both mark the same time, whether it is before or after noon, leave the instrument in this position for some time, observing the succession of times which the horizontal dial will mark, if this follows according to the order of the hours of the day, the clocks will be in their true orientation; and if otherwise, the point of the true hour will be on the other side of the clocks' meridian line.*

Not only does Vaulezard clearly outline the self-setting property here, but in his note he also discusses some of the difficulties of using this property also detailed by Michael Lowne.

In his 1644 expansion (*Traitté de l'origine, démonstration, construction et usage du quadrant analématique)* on his earlier work, Vaulezard repeats his discussion and gives a mathematical demonstration of why this combination has the self-setting property. (It should perhaps be noted here that not all dial combinations share the property; for example, a bifilar dial and a traditional polar-gnomon dial do not combine to be self-setting).

In England, the first mention of this property appears to be in Samuel Foster's 1654 *Elliptical or azimuthal horologiography ...if to this Elliptical Dial, be adjoyned a common Horizontal Dial with an Axis, then there needs no finding of a Meridian line before hand, because they two betwixt them will finde one, and consequently will place themselves in a true position*.

Now, although these earlier authors wrote about the dial combination, one might well ask if Tuttell in 1698 was the first to manufacture it. But this claim too is doubtful. I recently published a brief note (*'The Oldest Analemmatic Sundial?'*, *The Compendium*, **11**(4), pp.35-36, Dec 2004) illustrating what might well be the oldest extant dual dial, made by Anthony Thompson, Foster's friend and a prominent instrument maker, probably sometime in the period from 1638 to 1665. The dial is now owned by the National Museum of Ireland (Dublin). The museum purchased it in 1994 from the Egestorff Collection.

In closing, please allow me to point out that all of the texts mentioned here – Tuttell, Vaulezard and Foster – are reprinted in *The Analemmatic Sundial Sourcebook* published in 2004 by NASS.

Fred Sawyer
Glastonbury, USA

Michael Lowne replies:

I am grateful to Fred Sawyer for this correction. Tuttell's title implying that the dial was 'New Contriv'd' is quite misleading and is one further proof that there is nothing new under the sun........

Postcard Potpourri

Peter Ransom's pillar dial on the bridge at Ross-on-Wye (*BSS Bull* <u>19</u>(i), p.39) is SRNo 0477 and listed under Wilton, the suburb over the Bridge. It has been moved across the road at some stage; it is still pointing the right way round, the pavement edge in the photographs confusing the issue. David Young must have been standing in Wilton when he made the first record for the Register.

A.O.Wood
Gloucestershire

BRAIN TEASER

Question: After a hectic night celebrating New Year, I returned to my London home and decided to phone a friend abroad, who happens to live in another large city. I commented that the sun was just rising. My friend remarked that the sun was also rising at his home. Where does my friend live?

Answer: Rio de Janiero, Brazil. The terminator is the line across the earth's surface separating sunlit and dark areas. On New Year's morning it stretches across the North-East Atlantic to the South-West Atlantic and it crosses London and Rio at the same time; in London at just after 0800 GMT and in Rio just after 0500 local time.

I have verified this using the World Clock function on my Palm pda, but I am still looking for a more detailed map by entering the time on a web site. Does anyone know of such a site? (probably an astronomy one).

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PAINSWICK PHARMACY

The First BSS Grant-Aided Restoration

TONY WOOD and HARRIET JAMES

In 2005 the owner of Painswick Pharmacy, Mike Powis MPS, cleared the long-standing virginia creeper from the frontage of his property, a Grade II listed building called Nutgrove House. Previously hidden from view, an old vertical declining sundial was revealed, very faded, with the gnomon intact but requiring some faith to read the time (Fig. 1).

Painswick, in Gloucestershire, has a Town Hall on which is fastened a plaque for 'best kept village' and also a famous churchyard with an allegedly uncountable number of beautifully shaped and trimmed yew trees. The main street (New Street) runs roughly south-west and the dial faces south-east but is shaded by high buildings opposite during much of the morning. The dial is placed quite high by a first storey window over the front door and is inclined very slightly.

At about the time of the dial's discovery it was announced that the BSS could provide small grants for the restoration of suitable dials. The Painswick dial was originally painted and the delineation remained just visible. It was tentatively dated as late 18th century and, as the local Parish Council were offering to fund some of the restoration work, Tony Wood put forward a recommendation that a Society grant should also be made available. A matching grant was approved which prompted a further grant from the Painswick and District Preservation Society. Mike Powis obtained a quotation from Harriet James Sundials to carry out the necessary work and this was accepted.

Fig. 1. Before restoration. Photo: A O Wood.

As this was the first grant that the Society has made, the process for approving it was still in development. Consequently, it has allowed some recommendations to be made to the BSS Council for handling future applications.

The restoration work on the Painswick dial was carried out in February 2007. A large central crack in the limestone dial was stabilised and filled. The painted details of the original dial had protected the surface of the stone from erosion, leaving them slightly raised and clearly discernable in a strong side light. The delineation was measured and recorded and the dial was photographed in detail. Some traces of black paint remained along the top of the dial where there appeared to have been a painted motto beginning with the letters 'Vi…'. A search of the local Records Office and museums, as well as an article in the local magazine, failed to turn up any old photographs or records of the dial, so the motto was left unpainted for the time being. The rest of the dial was repainted in traditional linseed oil-based paints with black lines on a cream background (Fig. 2).

The gnomon was made of thin and corroded iron plate. It was cleaned and strengthened with a 3mm brass backing plate with the same outline, then painted black. It was set back into the dial with tenons leaded into the original slots in the stone.

There are several interesting dials in and around Painswick. The one shown in Fig. 3 is on the main baroque façade

continued on page 96

THE VERTICAL SUNDIAL OF PANAGHIA VLAHERNA CONVENT IN KYLLENE, PELOPONNESE

E.TH. THEODOSSIOU, Y. KOURIS & V.N. MANIMANIS

INTRODUCTION

The historical Byzantine convent (nunnery) of Panaghia Vlaherna (the Virgin Mary of Vlaherna), decorated with an exquisite vertical sundial, is near the Kato Panaghia settlement, 2.5km to the southeast of Kyllene's centre. Kyllene is a port and summer seashore resort in Eleia (Western Peloponnese), located at 37° 57′ N, 21° 08′ E.

Unfortunately, it is not known when exactly the convent itself was established; however, it is beyond doubt one of the oldest monasteries in Peloponnese. Its main church (Catholikon) incorporates materials from an older palaeochristian church of 330 to 630 AD The monastery was most probably established before 800 AD. The noteworthy Catholikon is dedicated to the Genesion (birthday) of Theotokos (Virgin Mary), which is celebrated on the 8th of September each year. The carved marbles incorporated in the Catholikon from the older church testify to the destruction of the latter by an earthquake, a common occurrence in the region. After 1204, and the 4th Crusade, the monastery passed into the hands of Western monks of the Principate of Achaia.

Fig. 1. The historical church of Virgin Mary in Vlaherna Kyllene - of the 13th century. The vertical sundial has been incorporated in the south wall of main church of the monastery.

The Catholikon lies at the centre of the large yard and it is a three-part basilica with wooden roof and no dome. According to the archaeologists who have worked on preserving and repairing of the church since June 1969, the eastern part is considered to be the older one, being built in Byzantine style *c.*1200 AD, while the western part is of Roman style. In 1205 the construction was stopped with the invasion of the Roman Catholics, who occupied the monastery, modified the original plans of the Catholikon and completed it by adding the second floor of the inner narthex and the outer narthex. Most probably, it was at that moment when they incorporated the peculiar vertical sundial in the wall of the latter, according to their tradition, because it was unusual – as we have already mentioned in previous publications[1,2] – to decorate Eastern Orthodox churches with sundials, in contrast with the West.

