The British Sundial Society

BULLETIN

VOLUME 11 (ii) JUNE 1999

Front Cover: *Sundial in Hesse, Germany*
made by Kieling, photographed by D.A. Bateman

Back Cover: *Vertical dial in Israel, of ceramic tile,*
made and photographed by S. Adam

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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

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EDITORIAL

This issue of the Bulletin of the BSS has a fair mix of past, present and future. Among Past objects are the Saxon dials of Northumbria and Hampshire, and in the more recent past, the Meridian Dial in Nottingham. The Present (up-to-the-minute) is the making of a sundial from a TV satellite dish; and the Future is represented by 'Sundials on the Internet' and a painstakingly restored Wall Dial. It has been delightful to edit all these articles, but the item that has given me most pleasure was 'The Scaphe of Carthage', at the first century A.D. the most remote in time. The design is unlike anything that most of us have seen before. Perhaps at some future BSS meeting we shall see a functional model based on this design and made for (say) the latitude of London.

A MERIDIAN DIAL IN A SUBSCRIPTION LIBRARY, NOTTINGHAM

DOUGLAS A. BATEMAN

Summary

In a large Georgian town house in the centre of Nottingham is the brass strip of a meridian dial that was installed in 1834. The strip, and a vertical line on wood, is on the first floor of a library, but the wooden board with an aperture is missing. The strip is in very good condition, and is supplemented by two longcase clocks that have been inscribed with tables of longitude and time differences. The brass strip has been covered over for many years and only quite recently has the significance of the dial been realised. Steps are in hand to make a partial restoration of this rare form of dial, which is in excellent condition in the finest surroundings.

Bromley House

In 1752 George Smith, the grandson of a local banker, built an elegant town house, called Bromley House, in the centre of Nottingham. Externally, it appears fairly plain (Figs 1 and 2), but internally, the house is distinguished by having a grand main staircase with glazed lantern in the roof. The rooms are large and well proportioned, many with plaster decorated ceilings, and large fireplaces.

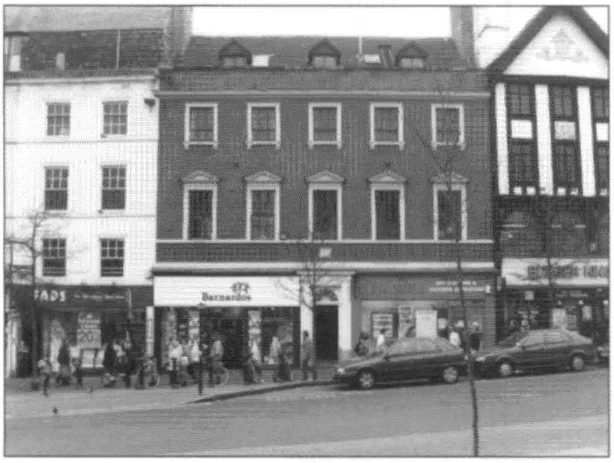

Fig. 1 Bromley House, Angel Row, Nottingham. Built in 1752.

The house had various owners for its first 70 years. In 1819 it was even used to billet soldiers: contemporary records give details of furniture being supplied for the officers and of damage done by the soldiers. Architecturally the house has suffered few major alterations, and one notable addition, in 1857, was an elegant spiral staircase to link two floors in the library. The staircase is unusual in that it has no central column and rises in one complete revolution with a short straight section.

Fig. 2 Rear view of Bromley House. The meridian line is in the room with the shutters partly closed: the aperture will have been in the upper part of this window.

Subscription Library

The desire amongst the professional classes for access to books was increasing during the early nineteenth century and in 1816 a subscription library was formed by distinguished members of the community. When Bromley House came on the market in 1820 it was purchased to give a permanent home for the growing library. The library has continued, and has a strong and active membership. The library, in turn, is a member of the Association of Independent Libraries.

From the beginning, members of the library maintained a very strong interest in the sciences. It is a matter of pride that the library supported, through access to books and help with financing publications, the mathematician and Nottingham miller known as George Green. Green was a member of the library from 1823 to 1833, before he went to Cambridge University. In 1828 he published a paper on *The Application of Mathematical Analysis to the theories of Electricity and Magnetism* and his invention of a class of differential equations and 'Greens's functions' have placed him on the first rank of mathematicians.

In celebration of the 175th anniversary the library published a booklet about Bromley House[1]. This 137 page booklet is a model of historical recording with 4 lengthy essays followed by extensive references, appendices and index. The booklet is an important link in the history of the dial.

The meridian dial

It must be assumed that after several years of use, the brass strip was covered over by carpets or linoleum for about 150 years. There has been no mention of a meridian dial either in Nottingham itself or in the general sundial literature, and apart from the early minutes of meetings in the library, the first formal record was in 1916 in the relatively obscure history of the library by Russell[2], and then again in the more accessible booklet mentioned above, in 1991. My own involvement came in 1997 when the assistant librarian, Adele Pucci, drew my attention to the booklet and arranged for me to see the dial. A very small portion of the brass strip could be seen in the corner of a doorway at the foot of a hint of the vertical line. In January 1998, the library authorities took the bold step of uncovering another metre of the brass strip. As part of a publicity campaign for the library, a very good feature on the dial appeared in the Nottingham Evening Post on 3 March 1998. It may have been this article that led one of Green's Mill scientific staff, Denny Plowman (see Note 1), to inform Peter Ransom, who in turn, mentioned the dial in his privately published booklet on sundials[3]. Although the dial was noted in the chapter on analemmatic dials rather than meridian dials, the Bromley House dial has a specific mention.

For details of the dial, and context, I quote directly from the second essay (by Neville Hoskins) in the anniversary booklet, pages 66-67.

> The members of the Library, in the early days of its existence, were extremely interested in scientific matters. They installed a remote indicating weather vane, though the date of this is not known. This was mounted on the roof, and connected by an ingenious system of rods to dials beside the fireplace in the main library room and the room below. As early as October 1832 it must have caused problems. The Committee instructed that 'the weather vane rod be taken down', but its repair was ordered two years later. The dials still exist, though they are no longer connected to the vane.
>
> In those days clocks and watches were set to local time and, in order that they may be checked, there was installed in the Standfast Room a device by which Local Apparent Noon could be ascertained. Russell *(the booklet gives a reference to the earlier history[2])* describes a 'wooden shutter-like erection fixed on the outside of the southern window and pierced by a small hole through which the sun would send a beam of light' Precisely at true solar noon the beam of light would cross the brass strip fixed to the floor. Associated with the strip was a plumb line suspended on a door frame in the north corner of the room. This strip survives though hidden by floor coverings, as does the recess housing the plumb bob. The function of the plumb bob is not clear; the brass strip alone would suffice to determine noon. Why a further marker was needed, and a plumb bob at that, is a matter of conjecture. Written notes of observations and clock errors, dating from the early days of the nineteenth century, are among the Library records. Both the longcase clocks in the library have inscribed on their faces a table of time differences between Greenwich and St Mary's Nottingham (4 minutes 33 seconds), and other locations in the Midlands.

Later, in the third essay (by Stephan Mastoris) on pages 93 and 95, there is some additional information

> This interest in science and society amongst the membership led to a fascinating assortment of furniture and fittings being purchased for the library, especially after its move to Bromley House. Soon after moving, the Committee purchased not only a clock but also a barometer, a thermometer and a pair of globes. .... What was to become an abiding interest in meteorology was enhanced by the fitting of a wind dial and index in the library reading-room which was connected to the weather vane on the roof. In 1834 one of the library's most intriguing features was created in the Standfast Room, - the Meridian Line marker referred to in Neville Hoskins' contribution. This equipment was complemented by the erection of a sundial in the garden in 1836. *(This dial has since disappeared, and the globes had been disposed of: my italics.)*

I quote again, this time from the minute books.

> At the 293rd Meeting of the Committee held September 1st 1834. The Rev R W Almond in the Chair. Resolved that the Meridian Line in the Standfast Library lately verified by Mr Bell and Mr Jackson be laid down in brass at the expense of tbe Institution...

As recorded above, the meridian line is installed in a small room in the library known as the Standfast Room. Fig.3 is a plan view. The strip is 6.69 metres long and 50 millimetres wide. The central line is deeply cut in the brass. Fig. 4 shows a general view. The location of the plumb bob

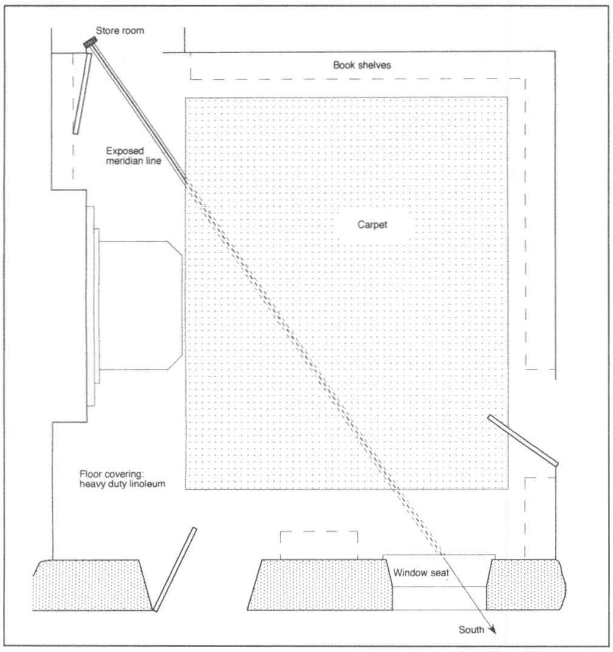

Fig. 3 Plan of the Standfast Room. From this plan the meridian line is at an angle of 55.3° to the wall.

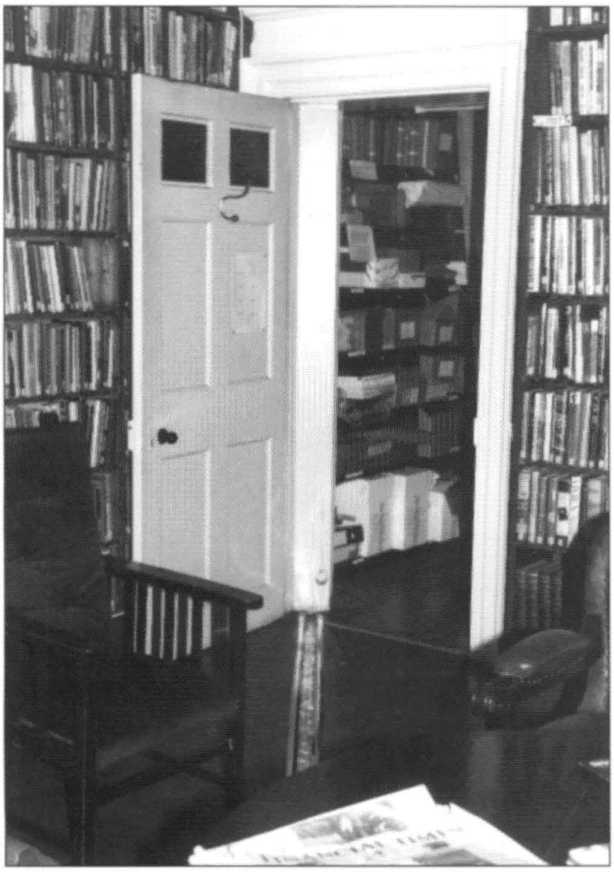

Fig. 4 The meridian line emerging from under the carpet below the table. The vertical continuation is on a specially fitted wooden board and is revealed by opening the storeroom door.

can be clearly seen in Fig. 5, and with oblique lighting, a vertical line can be detected in the substantial wooden board that adjoins the doorframe. For the photograph, the lines were emphasised with a 'dry marker' pen (the lines were afterwards removed with a soft cloth). The essayist in the Bromley House booklet was puzzled as to why the plumb bob should have remained at it serves no useful purpose. It is a matter for conjecture, and my own opinion is that the instruction to the carpenter to have this part of the meridian line vertical may have been so emphatic that the carpenter misunderstood this for inclusion of the bob as well. The line even extends to the top of the door frame!

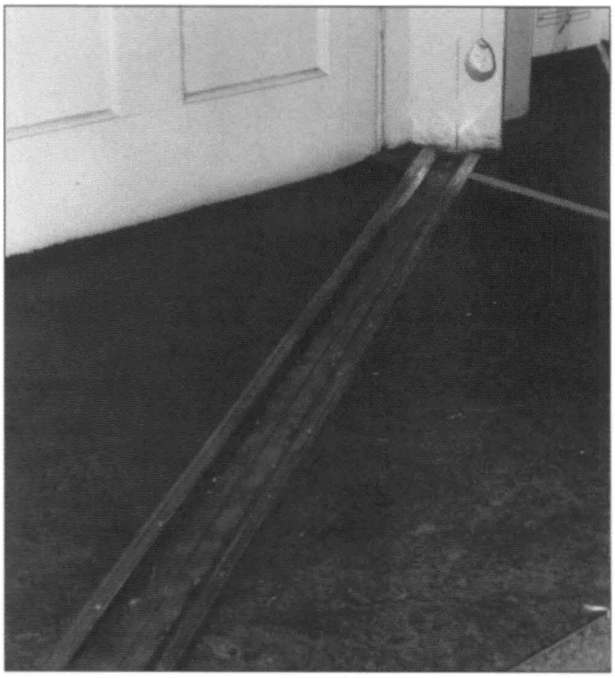

Fig. 5 The vertical line and recess for a plumb bob. The metal edging was fitted in 1998 after the linoleum was cut to reveal more of the brass meridian line.

The brass strip is in very good condition, and although the meridian line is clear, on the part that is exposed there seems to be no evidence of other marks that would indicate specific dates or the months - see Figs. 6 and 7.

The aperture must have endured the weather for over 80 years as Russell[2] reports it as being in place at the time of writing his History in 1916. No records exist of its removal, and the need for the dial was overtaken by telegraphed time signals, or an earlier lack of interest. Either way, members may have complained of the screening of daylight, a valuable commodity, by a large board in the window. However, there is some external evidence in the form of the remains of a wooden 'plug' for a screw or nail high on the brickwork of the window. On the same side there is a hint of paint in a vertical line, consistent with repainting the board at some time. Brickwork on the other side has been re-pointed, but there is extra mortar where a plug may have been. Figure 8 is a 'sectional' view showing where the spot of sunlight may have fallen, assuming the aperture to be in line with the panel fixings.

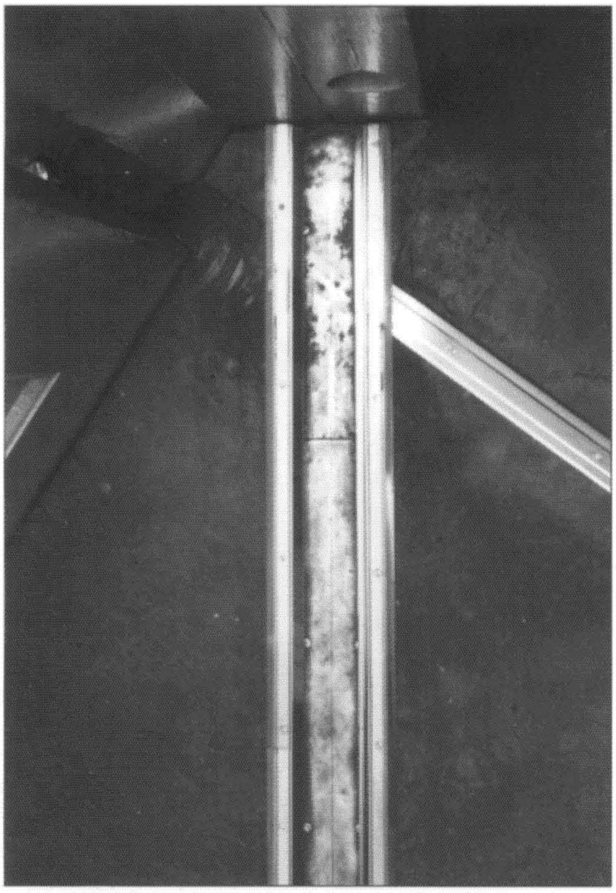

Fig. 6 Prior to 1988 the only part of the brass strip that was visible was a small portion just inside the storeroom door. The strip was covered over by linoleum, almost certainly well before 1916.

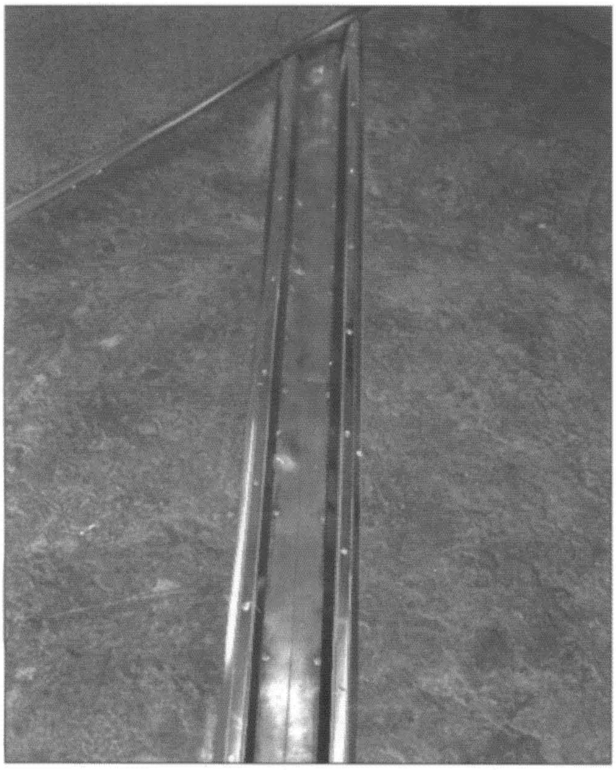

Fig. 7 A view of the brass strip looking towards the window.

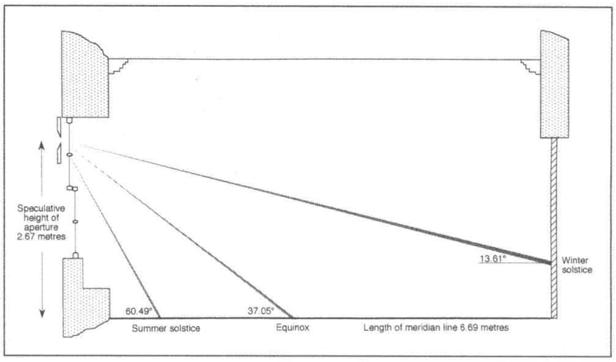

Fig. 8 A 'sectional' view. The height of the aperture is assumed to be on the same horizontal line as the fixing holes in the external brickwork.

Fig. 9 The white dial clock of 1780-90. Note the unusual two square apertures in the trunk. In the arch is a plate added later. It gives latitudes and longitudes as shown in Appendix 1.

The longcase clocks

As part of its timekeeping interests, the library has not one but two specially marked clocks. The first is an anonymous provincial white-dial clock dated, from the style, at about 1780-90. It has a recoil escapement and strike, and the dial is very plain and undecorated. The two most distinguishing features are an engraved panel above the dial that lists

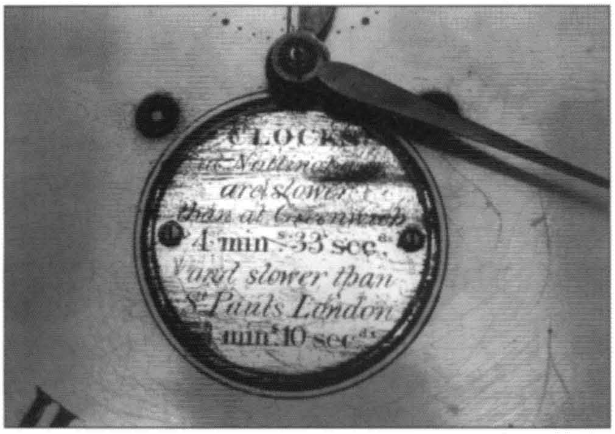

Fig. 10 The disc with time differences between Nottingham, Greenwich and St Paul's.

latitude, longitude and time difference. See Figs. 9, 10 and appendix 1.

Fig. 11 The 1830 Whitehurst regulator.

A second clock, of better quality with dead beat escapement, but without temperature compensation, had been commissioned from Whitehurst of Derby. This has been engraved directly on the dial with latitude, longitude and time differences from Greenwich and St Paul's Cathedral. See Figs. 11, 12 and appendix 2. The date, 1830, predates the recorded installation of the meridian line by 4 years, but it may well have been part of the overall planning for time-keeping. The functional inscriptions for latitude, longitude and time differences are extremely rare features in themselves. This clock, consistent with its discreet and sheltered existence, has escaped the attention of researchers and is not mentioned in the recent extensive study on John Whitehurst and his dynasty by Craven[4].

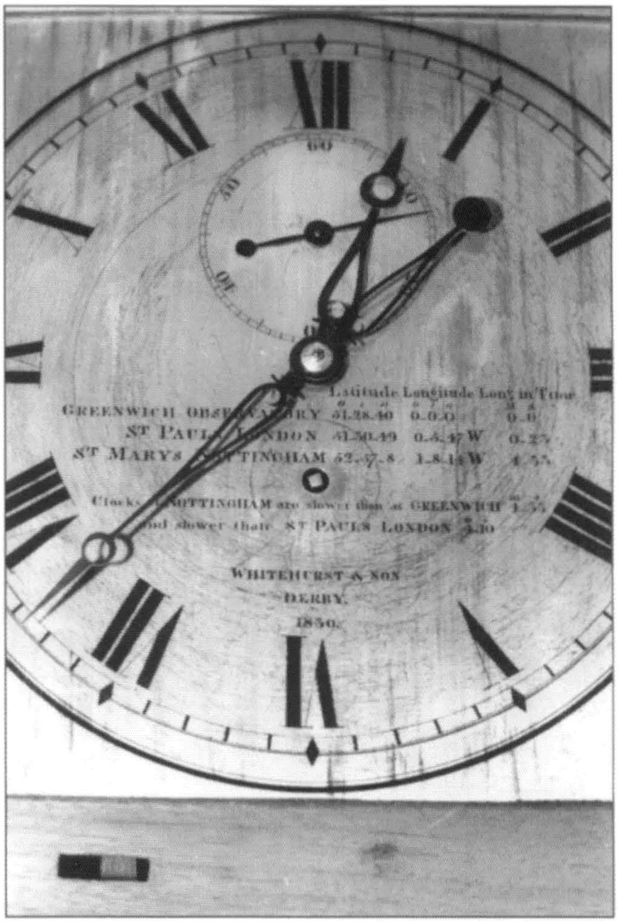

Fig. 12 Latitudes, longitudes and time differences engraved directly on the dial plate.