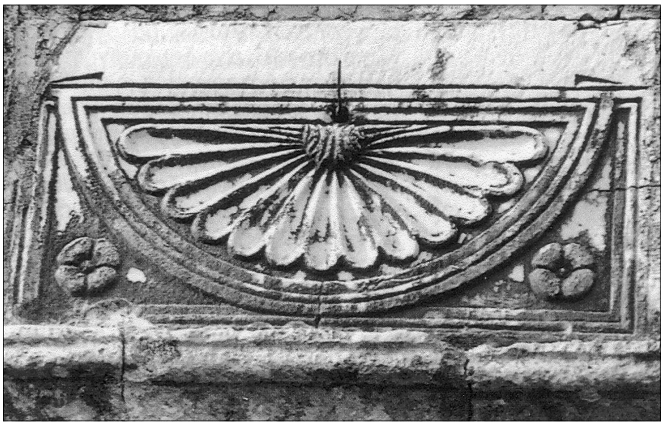

Fig. 2. The vertical sundial of Panaghia Vlaherna.

In 1978, following a decision by Eleia's bishop Athanassios, a home for the aged was established in the grounds of the monastery for the indigent old women of the area.

THE VERTICAL SUNDIAL OF THE CONVENT

An exquisite plane vertical sundial decorates the main church (Catholikon) of the monastery. This sundial is a rectangular plate of white marble, incorporated in the southeast wall of the outer narthex of the church, between two of the porous stones of the wall. All of the Byzantine part of the building, as can be seen in the photographs, has been built with rectangular reddish porous stones, surrounded on all sides with a double lining of bricks.

On the wall of the inner narthex stands out a two-light window with a marble base. The base bears Byzantine and Western decorative elements. Under the window a white marble plate has been incorporated in the wall, measuring 145×43cm. This plate's lower part bears some relief forms, while its upper part is divided by three arcs into three parts with one cross carved in each one. In addition, there are roses, tree leaves and fish, all favorite proto-Christian symbols. The archaeologists date it, as well as other incorporations to the Catholikon, in the palaeochristian era (330 to 630 AD).

Above the window, on the gable, are two reliefs: a cross with roses and large leaves at the corners, and on top of it a vessel from which spring helical vines with leaves and grapes, also beloved palaeochristian themes carrying symbolic meaning.

The outer narthex is 11m long and only 3m wide. Above its window of the southeast side has been incorporated the flat marble plate of the vertical sundial, a rectangle measuring 80×30cm; above the sundial there is another small arched window. This peculiar sundial resembles half of a flower with 26 petals, each petal corresponding to one section of the fan-shaped configuration. Thus, the sundial has 13 hour lines, theoretically inside the petal sections that correspond to the respective hours. It should be noted that exactly the same motif, but with only nine fan-shaped 'leaves', exists in the interior of the famous Byzantine Basilica of Saint Apollinaire the Old (San Apollinare in Classe, 549 AD) in Ravenna, Italy. This motif decorates the lintel of the small door in front of the marble Altar which leads to the temple's crypt.

As we have mentioned, the Byzantine sundials of Greece present a variety in their divisions. Ten hour lines, i.e. 11 hours, are shown by the sundials of Saint Lavrentios Convent[1] and of the Skripou monastery in Orchomenos, Boeotia, whilst eleven hour lines, i.e. twelve hours, exist on the dial of Zoodochos Pege in Pyle of Kithaironas Mountain, which we plan to describe in a future article. The Vlaherna's vertical sundial divides the day into 13 sections (hours).

The horizontal line of the sundial's upper part represents the horizon; at noon the Sun would transit the meridian, represented here by the vertical line. This line in this specific dial signifies the seventh hour. In any case, in a truly vertical plane sundial such as this one, carefully mounted on a wall, a shadow can never fall above the horizon line, while any place under the horizon is an area where the shadow will inevitably fall in a certain moment of the year.

In this sundial the numbers of the hours are not shown: neither Greek, nor Arabic numerals appear on its plate. This means that the monks knew empirically how much of the day had passed by observing the shadow of the gnomon upon the plate of the sundial. The same arrangement is found on many modern watches which do not bear numbers; their owners reading the time from the position of the hands.

The rectangular plate of the sundial is schematically composed of three protractor-shaped parts, the inner one being the 'half flower' sundial with its 13 petals. In the centre of its upper line is preserved its thin metallic gnomon, perpendicular to the plane of the plate. Outside the semicircles, to the left and right, are two carved flowers with four petals each. All these are included within three rectangles carved on the plate, one inside the other.

Professor Anastassios Orlandos believed[3] that this sundial has been reused in its current position, as is also the case with the sundial of St. Lavrentios.[1]

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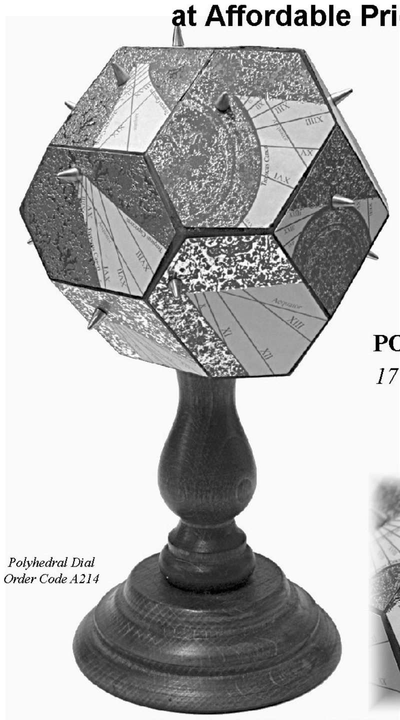
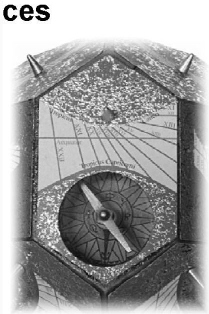
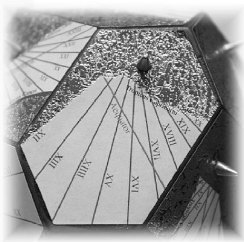






BSS ANNUAL CONFERENCE
FITZWILLIAM COLLEGE, CAMBRIDGE
13-15 APRIL 2007

CHRIS LUSBY TAYLOR

The sun shone, the stars twinkled, and even the International Space Station gave us a fly-past. And we were in Cambridge, where better to appreciate the heavens?

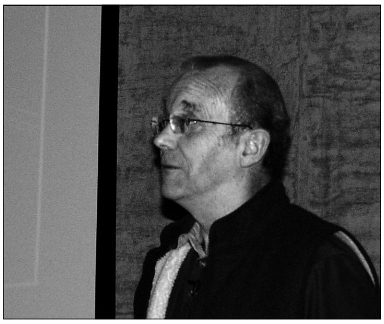
The Society's Secretary Doug Bateman very modestly deflected praise onto Frank King, Mike Cowham and other contributors, but the overall success of the weekend was certainly ensured by his planning, particularly of the conference programme. After dinner on Friday we were welcomed by our Chairman, Chris Daniel, who expressed his delight, firstly at seeing so many new members and foreign visitors and secondly that we have in Sir Mark Lennox-Boyd a Patron whose active interest in sundials is so evident. On the Society's visit to Italy, Chris had been so overwhelmed at Mark's La Meridiana villa/sundial that he said he thought it the kind of place he could die. "That could be arranged" said his host but, luckily for us, it wasn't.

Sir Mark's magnificent book discusses the history of the calendar and the determination of the correct date for celebrating Easter. He chose this topic for our introductory after-dinner talk. We learned that the Julian Calendar was actually Egyptian – Cleopatra having persuaded Julius Caesar that a leap year every four years would be a Good Thing. They knew the length of the year to about six minutes, thanks to a metal equatorial ring that showed the moment of equinox. Around 1430 Tamarlane measured the year to within a minute and by 1703 the accuracy was down to seconds, as measured by Bianchini's meridian line in Santa Maria degli Angeli in Rome – also seen on the Society's visit.

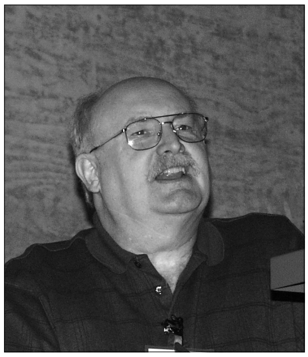
We also learned, and this was graphically confirmed by Frank King later, that 2007 is the last year this century on which the Vernal Equinox falls on March 21st. From now on, it's the 20th. That was quite a shock.

SATURDAY

Next morning, Kevin Karney built on Mark's introduction to give a staggeringly thorough history of the Equation of Time and how it was explained by earth-centric and sun-centric cosmologies from the Babylonians to modern times. Amazingly, the calculations performed by Ptolemy in AD150 were not improved on until around 1700. I'm sure few of us had been aware just how many Greek philosophers had had a hand in moulding cosmology. Aristarchus even placed the sun at the centre (as had



Akhenaten in Egypt over 1000 years previously), but the various flavours of earth-centric universe dominated, though with increasingly complex epicyclic spheres within spheres to explain the motion of the planets. The 2000-year-old Antikythera mechanism, found 100 years ago but only recently X-rayed and fully understood, was, it appears, an eclipse predictor. For now, though, the sun-centred solar system seems unassailable and Flamsteed's Equation of Time table remains the first reliable means to regulate your clock from your sundial.



Fred Sawyer led an impressive party of visitors from the USA, including John Carmichael whose latest enthusiasm is for vitreous enamel on steel as a way to make polychrome dials that will last many years. John was in listening mode this year. Fred meanwhile entertained us with a trial: we were to rule on whether Oughtred or Delamain should get credit for the horizontal quadrant. Fred was very fair, giving both claimants full rein, but in the end we voted for, let's be honest, the name we knew – Oughtred. Delamain, it seemed, had seen Oughtred's unpublished notes and claimed their ideas for his own. The number of uses they both claimed for the quadrant – essentially half a double-horizontal dial – was stunning. So, the moral is: publish or be damned.

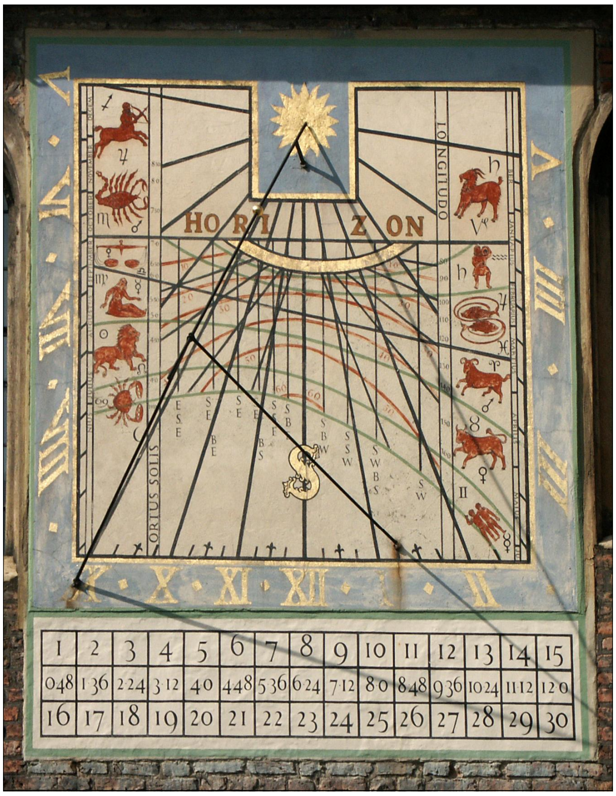
Coffee break next, and a chance to patronise the Rogers Turner bookstall, then back to hear Bernard Rouxel explain how an analemmatic sundial can be made to indicate the times of sunrise and sunset. I don't know what Roger Bailey made of this, but we were to hear his method later. Bernard is one of our number, like Fred and Tony Belk, who finds quadratic equations and spherical trigonometry soothing. Some do not, so may not have followed his exposition, which is a pity as he showed how, by having a non-vertical gnomon and/or a non-horizontal dial, you can construct an analemmatic dial that shows sunrise/set automatically. The insight he used dates from Apollonius, 2000 years ago. Is anything new?

Well, bees certainly aren't. They've been around for millions of years. As Julian Lush showed us, Karl von Frisch's 40-year-old theory has recently been proven by attaching radar antennae to bees. They really do indicate the distance and orientation of nectar sources by dancing, in the dark, on a vertical comb. So they are nature's true sundiallers, using their UV-sensitive, polarizing lenses to set their azimuths relative to the sun.

Next, Karl Hofbauer delighted us all with his account of how he has put together a team to reconstruct high quality sundials originally published as paper cut-outs. In 1711 Johannes Gaupp published a book with thirteen extremely elaborate copperplate engravings of sundial designs. These were to be cut out and pasted onto wooden formers to create various form of dial, including a moon dial, cube, prism and cross dials and an unusual polar dial, the Kircher Dial. These are all universal, thanks to ingenious pivots invented by Gaupp. Karl bought the book, for an awful lot of Swiss francs, and has now made most of the dials in very high quality materials, though without cutting up the actual book. He hopes to make reproductions of the plates available, perhaps on a CD.

Kircher invented not only this polar dial, but also the noon cannon. Piers Nicholson has one and enjoys terrifying us with it. But Piers, it's supposed to go off at noon, not 1:30! At lunchtime there was time to take in the sundial display area which showed off the work of several members, including reproductions of Delamain's quadrant by John Davis and a wall declination instrument by Tony Moss that was so good looking it seemed a shame it was only a constructional tool. Anton Schmitz brought along photographs that prove him to be one of the world's best makers, but one has to go to Germany to see the real thing.

After lunch, we were offered a choice of a coach trip to Anglesey Abbey or a walking tour of Cambridge. Your correspondent chose Cambridge, organised by Mike Cowham and led by Frank King. A wise choice. Like Oxford,



Another essential visit in Cambridge is to the dial in the Queens' College quad, now expecting another repainting.

David Le Conte

Below, one of the dials seen at Anglesey Abbey, supported by the figure of Kronos.

The modern and very clear dial at Pembroke College.

Don Unwin (right) explains his replica of the de Dondi astronomical clock to Julian Lush.

One of the three walking groups around Cambridge cluster around a Scottish multiple dial beside the famous King's College Chapel. We had special permission to stand on the hallowed grass!

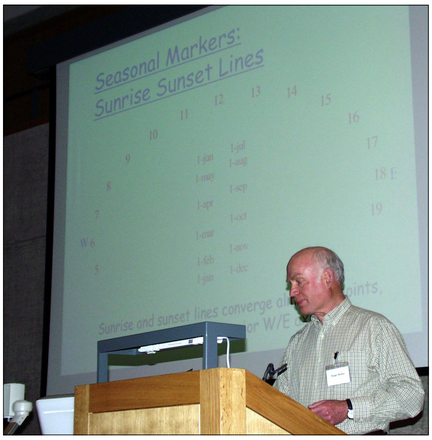
Below: an unusually-shaped dial from Tony Moss to celebrate andAmerican anniversary.

Cambridge colleges have many fine and historic dials. Perhaps none finer or more historic than the Queens' College dial, and no-one better qualified to explain it than Frank. Disappointingly, perhaps, it wasn't designed by Sir Isaac Newton (any more than the Mathematical Bridge in the same college) and its use as a moon dial is very limited. Indeed, Frank advises using the nocturnal at night.

Not too surprisingly, our tour took in the magnificent Pembroke College dial designed by none other than Frank King. It is a model of modern design: restrained, totally accurate, beautifully proportioned, expertly carved. The Web cam that used to be trained on it is no more, unfortunately.