Latitude and Longitude

The precision with which the various latitudes and longitudes are quoted, and the mention of Colonel Mudge on the first clock, invites comparison with modern values. From a 1:25,000 scale map the latitude and longitude of Bromley House is 52° 57' 12" N and 1° 9' 3" W. For St Mary's Church the respective values are 52° 57' 31" N and 1° 8' 29" W. The differences from the early surveys for St Mary' s are 5" latitude and 15" in longitude (155 metres and 280 metres respectively).

These differences are trivial from a sundial point of view, and the modern longitude alters the time difference between Greenwich and St Mary's by only one second of time to 4min 34sec (Bromley House is 4min 36sec after

Appendix 1

Inscribed on the white dial striking clock

LATITUDES AND LONGITUDES
from the Trigonometrical Survey of England
and Wales by COL MUDGE and others

Names of Places	Latitudes			Longitudes West of Greenwich			In Time	
	°	'	"	°	'	"	m	s
Greenwich Observatory	51	28	40	0	0	0	0	0
London St Paul's	51	30	49	0	5	47	0	23
Lincoln Minster	53	44	7	0	32	1	2	8
Bottesford Church	52	56	40	0	47	45	3	11
Newark Church	53	4	30	0	49	18	3	17
Langar Observatory	52	55	3	0	51	27	3	26
Bingham Church	52	57	12	0	56	38	3	47
Nottingham St Mary's Ch	52	57	8	1	8	14	4	33
Loughborough Church	52	46	31	1	11	54	4	48
Derby All Sts Church	52	55	32	1	28	16	5	53

CLOCKS
at Nottingham
are slower
than at Greenwich
4 mins. 33 secds.
and slower than
St Pauls London
4 mins. 10 secds.

Appendix 2

Inscribed on the Whitehurst clock

	Latitude			Longitude			Long in Time	
	°	'	"	°	'	"	M	s
Greenwich Observatory	51	28	40	0	0	0	0	0
St Pauls London	51	30	49	0	5	47W	0	23
St Marys Nottingham	52	57	8	1	8	14W	4	33

m s
Clocks at Nottingham are slower than at Greenwich 4 33
m s
and slower than St PAULS LONDON 4 10

WHITEHURST & SON
DERBY
1830

Greenwich). From a map-making perspective, however, the errors are quite significant, and cannot be explained by the successive eastwards shifts of the Greenwich meridian due to new locations of transit telescopes after Flamsteed, Halley, Bradley and Airy. In fact the Bradley telescope was taken as the reference for the original triangulation of Great Britain between 1783 and 1853. When Airy's meridian was set up some 19 feet to the east it appears that the Ordnance Survey did not amend their records and the re-triangulation of 1936 to 1957, linked to Airy's meridian, appeared to reveal a large discrepancy. Further checks reduced the difference to 1.95 metres in longitude[5].

The Colonel Mudge mentioned on the white dial clock was William Mudge who was appointed as the second Superintendent of the Ordnance Survey in 1798. He was made a Fellow of the Royal Society in the same year. Mudge had been extremely successful in mapping a large part of the British Isles, but it was known that errors existed. The second superintendent, Captain Colby, urged resurveying, and payment to contractors that encouraged accuracy rather than speed. In a letter to a customer to explain the problem of representing part of the surface of a sphere on a flat sheet, Mudge himself explained that to introduce as little error as possible due to convergence, three meridians were established, one for the centre of the British Isles, the other two for the east and west[6].

It should not be surprising that latitudes and longitudes should contain errors, or should be subject to redefinition. In the latter part of this century we now have the satellite based Global Positioning System. To give a global 'best fit' around the earth, the zero meridian has moved again, this time a further 102 metres east. The Bromley House position (by conversion from the Ordnance Survey) under the GPS reference system, WGS84, is 52° 57' 13"N and 1° 9' 9"W.

Conclusion

Meridian lines in Italy and France have reported by Aked[7]. In addition, Aked mentions a line in a library floor at the University of St Andrew's in Scotland. However, this line was set out, in 1748, purely as a meridian for astronomical purposes: being without an aperture it would not have served as a noon time dial[8].

In the British Isles, meridian lines that serve as noon dials, and that are mostly horizonal, are very rare. There is one in Durham Cathedral, and a partially restored line in Ramsgate[9]. To have a line, still with its brass strip, and with accompanying longcase clocks, in surroundings of such charm and elegance, is unique indeed.

Note 1

Green's Mill is a traditional tower windmill built of brick, some 1.5km east of Bromley House. The mill was built in 1807 by George Green Sr. It ceased milling in 1867. It was restored in 1979-86 to be in full working order. There are 'milling days' and the adjacent buildings house an educational and 'hands-on' scientific centre.

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4. Maxwell Craven: *John Whitehurst of Derby, Clockmaker and Scientist 1713-88,* Mayfield Books, Derbyshire, 1996.

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8. Kenneth C Fraser, Senior Assistant Librarian, University of St Andrews, private communication, January 1999.

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John Davis tells us that the Ventnor (I.O.W. town council is Thinking Big about a millennium project: a massive sundial on the cliff above the Eastern esplanade. Our village Parish Council is Thinking Smaller: a vertical dial on the front wall (S dec.40°E) of the Primary School.

NOON MARKS AND THE PROJECTION OF THE ANALEMMA, WITH SOME NEW VERSIONS OF THESE OLD INSTRUMENTS

ALLAN A MILLS

Daily and annual motion of the Sun

The instant that divides the sunlit day into two halves is signalled by the Sun attaining its greatest elevation on the southern arc of the observer's meridian. It is called local noon or midday.

The noon Sun at the equinoxes is, by definition, on the celestial equator. (For solar timekeeping purposes the Sun's declination is considered to change abruptly at midnight rather than following a smooth annual spiral.) Its altitude ω above the southern horizon is therefore equal to the observer's co-latitude (Fig.1). During the course of the year the noon Sun appears to oscillate above and below its equinoctial position, the maximum positive and negative excursions representing the summer and winter solstices respectively. This apparent motion fundamentally results from the inclination of the celestial equator to the ecliptic by a current value of 23.46° (ref.1), adequately approximated to 23.5° when laying-out sundials

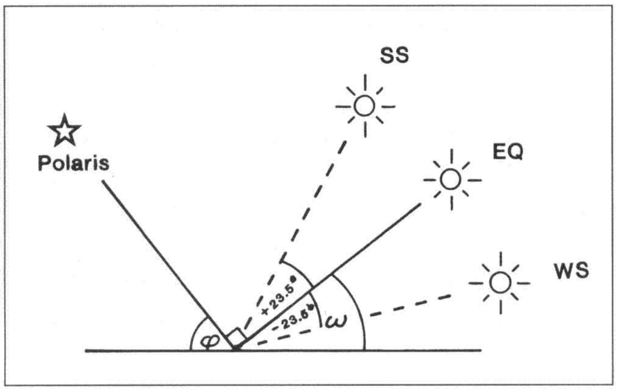

Fig. 1 Relationship between latitude, equinoxes and solstices.

The simple horizontal noon mark

The Sun is too bright to be observed directly, and there are no calibration marks in the blue sky, so mankind has long used shadows to mark the passage of time in general, and the instant of noon in particular.

A stick thrust into the ground provides the simplest shadow-caster or gnomon. We know that the shadow of its top describes a certain curve upon the ground, but for prehistoric man the most important empirical facts would be that the shadow on any day is of minimal length at midday, and is shortest of all during the long sunny days of midsummer. The 'shadow stick' therefore marks – albeit rather poorly – both time of day and time of year. Both were important to any culture evolving from a hunter/gatherer existence to a more settled agricultural society.

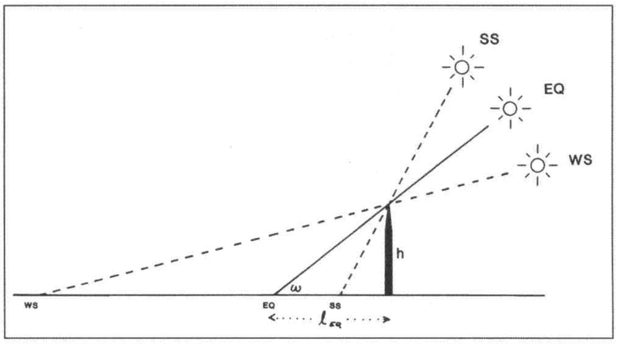

Fig. 2 The basic horizontal noon mark.

Quantification and modification

Figure 2 shows the relationships of the various shadow lengths: Let:

Height of gnomon	=	h
Latitude of site	=	φ
Co-latitude of site	=	$90 - \varphi = \omega$
Length of shadow	=	l

If Summer solstice, winter solstice and equinoxes are denoted by the subscripts SS, WS and EQ respectively, then:

$$l_{EQ} = \frac{h}{\tan \omega} = h \cot \omega$$

$$l_{SS} = h \cot (\omega + 23.5)$$
$$l_{WS} = h \cot (\omega - 23.5)$$

Substituting the modest figure of h = 1 metre for a mid-England site of latitude 52°, we find that:

$$l_{EQ} = 1.28 \text{ m}$$
$$l_{SS} = 0.54 \text{ m}$$
$$l_{WS} = 3.87 \text{ m}$$
$$l_{WS} - l_{SS} = 3.33 \text{ m}$$

The length of shadow thrown by a weak midwinter Sun is so excessive that it would be both faint and fuzzy[2], difficult to see against a background lit by scattered light. To attempt a complete sundial around even a vertical short pillar is quite impracticable: we often fail to realise that we are utilising only the lowermost portion of the normal sloping gnomon.

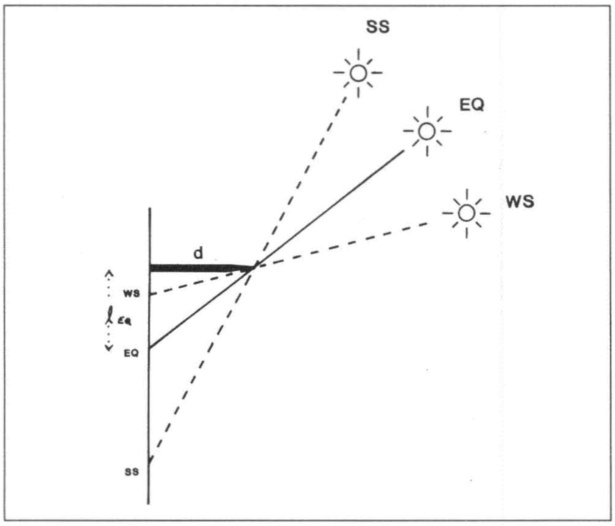

Fig. 3 The basic vertical noon mark.

The vertical noon mark

If the shadow is arranged to be intercepted by a vertical receiving surface (such as a wall) at a perpendicular distance d from the point of the gnomon (Fig.3), the relevant equations become:

$$l_{EQ} = d \tan \omega$$
$$l_{SS} = d \tan (\omega + 23.5)$$
$$l_{WS} = d \tan (\omega - 23.5)$$

Substituting the same numerical values of d = 1 metre at a latitude of 52°, we find:

$$l_{EQ} = 0.78 \text{ m}$$
$$l_{SS} = 1.84 \text{ m}$$
$$l_{WS} = 0.26 \text{ m}$$
$$l_{SS} - l_{WS} = 1.58 \text{ m}$$

These lengths are much more practicable for a real installation, whilst the elevated noon mark is also more visible and protected against accidental damage. However, the problem remains that, due to the finite angular diameter of the Sun, the shadow of the tip of a pointed rod may still be rather ill-defined and difficult to locate with precision.[2]

The aperture gnomon

The solution is to replace the solid gnomon by an aperture in an opaque disc[3]. This acts as an (oversize) pinhole lens, projecting a bright inverted image of the Sun within the elliptical shadow cast by the disc. The diameter of the hole is commonly around 1/1000 of the perpendicular distance between it and the receiving surface[4], but it is best to find by experiment the optimum size to balance intensity against definition for the final installation and its viewpoint. Theories based on achieving maximum resolution within a pinhole image are not particularly helpful.

Some well-known examples from the past are shown in Cousins[5] and in a previous issue of this journal[6].

Meridians

Long calibrated noon lines were once used to determine the solstices and equinoxes for calendrical and astronomical purposes, and are rather confusingly also termed meridians. In Europe, aperture gnomons throwing a solar image within the dim interiors of cathedrals were preferred[4,7,8], but a large open-air example employing a conventional shadow was built in medieval China[2,9].

Straight-line scales and local noon

All the older noon marks embody a straight-line scale, either as a horizontal strip or a vertical line. This shows that they were designed to indicate local apparent noon. Any modern noon mark is likely to be compared with the time indicated by a quartz watch or radio time signal, so on many dates through the year would be judged to be in error if marked in this way. This is because we now employ:

a) Standard time zones, such as Greenwich Time for the whole of the UK. A longitude correction is therefore required.

b) Mean time rather than apparent solar time. This employs a fictitious Mean Sun moving uniformly along the celestial equator, rather than the real Sun moving at a slightly varying velocity along the ecliptic. Due to the ellipticity of Earth's orbit and the inclination between ecliptic and celestial equator, this variation must be compensated by a correction curve conventionally known as the Equation of Time[10, 11].
   Strictly, this is slightly different from year to year[12], but for sundials it is sufficient to employ a mean curve calculated over the leap year cycle. A table of these mean values is reproduced by Cousins[5],

The analemma

Hence, the apparent altitude of the noon Sun varies through the year as a result of its changing declination, and the instant indicated as noon must be adjusted if it is to agree with a 'national standard noon'. A plot of declination versus the Equation of Time is known as the analemma[11]. For the Earth it always has a characteristic asymmetrical figure-8 shape, but the exact outline depends on the presentation

TABLE I

DATE	Declination δ°	Equation Correction E°		Date	Declination δ°	Equation Correction E°
Jan 1	-23.03	-0.86		July 1	23.12	-0.92
10	-22.00	-1.86		10	22.25	-1.30
20	-20.18	-2.75		20	20.67	-1.56
Feb 1	-17.18	-3.40		August 1	18.03	-1.56
10	-14.43	-3.58		10	15.58	-1.33
20	-11.02	-3.46		20	12.47	-0.84
March 1	-7.60	-3.11		Sept 1	8.30	-0.01
10	-4.12	-2.60		10	4.97	0.74
V.E. 21	0.22	-1.82		A.E. 23	-0.05	1.89
April 1	4.53	-0.99		Oct 1	-3.17	2.57
10	7.93	-0.35		10	-6.63	3.23
20	11.50	0.27		20	-10.33	3.79
May 1	15.07	0.73		Nov 1	-14.42	4.09
10	17.62	0.92		10	-17.13	4.02
20	19.97	0.90		20	-19.68	3.60
June 1	22.05	0.58		Dec 1	-21.80	2.75
10	23.02	0.18		10	-22.92	1.81
S.S 21	23.45	-0.40		W.S. 21	-23.45	0.49

Mean Time = Sundial Time - Equation Correction

This is the modern astronomical convention. An opposite convention is used on some older dials, but gives the same final result if due account is taken of sign.

(see below). The shape of the analemma is controlled by the orbital characteristics obliquity and eccentricity, so corresponding figures may be drawn for any other planet of the solar system. These are illustrated by Harvey[13].

The idea of correcting noon marks directly by replacing the straight line with a graphical plot of the analemma was conceived in 1740 by Grandjean de Fouchy[14]. It may, of course, be extended to transform every hour line on any sundial[4, 15, 16], but the computation required is so tedious (or was before the introduction of the computer) that the analemma tends to be associated with noon marks. A related diagram used to be printed on terrestrial globes[11]. An ingenious variation is to shape the gnomon of an equatorial dial into a matching analemma[5].

The analemma on the celestial sphere

The mean values tabulated by Cousins are in terms of calendar date, degrees and arcminutes of solar declination (δ), and minutes/seconds of time for the 'Equation Correction'. The latter, combined with the longitude correction, gives the period to be added or subtracted to produce Greenwich Mean Time from sundial time. These figures may be tabulated or graphed on any convenient scales.

However, if it is desired to truly represent the motion of the real Sun in the real sky, then time must be converted to arc by the relationship:

$$4 \text{ minutes of time} = 1^\circ \text{ of arc}$$

to give the values shown in Table I. These could be plotted on ordinary graph paper with equal lengths representing equal increments in RA and Declination. This is useful to summarise data and check there have been no arithmetical errors, but it does not accurately represent the true analemma on the celestial sphere, where both axes are curved.

In the real sky at noon the virtual analemma would appear in its normally-depicted upright stance relative to the horizon, but at other times of day it would (like its axial meridian) seem to slope to one side or the other by amounts dependent on the latitude of the observer. Dramatic photographs of the celestial analemma have been published by DiCicco[17] and Arnold[18].

The celestial analemma projected on a perpendicular axial plane

It will be realised that any camera used to photograph the celestial analemma automatically converts the 'analemma on the celestial sphere' to the matching 'analemma on a perpendicular plane' – *viz.* the film plane. This is an example of a gnomonic projection:[19] a wide-field astrophotograph of a constellation of stars is in this projection[20]. The foreshortening leads to serious distortion when the angle from the origin exceeds some 20°, so it is rarely used for geographic maps apart from the polar regions.

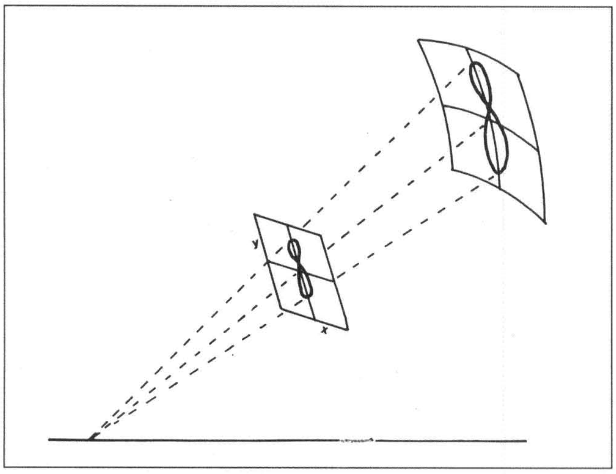

Fig. 4 The analemma on the celestial sphere projected upon a plane tangential to its origin.

Plotting inside a bowl is not easy, and photography of a hemisphere of any practical size is likely to lead to illumination and depth-of-focus problems. Plotting the data of Table I on an oblique gnomonic graticule[19, 20] also proved unsatisfactory. Much the best technique is spherical trigonometry allied with a 'scientific' electronic calculator. A clear introduction to this branch of mathematics has been written by Smart[21], and an excellent account of its application to navigation and dialling provided by H.R. Mills[22].

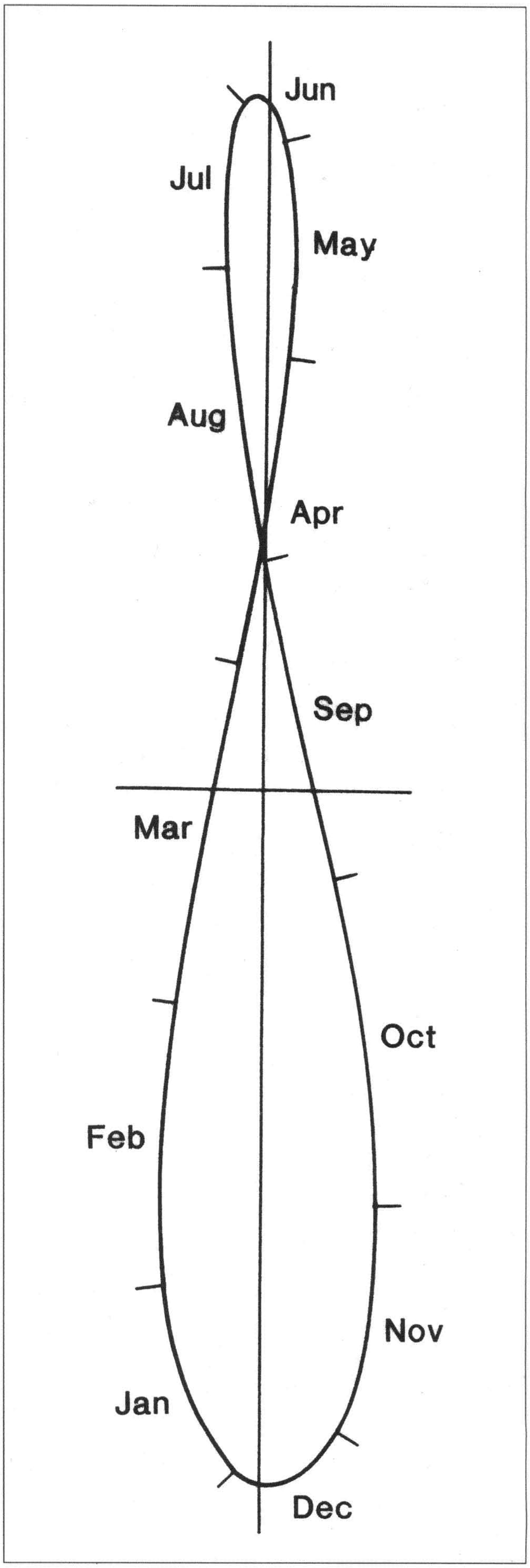

Fig. 5 The celestial analemma projected on a perpendicular plane: detailed result of figure 4

The situation for a receiving plane tangential to the origin of the analemma on the celestial sphere is represented by Fig.4, and the relevant transformations are:

$$x \propto \tan E$$

$$y \propto \frac{\tan \delta}{\cos E}$$

where E is the Equation Correction and δ is the Sun's declination. These angular parameters are given in Table I and plotted in Fig.5: this is the celestial analemma converted to the analemma on a perpendicular axial plane. Its shape is independent of the latitude of the observer.