Another highlight was our private visit to the little Whipple Museum, where we met Don Unwin, maker of exquisite reproductions, including de Dondi's planetary clock. Dondi's 1364 clock hasn't survived, but the drawings have. Using Ptolemy's model, it shows the motions of the Sun, the Moon and five planets. It was the first clock ever to show the date of Easter, a feat not again achieved for 300 years.

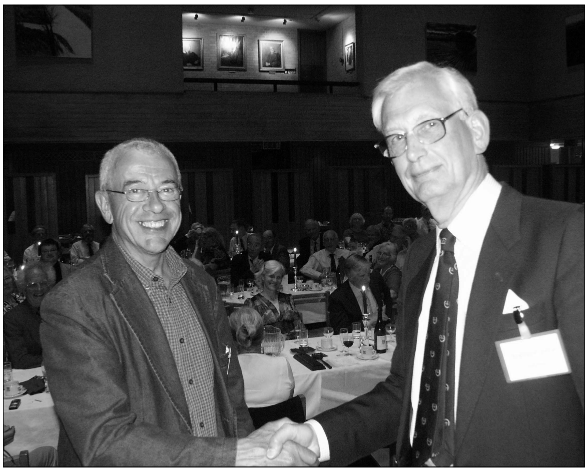
After we got back Roger Bailey, Secretary of NASS, gave us his perspective on time. The world should get over its obsession with atomic



Frank King explains the polyhedral dial on the Downing Site (see front cover).

A scene at the banquet including, on the right, Tony and Mary Belk, Irene Brightmer and John Lester.

David Brown and Donald Bush entertained us at the banquet. Fitzwilliam Museum have Handel's original manuscript.



Chris Daniel presented prizes for the Photographic Competition—third place went to David Hawker (left).

clocks and microsecond accuracy. Solar time is reality! From his extensive travels, he showed us pictures of dials from Prague, Istanbul and elsewhere to show that the passage of time is most meaningful when related to the rhythms of life: the seasons of the year, anniversaries, mealtimes, time to sunset, and so on. Many religions have mandated prayer times according to the altitude or azimuth of the sun – easily measured with a sundial. Roger has given his name to Bailey Points, marks on the East-West axis of an analemmatic sundial that indicate the time and direction of sunrise and sunset. Not, perhaps, as precise as Bernard's evolutes, but a lot simpler and surprisingly accurate. Altogether, this was a most refreshing reminder of what time is all about and its relevance to human beings.

At dinner, a few latecomers were spotted, including David Harber – reckoned to be almost the only person who actually makes money out of sundials. Chris Daniel proposed the loyal toast and a toast to the Society, then presented the awards for last year's photographic competition and the new annual award for the best article in the Bulletin by a new author. We were then entertained by Donald Bush and David Brown on recorder and harpsichord playing Handel. Very civilised.

SUNDAY

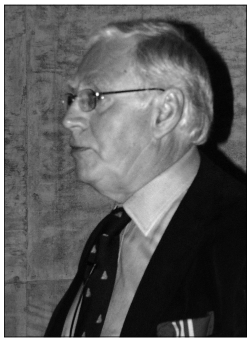
Another full morning of talks started with Alain Ferreira telling us about French Revolutionary Time. 1792 gave the world the guillotine and the Metric System for all weights and measures. Why not metric time, too? So they threw out the old, monarchist 60 second / 60 minute / 24 hour day and replaced it with a 100 second / 100 minute / 10 hour day. Logique, non? But most clocks were imported from England and Switzerland where the French market wasn't important enough to create separate movements. Ah, but sundials don't have wheels and pinions. They can be calibrated any way you like.

A group of diallists, led by Michael Harley from Ireland, stream across the King's College bridge over the Cam on their way to the chapel.

And a very few were, but this was one revolutionary idea that didn't take off. Alain knows of only three decimal sundials that have survived, only one of them still in France.

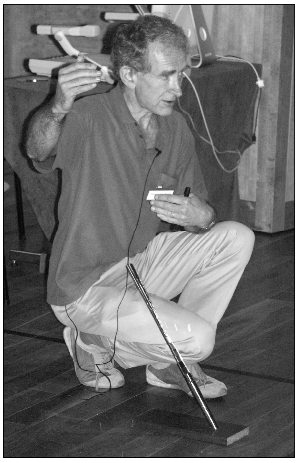
They threw out the Gregorian calendar while they were about it, and decided to start the year on whichever day the Autumnal equinox fell. But this proved too unpredictable so was also abandoned. Unpredictable? They should have asked Frank King, as you will see.

Next, and at last we heard about some British sundials: John Davis has found a wealth of historical information about the sundials in the Inns of Court in London. Fortunately for us, their treasurers seem to have had a habit of endowing dials regularly: 1685, 1686, 1687,... Many survive, others are known only from the accounts, so at least we know what they cost. John's old friend Henry Wynne crops up in 1707. His research painted a detailed picture for us of the sundial business as it existed in London 300 years ago.



Still in Great Britain, just, are the Channel Islands, home to David Le Conte. He's been studying the orientation of the many megalithic tombs on the islands. He showed us that, unlike those in some parts of the continent, they nearly all face the rising sun. However, the earliest, some 6500 years old, seems to face the most northerly moonrise. Unsatisfied with traditional means to measure orientation, he uses differential GPS. I wonder what Tony Moss makes of that?

Walter Hoffman took us back only to Roman times and the hemisphericum in order to discuss Temporary Hours. These are equal divisions of the day into twelve, with the night treated similarly. I'm sure Roger Bailey would approve. Walter showed how difficult it is to draw lines in a hemisphere that achieve this accurately. By 'accurately' he means he's looking at fractions of a millimetre, and at the difference between culmination – when the sun is at its highest – and meridian passage or superior transit as Frank King called it.

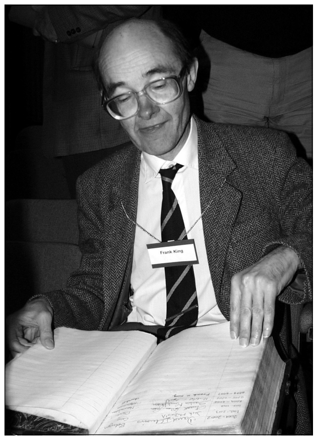


Walter was followed by your correspondent, whose talk was 'All Smoke and Mirrors'. Mirrors are much more flexible than gnomons and nodi in that they have not only a position but an orientation. So they can redirect sunlight in any desired direction. An array of 24 mirrors can send a spot of light over a dial every hour, exactly an hour apart. A mirror attached to a clock can place a spot on an analemma so that, unlike a conventional noon mark, it indicates the date and Equation of Time constantly. Lastly, by using a sidereal clock the image of the stars in the mirror can be made stationary, so that the spot of light from the sun traces the Zodiac on an appropriately marked scale.

And so to the highlight of every conference, the Andrew Somerville Memorial Lecture. We were in Cambridge. The speaker had to be Frank King. As the Senior Proctor of the University he carries the leather-bound Statutes of the University to all important events. There, if called upon, he speaks in Latin, but we allowed him to use the vernacular this time.

Mark and Kevin had already taught us a lot about the history of the calendar and the many ways leap years have been used to keep it on track. Alain had told us how the French failed to standardise the date relative to the equinoxes, but Frank showed how Omar Khayyam proposed a much better system nine hundred years ago.

The BSS Sales desk did good business.

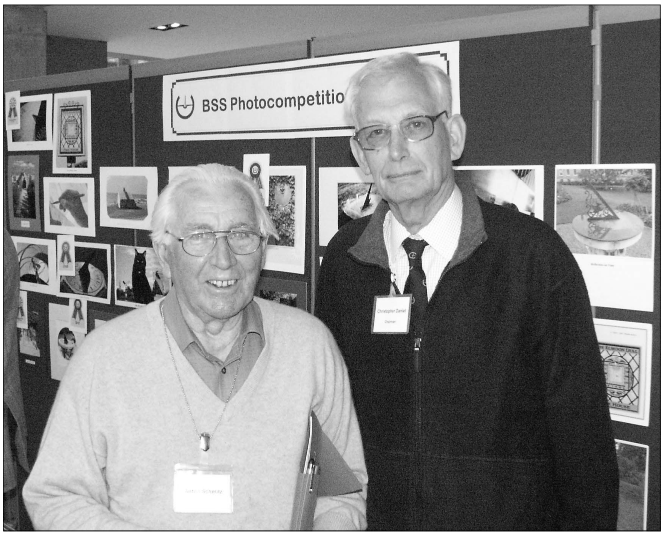


This uses a 33 year cycle. Instead of leaving out a leap year every 100 years as we now do, he mixed 4 year and 5 year intervals to get a much more accurate calendar. This enables the date of the Vernal equinox to be fixed without, as Mark had pointed out, varying between March 19th and March 21st. But it would still fall on a single day only at one particular longitude, which turned out to be that of Washington DC and, perhaps because of that, this calendar was not adopted by Pope Gregory and the Catholic Church.

The relevance of this to sundial design became clear when Frank turned his attention to his Paternoster Square noon mark. He has plotted the path of the shadow of the nodus every day for the next 40 years, and showed how the Gregorian Calendar makes the date unambiguous at noon over that period. Thus the analemma noon mark has all dates marked so, if you can read it from the ground, you can tell the date exactly.

Frank also considered the inverse question: what declination should be drawn to illustrate a particular date? This is relevant to the Queens' College dial, for which Frank has been asked to advise on repainting. Apparently, it needs repainting every 30 years or so. Perhaps John Carmichael could suggest a better material. Anyway, this dial has lines between the names of the months and between the signs of the Zodiac. Those between the months are, as he showed, wildly inaccurate.

That wrapped up another hugely enjoyable conference. The range of topics covered by speakers, the historical and international perspective were broader than ever. There wasn't time to admire all the beautiful photographs and dials, or even to chat to all one's old friends. Time's winged chariot – you hurry too fast.



The annual conference is always a chance for old friends to meet up. Here is the skilled German diallist and craftsman Anton Schmidt with our Chairman.

Unmarked photos from Chris Lusby Taylor & John Davis.

ASTROLABES
Part 1 – Introduction

TONY ASHMORE

INTRODUCTION

The BSS Reader Survey last year showed that, among other topics, some members are interested in astrolabes and would welcome some information in the *Bulletin* concerning these instruments. To satisfy this interest the *Bulletin* will include a short series of articles to explain the principles behind the design of and the uses of an astrolabe and some descriptions of instruments originating in different cultures. The series will describe the different types of astrolabes, including the less common, a reference to the occurrence in art and an explanation of the somewhat related instrument, the nocturnal.

Fig. 1. Front view of a standard type of European astrolabe. (V&A Museum, London.)

For the benefit of members not at all familiar with the instrument, the front view of a typical western astrolabe dating from the 15th century is shown in Fig. 1. It is sometimes described as an analogue computer that can solve spherical trigonometric problems relating to the heavens and time finding. In this it has a function similar to that of a sundial, a time finder and not a time keeper. This latter function is, of course, the domain of the clock. At first sight the astrolabe may look complex but, as we shall see in considering its principles, it is inherently a simple device. As it is essentially a two-dimensional version of the three-dimensional heavens it is known as a *Planispheric Astrolabe.*[1]

The back of an instrument, Fig. 2, is invariably engraved with various scales and diagrams. There is much variation in these, some of direct relevance to the basic time and astronomical functions of the device and some fairly far removed from these basic purposes. Some of these scales will be considered later in the series.

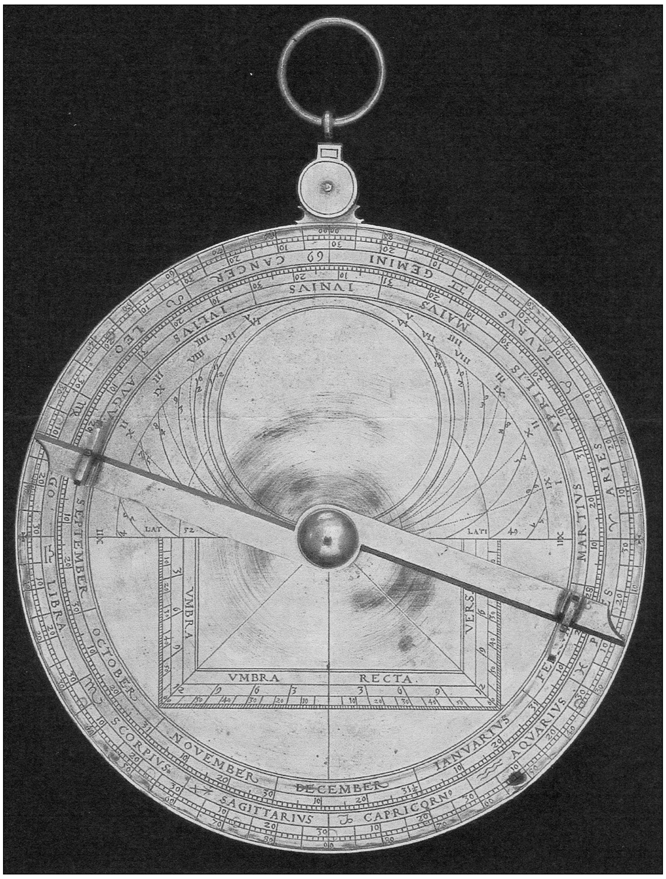


Fig. 2. Back view of a late 16th century European astrolabe.

HISTORY

The underlying ideas for the astrolabe are said to date back to at least the Greek mathematician and astronomer Hipparchus (2nd century BC) but it is very doubtful if he produced an instrument in the form we would recognise today as an astrolabe. It is more certain that Ptolemy, in the 2nd century AD, understood the theory behind the instrument and possibly was familiar with a version we would know today. Certainly writings of the 5th to the 7th centuries point to the origins being in Alexandria from where it was developed by Arab and Persian astronomers, being in common use by them by the 8th/9th centuries. Its introduction to the west was part of the transmission and translation of much Greek and Arabic learning and writing via Spain starting in the 10th and 11th centuries. From then on further development took place in Europe until about the late 17th century when its use started to decline following the introduction of the telescope for astronomical use and of mechanical clocks and watches for time purposes. In the Islamic world it continued in common use until the 19th century. Today, reproductions are still being made, some of good quality and some very degenerate versions which are non-functional and may best be compared with 'garden centre sundials' for lack of usefulness! Also, fakes are nothing new amongst astrolabes.