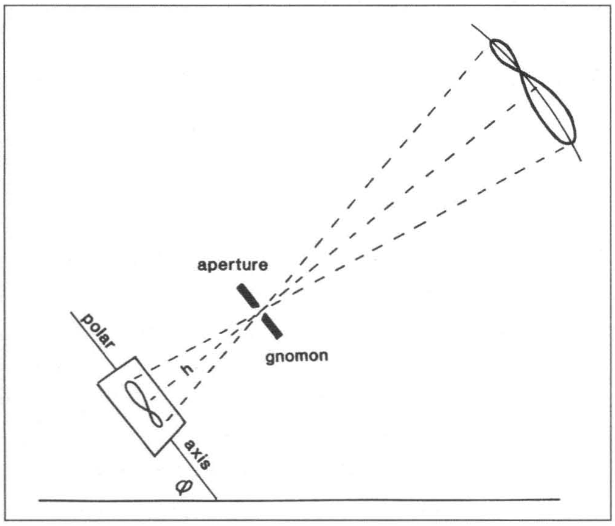

Fig. 6 The polar analemmatic noon mark.

The polar analemmatic noon mark

The geometrically simplest noon mark consists of an aperture gnomon throwing a spot of light upon a plane surface centred perpendicularly to its axis, as in Fig.6. The situation is akin to the central section of a polar sundial, and the above equations become:

$$x = h \tan E$$

$$y = h \frac{\tan \delta}{\cos E}$$

where h is the height of the aperture (or any nodus) above the receiving plane. Note must also be taken of the fact that the image of the celestial analemma is both inverted and reversed. Fig.7 is therefore the inverted mirror image of Fig.5, and includes a scale bar to show the corresponding height of the aperture above the plane. When the spot of sunlight falls upon the vertical axis it is local noon. A small longitude correction may easily be accomplished by a slight rotation of the entire instrument about an axis parallel to the polar axis passing the aperature. The vertical axis of the figure will no longer constitute a local noon mark, so is probably better omitted.

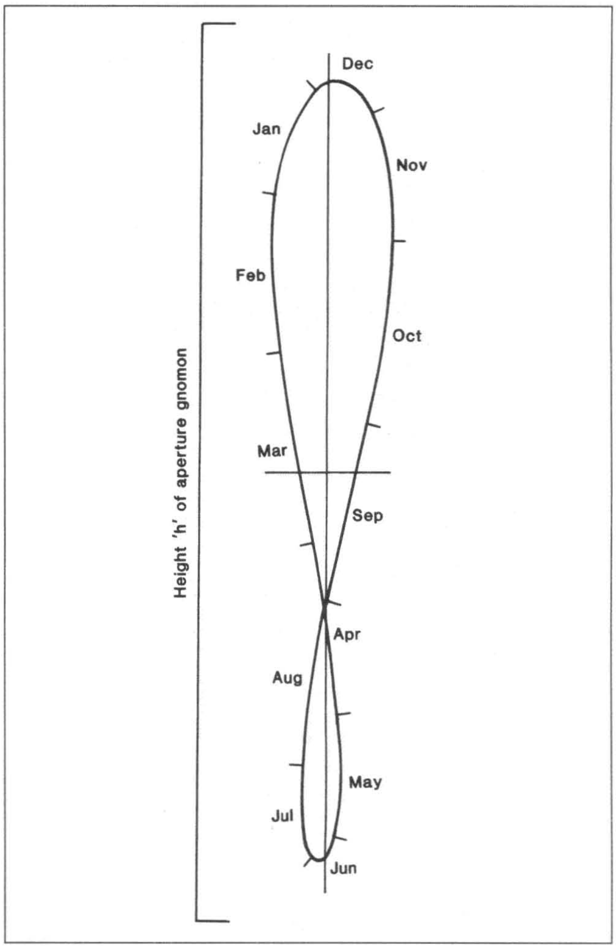

Fig. 7 The polar analemmatic noon mark: detailed result of figure 6.

Inspection of Table I will show that cos E is always very close to unity. Therefore, unless a polar dial is especially large, it is usually adequate to plot the distances of E and δ along the x and y axes as directly proportional to their tangents. It must be remembered that an accuracy within ± 15 seconds is probably the best that can be expected with an analemma averaged over the leap year cycle.

An example of a polar analemmatic dial is represented by a concept model in Fig.8. It has been deliberately designed to resemble the popular conception of an astronomical instrument.

The vertical analemmatic noon mark

The latitude and longitude of the site must now be taken into account. The longitude is considered positive if west of Greenwich, and subtracted from the Equation Correction.

E' = E - longitude correction
Solar altitude A = ω + δ
Solar azimuth Z is found from

$$\sin Z = \frac{\sin E' \cos \delta}{\cos A}$$

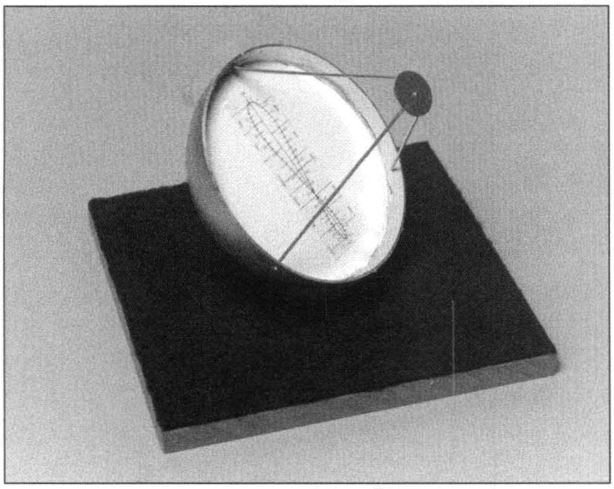

Fig. 8 Concept model of a polar analemmatic noon mark.

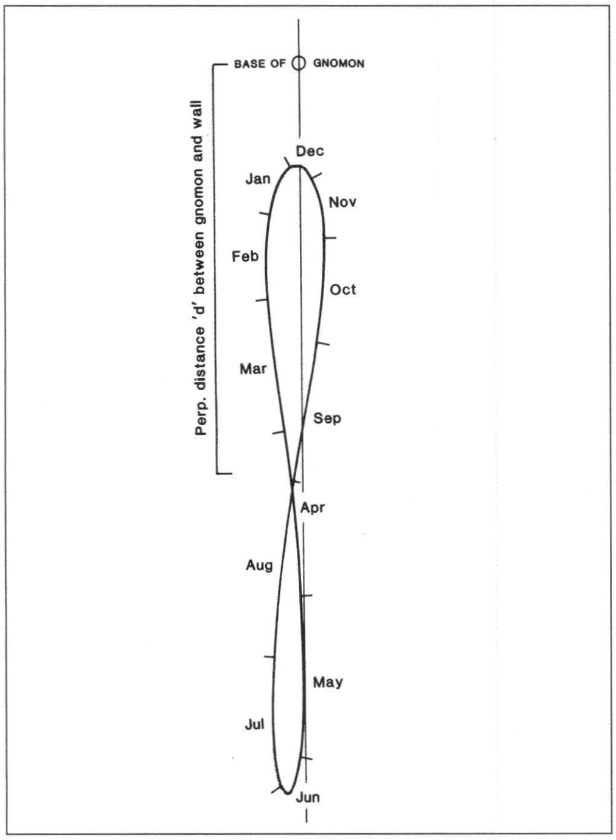

Fig. 9 The vertical south-facing analemmatic noon mark: detailed plot.

Then:

$$x = d \tan Z$$

$$y = d \frac{\tan A}{\cos Z}$$

In Fig.9 this analemma is plotted for a mid-England site (Leicester) at Lat.52·63°N, Long. 1·08°W, the perpendicular distance d of the gnomon in front of a vertical south-facing wall being shown by a scale bar.

Fine modern examples of this genre have been designed by Christopher Daniel and Douglas Bateman. The former is engraved on slate and installed on a southerly wall of one of the buildings of the former Radcliffe Observatory, now part of Green College, Oxford[23, 24]. Bateman's dial is on glass, being intended to be viewed from inside an entrance hall[25]. Another elegant example in slate has been produced by Alan Smith: it was laid out by marking the position of the projected spot of sunlight at civil noon on every sunny day throughout a year[26]. All these dials indicate the approximate calendar date as well as the instant of noon.

For the analemma on a declining vertical wall see the formula quoted by Cousins[5].

Analemmatic noon marks on surfaces other than planes

The modern dials mentioned above are members of a very rare group, for few noon marks have been built for two centuries. It is true that these devices are no longer required to regulate clocks and watches – but neither are sundials! Yet the latter have found a much-loved place as decorative and interesting objects in many architectural settings. Now noon marks are much less demanding of their site than sundials, needing only to 'see' the Sun at its maximum southern elevation, so lend themselves to built-up urban areas. Perhaps the straight-line noon mark is seen as too plain, and the analemmatic as intriguing but confined to a vertical wall. This last condition is not in fact essential, for any shape at any angle may serve as the receiving surface.

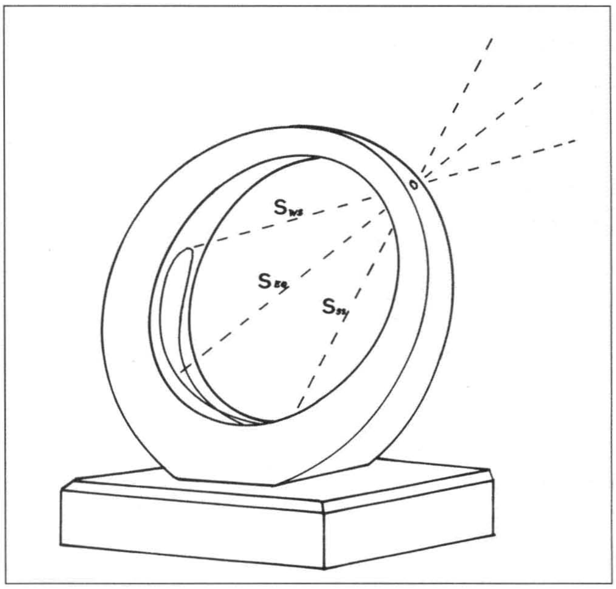

Fig. 10 Sketch of mode of operation/calibration of a sculptural analemmatic noon mark with a curved receiving surface.

The main problem is to project the celestial analemma upon such a curved or irregular surface. The most straightforward technique is that employed by Smith[24], where the Sun itself traces its own analemma over the course of a year. It is probably best (if there is a choice) to work through a year at the midpoint of the leap-year cycle. This method does, however, require determination as well as noon-time availability on the part of the designer. Calculation is generally more practical!

The geometry of a surface that is part of a circle passing through the aperture gnomon is comparatively simple, and has already been considered in connection with ring dials and the Cooke heliochronometer[27] Shapes that are smooth curves in one plane, and more-or-less flat at right angles to that plane (i.e.'squashed rings') may be dealt with graphically as indicated in Fig.10. The inner surface is traced or drawn at full scale on paper, and the position of the countersunk aperture carefully marked. The equinoctial noon ray corresponding to the co-latitude of the site is then drawn with a large protractor or, better, by dropping a plumbline or perpendicular from the aperture and applying simple trigonometry. The declinations listed in Table I are then drawn either side, and the intercepts with the outline of the interior marked. A strip of stiff paper is then laid edge-on around the perimeter of the curve, and the intercepts transferred to it. The strip is then flattened, and the corresponding Equation Corrections (calculated from S tan E') entered either side of the central axis. The points are then joined by a smooth curve and dates etc. added as desired.

Check that allowance has been made for the inversion of the image – the June end of the analemma should be at the lowest point! The calibrated strip of paper may then be secured within the actual dial, and markings transferred with carbon paper or as appropriate.

Fig. 11 Virtual montage of the dial of figure 10. Imagined about 8 ft high, in white limestone, set within a pool. Created with Adobe Photoshop.

Hollow stones and bronzes characterise the work of the modernist sculptors Henry Moore and Barbara Hepworth. Representations of two proposed analemmatic noon marks in their style are shown in Figs. 11 and 12.

Fig. 12 Maquette of another proposed analemmatic noon mark. Imagined to be in polished and darkened bronze, about 4 ft high, with matt gold-plated interior receiving surface.

Calibration by optical projection

An alternative (or confirmatory) non-mathematical method - essential when irregular receiving surfaces are involved - is direct optical projection. Figure 5 is surrounded by large sheets of white paper, uniformly illuminated, and photographed on high contrast black-and-white film. By moving further away from the diagram for each successive frame, the processed film provides a series of diminishing negative versions of the basic analemma as clear lines on a black background. Selected frames may then be mounted in suitable holders.

To calibrate a given noon mark, for example that shown in Fig. 10, a central position is first marked corresponding to the equinoctial noon Sun at the latitude of the proposed site. This mark is then flanked by the + $23\frac{1}{2}^\circ$ and $-23\frac{1}{2}^\circ$ positions as above. The aperture gnomon is then temporarily reduced in diameter with a stiff aluminium foil disc perforated with a (literal) pinhole at its centre. A 15mm hole is made in the bottom of a paint can, and a 60 or 100 watt frosted glass lamp supported within the enclosure by a lamp holder passing through the lid. The top of the lamp bulb should be about 10 mm from the hole. This assembly is then clamped on the outside of the noon mark, as close as possible to the pinhole aperture. The arrangement must provide a brightly illuminated surface everywhere within a cone of apex angle not less than 50° measured at the pinhole if a sufficient area of the interior is to be illuminated.

Working in a darkened room or at night, the photographic negatives prepared above are then held in the interior of the sculpture at right angles to the equinoctial axis, until one is found that, properly positioned, gives a projected analemma with its origin on the marked centreline and its extremes coincident with the ± 23½° positions. Make sure the pattern is the correct way up and way round! Clamp the slide in position, and mark the projected analemma with a pencil or as appropriate, omitting the axes if desired. The clarity of the lines depends on how closely a point source of light has been approximated, so an over-run T1 'grain-of-wheat' lamp, placed within the aperture itself, is another possible illuminant.

It generally looks best if the analemma is positioned centrally within a sculptural noon mark. For a large dial, or considerable longitudinal displacement, the revised altitude and azimuth should be calculated so that the structure stands exactly vertical and is supported by a truly horizontal plinth.

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PUTTING THE SHEPHERD'S DYAL ON THE MAP

JOHN MOIR

Fig 1. The West Prospect of Settle (1720) by Samuel Buck (Copy-J.M.)

The shepherd's dyal in the title is not of the customary portable variety, but is the description given by Samuel Buck to a hill-side sundial featured in his sketch of 1720 (Fig 1.). The drawing shows stone hour markers ascending the West facing slope of Castleberg Hill, Settle, in Yorkshire, but sadly they have long since vanished. On the map, (Fig 2.) the dial was sited just above the "S" in Settle. To complete the setting of the scene, Fig 3 shows the hill in recent times, the view being from the famous Settle-Carlisle railway, with the Parish church in the foreground.

I first learnt of the dial whilst walking the Settle Town Trail last year. The leaflet mentioned briefly that at one time the crag cast its shadow on to numbered blocks, but did not answer any of my questions-"When and by whom was it created?", "When did it vanish?" and "How well did it function?".

Fig. 2. Map showing Castleberg Hill.

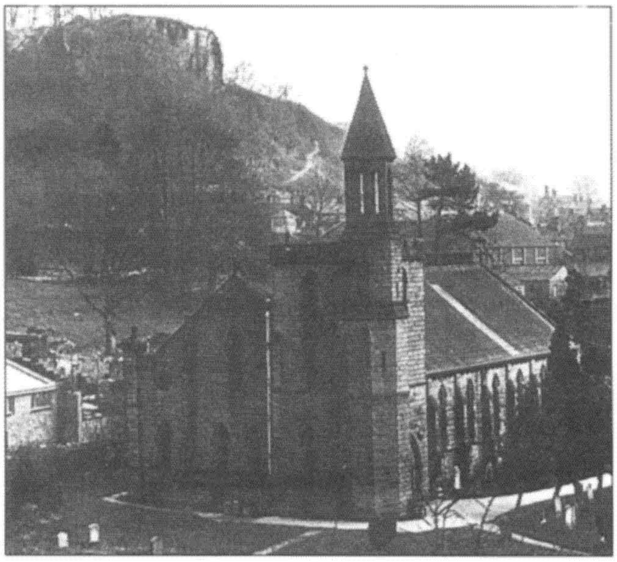

Fig. 3. Castleberg Hill behind the Parish church

Although there is a lack of hard evidence on the subject, a book by local historian Thomas Brayshaw[1] throws some light on the first two questions, whilst I have attempted to analyse the gnomonic aspects of the dial.

When and by whom was it created ?

Brayshaw conjectures that the dial could not have been very old when drawn by Buck in 1720, as the severe Yorkshire weather had not yet obliterated the engraved numbers. He draws a possible connection between the sundial and a house of eccentric design at the foot of Castleberg Hill, known as the Folly, or Prestons Folly. Its date stone, now unreadable, is said to have read 1675. Tradition has it that a man called Preston built the Folly, and that he was interested in landscape gardening. He could well have owned the land rising up behind the house, so it is tempting to imagine him supplementing one folly with another- an enormous sundial. We may never know.

When did it vanish ?

Evidence for the dial's continued existence comes from a letter written by Bishop Pococke, describing a journey through Settle in 1750:-

"A little further we came to a most pleasant village called Giggleswick.... Crossing the Ribble a little beyond this place, we came in ¼ mile to Settle, a little town situated under a high rocky hill, on the lower part of which four stones being placed they serve as a sundial......." (The fifth stone marked VIII was perhaps placed too low to be seen from Pococke's viewpoint). It was probably some time between 1750 and 1779 that the stones perished or were removed, because in his journal of that year the Rev. John Hutton has much to say about Castleberg and the quarry at its base, but makes no mention of the dial nor of any tradition connected with it.

How well did it function?

For a sundial to indicate the correct hour the whole year round, the gnomon should be inclined towards the celestial pole. We can suspect then that a near-horizontal, North-South cliff edge would have functioned less than ideally as a gnomon, as the following analysis will demonstrate. Fig.4 represents a simplification of the hill's actual topography, is roughly to scale and can be considered as a West declining, reclining planar sundial. The diagram shows the sun casting a shadow A'B' of a section of the cliff edge AB. The hourly positions of A'B', at both the Equinox and Summer Solstice[2] were calculated and plotted, as in Fig.5. What Fig.5 proves is that the flagstones must have been laid out, albeit empirically, at or close to the Summer Solstice. Only then could they cover all the hours from 8a.m. to 12 noon in a line running vertically up the slope, exactly as Buck had observed in 1720 (Fig.1). My reluctant conclusion is that, apart from its great novelty value, the dial would really only have been useful as a time-keeper for a few weeks around mid-summer, i.e. the time it appears to have been laid out.

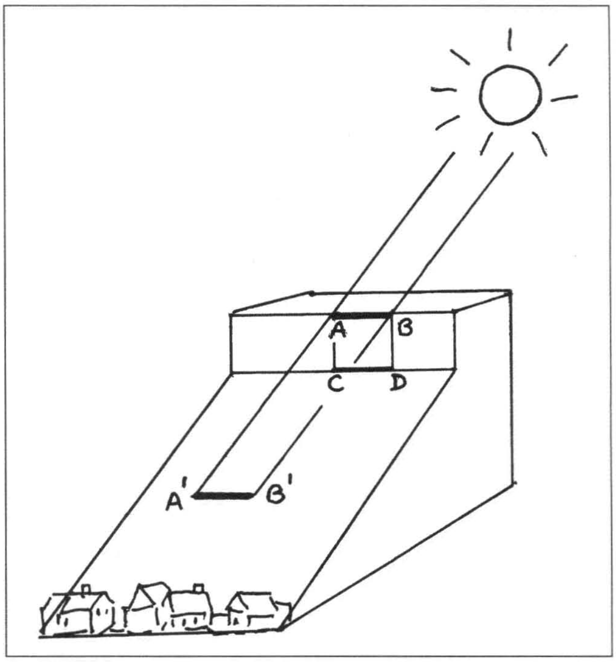

Fig. 4. A simplified block diagram of the hill.

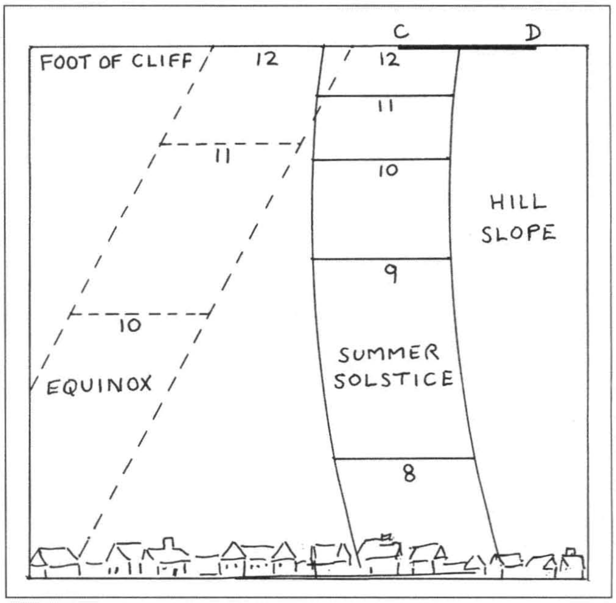

Fig. 5. The hour lines plotted on the hill-slope.