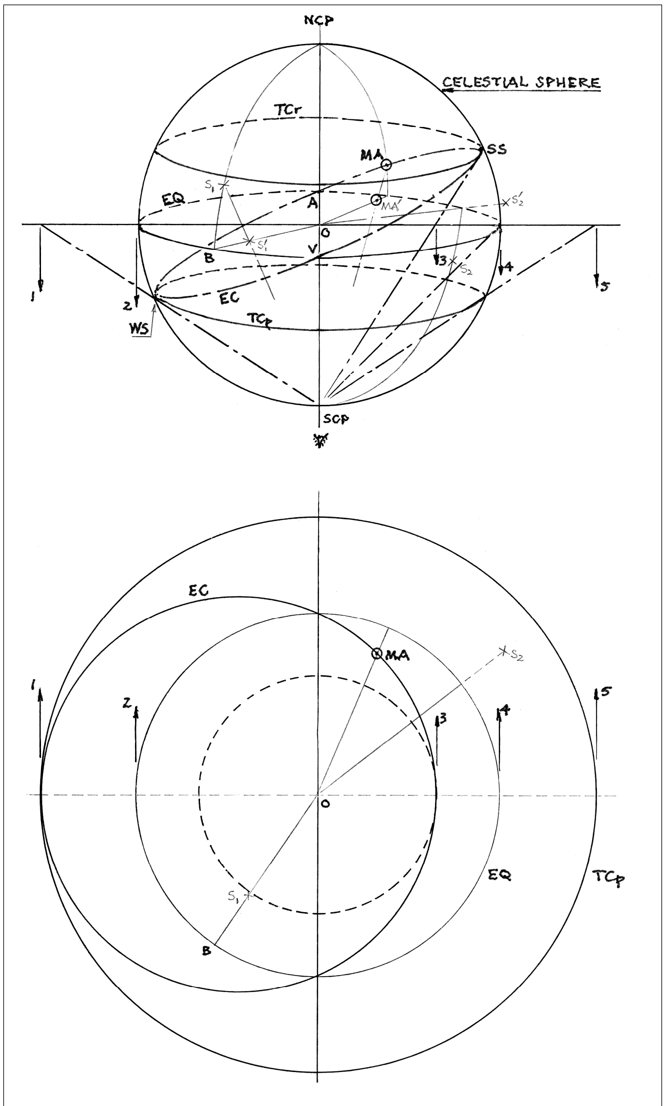


Fig. 3. The celestial sphere and its stereographic projection onto the equatorial plane.

PRINCIPLES OF DESIGN

The instrument is essentially two maps of the heavens, one superimposed on top of the other. The first map shows the relative dispositions of the fixed bodies, the stars, but also makes provision to include the position of the sun, an apparently moving body. Other moving bodies, the moon and the planets, are not included. The second map is related to the user in terms of a grid of lines showing the altitude, and sometimes the azimuth, of any point in the sky that he may be observing. These terms are familiar to sundialists when considering the position of the sun during a day and the year. The heavens appear to us to rotate on a daily basis (although in reality it is the earth that is rotating). So the first map is made rotatable. The observer's view is static – a point in the south east at an elevation of 30°, say, does not change its position with time so the second map is fixed.

We are all used to the idea of depicting a spherical feature, the earth, on a flat surface in an atlas and providing some scales to determine distances and directions. Our grid on which the map is drawn does not have to be rectangular as we use in our road atlas or Ordnance Survey maps. Our world atlases show the polar regions as we see them looking down directly from above the pole, on a grid of circles about the pole (circles of latitude) and radial lines (of longitude). Exactly the same principle is applied to the two maps used in the astrolabe.

Consider the map of the fixed bodies. The distance to the stars, and the sun, is so great that we perceive them as being on the surface of a sphere. This *Celestial Sphere*, Fig. 3 upper diagram, mirrors that of the earth in that the north (NCP) and south (SCP) celestial poles are directly above the earth's geographic poles and in line with the earth's axis. The celestial equator (EQ) is in the same plane as that of the earth and the Tropics of Cancer (TCr) and Capricorn (TCp) are likewise in the same planes as our familiar Tropics. The ecliptic (EC) delineates the apparent path of the sun during the course of the year, V showing the position at the Vernal Equinox, SS the Summer Solstice, A the Autumnal Equinox and WS the sun's position at the Winter Solstice. The ecliptic is tangential to the two tropics at SS and WS, each being at 23½° above and below the equator giving the variation of the sun's declination between these two limits during the year. The position marked MA is the position of the sun in about mid August. The earth is, on this scale, simply a dot at the centre of the sphere. Also indicated are two typical stars, S_1 and S_2, on two azimuth lines and the azimuth line of the sun at MA is also included.

An observer at the SCP looking northwards will see the 'imaginary' circles of EQ, TCr and TCp and the real stars projected onto a plane perpendicular to the polar axis. The equatorial plane is as convenient as any for this projection. The chain-dotted lines on this diagram show the observer's view of some of the circles' left or right extremities and of the sun and the two stars. The short arrowed line 3, for example, indicates the position where the sun at the summer solstice (SS) will appear to be to the observer at the

South Pole. This projection is known as a *stereographic projection* and has the property that any circle, great or small, on the celestial sphere remains a circle when projected and angles between lines on the spherical surface are preserved on the plane surface. The lower diagram of Fig. 3 shows a perpendicular view of the equatorial plane. A convenient limit to this map of the heavens so projected is the circle of the Tropic of Capricorn (TCp). This is a sufficient extent to be able to include the sun's position at all times of the year and also the majority of stars of interest to northern hemisphere observers, since users were invariably well north of the equator. The dashed line on this diagram represents the Tropic of Cancer (TCr) and is included for completeness but is not usually included in actual instruments.

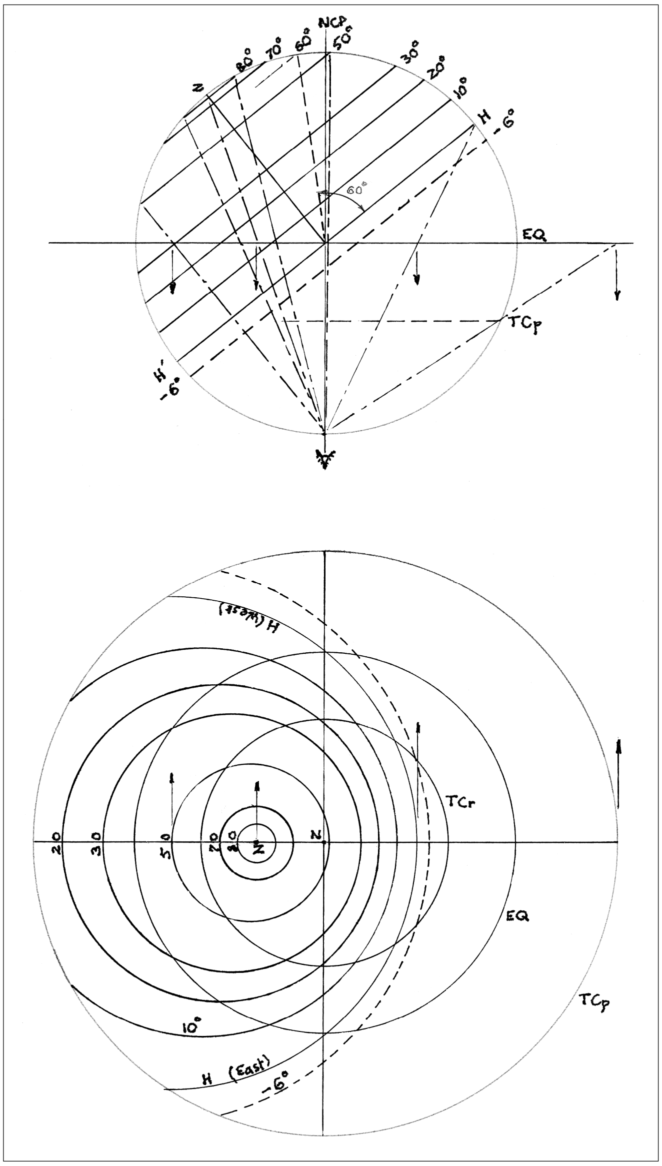


Fig. 4. Circles of altitude on the celestial sphere and their stereographic projection onto the equatorial plane.

The position of star S_1, for example, is obtained by projection of the point B, where the star's azimuth line intersects the equator onto the lower diagram. To the observer S_1 appears on the line joining B to the centre of the celestial sphere, O, at S_1'. This point is then projected onto BO in the lower diagram. Similarly for all stars and the sun on the ecliptic.