Some shady business ?!

There is further pictorial "evidence" for the dial in the "Buck and Feary" engraving of 1778 (Fig.6). Strangely, though, the stones are here placed down the southern slope, and a shadow from a quite imaginary hill has been introduced, between the VIII and IX, to give spurious credibility to the picture! How can we account for this astonishing mis-representation?

To answer this question we must go back to 1720, when Samuel Buck was commissioned by John Warburton to produce for him a large number of sketches, one being that of the sundial. These were intended to illustrate the latter's proposed but never completed book of Yorkshire history.

That these sketches are accurate and that Buck was a reliable observer I have no doubt, having myself been privileged to examine the sketchbook in the British Library.[3]

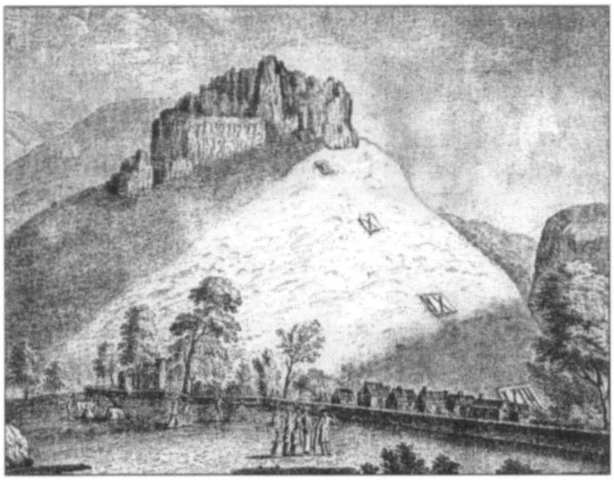

Fig. 6. The "Buck and Feary" engraving of 1778.

Buck went on to produce annual portfolios of English scenic engravings, which were highly collectable. In 1753, ill health brought this to an end, and his life became a struggle, until his death in 1779. A possible explanation of the extraordinary "Buck and Feary" engraving is given by Brayshaw- " It is impossible to believe that Buck, a dying man of 82, who had given up work 25 years before, took any share in the production of the prints of 1778. Of Feary little is known, but we may conjecture that Buck, during a period of financial difficulty, sold him his stock in trade; that Feary found rough drawings or unfinished plates of the Settle and Giggleswick subjects, and completed them from his own imagination. It is improbable that Feary himself ever came to Settle, for there are good reasons to believe that the sundial had vanished some years before 1778. But the success of Buck's testimonial would convince him that Buck's name still appealed to the public and cause him to add it to his own in the corner of the engravings. He certainly had no means of consulting the sketchbook, for this passed to Warburton, and, on his death in 1759, was purchased by the 1st Marquess of Lansdowne, who subsequently bequeathed it to the British Museum".

Conclusion

No doubt there is much more to be discovered about this sundial's history-perhaps one of our Yorkshire members would be interested in delving further into the local records? Also, it would be fascinating to know if other examples of "landscape" dials exist in England or abroad, or was the Shepherds Dyal at Settle unique?

Acknowledgement

I am much indebted to Alison Boswell of the Settle Tourist Information Office for guiding me through the available source material, providing photographs and showing great enthusiasm for this investigation.

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2. The winter solstice was not considered, as the sun's altitude would then be too low to register a useful shadow on the west facing slope.

3. Lansdowne MS 914,p.l27. It is well worth a visit to the British Library to see this sketchbook, for its superb views of countryside and houses, several of which display vertical sundials.

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DIAL DEALINGS

MIKE COWHAM

There have been two major sales so far this year, both turning up a quantity of quite exciting dials. Space will not permit a description of them all, so I will pick out a few of those of greatest interest. Note that the catalogues issued by the main auctioneers make excellent reference books. Their descriptions and photographs of dials and other instruments, over a period of time, make a valuable record of what has been sold. For anyone interested, an annual subscription is really worthwhile. Even better than reading the catalogue is the opportunity to view these sales. The viewing is free of charge, and it provides a rare opportunity to handle and study these treasures. It is a good way to learn about these dials, and familiarity with them helps identify those of the best quality.

The first sale was from Christies on 15 April. I went to view the sale having marked 25 sundial lots on my paper. Very few of the lots offered were what I would call 'standard' dials. Most were rather special. The estimates given to the lots appeared to be very high, but from the results achieved, it seems that Christies got their estimates about right. However, more lots than usual failed to reach their reserves; so some of the best items remained unsold. Hopefully they will be re-offered at another sale in due course. It was interesting to note that 9 of the lots in this sale were formerly exhibited at La Societe General de Banque in Brussels, 1984. They are described and illustrated in the catalogue of that exhibition, 'La Mesure du Temps dans les Collections Belges', which is still available from technical booksellers.

There were 5 ivory diptych dials. Fig.1. shows a dial by *PAVLVS REINMAN* made around 1700. Its most unusual feature was the engraving on the underside of the lid showing two men, one holding a pillar dial and the other a diptych dial. Although these unique figures were the main attraction of this dial, I was a little concerned about the quality of the engraving of them, and also the patterns in the corners of the top face. There was no evidence to show that these features or patterns were later additions, but they were almost certainly by another somewhat inferior hand. This may be the reason that this was one of the unsold lots.

Another diptych, Fig. 2, was an early dial by *HIERONIMUS REINMAN* of *NORENBERGE* dated 1566. It made a healthy £4600. Two other large diptychs remained unsold.

An inclining dial by *CHAPOTOT A PARIS* is worth mentioning, Fig.3. It was similar in most ways to other inclining dials, but this one had a bird's beak latitude pointer rather than the more common side latitude arc. Therefore the dial plate required a slot cut in it to allow the bird support to slide through. It sold for £2645.

One of the most exciting dials in the sale was an astronomical ring dial, Fig. 4. Although unsigned, this can be attributed to Louvain and dated c.1550. It may be the work of *Frater Joannes Motter.* It sold for £20,700. Other dials of this style are known from Louvain, also believed to be made by Motter.

For lovers of ring dials, there were two that were rather special. One was a standing ring dial by Heath & Wing c.1700. This failed to reach its reserve. A price of £40,000 to £60,000 had been estimated. The other, somewhat more modest, was 24cm diameter, made by *Tho. Wright, Instrumt maker to His MAJESTY.* One special feature was the incorporation of a vernier scale between the suspension loop and the latitude scale to allow for precise latitude settings. It was in superb condition, but also failed to reach its reserve.

Also of interest, although not strictly a sundial, was a medieval astrolabe from 14th century, Fig.5. It was originally offered for sale last year in Nancy, France, where it failed to sell. Detective work on its engraving and construction shows that it was probably made by at least 2 craftsmen over a period of time. It seems that it was probably started by a Spanish Jew and was embellished later by an Arab. One charming feature was the inletting of silver cartouches into the brass. These were engraved in decorative Arabic with the names of the months and zodiac signs, Fig. 6. It sold below its estimate for £70,000. Christies catalogue devotes 10 pages to this astrolabe giving fascinating details of its many features.

The sale at Sotheby's on 27 April also turned up some exciting dials.

A mechanical equinoctial dial by *J. J. Knittel* in gilt brass, Fig. 7, uses a separate minute dial to achieve accurate readings. The Knittel family is well known for this type of dial, but it is the first time that a dial signed *J. J. Knittel* has been recorded. It sold for £34,500.

A much rarer dial, a scaphe dial, Fig.8., in the form of 'Dial of Ahaz' was made by Georg Hartmann of Nuremberg, 1547. I think that this is the first time that I have seen a dial of this type for sale. Unfortunately the original gilding has worn off its bowl, and it looked a little drab in basic bronze. This type of dial will only work correctly when filled with water, giving the necessary refraction of the sun's rays. A hole in the bottom of the bowl would originally have contained a compass, suitably sealed with wax or pitch against the potentially damaging water. It sold for £78,500.

The other exceptional dial, of which there are only about 4 known, was by *Timothée Collet,* c.1675. These dials are in the form of those made by Butterfield, but they are very individual, and unique to Collet. Fig.9. They are most attractive, always with silver dial plates, with gilt gnomons and were usually, (but not in this case), engraved with their date of manufacture. Each of Collet's dials have two unusual distinguishing features. The **XII** numeral marking is always extended from the main dial plate in a decorative cartouche, so that the numeral is not obscured by the gnomon; and on the underside of his dials is a lunar volvelle surrounded by a very attractively fretted gilt gnomon support spring. Fig.10. This dial was unsold.

The Scientific Instrument Fair, 25 April had two dealers offering a quantity of pocket dials. Some were of quite low value, ideal candidates for starting a collection. One dealer had a particularly fine garden dial by *John Worgan.* He is one of my favourite makers and always uses an English rose on his instruments, placing it in the centre on his garden dials. This one was in good condition for a dial made before 1700, and was reasonably priced at £800.

The Instrument Fair is always worth a visit. There are many dealers from around the world offering instruments of all types. There always seem to be some interesting dials to be found - but you need to get there early to beat me!

CALENDAR FOR SALES in 1999.

Note that some of these dates are tentative and may change. You are advised to contact the various salesrooms to verify the dates given.

Christies South Kensington.	Jeremy Collins - 0171 321 3149 10 June, 9 December
Sotheby's	Catherine Southon - 0171 293 5209 2 November
Philips	James Stratton - 0171 629 6602 ext 364 15 June, 14 September, 7 December
Bonhams	Jenifer Middleton - 0171 393 3950 6 July, 16 December
Scientific Instrument Fairs, Radison SAS Portman Hotel, London.	Peter Delehar - 0181 866 8659 27th Fair - 27 October.

ACKNOWLEDGEMENTS.

I would like to thank the following for permission to use their photographs. These remain their copyright.
Christies South Kensington for 1 to 6, and Sotheby's for 7 to 10.

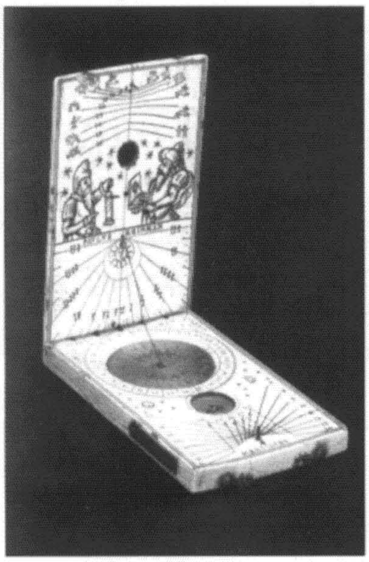


Fig. 1

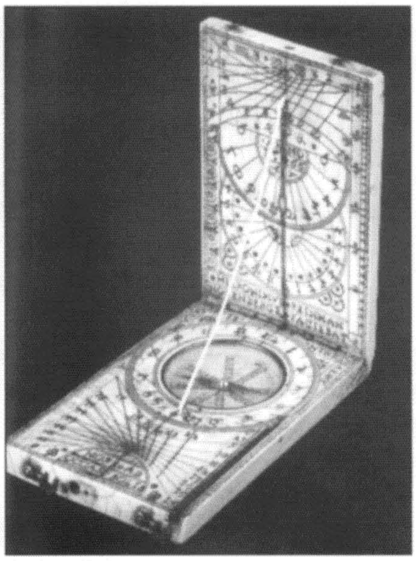


Fig. 2

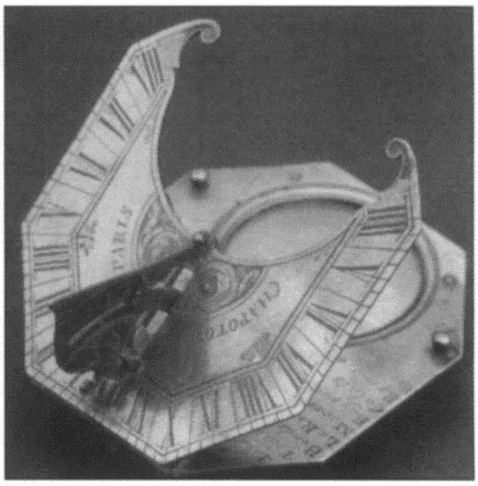


Fig. 3

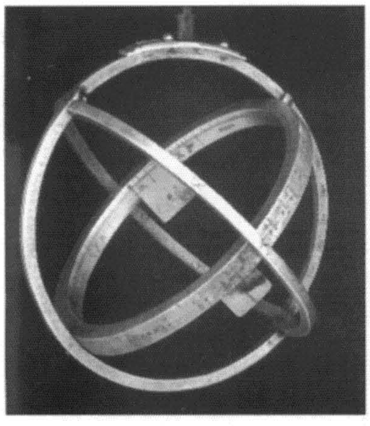


Fig. 4

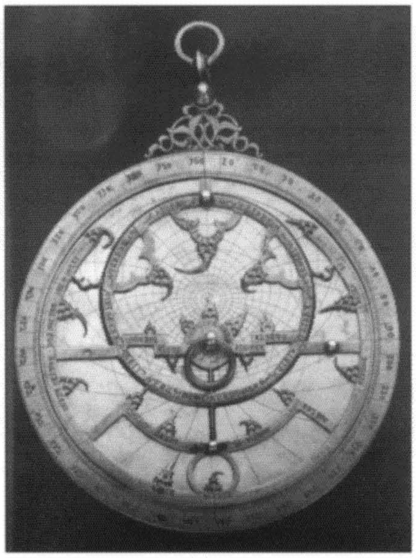


Fig. 5

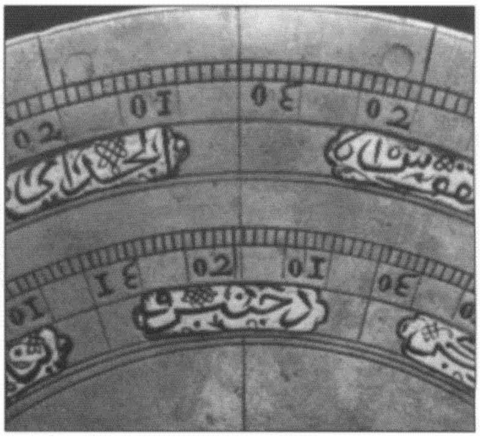


Fig. 6

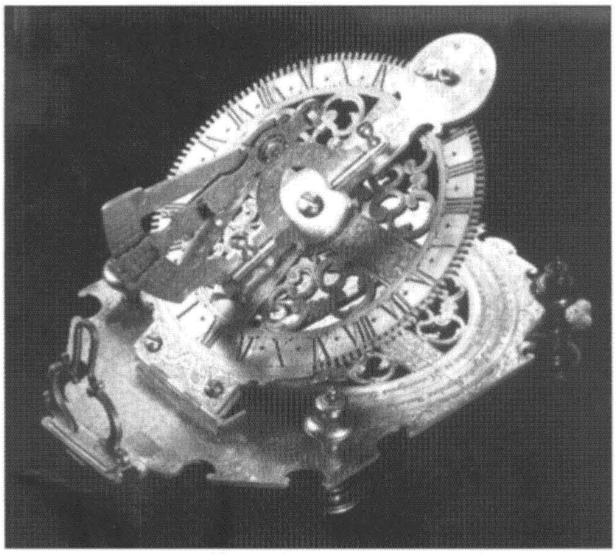


Fig. 7

Fig. 8

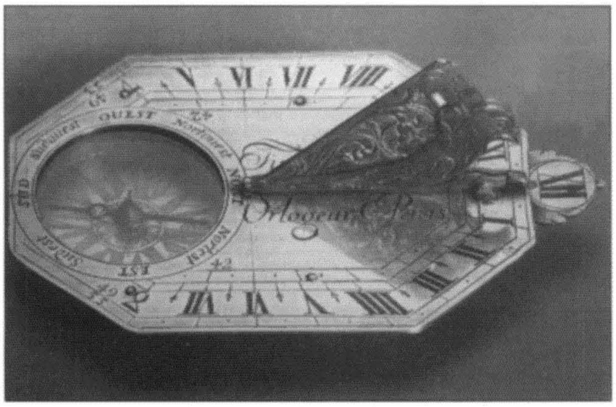


Fig. 9

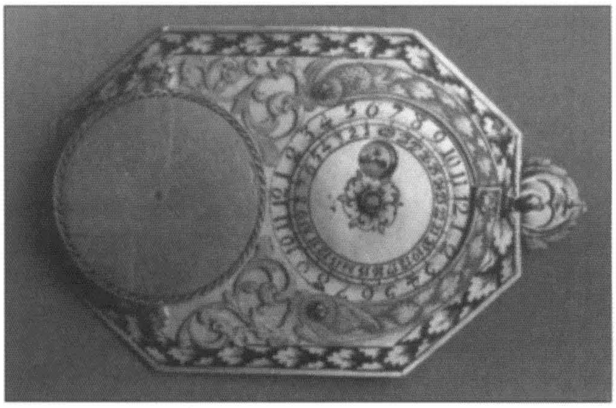
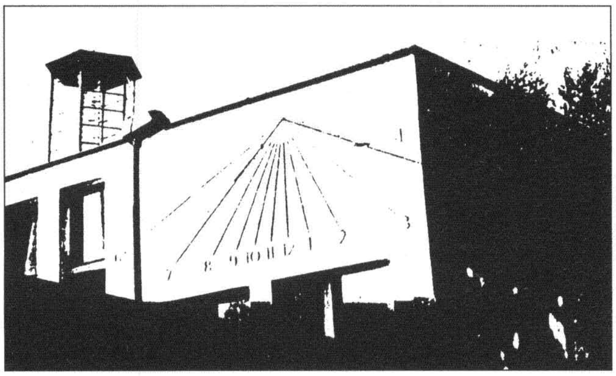


Fig. 10

Maurice Kenn sent a photocopy (from Country Life) of 'the first Sundial on the Internet', which is on the wall of the Foundress's Building in Pembroke College Cambridge.(See photo). It was designed by Dr. Frank King of the University Computer Laboratory, and was inscribed by the Cardozo Kindersley Workshop. From the top of a nearby building, the dial face is continuously scanned by a high-resolution camera (Olivettti and O.R.L.). The picture is transferred to the Internet where viewers can see it on www.uk.research.att.com, correct to within two minutes' local solar time. When the sun clouds over (an event not unknown in Cambridge) a sunlit substitute will appear.



CHINA SUNDIALS

PETER RANSOM

Yes, these are china sundials, not sundials from China! Always keen to expand my collection of sundials, but without a budget that allows me to purchase the real things, I recently discovered some within my price range. These are a bit more expensive than sundials on postcards (see article in Bulletin 96.3), but at £4 to £22 they are still less than many others!

Crested china collecting became a craze in Victorian and Edwardian times when, with the advent of cheaper travel and public holidays, a demand for inexpensive souvenirs developed, first in resorts then spreading rapidly over the country and eventually overseas to more than forty countries.

William Henry Goss and his son met this demand with a range of small white porcelain models of historic shapes decorated with coats of arms. These souvenirs caught on and by 1910 the craze was at its height. Trade declined after the Great War and by 1940 production had ceased. The nation then spent thirty years throwing the stuff away until it started to be collected again in the 1970's. Goss was not the only manufacturer: this type of souvenir china was also made by Carlton, Arcadian and Willow Art to name a few others.

Fig. 1 Carlton China Newmarket sundial

My first sundial souvenir was a piece of Carlton China with the Newmarket crest on it. This is 75 mm (millimetres) from the gnomon tip to the base and most of the gilt on the top is missing. There are no hour lines marked, and I would have been surprised if there were as the top has a diameter of only 25 mm! The gnomon angle is about 40° - rather low for Newmarket (52° N). Some of the larger Arcadian pieces do have hour lines on, but I have not yet acquired a piece to check the accuracy.

Fig. 2 A group of crested china sundials with a cross-stitch sundial

The group photograph shows my four pieces of crested china sundials around a cross-stitched sundial of her own design made for me by my daughter Madeleine for Christmas. From left to right these sundials are

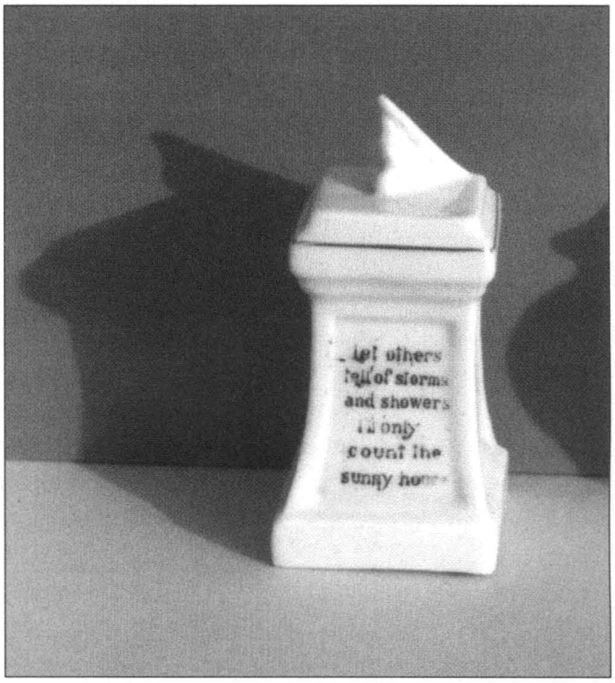


Fig. 3 Motto on reverse of Carlton China sundial

¥ Carlton China from Great Yarmouth. A square top of 30 mm and 85 mm in height. The gnomon angle is 45°. This gives the impression it would be a reasonable working model. The reverse of this has the motto 'Let others tell of storms and showers. I'll only count the sunny hours.'

¥ Willow Art China fróm Berwick-on-Tweed. A rather stubby thick gnomon which lacks confidence. It has a round top of diameter 27 mm and height 95 mm. I measure the gnomon angle to be 65°. As Berwick is 56° N, it's probably appropriate that people took it away from there!

¥ Warwick China from Cleethorpes. Similar to the Berwick item, but a square top of side 25 mm and 87 mm high. With a gnomon angle of 30°, it's only 23° out!

¥ Carlton China from Newmarket already discussed.

So now more of my time is eaten up. Not only do I have to investigate every second-hand book shop (for sundial books), and attend every postcard fair (for sundial postcards), but I now also have to look around every antique shop and fair for crested china sundials!
Two firms dealing in crested china are
¥ Goss and Crested China Limited,
62, Murray Road, Waterlooville, PO8 9BR

¥ The Crested China Company,
Station House, Driffield, YO25 7PY

29 Rufus Close
Rownhams
Southampton
SO16 8LR

SATELLITES AND SUNDIALS

JOHN DAVIS

As a sundial recorder, I've become fairly adept at driving along with one eye on passing buildings, watching for possible sundials. Some things catch me out momentarily, such as the brackets for a hanging basket, which can be mistaken for a gnomon at a distance. The most common mis-sightings, though, are caused by satellite dishes, especially as they are about the right size and are in the most likely position, facing approximately south. I've idly wondered for some time whether it would be possible to use a satellite dish as a dial – it would certainly relieve some of the visual blight on the urban landscape (Fig.1).

Fig. 1 Satellite dishes on a row of houses in an urban environment.

Thus, I was surprised by a recent article in the popular monthly Electronics World[1] which described the use of sundial-like properties to enable fixed satellite dishes to be correctly aligned to multiple satellites. Old world meets new world! It's worth mentioning that the magazine has a good foundation for this article as, back in 1945 when it was still called Wireless World, it published an article by Arthur C Clarke which predicted the possibilities for geostationary telecommunications satellites.

For the cheap domestic broadcast satellite receiver, such as those designed to receive the BSkyB TV broadcasts from the Astra group of satellites, the dish itself is a simple metallic reflector in the form of part of a parabaloid which reflects and focuses the radio waves into an amplifier (the LNB or Low Noise Block) suspended in front of it. The sun alignment method relies on the fact that on some special occasions, the satellite of interest will be at the same position in the sky as the sun. Hence, if the dish surface is made optically reflecting (the article advises that this can be done with soapy water), it will focus and reflect light back to the position where the LNB should be positioned. The article goes on to explain how signals from several satellites with different longitudes can be received by a fixed dish by the correct location of separate LNBs in offset positions. These positions can be found by the reflection of the sun at different times.

I've since come across a US patent by NASS member Richard Pauli[2], in which he describes a special adjustable gnomon for aligning dishes, so clearly there is a stronger link between satellites and sundials than is immediately apparent.

The geometry of satellite systems is worth studying as it is the basis for the design of a sundial, as well as helping align the dish and indicating the likelihood of satellite reception. The basic geometry is shown in Fig.2. Broadcast satellites orbit in circular geostationary orbits 35,786 km above the equator (i.e. with latitude 0°), in what it often called the Clarke band. Different satellites are set at different longitudes; the Astra 1 satellites are at 19.2° East, with other common European satellites being Astra 2 at 28.2°E and Hot Bird at 13°E. The altitude and azimuth of the satellite as seen from a ground-based observer O is then given by standard spherical trigonometry[3] as:

$$\cos(elev)=\frac{R+r}{d}\sqrt{1-\cos^2\phi\cos^2\lambda)} \qquad (1)$$

$$\sin(Az)=-\frac{\sin\lambda}{\sqrt{1-\cos^2\phi\cos^2\lambda)}} \qquad (2)$$

where

elev is the elevation of the satellite from the groundstation horizon

Az is the azimuth of the satellite from the groundstation

λ is the difference in longitude between the satellite and the groundstation

ϕ is the latitude of the groundstation

R is earth's equatorial radius (6378.16 km)

r is the height of the satellite above the sub-satellite point (35,786.3 km)

and d is the range from the groundstation to the satellite, given by

$$d=\sqrt{r^2+2R(R+r)(1-\cos\phi.\cos\lambda)} \qquad (3)$$

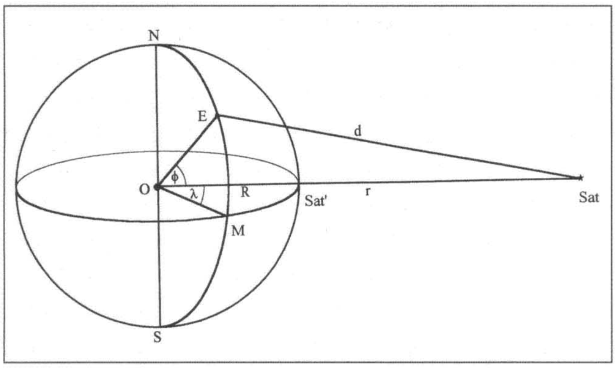


Fig. 2 Basic earth station – satellite geometry.

Sun Blinding

The sun emits radiation across a very wide portion of the electromagnetic spectrum, not just in the visible region. Hence it can act as a microwave source which will interfere with the satellite signal if it enters the receiver system. Although the sun itself is only 0.5° in diameter, its corona is also a radio source and extends to several degrees. Added to this, the beam width of a standard 60cm BSkyB dish is around 3° (2° for the 80 cm dishes used for Scotland). As a result, the sun will "blind" the receiver for a few minutes on several days each year. The dates and times when this will happen can be calculated by determining when the sun's elevation and azimuth will match that of the satellite that the dish is aligned to. For example, in central UK (eg Manchester), a dish aligned to Astra1 will be blinded on 1 March at 10:47 GMT and 12 October at 10:22 GMT. Time differences to other UK locations can be approximated by knowing that the satellite's shadow travels *eastward* at 1° in 20 seconds (as compared to the sun's shadow moving westward at 1° in 4 minutes). Damage caused to the LNB by this concentration of energy is prevented by providing the dish with a surface finish which is non-reflecting outside its operating bandwidth, but this does not prevent a loss of reception for these short periods.

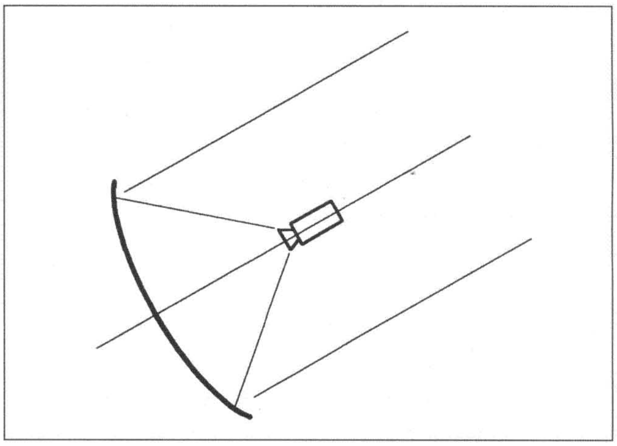


Fig. 3a Cross sections of typical dishes.

Designing a Satellite-dish Dial

Equations (1) and (2) give the fixed alignments that the dish must be set at, and form the basis of the calculations for a dial fixed to the dish. In general, the dial will both decline and recline. Professional and steerable dishes usually have the reflector in the form of a symmetrical section of paraboloid, with the LNB located centrally at the nearest focus (Fig.3a). The azimuth and elevation in this instance can be equated directly to the dial's declination and reclination. However, as shown in figure 3b, most cheap and cheerful dishes are offset and do not point directly at the satellite. The satellite azimuth figure can still be used directly as the declination but the angle that the dial reclines will be nearer to vertical than the satellite altitude. Usually, the arm that holds the LNB in position is at 90° to the front plane of the dish. This, together with the equality of the angles of incidence and reflection of the incoming microwave signal from the centre of the dish into the LNB, allow the angle of the dish to be calculated by simple planar geometry. Alternatively, a dish properly aligned to a satellite could be measured with an inclinometer. For my dish, located near Ipswich (latitude 52.081°N) the inclination is just 11.2° from the vertical. It should be noted that this needs to be expressed as an inclination of 101.2°in most sundial equations.

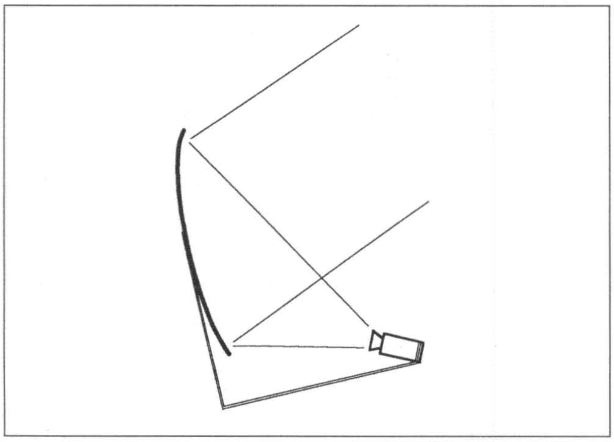


Fig. 3b Cross sections of typical dishes.

Practical Details

I have only ever built one satellite dish dial, so the following observations are some suggestions only. Two possibilities for the gnomon are to attach a standard polar-pointing rod gnomon towards the top of the dish, or to provide a nodal point or aperture gnomon supported from the arm holding the LNB. I chose the former option. Although fixing the gnomon to the rim of the dial would have given the simplest mechanical fixing, the elliptical face of the dial would have severely restricted the hour lines which could shown with such a high centre. Instead, I opted to put the base of the gnomon a few inches down from the top. This necessitated drilling a small hole in the dish, and running the gnomon rod into a pre-drilled block of wood epoxied onto the back of the dial. Correct alignment was achieved by making use of an accurate jig dial as shown in Fig.4.

There are two major options for the dial face; the lines can either be painted directly onto the inner surface of the dish, or they can be drawn on a flat plate fixed across the rim of the dish. Calculating and delineating the lines on a curved surface of the disk is possible, but no easy feat especially as the parameters of the paraboloid are not easily found. An alternative technique would be to draw the lines experimentally, using either the sun itself or a laser trigon[4] to provide an indication directly onto the dish. This technique would work best on solid, light coloured dishes rather than the black perforated ones that are common at the low-cost end of the market. It would also be most appropriate to use an aperture gnomon.

If a plane surface across the rim of the dish is to be used as the dial face, the calculations are reasonably

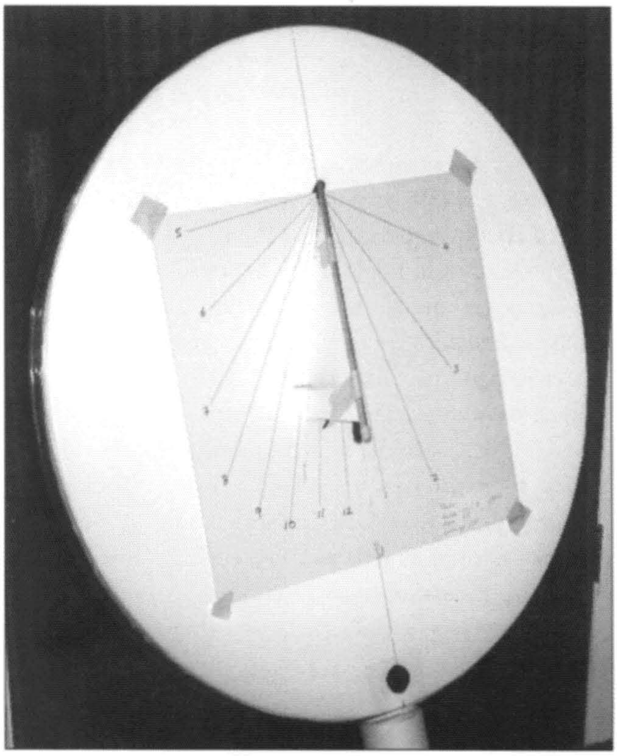


Fig. 4 Laying out the dish dial with the aid of a cardboard jig.

straightforward for a standard declining and reclining dial. The equations for the hour lines on this type of dial are not given in all the textbooks, but can be found in Rohr[5] and in a recent Bulletin[6]. They are also given in the appendix for completeness. The practical question is what to make the dial surface from, as it will lie in the microwave path between the dish surface and the LNB. Assuming that the dish is still being used for its original purpose of receiving satellite transmissions, the material must be very thin and non-conducting if it is to avoid too much signal attenuation. One good candidate for this is mylar™, a very strong thin polyester sheet. When I consulted my professional engineering colleagues they told me that one common source of mylar which they had used for small telecommunications dishes is drumskins, whereby the material comes attached to a circular metal ring for tensioning. A similar type of plastic material is that sold for covering the wings of model aeroplanes. This has the advantage that it is heat shrinkable, so that a domestic iron can be used to pull it into a tight, wrinkle-free surface. Another alternative material which is worth investigating is the plasticised film used in drawing offices for large plans. Again, some form of tensioning is required. For a self-supporting plane surface, a thin (1.5mm) sheet of perspex would probably be acceptable as long as the dish was not operating on the edge of the receiver sensitivity. From all these options I chose the model aeroplane covering, as the range also includes coloured material which can be cut for the numerals and lines. The gnomon

ERRATUM

Bull.BSS **11**, p.80, 2nd column

In 'Satellites & Sundials' by J.R.Davis, a term in one of the equations related to the hour lines of declining/reclining dials was omitted.

The equation should read;

$$\omega = \tan^{-1}\left(\frac{\cos i \cos d \sin\phi + \sin i \cos\phi - \cos i \sin d \cot HA}{\cos d \cos HA + \sin d \sin\phi}\right)$$

where *d* is the declination of the dial, *i* is the inclination of the dial, HA is the hour angle, ϕ is the latitude

The author apologises for this error.

See Next Page

was made from a piece of $^1/_4$" wooden dowel, with a hollow plastic sphere as the nodus – both materials selected as electrical insulators.

Since most dishes are mounted quite high up on the wall, simple designs with large numerals are necessary if the dial is to be read from the ground. The design of my finished dial can be seen in Fig.5. I drew the declination lines for the equinoxes and solstices using the laser trigon[4], as I could not find the appropriate equations easily. Perhaps this is a challenge to set the mathematicians? The lines were marked on with a felt tip pen tracing the laser spot, then covered with a narrow strip of the plastic film. The gnomon and the LNB arm pass through holes in the dial face, with reinforcing rings to prevent the film splitting. Although the dial may not last as long as a stone one, it will probably outlast this generation of electronics!

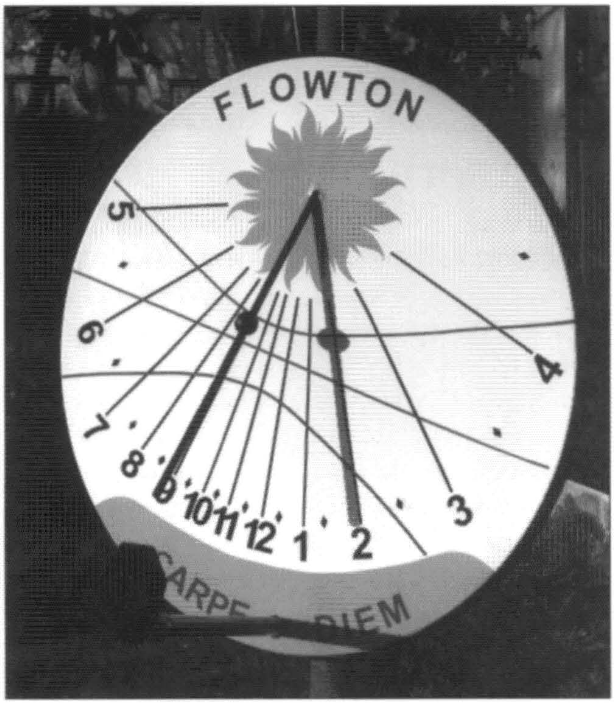


Fig.5 The finished satellite dish dial.

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2. R. A. Pauli, "Method and Apparatus for aiming a directional antenna" US Patent 5,760,739, June 1998

3. Rainger, Gregory, Harvey and Jennings: *Satellite Broadcasting* Wiley 1985 28-33 and 283-295

4. J. R. Davis, 'A Lightweight Laser Trigon', *Bull. BSS,* To be published.

5. R. R. Rohr: *Sundials – History, Theory and Practice,* Dover Publications, New York, 1996.

6. J. Singleton, 'Reclining and Declining Dials', *Bull. BSS* 1998 No.2 38-39.

APPENDIX – *equations for a reclining, declining dial*

Noon line angle to line of greatest slope (ν)

$$\nu = \tan^{-1}(\tan d \cos i)$$

Sub-style angle to noon line (γ)

$$\gamma = \tan^{-1}\left\{\frac{\sin i \sin d}{\cos i \cos\phi - \sin\phi \cos d \sin i}\right\}$$

Style height above sub-style (α)

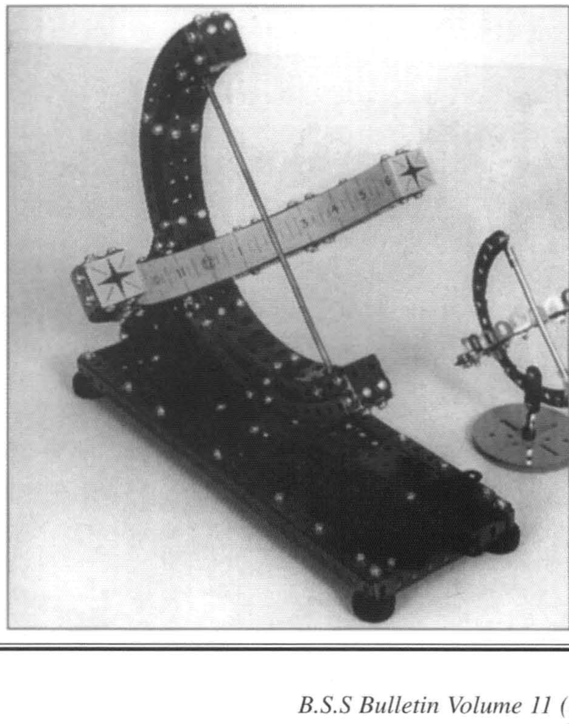
$$\alpha = \sin^{-1}\{\sin\phi \cos i + \cos\phi \sin i \cos d\}$$

Angle between hour-line and line of greatest slope (ω)

$$\omega = \tan^{-1}\left\{\frac{\cos i \cos d \sin\phi - \cos i \sin d \cot HA}{\cos d \cos HA + \sin d \sin\phi}\right\}$$

where:
d is the declination of the dial
i is the inclination of the dial
HA is the hour angle
ø is the latitude

P.Briggs, our Meccano expert, has sent us a copy of an article about the making of a 'Bowstring Equatorial sundial'. The article is by another expert, Keith Cameron, and comes from 'Constructor' Newsmag for November 1998. The dial is made from standard Meccano parts plus curved strips and angle-plates. The dial consists of a bow-arc, a dial-arc and a thin rod (the 'bowstring' gnomon) between the ends of the bow-arc. The result, simple and satisfying, is shown in the photograph. Also in the photo is an even more basic sundial, made by Dr. Boerdijk of Holland.



READERS' LETTERS

THE BENEDICTINE RULE AND ANGLO-SAXON LITURGY

I wish to comment on the interesting and well-written article about medieval sundials 'Sundials in Anglo-Saxon England' by D. Scott, (Bull.BSS 11, 4-7, 1999). On p.6 we read: 'Benedict's Rule included stipulated times for prayers during the day: Lauds at daybreak, Prime at sunrise, Terce, Sext and None at the third, sixth and ninth hours of the day, Vespers at sunset and Compline at nightfall'. This may indeed be what happened in the Anglo-Saxon liturgy. But it is not true for the Benedictine Order as a whole. I do not know T. Fry's book cited in the article, but I do know Saint Benedict's Rule (hereafter called RB) Terce, for example does not fall throughout the year at the same hour. From the first of October until the beginning of Lent, Terce started at the end of the second hour (RB,ch.48,14-*hora secunda plena*), and from Easter till the first of October the same service started at the beginning of the fourth hour (RB,ch.14-*hora pene quarta*). Only during Lent the bell for Terce sounded at the end of the third hour (RB,ch.48,14-*hora tertia plena*). Sext was not at the end of the sixth hour, midday. It was brought forward, half way through the sixth hour (RB,ch.48, 4-*hora quasi sexta plena*). At the sixth hour they usually ate.

None was half way through the eighth hour, that means one and a half hours past midday (RB,ch.48,66-*mediante octavo hora*). Vespers was brought forward too. Saint Benedict wrote that this office should be celebrated without candle lights; and they should be able to eat, after the celebration, by daylight; (RB,41,8-9) And it is almost certain that the right time for Vespers was around the tenth hour of the day (RB,ch.48,14-*decima plura*). Compline should also be recited not in darkness.

Though we stereotype the moments of monastic prayers it was not so in the sixth century and matters changed again in the year 817, after the Aquisgrana Council.

M.Arnaldi
Lido Adriano, RA
Italy

SAXON DIALS

David Scott's article on Saxon Dials (Bull.BSS 11, p4,) provides a good summary of our records and knowledge at present.

The paragraph about 'no doubt each community used its own dial unaware of any difference...' raises some questions.

Isolation may explain differences in dial configuration; the isolation may be in time as well as being geographical. However there is sufficient similarity (all circular, in relief and many with end crosses) to ask where the commonality is derived from. In other words, where did a foundation 50 miles away, 50 years later, get its dial design from?

On the question of circularity, incidentally, I am convinced that the square dial at Stowell Church, (Glos.) is Saxon. I should like some other people to give an opinion if possible.