The second map showing the observers reference grid of altitudes, in particular, is likewise generated by viewing from the south celestial pole, Fig. 4 upper diagram. Although the observer will be on the surface of the earth and not at the exact centre of the celestial sphere, the very small offset from the earth's centre, say 4000 miles, can be neglected when compared with the millions of miles radius of the celestial sphere. The zenith, Z, is the point directly over the observer's head, at an altitude of 90°, and his horizon is at 0° altitude. The example of 60° altitude is indicated on this diagram. Unless the instrument is being used north of the Arctic Circle, a situation never catered for, the southern part of the horizon will always extend beyond the Tropic of Capricorn. The altitude lines, known as *almucantar*s, will, as stated above, be circles but not concentric since their centres do not coincide with the centre of the celestial sphere. Like the horizon circle, the lower almucantars will be limited to the parts above the Tropic of Capricorn. Azimuth circles can be projected similarly, all passing through the zenith and also limited to the parts above the tropic but many astrolabes do not include these as they have limited use and are not necessary for the main uses of the instrument. Depending on the size of the instrument, almucantars may be drawn at 1° intervals, at 2° if the instrument is smaller or, say, 5° for a very small item. At greater intervals than this the instrument largely loses its usefulness. The lower diagram of Fig. 4 shows the projection onto the equatorial plane. The dashed line, called a *crepuscular line*, represents an 'altitude' of -6°, regarded as the limit of civil twilight.

The observer's map remains static in the instrument, held by a small lug on its edge, as do his zenith and circles of altitude. The map of the stars and the ecliptic is superimposed on this and needs to rotate as the bodies move across the sky. So that the almucantars can be seen through the rotating map, this latter is skeletonised. This is done in such a way as to provide a strap-work arrangement which not only gives the necessary strength and rigidity to hold it together but also provides for pointers showing the positions of the stars and space to engrave names of the stars adjacent to the pointers. The resulting network is called a *rete* (pronounced to rhyme with 'sweetie'). The instrument in Fig. 1 shows the rete on top of the observer's grid of almucantars (engraved every 2°) and, in this case, azimuth lines all passing through the zenith. The observer's map is engraved on a 'plate'. The frame of the instrument, the *mater*, is recessed for the rete and the plate to sit inside the surrounding *limb* and they are all held together with a pin at the centre, the position of the North Pole.

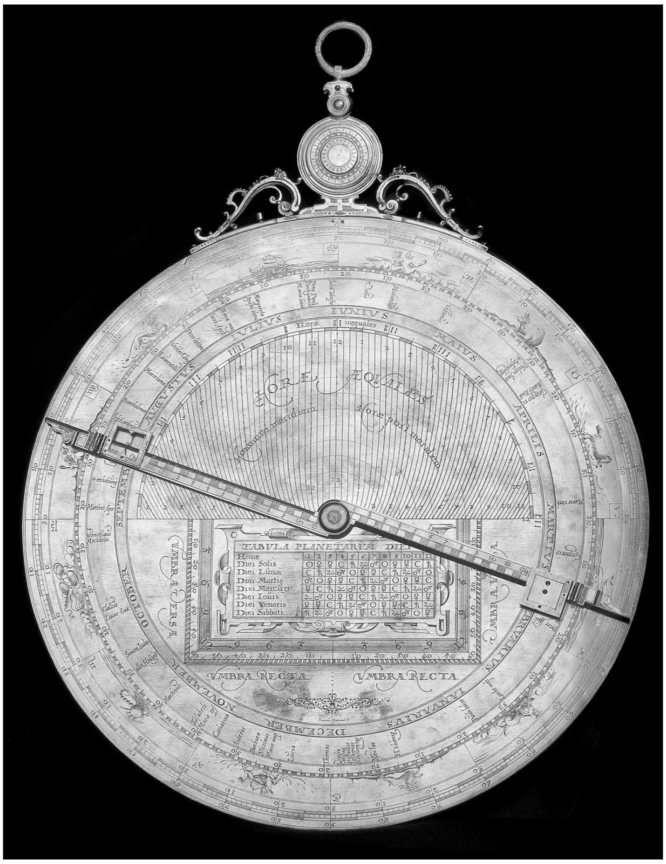


Fig. 5. Degree, zodiac and calendar scales on the back of an astrolabe.

Fig. 6. Rule, ecliptic and time scales on the front of the astrolabe shown in Fig. 5.

Only one rete is required for the instrument since, as Fig. 3 shows, the user's position has no effect on and is not involved in its design. However, looking at Fig. 4 it may clearly be seen that if the observer's latitude changes the position of the zenith and the almucantars also change and the circles on the plate change. That means that each latitude of use requires a differently engraved plate. In practice a plate will suffice over a latitude range of, say, 3°. Many astrolabes were supplied with a number of plates, engraved on both sides, each for separate latitude intervals of three or so degrees. The plate appropriate for the observer's position was fitted into the mater before taking a reading. In this way if plates for 36, 39, 42, 45, 48 and 51 degrees were provided, with a different latitude engraved on each side, just three plates could cover a traveller's journeys between the Mediterranean coast of Europe and southern Britain to just north of London, allowing for the acceptance of 1½° either side of the stated latitude of the plate.

USING THE ASTROLABE TO FIND THE TIME

The astrolabe is used to find *Local Apparent Time*, that is time by the position of the real sun at the location of the user. Thus two things are required; the position of the sun on the ecliptic and the altitude of the sun as measured by the observer. Fig. 5 shows the back of an instrument from the late sixteenth century by the well known maker Erasmus Habermel, working in Prague at that time. The outer edge is engraved with a scale of degrees from zero to ninety in each quadrant, measured from the horizontal. Pivoted in the centre is an *alidade* with a folded-down sighting vane near each end. After erecting the sights, suspending the instrument by the shackle at the top and turning it so that it is edge-on to the sun, the alidade is turned about the pivot until the sun shines through both vanes. The altitude of the sun is then read from the scale of degrees. Between sunset and sunrise, the altitude of a suitable star is measured in the same way except the astrolabe is held up to the eye and the chosen star sighted through the two vanes. Inside the degree scales are two other scales. The outer is a zodiac scale running anticlockwise, each sign being indicated by its sign and symbol and divided into the normal thirty divisions. These markings are just inside the degree markings. The inner scale is the normal calendar with the days of the month, 28, 30 or 31 as appropriate, being engraved just below the zodiac signs. This pair of scales then relates the calendar date and the position of the sun in the zodiac. In the past many people were as familiar with the 'zodiacal calendar' as we are today with our normal one. The user can then turn to the front of the instrument, Fig. 6, and locate the sun's position for that day by the zodiac division on the ecliptic, which was nearly always engraved with the zodiac scale. The rete is then turned until the sun position, at the edge of the ecliptic, is on the almucantar representing the previously measured altitude. The pivoted *rule* is then lined up with the sun position on the ecliptic and the time is shown by the end of the rule against the scale of hours, divided into quarters, engraved around the outer edge of the limb. Twelve noon is at the top and midnight at the bottom. If working during the hours of darkness, when a star has been sighted, that star's pointer is lined up with the almucantar of the measured altitude and the rule set to the sun's position as before, the sun being the body determining the time. In this case the ecliptic will show the sun as being below the horizon and the rule shows the hour on the lower part of the hour scale. For a given altitude there are two places on the almucantar at which the sun or star can be positioned, before or after noon or midnight. Usually the observer will be aware which side of these the observation has been made but if it is close to either then a repeat observation a little later will solve the problem. If the altitude has increased then the time is before noon or midnight. If the altitude has decreased the time is after.

ACKNOWLEDGEMENTS

My own photograph, Fig. 1, used with the agreement of the Victoria and Albert Museum, London. Figs. 2, 5 and 6 are taken, with permission, from the excellent website of the Museum of the History of Science, Oxford, (www.mhs.ox.ac.uk/astrolabe/).

REFERENCE

1. J. Davis, (Ed): *BSS Sundial Glossary*. 2nd Edition (2002). The alphabetic section and Appendices I and X give a selection of terms relevant to astrolabes.