A.O.Wood
5 Leacey Court
Churchdown
Glos. GL3 1LA

TEN YEARS AGO: MORE REMINISCENCE

The development of the Society has been splendid. The far-flung meetings have been specially memorable: Edinburgh, Ireland, Paris (I missed Germany). These meeting particularly seem to have produced fruitful discussions. The Bulletin is a mine of interest: more than I can take in.

I cannot remember when my serious interest in sundials began. It was well-developed in the 1960's and A. P. Herbert's book (1967) greatly encouraged it. I have always seen sundials as precise scientific instruments from which the lay person should be able to deduce easily the legal time; I have concentrated on displaying the equation of time clearly, or eliminating it by mean-time dials.

One maverick idea, for ocean-going yachtsmen, was the converse of a sundial. Instead of 'you know your position: this gives you the time', the idea was: 'you know the time: this gives you your position'. No tables, no sextant, no calculations. In mock-up form, it worked, 30 years ago; but was soon supplanted by inexpensive radio-position-finding.

The Society came along just when I was ready to study and discuss other people's views and achievements. It has fulfilled these expectations perfectly, and has opened my eyes to undreamt-of developments, to sources of information, and to much historic and aesthetic satisfaction.

I only wish that there was a greater profusion of local minimeetings, or that I was more of a traveller, or that Newbury was nearer to Bristol.

James Richard
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(December 1998)

'KING'S ENGLAND-LANCASHIRE'

Arthur Mee's 'King's England' series provides a useful guide to the location of sundials and it was a great surprise to me to discover an uncharacteristic error which I am reporting with the aim of saving others a wasted journey. In the Lancashire volume he says of St. Mary's, Radcliffe, 'A sundial four feet square paves the ground outside a corner of the church, but no longer has a gnomon to point the hours with its shadow. Probably it hung on the tower…'

What is actually there is a stone slab about 1560mm square with a central hole surrounded by a circle 1310 mm in diameter. The numerals I to XII are engraved at regular intervals round the circumference of what is clearly an old clock face. Mee was right about its former position, as the outline can still be seen surrounding the more modern clock face on the north side of the tower.

J.P.Lester
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West Midlands WS1 3AU

INFORMATION OFFERED AND SOUGHT

(a) Offered

In the article on Glass Sundials, (Bull.BSS, 11,p25) Dr. Allan Mills shows a 'repeating caliper', and asks whether this device is still available. I have a copy of the Simbles Tools catalogue no.20 (of about 1995) which shows two types of lathe calipers of the same principle, of different sizes (refs 5015 to 5017). The address is: Simbles, The Broadway, Queens Road, Watford, Herts. WD1 2LD, (01923 226052)

(b)Sought

Is there an internationally agreed system for the symbols commonly used in gnomonics-such as altitude, azimuth, declination etc? Different authors seem to use different symbols and sometimes one single writer does not maintain consistency. If there is some general agreement, could the recognised symbols and their meanings be listed in the Bulletin?

K.H.Head
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MEMENTO MORI

Further to my brief account of the sundial carved on a tombstone in Kirkwall Cathedral, Orkney, (Bull. BSS, **11,** 3, 1999) Mr. Roger Bowling has kindly pointed out that what I thought was an urn is, in fact, a *candlestick,* and he also suggested that the skeleton is extinguishing the candle with a conical *snuffer* connected to the trumpet. As evidence for this he has provided me with an illustration of a headstone from Sherington, Bucks, of 1787, where what I thought was a two-handled urn is quite definitely a candlestick. The Sherington stone was cut over a hundred years after the Kirkwall example; it is interesting to note the long continuity of the same symbols of mortality. I am most grateful to Roger Bowling for his valuable observation.

Alan Smith
Worsley, Manchester

EDITOR'S NOTES

MASS DIAL SAFARI

Members interested in Mass Dials are invited to look at the notice in the Newsletter of June 1999 about the plans for the next Mass Dial Safari. It is to be held in the area of the East Midlands, based at Southwell, Nottinghamshire, for the weekend of 17th – 19th September. Further particulars from Tony Wood, (01452 712953)

"It is said that there is hardly an unrestored church in Warwickshire, Northamptonshire or Leicestershire but has these circles or imitation dials on its walls"

Alice Morse Earle: Sundials and Roses of Yesteryear

SACKCLOTH-AND-ASHES CORNER

The photograph of the Mass Dial at Kenton, Suffolk, on p.52 of the February 1999 issue, was wrongly attributed. It was taken in fact by John Davis. It was also printed, in error, turned through 90°

The front-cover photograph on Bull.BSS 98.2 showing the dial on the Ponte Vecchio in Florence was taken and sent in by K-H Schaldach.

The Editor apologises for these errors

John Moir writes: Two dials mentioned in 'Shadowy Secrets' Bull.BSS 11, 40 were given incomplete attributions. The cat dial memorial to Noel T'a Bois was commissioned from Edwin Russell's Lethendry Studios and Brookbrae Ltd. Tanya Russell modelled the cat sculpture, Joanna Migdal delineated and advised on the sundial side and Edwin Russell designed and carved the faces of the plinth. The Hitchin Museum dial was made by Joanna Migdal with Brookbrae Ltd. Apologies to all concerned for these omissions.

THE BRITISH MUSEUM

The British Museum is organising a number of special events and exhibitions to celebrate the year of the total eclipse.

(a) From April until early October, *Heavenly Houses Exhibition,* Room 34, will be concerned with astronomical imagery and instruments in the arts of the medieval Islamic world

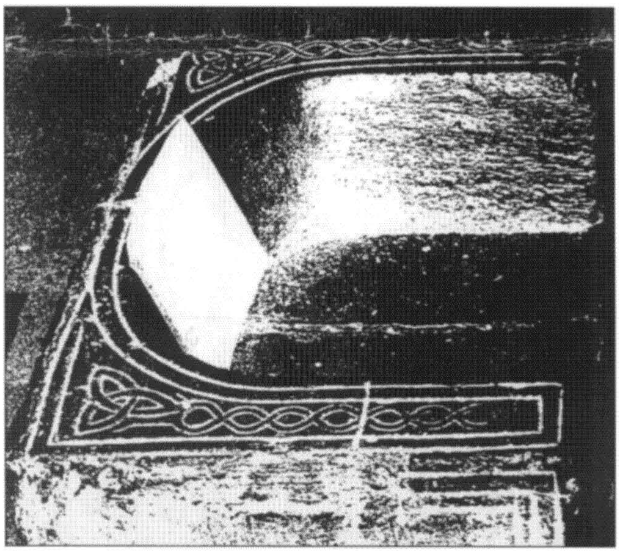
(b) From 26 July until 31 July, there will be lectures by eminent astronomers including the Astronomer Royal, on the solar system, solar eclipses, and astronomical instruments.

(c) On the day itself 11th August, viewing will take place from the front courtyard of the Museum, weather permitting

More information can be obtained from the Education Department, British Museum, phone 0171 323 8511.

FRITH STOOL

Readers of David Scott's account of the Saxon Dial at Escomb, Northumbria, maybe wondering what a *frith-stool* is. David Scott has kindly provided this illustration of the one at Hexham Abbey. It was probably made for the 7th century Bishop Wilfred as a throne for his visits to the abbey. The triple-knot ornament on the arms is clearly visible.



Frith Stool, Hexham Abbey

SUNDIALS IN ANGLO-SAXON ENGLAND: PART 2, THE EARLY PERIOD-ESCOMB AND CORHAMPTON

DAVID SCOTT

(Numbering of Figures and items of reference- list follows in sequence from Part 1, Bull.BSS 11, 4-8 1999)

Figure 2 shows diagrams, drawn to a scale of one tenth full size, for the dial stone shape and line arrangement of six sundials surviving from the Anglo-Saxon period which have been chosen for closer examination. Few have survived from the early period, that is, roughly the seventh and eighth centuries. Two of the best preserved, and possibly the oldest, are those at Escomb in County Durham and Corhampton in Hampshire.

Escomb is 15km south west of Durham, on the southern edge of the early period bishopric of Hexham. The church of St John the Evangelist is unique from the period, almost unaltered except for the addition of a south porch and the insertion of extra windows. It may have been built with squared stone blocks taken from the abandoned Roman station at Binchester a short distance away to the north east, and has come to typify Anglo-Saxon architecture in Northumbria during the seventh and eighth centuries. There is no direct evidence for the date, but the church bears a strong resemblance to the surviving nave of the monastic church at Jarrow, which was dedicated in AD 685. It may have been one of the private churches put up on the estates of Northumbrian noblemen, such as Addi who was recorded by Bede[6] as asking John of Beverley, bishop at Hexham from AD 687 to 705, to consecrate his new church.

The sundial, Figure 3, is generally believed to have been placed in the nave wall at Escomb when the church was built, and thus it can be dated with some confidence as seventh to eighth century by its association with the church. It is six metres above the base of the wall, set among large stone blocks some two metres below the top. The sundial was cut on the end of a hexagonal-section sandstone block, 76cm wide by 41cm high, which appears to pass right through the wall. The unusual shape suggests that once it

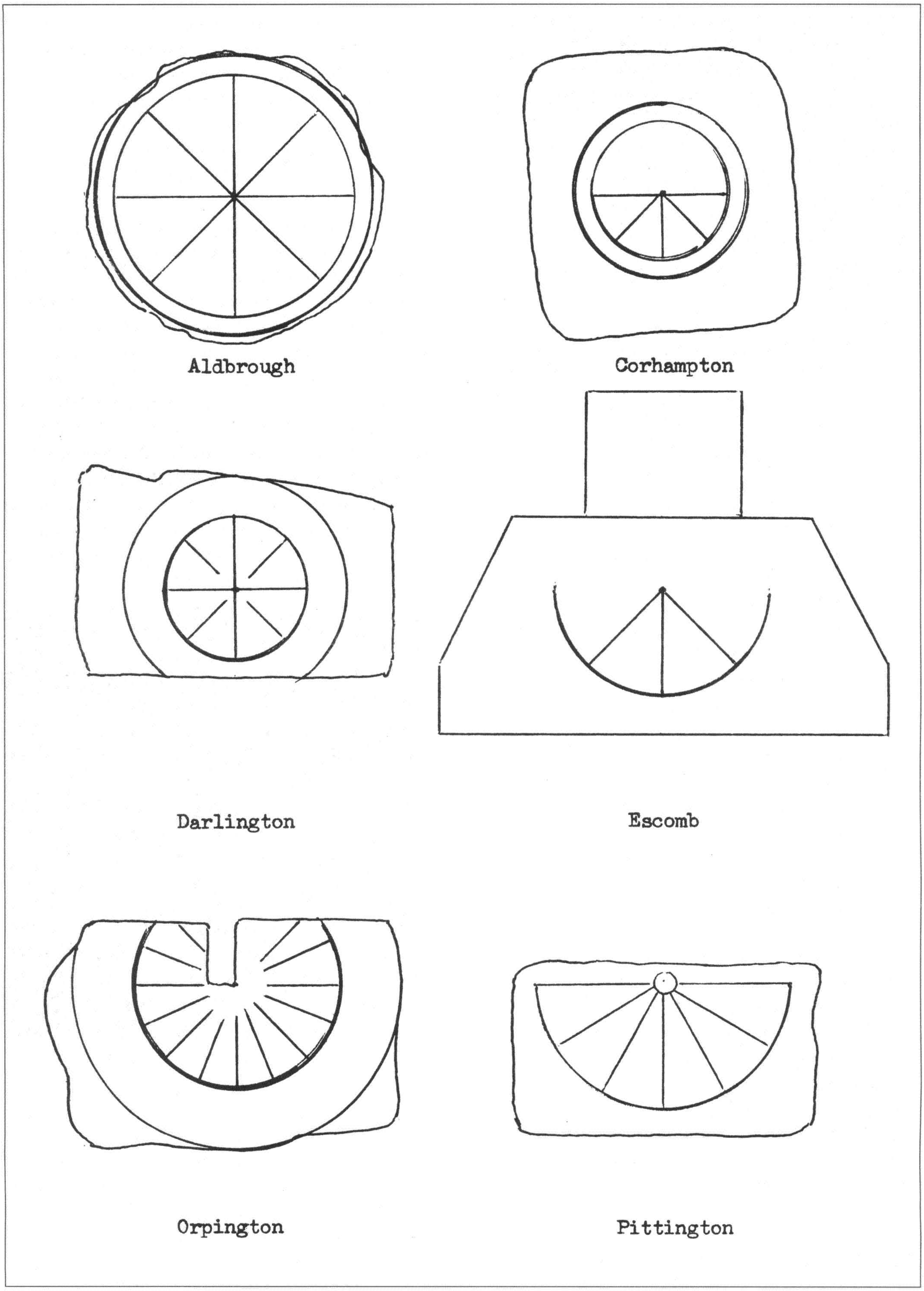


Fig.2 Surviving Anglo-Saxon Sundials Dial-Stone Shape and line Arrangement. One Tenth Full Size

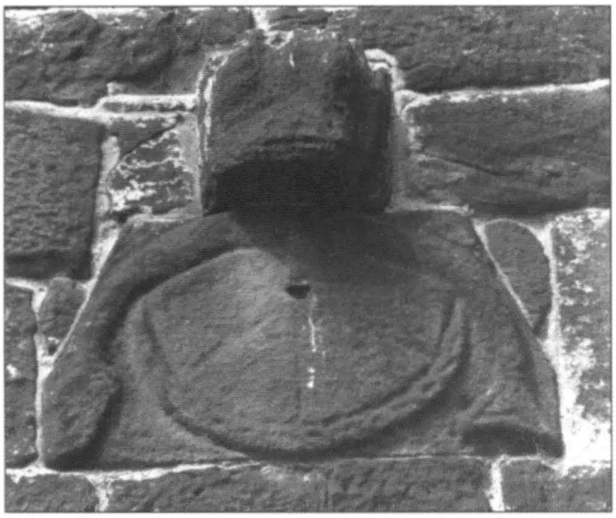


Fig. 3 Escomb Church Sundial. Copyright Department of Archaeology, University of Durham. Photographer, T Middlemass.

may have been a coping stone, perhaps also from Binchester. It is undamaged, at least the part we can see, which may be evidence for the belief that it has remained in its original position. The pattern of lines is very simple, one vertical and two at about 45°; originally there may have been a horizontal line which has eroded away in the course of twelve centuries. The lines are enclosed from below by a double circumference on which a twist pattern is carved in relief, and encircled from above by a serpent-like creature carved in bold relief. The serpent is much weathered but appears to have the head of a snake with hooded eyes, a chevron pattern along the top, a twist pattern down the right side and a fish-like tail within which is carved a triple-knot. Above the dial stone, and in contact with it, a rectangular block projects forward from the wall, on the end of which was carved what appears to be the head of a mythical beast, also much weathered but seeming to have bulging eyes, a slit-like mouth and possibly short horns.

Corhampton is in the Meon Valley of Hampshire south east of Winchester. The church dates from the early eleventh century but was almost certainly built on the foundations of a much earlier Anglo-Saxon church. It is regarded as a typical pre-Conquest village church but has no known dedication, being known always simply as Corhampton Church. The original building was dated by Haigh[7] as between AD 681 and 686, the years during which bishop Wilfrid of Northumbria was in the area converting to Christianity the pagan peoples of Sussex and east Hampshire.

The sundial, Figure 4, which is believed to date from time of the original church, is mounted at eye level in the nave wall just to the east of the south porch, and can be tentatively dated as late seventh century by association, with bishop Wilfrid in the absence of any contrary evidence. It is carved on a block of reddish-brown stone, a material quite different from any other used in the construction of the existing church. The block is 50cm wide and 55cm high, and appears to be angled, (although the sundial itself is aligned vertically, no doubt due to damage received before being placed in wall of the present church. It may have been considered a relic from the distant past even at that stage, mounted in the wall of the replacement church not to serve its original purpose, which may have been long forgotten, but rather as respect for a mysterious religious object. The lines are enclosed within a double circumference on a raised central part of the block, and surrounded by decorative sculpture carved in relief. The arrangement of lines, one horizontal, one vertical and two at about 45°, is the usual arrangement for sundials from the early period. Outside the circumference are four diagonal arms with leaf-like terminals, and between them short lug-like projections with rounded ends. The gnomon hole is large and round, which may be the result of countless visitors pushing a stick into the hole to try it as a sundial, for it is conveniently low down and a notice inside the church suggests that this might be done.

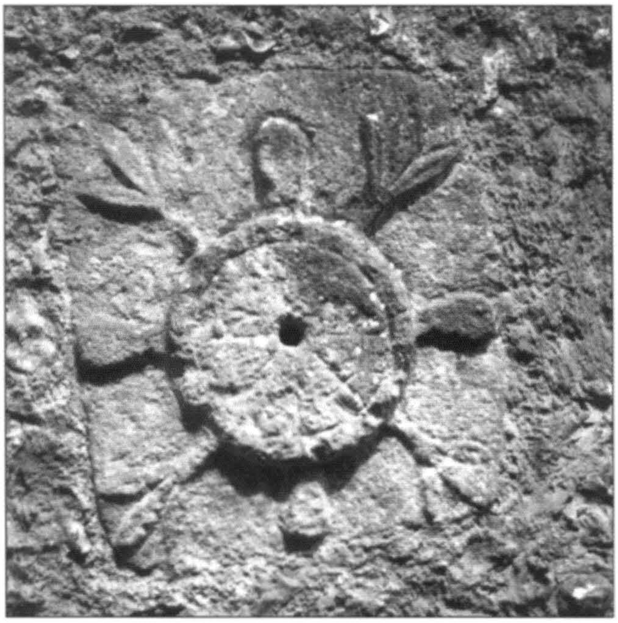


Fig. 4 Corhampton Church Sundial. Photograph: David Scott.

Most writers on sundials from the early period assume their main purpose was the measurement of time, dividing the day between sunrise and sunset into four equal parts, or marking the ends of the third, sixth and ninth seasonal hours. No doubt on occasions they did serve that purpose, but it was not necessarily their main function. It seems unlikely that the lay population of the seventh and eighth centuries used sundials as day to day timekeepers. Dials were too few in number, of little use except at close range, and inferior for practical purposes to the ancient horizon marking system. The pagan Anglo-Saxons seem to have managed time-keeping well enough without wall-mounted sundials; in all probability they used the ancient system described by Haigh[8] and others, in which each community divided the local horizon into eight parts, using natural features as markers. By noting the position of the sun between dawn and dusk, and certain stars during the night, relative to these markers, it was possible to divide the day and night each into four approximately equal parts throughout the year. Haigh called these intervals 'tides' and the eight divisions gave rise to the so-called octaval time system.

A panel in the church porch at Escomb, attributed to Beddow[9] late parson of the parish, suggests that the presence of the sundial in the wall does seem to indicate that it may have served a small monastic community. Sundials may have been used in monasteries to mark the time for the 'canonical hours' of terce, sext and none, although we know from Bede's table of shadow lengths that such communities divided the day into twelve hours, and this may have been the method used to regulate the day. None of the surviving sundials were found on known monastic sites.

Few village churches of the period had resident priests, and the bishop or one of the priests from Hexham may have conducted services at Escomb from time to time. The sundial, and the one with a similar arrangement at Corhampton, may have marked the times for such services, but their complex design seems to suggest something more.

The importance of visual images for instructing the newly converted was recognised by the early Christian missions. Pope Gregory the Great had explained how images produced 'A living reading of the Lord's story for those who cannot read'[10]. Anglo-Saxon sculpture was often covered with a thin layer of plaster and then painted in bright colours, to stand out against the background and play on the imagination. The sundials at Escomb and Corhampton may have been treated in this way and placed high above the ground to signify authority from above. The sundial at Corhampton although now at eye level was probably higher up on the original church.

The movement of the shadow of the gnomon over the face of the sundial, apart from possibly marking the time for services, may have illustrated the inexorable passage of time, serving as a reminder of the brevity of human life and warning men to prepare for that other life which has no end. Clearly the sculpture had no time-measuring function but was nonetheless an essential part of the message. The serpent at Escomb may have been a symbol of the Devil, the tempter of Eve. We can imagine the visiting priest preaching the story from Genesis and linking it with the serpent on the sundial. 'Now the serpent was more subtle than any beast of the field which the lord God had made. And he said unto the woman (Eve), Yea, hath God said, Ye shall not eat of every tree in the garden? And the woman said unto the serpent, We may eat of the fruit of the trees in the garden: But the fruit of tree which is in the midst of the garden, God hath said, Ye shall not eat of it, neither shall ye touch it, lest ye die. And the serpent said unto the woman, ye shall not surely die: for God doth know that in the day ye eat thereof, that your eyes shall be opened, and ye shall be as gods, knowing good and evil'.When the congregation left the church and looked up at the sundial they saw the carving of the serpent , and when the visiting priest had left, it served as a permanent reminder. The beast's head sculpture may have been an adaptation of a pagan symbol.

The serpent as a symbol had featured in the Celtic church, which had flourished in Northumbria for a generation before the permanent establishment of the missions from Rome. Serpents with the same stylised snake's head and fish-like tail appear as illustrations in the Book of Kells, and the twist pattern and triple knot also appear on the arms of the stone frith-stool at Hexham.

No interpretation has been offered for the carvings on the sundial at Corhampton, as far as we know, but it was an area without contact with Christian ideas before the arrival of Bishop Wilfrid. The sculpture may incorporate both Christian and pagan symbolism, for pope Gregory also advised that wherever possible existing pagan practices should be adapted for the purpose of teaching Christian faith. The rotating shadow may have illustrated the passage of time, as at Escomb, and the diagonal arms with leaf-like terminals may have represented crossed boughs, which formed part of a pagan ritual in the worship of Thor and woodland deities. Something similar can still be seen in the routines of Morris Dancing, where sticks held in both hands are crossed by the dancers, and used to beat the ground to drive away evil spirits. The lug-like projections with rounded ends could be the visible ends of a Christian Cross, superimposed over the crossed boughs to show that it superseded them.

This might have been the purpose of sundials in the early Anglo-Saxon period, before the arrival of the Danes at the beginning of the ninth century. There must once have been many more sundials, but most Anglo-Saxon churches, including all the largest, were either destroyed by the Danes or swept away by the Normans or others to make way for later replacements. A hypothesis based on only two sundials may be seriously flawed.

If we accept that the primary purpose of a sundial was not necessarily that of time measurement, then its inherent inaccuracy as a time-keeper, together with the non east-west alignment of many early churches, does not raise the problems so often imagined.

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7 D H Haigh: 'Church Notes taken in the Neighbourhood of Winchester'. *The British Archaeological Assocciation,* Winchester, 1845

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10 J Romily Allen: *Early Christian Symbolism in Great Britain and Ireland Before the Thirteenth Century.* London 1887.

THE SCAPHE OF CARTHAGE

PAUL GAGNAIRE

from L'Astronomie, vol. 112, pp.179-182 (1998)

(We thank the Société Astronomique de France and the editor of L'Astronomie for permission to publish this article.-Ed.)

Introduction

A remarkable event in the field of Greek and Roman gnomonics has recently taken place: a French collector of antiquities based in Paris has been able to acquire an eyelet-hole scaphe. It was brought to light before the last war on the excavation-site of a Roman villa in Carthage, and was formerly owned by a family who did not attribute to it the importance it deserves. Now for the first time this exceptional but unknown artefact can delight gnomonists and archaeologists.

The new owner has asked me to prepare for publication a detailed account of this ancient sundial. At the same time he has honoured the Société Astronomique de France (SAF) and particularly its Sundial Section, by allowing them to present the first description. We are deeply touched by his choice of the French language and of this initial presentation to the French public

The Artefact

Exterior

The scaphe is a large cup of 'skyphos' shape, (See Note 1) almost hemispherical, hollowed from a block of pale brown crystalline marble, probably of Greek origin. Its general shape is that of an almost cylindrical truncated cone. On the outside are two handles, diametrically opposite, each formed by a large ring inserted between a scroll-ended projection from the rim of the cup above, and a half-buckle below, also cut from the block.(Fig.1)

Fig.1 Photograph of scaphe showing oak-leaf and acorn decoration. The wedge by which the scaphe is fixed to the correct angle on its plinth is visible on the left.

On the opposite diameter to the handles, there is, on one side, a thick triangular wedge pierced by a fixing-hole to almost half its depth; and on the other side, the gnomonic eyelet-hole through which the sun's rays must pass. The fixing-hole allows the firm attachment of the wedge onto a metallic bolt, undoubtedly placed on top of a plinth in such a way that once in its correct position the scaphe could not roll or fall off.(Fig.2)

The gnomonic eyelet-hole, always a very important feature in this type of sundial, is 50mm in diameter. It was once covered by a metallic plate, now missing, of semicircular shape, pierced by an extremely small pin-hole. The plate was fixed into the marble by a number of lead rivets, mainly ending in the stone, but some, around the hole, going through the thickness of the wall of the cup.

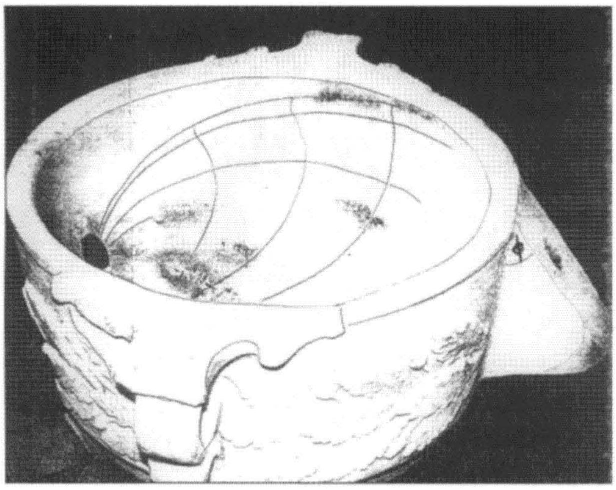


Fig.2 Photograph to show wedge for fixing scaphe to the plinth. The latitude angle has been marked Ø on the photo

This part of the scaphe, in a large area centred on the hole, has been thinned-down, in a segment shaped like a melon-slice, obviously to make the hole-boring easier, but mainly so that the rays of the rising and setting sun from any point on the horizon could shine into the cup even at very early and late hours.

Around the outside of the scaphe from top to bottom is a chaplet of oak leaves cut in relief, finely carved, with several stems of acorns.

Finally, though the base of the scaphe is flat, since it is decorated with concentric circles of ropework also carved in relief, any idea of placing the object mouth upwards like a bowl is shown at once to be wrong, even to a person knowing nothing of gnomonics.

The diameter of the scaphe with its handles is 730mm; its height is 300mm. Its interior diameter to the edge of the cavity is 490mm.

Interior

In the highly polished interior, three sets of markings have been engraved with precision and elegance.

Firstly: seven closed curves which we will call, for convenience, circles. They are not concentric, as all of them at some point come close to the gnomonic eyelet-hole; the outermost circle passes very close to the hole

Secondly: eleven curves which run from the first to the last circle crossing each one at an angle which is close to a right-angle.(Fig.3 a & b)

Thirdly: inscriptions in Greek capitals which are closely related to each of the seven circles.

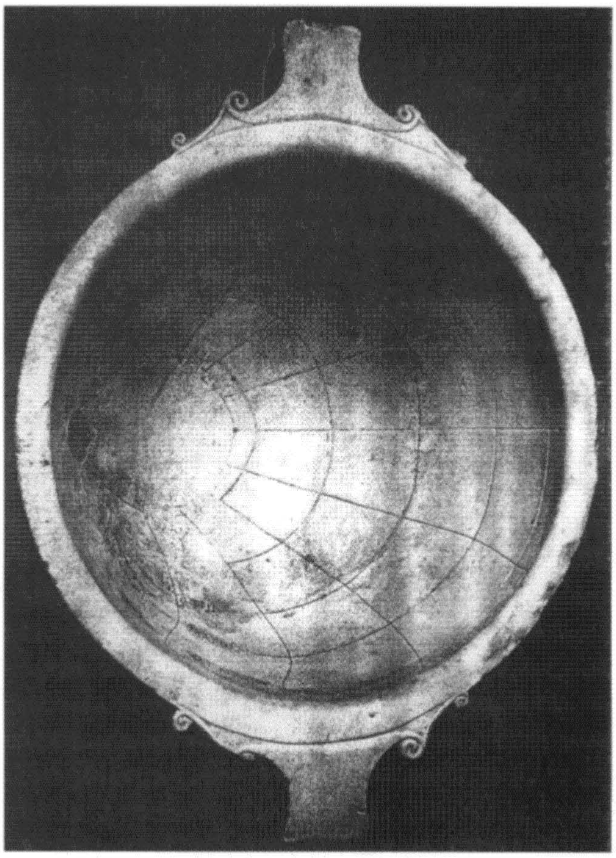


Fig.3a Photographs of the interior of the scaphe to show date lines and hour lines

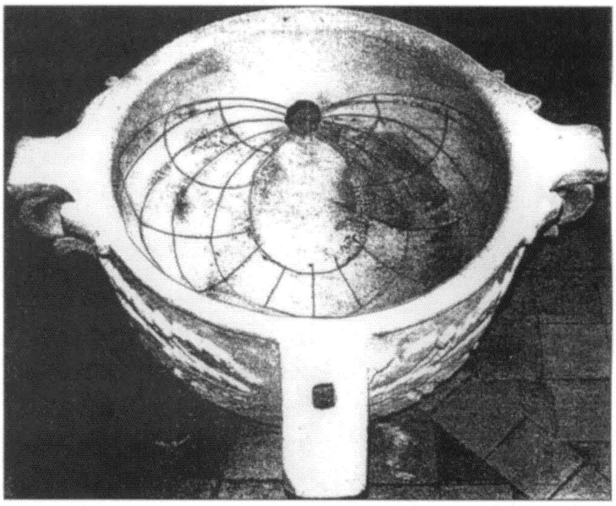
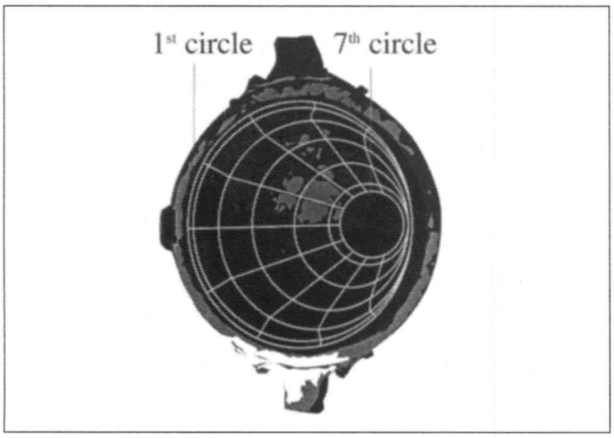


Fig.3b Photographs of the interior of the scaphe to show date lines and hour lines

The first (outermost) circle is annotated with six words: and it seems likely that the same was true of the innermost circle, but so many of the letters have been worn away that we cannot be certain of this. The five intermediate circles are each annotated by two separate inscriptions, and by a cipher, the same for each circle, for which I propose an interpretation: Π $\overline{\text{H}}$ $\overline{\text{K}}$ may mean "the seventh day before the kalends of..."

It is remarkable that the inscriptions contain a mixture of authentic Greek words and words signifying the names of the months of the Julian calendar, and therefore in Latin. These words bear no resemblance to the Greek names of the months. Furthermore the occurrence of the month AUGUSTUS gives us an indication of the date of the scaphe. We know that it cannot be earlier than 9 years B.C., because in this year the month *sextilis* was renamed 'Augustus' in honour of Augustus Caesar, 23 years before his death; and *quintilis* was renamed 'Julius', in posthumous honour of Julius Caesar.

Another noteworthy feature is that the inscription of the outermost circle gives not only a date---the eighth day before the kalends of July---but also an astronomical position in the zodiac: the summer solstice. It may be assumed that the innermost circle would signify the winter solstice.(Fig.4)



1. ΚΥΚΛΟC ΘΕΡΙΝΟC ΤΡΟΠΙΚΟC ΠΡΟ-ΟΚΤΩΙ ΚΑΛΑΝΔΩΝ ΙΟΥΛΙΩΝ
2. ΙΟΥΛΙΩΝ ΑΥΓΥCΤΩΝ
3. ΜΑΙΩΝ CΕΠΤΕΜΒΡΙΩ
4. ——— ΟΚΤΩ--ΩΝ
5. ΜΑΡ.Ι ΝΟƐΝΒΙ
6. ——— ΔΕΚΕΜΒΙΙΩΝ
7. —ΚΛΟC --- ---ΠΗ–Κ–ΙΑ.ΝΑΡΙΩΝ

Fig.4 The inscriptions in Greek characters on the 7 circles in the cavity of the scaphe, from the outermost circle inwards

The translations are:

1st circle: Circle of the Tropics for summer solstice-eighth day before the kalends of July

2nd circle: of June of August

3rd circle: of May of September

4th circle: -------- of October

5th circle: of March of November

6th circle: -------- of December

7th circle: Circle of ----- the seventh day before the kalends of January

The space on the intermediate circles is occupied by the cipher described and interpreted in paragraph 5 of section "Interior", above.

('kalends' meant the first day of the month in the ancient Roman world)

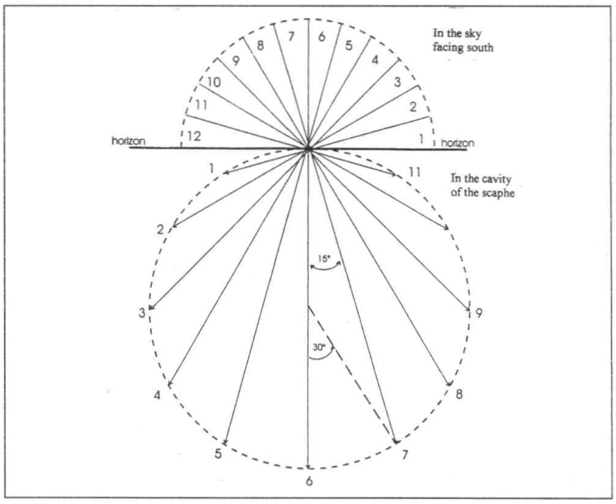


Fig.5 Eyelet-hole scaphe: The arc of the sun's daily course, subdivided into 12 temporary hours. On the inner wall of the scaphe, the hour-points divide each declination-circle, not into 12 equal arcs, but into arcs symmetrical in length in pairs about the sixth-hour midpoint. Only the true circle of the equinoxes is divided into twelve equal arcs.

The gnomonic function of the scaphe

The eyelet-hole scaphe differs from all other ancient sundials hollowed from stone, and even from other hemispherical scaphes, in that the hours are not indicated by the movement and position of the shadow of the tip of a gnomon on a certain line; but rather, by the movement and position of a small spot of sunlight coming through a hole pierced in the wall of the dial. The light-spot is the image of the sun, distorted according to mathematical principles and to the slope of the illuminated surface.(Fig.5)In the eyelet hole scaphe, the light-spot moves along a circle whenever the sun is above the horizon, since the hole is made at the zenith of the cup; that is, the cup is placed on its side in such a way that the hole comes at the top. The light-spot actually traces out a *cycloid* curve. But since in gnomonics it is assumed that the sun maintains the same declination in the course of one single day, we may draw closed curves, that of the equinox being an exact circle. The sundial maker of Carthage therefore had to calculate the intersection of seven cones with a sphere, and the axes of none of the cones passes through the centre of the sphere, a remarkable mathematical feat for the 2nd or 3rd century A.D.: at least if the maker did not simply use the empirical method. (Fig.6)

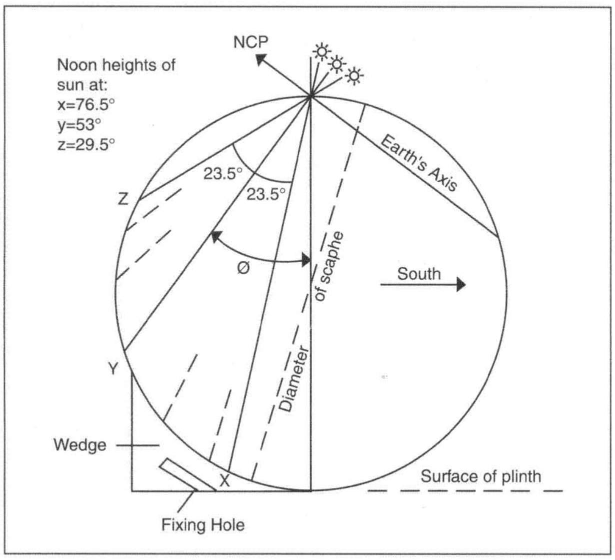


Fig.6 Eyelet-hole Scaphe of Carthage, Ø = 37° : how it functions. For clarity, the four intermediate circles between the solstices and the equinoxes are shown simply by short dotted lines. NCP = North Celestial Pole. A drawing on the same principle, but adapted for other latitudes, would show clearly that the eyelet-hole scaphe would not function in tropical latitudes or north of the arctic circle. In tropical or arctic regions, reading the dial becomes too difficult, the hemispherical form is aberrant, and the observer would require acrobatic contortions.

Because of its position, the eyelet-hole scaphe is bound to receive the light-spot on curves nearer and nearer to its edge as the declination of the sun increases, since the gnomon hole is at the zenith of the cup; so the entire daily arc of the sun's path can be captured by the scaphe.

As to the hour-lines (temporary hours at this period) the sundial maker marked them simply by dividing into twelve arcs (symmetrically in pairs from the centre) each of the seven declination circles.

Greek and Roman Sundials

In order to understand the exceptional nature of the Scaphe of Carthage we must place it in context, comparing it with other ancient sundials.

Several authors have written of sundials of antiquity, but Sharon L.Gibbs in 1976 wrote a masterly study, 'Greek and Roman Sundials' which has become the recognised standard work on the subject. The SAF is fortunate in possessing a copy of this work

She has gathered together the sundials of antiquity from the 3rd century B.C. until the 4th century A.D. and here is the harvest: 98 spherical dials, 109 conical dials, 40 flat dials, 6 cylindrical dials and 3 others. Among the spherical dials she found only 24 eyelet-hole scaphes, which she calls 'roofed spherical dials' in the text, and 'spherical variants' in individual notes. So the eyelet-hole scaphe is clearly something of a rarity. Sixteen of the 24 'roofed dials' come originally from Aquileia or Northern Italy. None of them have seven declination circles; normally only three (or five, on one multiface dial). Furthermore, none of the 24 scaphes listed by Gibbs is endowed with inscriptions giving date and zodiac sign, or even date/zodiac-sign separately.

It is because of these inscriptions and the seven declination circles that the Scaphe of Carthage surpasses all other eyelet-hole scaphes. It is supreme also in the beauty of its carved decoration, and its excellent state of preservation. Among all 256 ancient sundials, Gibbs has found only 3 dials with the name of the month and 4 with zodiac signs. In France, Gibbs has listed 15 ancient dials but no eyelet-hole scaphe. The SAF knows of 4 other dials, not listed by Gibbs, none of which are eyelet-hole scaphes. So we do not exaggerate by considering this discovery an important event in the field of sundials of antiquity. .

Note 1

The *skyphos* was a goblet-style drinking cup with almost cylindrical sides and a simple annular base. It had horizontal handles fixed to the rim. It was very fashionable in the first century A.D. It can be admired in the Musée du Louvre, in the collection of the silverware discovered at Boscoreale

P.Gagnaire
67 Avenue Viviani
F. 69008 Lyon
France

(Translated by M.S.)

Since submission of this article for publication in the BSS Bulletin, M.Gagnaire has sent us the following information:
(a) A booklet about the Scaphe is in preparation, and will be available in a few weeks' time.

(b) The owner of the Scaphe has generously offered an excellent copy of the artefact to the Société Astronomique de France in Paris. Readers of the Bulletin, when passing through Paris, are warmly invited to come and admire it.

SUNDIALS ON THE INTERNET - THE FIRST THREE YEARS

PIERS NICHOLSON

Sundials on the internet at www.sundials.co.uk was born nearly 3 years ago. For most of thIs time, it has been sponsored by the British Sundial Society and also later by the North American Sundial Society. So it is appropriate to report to members whether or not they have access to the Internet, what this major new development is doing for the Society, and for the world of sundials generally, and what it is planning to do in the future.

When the Idea of having an Internet site was first suggested at a BSS Council meeting, the Internet was very young, few people had had experience of using it, the costs were very uncertain, and the benefits could not be quantified. So the Society decided not to establish a site of Its own. Piers Nicholson was just starting a website development company, and decided to start a "Sundials on the Internet" as a 'showcase' site.

The Internet is growing very rapidly. The growth of traffic on 'Sundials on the Internet' illustrates this growth vividly. In January 1997, we were getting 140 page views per day. By January 1998, we got 501 page views a day, and, by March 1999 we got over 1,000 page views a day.

This growth reflects the general growth of the Internet, the growth of the site from some 40 pages in early 1997 to some 140 today, the evolving design of the site to make it as easy as possible for people to find what they want, and the growing number of links to other sites.

Many people all over the world have generously helped with content material. We have had Sundial Trails for far-flung places like Seattle and the Queyras in France, (and would welcome more of these from members), and some major contributions to the Sundial Projects page from Jane Walker, Tony Helyar, Andre Bouchard, Allan Mills, and Randall Brooks. We have had pages translated into other languages by Fer de Vrles, Karl Schwarzinger, John Crawford and others.

Since last month, we have had a completely redesigned home page which gives much Improved navigation round the site. Nearly every page on Sundiaals on the Internet has a direct link. As part of this redesign, we incorporated the logos of both of our sponsor societies right at the head of the home page. There are also direct links to the pages of each Society. It is hoped that this will result in more publicity for each society, and will this also increase the number of new members who join from the internet.

We were particularly pleased that Sundials on the Internet has been chosen for inclusion in the BBC Education Web Guide. Their invitation said The Education Web Guide team were particularly impressed by the quality and educational content of your site and have placed a short review of it in our searchable database which can be accessed by internet users everywhere". The BBC Education Web Guide is at
http:/Iwwvy.bbc.co.uk/education/webguide

Their review reads: *These pages provide a gateway to the expanse of sundial information on the Net. They contain all the background Information you need to begin constructing your own sundials. A number of simple projects are included to get you started, all with excellent diagrams and clear instructions. The site has many links to other sources of sundial information on the Net, including pictures of existing dials and computer programs for generating sundials.*

Sundials on the Internet is thus making a powerful contribution to the educational aims of the British Sundial Society. A major aspect of this is our projects page which is much used by school children the world over. One sent us a charming e- mail: "I was at my wits end when my teacher said to make a sundial by Wednesday Until I found your website. Now I've built a lovely sundial, and I think I will get a very good grade. Thanks a lot. Jennifer (now a very happy person)" Some of the children building sundials with our help will be our members in the future.

Our main objectives for this year are.

A) to put up translations of the new "grid" home page in very many languages including French, German, Spanish, Portuguese, Italian, Greek, Hungarian, Czech, Danish, Norwegian, Finnish, Swedish and hopefully some others. We have made a good start on the German and Italian pages. We would welcome any offers of help with this.

B) to put up at least one new Sundial Trail in each country in Europe, and hopefully also elsewhere in the world, so that we will have a truly international network of sundial trails.

C) to start a page on "Newly Constructed Sundials" where designers or makers can post, free of charge, a short description of any newly constructed sundial.