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2, The Paddock
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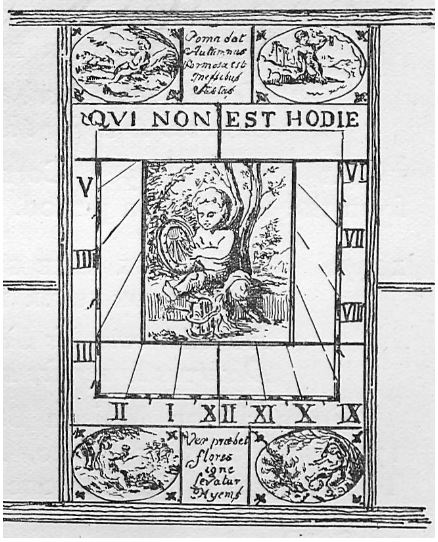
To be continued.



The stained glass dial from Nun Appleton Hall. Compare with the photograph on page 70. *After Gatty*.

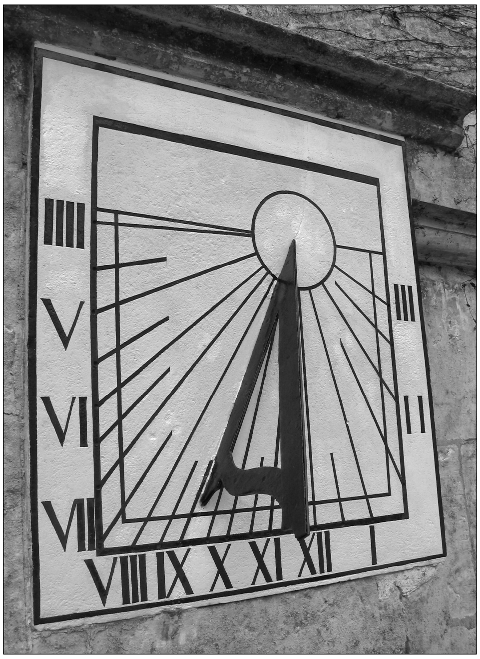
SOLAR & LUNAR DATA 2007

Data kindly supplied by Fiona Vincent.

	June			July			August			
Day	Declination	Transit	Moon	Declination	Transit	Moon	Declination	Transit	Moon	Day
1	22°02'31"	11:57:46	F 01:04	23°06'53"	12:03:47		18°02'25"	12:06:20		1
2	22°10'30"	11:57:55		23°02'41"	12:03:58		17°47'12"	12:06:17		2
3	22°18'06"	11:58:04		22°58'06"	12:04:10		17°31'42"	12:06:12		3
4	22°25'19"	11:58:14		22°53'06"	12:04:21		17°15'55"	12:06:07		4
5	22°32'09"	11:58:25		22°47'42"	12:04:31		16°59'51"	12:06:01	LQ 21:20	5
6	22°38'34"	11:58:36		22°41'55"	12:04:41		16°43'30"	12:05:55		6
7	22°44'36"	11:58:47		22°35'44"	12:04:51	LQ 16:54	16°26'53"	12:05:48		7
8	22°50'15"	11:58:58	LQ 11:43	22°29'09"	12:05:01		16°10'00"	12:05:41		8
9	22°55'29"	11:59:09		22°22'11"	12:05:10		15°52'52"	12:05:33		9
10	23°00'18"	11:59:21		22°14'49"	12:05:19		15°35'27"	12:05:24		10
11	23°04'44"	11:59:33		22°07'05"	12:05:27		15°17'48"	12:05:15		11
12	23°08'45"	11:59:46		21°58'58"	12:05:35		14°59'55"	12:05:05	N 23:03	12
13	23°12'21"	11:59:58		21°50'28"	12:05:42		14°41'46"	12:04:55		13
14	23°15'33"	12:00:11		21°41'35"	12:05:49	N 12:04	14°23'24"	12:04:44		14
15	23°18'21"	12:00:23	N 03:13	21°32'21"	12:05:56		14°04'48"	12:04:32		15
16	23°20'44"	12:00:36		21°22'44"	12:06:02		13°45'59"	12:04:20		16
17	23°22'41"	12:00:49		21°12'46"	12:06:07		13°26'57"	12:04:08		17
18	23°24'15"	12:01:02		21°02'26"	12:06:12		13°07'42"	12:03:55		18
19	23°25'23"	12:01:15		20°51'45"	12:06:16		12°48'14"	12:03:41		19
20	23°26'06"	12:01:28		20°40'42"	12:06:20		12°28'35"	12:03:27	FQ 23:54	20
21	23°26'25"	12:01:41		20°29'19"	12:06:23		12°08'44"	12:03:13		21
22	23°26'19"	12:01:54	FQ 13:15	20°17'35"	12:06:26	FQ 06:29	11°48'41"	12:02:58		22
23	23°25'48"	12:02:07		20°05'31"	12:06:28		11°28'27"	12:02:42		23
24	23°24'52"	12:02:20		19°53'07"	12:06:30		11°08'03"	12:02:27		24
25	23°23'31"	12:02:33		19°40'23"	12:06:31		10°47'28"	12:02:10		25
26	23°21'46"	12:02:46		19°27'20"	12:06:31		10°26'43"	12:01:54		26
27	23°19'37"	12:02:58		19°13'57"	12:06:31		10°05'48"	12:01:37		27
28	23°17'02"	12:03:11		19°00'16"	12:06:30		9°44'43"	12:01:19	F 10:35	28
29	23°14'03"	12:03:23		18°46'16"	12:06:28		9°23'30"	12:01:01		29
30	23°10'40"	12:03:35	F 13:49	18°31'57"	12:06:26	F 00:48	9°02'07"	12:00:43		30
31				18°17'20"	12:06:24		8°40'35"	12:00:25		31

Summer solstice 2007: June 21st, 18:06

PAINSWICK PHARMACY continued from page 83



H James

Fig. 2. The restored dial—the paint still wet.

H James

Fig. 3. The dial at Castle Godwyn, in a similar style to the Nutgrove House one.

at Castle Godwyn (SRN 4432), built in 1741, and is very similar in design and delineation to the Nutgrove House sundial. It bears the painted Latin motto 'Pereunt et Imputantur' (*The days/hours perish and are accounted* from Martial's *Epigrammata*). The façade was probably built by a local mason, John Bryan (1716-87), who also worked on the fine tombs and monuments at Painswick church.

The Nutgrove House dial may have been made to regulate a clock. It is neatly built into the stonework of the house but to our eyes is placement is strangely asymmetrical, up against a (now-blocked) window. Perhaps the maker intended one to lean out of the window to read the time before setting a clock inside the house.

The next-door property, attached to Nutgrove House, is called Watch House which suggests a possible connection with a watch-maker. There are eight 18th and 19th century clock makers listed for Painswick in Dowler's *Gloucester Clock and Watch Makers*, (1984, published by Phillimore). A tavern clock signed "Tho. Woodall, Painswick, 1766" still exists as do two brass clock faces signed by Thomas Wood (1776-97).

The only clockmaker recorded with an address is H. Hart of New Street in 1879. A Hart family appear in the 1881 census, living in Nutgrove House. Thomas Hart (aged 63) is listed as a chemist and Sara Hart (aged 58) ran the pharmacy until the turn of the century.

It is intended to erect an etched plaque beside the door below the restored sundial which will acknowledge donors and explain how to read the sundial. Harriet James gave a talk about sundials to the AGM of the Painswick and District Preservation Society in April 2007.

ACKNOWLEDGEMENTS

Our thanks to Douglas Bateman, Leonard Chittenden, John Davis, Andrew James, Mike Powis, Stroud Museum, Gloucester Museum, Gloucestershire Archives Office.

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A page from 'Sun-Dial Notes', a short book by Nellie Stearns Goodloe, published in the form of a calendar, California, 1893. A photograph of this dial, from Kells, Co Meath, Ireland, can be seen in Mario Arnaldi's book 'The Ancient Sundials of Ireland'. Notice also the dial from Kilmaldekar behind the initial letter of the stanza from Thomas Moore.

The calendar, designed for 1894, is also correct for 2007. A fuller note on the book will appear in a later issue of the Bulletin.

Kindly contributed by John Foad.

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