D) to encourage any non-commercial BSS member who wishes to do so to post, free of charge, a short piece of text on the.../personal.htm page,again with links to their own web space or images on other sites if they wish. This page has been operative for a couple of months so far.

We welcome any feedback/comments/suggestions from all gnomonists.

9 Lynwood Avenue,
Epsom,
Surrey,
KT17 4LQ

Tony Wood reports:
(i)There is a SUNDIAL THEATRE in Cirencester, and it is named after the sundial which was there when the theatre took over the building, a former school.
There is a (bad) play about sundials, produced in New York in 1918. It must be the only play ever to display a scientific graph (the equation of time) on stage.
(ii) Thanks to a kindly response by many Church Secretaries, I have obtained County Lists of Churches and Chapels used in the Annual Sponsored Bike Rides. They come in useful to dial recorders, and our Registrar Patrick Powers is getting a set
The teacher in me was unable to resists giving grades to the lists produced; and Essex Girls (and Boys) will be pleased to know that their County came top. At the other end, the County name begins with 'S'. I can run off copies if anyone is interested.

THE SUNDIALS BY FRANCIS BARKER & SON, SUNDIAL HOUSE CLERKENWELL ROAD, LONDON.

DAVID J. BOULLIN

Clerkenwell is associated with clock and watchmaking, and Clerkenwell Road was the hub of the horological industry in London in the latter part of the nineteenth century, following the construction of the road through Victorian slums in 1872. However, not all firms were actually involved in clockmaking and watchmaking. Francis Barker & Son, Ltd., were famous manufacturers of sundials of all types plus a wide variety of scientific instruments. Their business started about 1850, and they moved to their final address, *Sundial House,* ~12/14 Clerkenwell Road, about 1879. They made many varieties of dials but specialized in horizontal dials for private and public gardens.

I first came across one of their dials about 1983, in the garden of a large house that was once private but is now used commercially. The discovery of a very fine dial had particular poignancy for me as my father Stewart John Boullin [1899-1983], had lived on these premises there for four years as a boy from 1912 to 1916 prior to serving in the Army in the Great War.

On the 200 yard long rear terrace to the main house is a fine horizontal dial, marked *Francis Barker & Son, Ltd., 12/14 Clerkenwell Road, London EC, AD 1900.* The gnomon is missing, but otherwise the dial is in good condition (see Note 1)

A virtually identical and complete garden dial is to be seen in the gardens of the Royal Horticultural Society, Wisley, Surrey just off junction 10 of the M25. (see Note 2).The dial is shown in Figure 1 a & b.. A commemorative plaque records that it was erected in 1922 in memory of the Secretary of the Society Mr S. T. Wright. Everyone who enters the gardens by the main entrance would pass it.

Although Francis Barker & Son, Ltd. began making dials in 1850, they did not start seeking serious publicity until the 1890s. From that time until 1926 there were a number of articles in the *Horological Journal* [HJ] concerning sundials, and virtually all of these articles refer directly or indirectly to the dials of Francis Barker & Son, Ltd. We would refer to the texts today as 'advertising tie-ins' as they

Fig. la The sundial and plinth by Francis Barker & Son, Ltd., dated AD 1900, at the grounds of the Royal Horticultural Society [RHS], Wisley, Surrey.

Fig. lb Another view of the RHS dial showing the dial plate and top of the plinth.

were commonly accompanied by advertisements. As the articles often mentioned Barker dials and showed detailed and probably accurate engravings of them, they serve today as an important source of information.

The first article appeared in November 1892 and was simply entitled *'Sundials'.* The very brief text gave some account of dialling and showed one garden dial that was almost certainly by Francis Barker; it is very similar to the dial at Wisley and also to the dial on private property cited above [Figure 2]. The article also mentions that: ... *'On the front of the premises of Messrs Francis Barker & Son, is a handsome dial, very much inclined by reason of the aspect of the building, and consequently the unequal spacing of the hours arouses the curiosity of many passers-by'.* What a pity there is no trace of the property today.

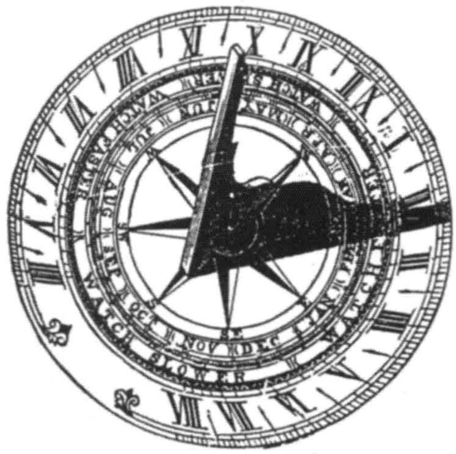


FIG. 2.

Fig. 2 A horizontal garden dial probably made by Francis Barker & Son. The associated text states: 'By favour of Messrs Francis Barker & Son, I am enabled to give three illustrations .... Fig 2 [this one] is a horizontal dial. [Ref HJ 33, November 1892 pp 41-42].

In the same issue the first advertisement appeared. It mentioned only scientific and navigational instruments with no mention of dials.[1]

A decade later the position had changed, and in 1902 an article called *'Horizontal Sun-Dials'* said that: *"doubtless inspired by Mrs Gatty's book on the subject, the taste for sun-dials shows a remarkable revival. By favour of Messrs Francis Barker & Son are illustrated two choice designs for horizontal dials of the most popular kind"* [2]

These are illustrated in Figures 3 & 4. The dial of Figure 3 was described as: *'...arranged to show distances to various places as the crow flies, from where it is fixed.* The centre of the dial was engraved as follows: on one side of the gnomon [not shown]:

'This spot is 30feet above sea level
and is in
Lat 51°30'18"N and Lon 0° 7'20"W

On the other side of the gnomon we have:
THE FIGURES REPRESENT THE DISTANCE IN MILES
AS THE CROW FLIES FROM THIS SPOT

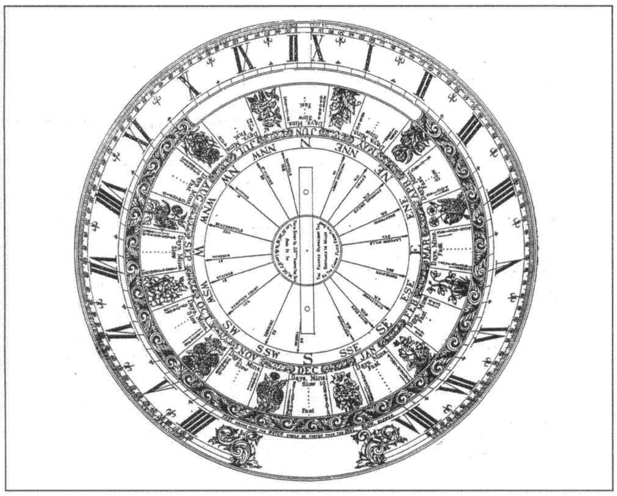


Fig. 3 A dial by Francis Barker & Son'... arranged to show distances to various places as the crow flies, from where it is fixed.'

Outside this circle is given a version of the equation of time on a monthly basis, with engravings of flowers appropriate to each month. On the outside rim are the words:

FAST MEANS THAT THE WATCH SHOULD BE FASTER THAN THE DIAL, SLOW, SLOWER (see note 3)

The dial was designed for Charing Cross and gives the miles to eighteen towns, including Hampton Court 12.5; Windsor 22; Epping 17.5; Waltham Abbey 14 and so on.

The second dial (Figure 4) is engraved to show local time at four different latitudes, for example 'London', 'Cape Town', 'Montreal', and 'Melbourne'. The latitude for each place is given, with:

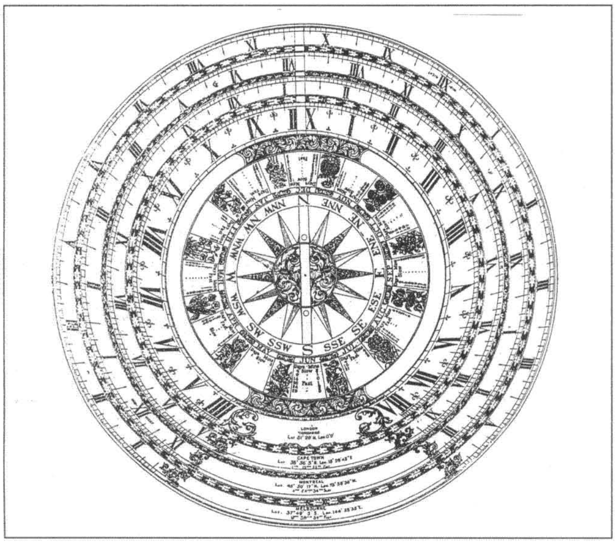


Fig. 4 Another dial by Francis Barker & Son with three concentric time scales for 'London', 'Cape Town', 'Montreal', and 'Melbourne'., or: 'any part of the globe, such as any town or place in India or any other part of the British Empire'.

LONDON "(GREENWICH)" LAT 51°N LON 0°.

As the accompanying text says: *It is divided and engraved so that a person can see at a glance, in addition to time of place where fixed, the time of three or more other places on any part of the globe, such as any town or place in India or any other part of the British Empire'.*

Note in particular the quality and elaboration of the engraving on these two dials..... similar to that on the two actual specimens that I have seen.

Many years were to pass before sun-dials came up again to any degree in the HJ. Then, in 1925 Frank Hope-Jones, an important electrical horologist and Managing Director of the Synchronome Company, (only doors away, at 32/34 Clerkenwell Road, from Francis Barker & Son, Ltd, at 12/14), described *the Sun Clock* or heliochronometer devised by Professor W. E. Cooke, Sydney[3]. This instrument was made in Australia at the time. Whether Francis Barker & Son, Ltd, also made it is unknown. Possibly Australian members of the BSS can throw light on the subject.

The relevant unattributed article was entitled merely *'Sundials'.*[4] The text and illustrations are mostly secondarily derived, as the author acknowledges, from *The Book of Sundials* by Mrs Gatty, reprinted in 1900, and Ye *Sundial Booke,* by Geoffrey Henslow, 1914 .For a complete list of twentieth century sundial books, see Young, 1994[5].

This text gave a brief history of dialling from early times, concluding with an account and illustrations of many dials in various places in Britain: 'The Old Parsonage', Didsbury; a most unusual pillar dial at 'Old Place', Lindfield; a complicated vertical dial on Eyam Church, Derbyshire, and an ivy-clad horizontal sundial in the Dutch Garden at Sandringham ('a spot beloved by the late Queen Alexandra'); and finally a sundial at Windsor Castle described as 'erected by King Charles Ye 2nd [see Note 4].

There were also two of the products of Francis Barker & Son Ltd.: horizontal garden dials on plinths, the 'Gloucester' and the 'Salisbury'. Neither of these resembles the plinth of the RHS Wisley dial. Again the article *'Sundials'* was accompanied by a full-page advertisement, headed: *'SUNDIALS FOR ALL PARTS OF THE WORLD'* (Figure 5)

There are four horizontal garden-type dials: the top left is called 'best brass horizontal dial plate'; it has the equation of time for each month and is inscribed *SINE SOLE SILEO.* The top right dial, called the 'antique design sundial', is

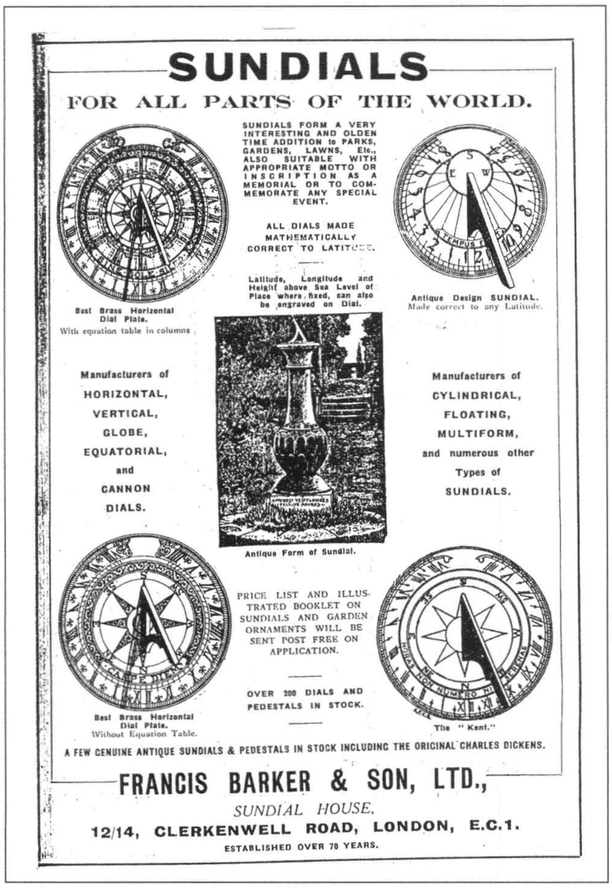


Fig. 5 The full-page advertisement by Francis Barker & Son Ltd, in the Sixth Overseas Number, Horological Journal, 68, July 1926, pp 22-30.

simpler, with Arabic numerals and the commonplace *'tempus fugit'*. The bottom left dial is described as the 'best brass horizontal dial plate without equation table', which is self-explanatory. Finally the dial on the lower right is merely referred to as the 'Kent'.

In this advertisement there is also: *'the antique form of sundial'* in the centre of the page; this might well deceive or already have deceived many collectors.

At the bottom of the advertisement is the line:
A FEW GENUINE ANTIQUE SUNDIALS & PEDESTALS IN STOCK INCLUDING THE ORIGINAL CHARLES DICKENS.
Does anyone know anything about the Dickens dial? (See Note 4)

This article shows that Francis Barker & Son Ltd were makers of a wide variety of sundials of many different types, and, from the articles and advertisement in the HJ from 1892-1926 it would appear that a very wide selections of examples were manufactured. These deserve much more study than they have had hitherto.

NOTES

[1] For security reasons the location of this sundial cannot be disclosed.

[2] The RHS Gardens are open to the public, except on Sundays which is 'members only' day.

[3] Changes in size of type font are copied from the original.

[4] The Sundial of Charles Dickens, Gadshill, Gillingham, Kent, is shown on p. 271, and the Charles II dial, Windsor on p. 263 of *Ye Sundial Booke* by G. W. Henslow, (London: Edward Arnold 1914).

REFERENCES

1 First advertisement: *Francis Barker & Son, 12 Clerkenwell Road London EC, Manufacturers for the trade and export.*. Horological Journal, 43, November 1892.

2 *'Horizontal Sun-dials'*, [unattributed], Horological Journal, 44, January 1902, pp 60-61.

3 *'The Sun Clock'*, by F. Hope-Jones MIEE, ERAS, Horological Journal, 67, August 1925 pp227-230.

4 *'Sundials'*, [unattributed], Horological Journal, 68, July 1926, [sixth overseas number], pp 22-30.

5 Young,D.A. (1994) *'Sundial Books published this century in English'*. Bull.BSS 94.1 p.47

6 Advertisement, Francis Barker & Son, Ltd., Horological Journal, 68, July 1926, page 13.

VERTICAL DIALS - A METHOD OF ESTIMATING THEIR DECLINATION

DAVID YOUNG

Members who take part in our recording activities will know the difficulty experienced by m~ of us when determining the declination of a vertical dial. Often high up on a building where the base of the wall is hard or impossible to reach, it is a job that needs some basic equipment, some little time and the co-operation of the sun. The use of a compass is not generally recommended and is unlikely to be more accurate than the method described here.

The true south facing dial of course causes no problems, the gnomon is in line with the vertical and lies directly over the noon line. Also the morning hour lines will be symmetrical with the afternoon ones.

Declining verticals however are a different kettle of fish. In order to keep the gnomon in line with the earth's axis a triangular solid gnomon could be tilted to the left or right but this method has the disadvantage that part of the dial face is hidden from an observer standing in front of the dial; indeed for heavily declining dials most of one half of the face is obscured. This problem is traditionally got over by re-calculating the style angle and establishing the gnomon at right angles with the dialplate but on a new base line at an angle with the noon line. The new base line is called the substyle and its angle from the noon line the 'substyle distance'. This can be calculated once the declination of the wall is accurately measured. The angle can vary between 0 (for a south facing dial) and the co~latitude for a dial which is facing directly east or west. Thus for a place in central England there would be a change of 38° in substyle angle for a 90° change of wall declination. The graph (Fig. 1) shows clearly the relationship between the substyle distance and the wall declination and as can be seen it is far from linear! Up to about 10 the two angles are not far apart but they diverge sharply with heavy decliners.

Figure 2 is a table showing tbe substyle distance for every 5° of declination and if we can estimate this angle reasonably accurately by direct observation we could easily determine the wall angle. Without some fixed markers such as on the face of a clock this is very difficult to do. However there is another approach to this problem avoiding the necessity to know the substyle distance at all. Although the hour lines of a vertical sundial are not regularly spaced, for any specific wall declination they are fixed, and will

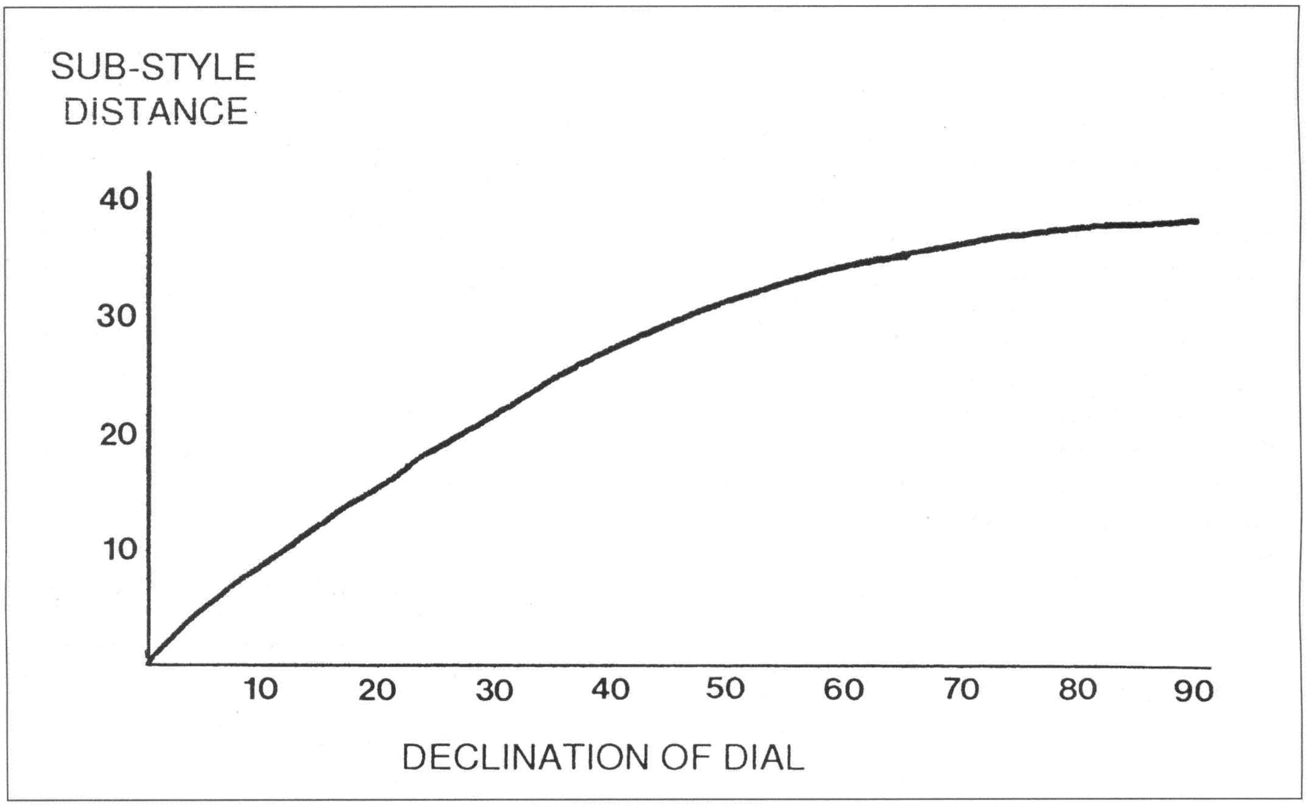


Fig. 1

DECLINATION OF DIAL	SUB-STYLE ANGLE
05	4
10	8
15	11.5
20	15
25	18
30	21.5
35	24
40	27
45	29
50	31
55	32.5
60	34
65	35
70	36
75	37
80	37.5

Fig. 2

DEC	SUB-STYLE DISTANCE	EAST SS TIME	WEST SS TIME
05	4	11.6	12.4
10	8	11.2	12.8
15	11.5	10.7	1.3
20	15	10.3	1.7
25	18	10.0	2.0
30	21.5	9.6	2.4
35	24	9.2	2.8
40	27	8.9	3.1
45	29	8.5	3.5
50	31	8.2	3.8
55	32.5	7.9	4.1
60	34	7.6	4.4
65	35	7.3	4.7
70	36	7.1	4.9
75	37	6.8	5.2
80	37.5	6.5	5.5

Fig. 3

bear a direct relation to the substyle angle. Hence, the 'hour' (or fractions of an hour) at which the gnomon itself points will determine the declination of the dial without even worrying about the substyle angle.

It will be necessary to work out these 'times' for (say) every five degrees of declination for both east and west declining dials and add two more columns to our table (Fig.3). This table, which I always keep in my sundial notebook, is for a latitude of 52 degrees. By standing directly in front of a dial the declination could be read anywhere in the south or midlands of England to an accuracy of about 2/3 degrees; much better than a wild guess, even although this method does rely on the maker of the dial doing his job properly in the first place! Of course anyone wanting to restore or replace the dial would want to make their own determination by the recognised methods. Figure 4 illustrates an example of a dial declining at about 60 degrees to the east.

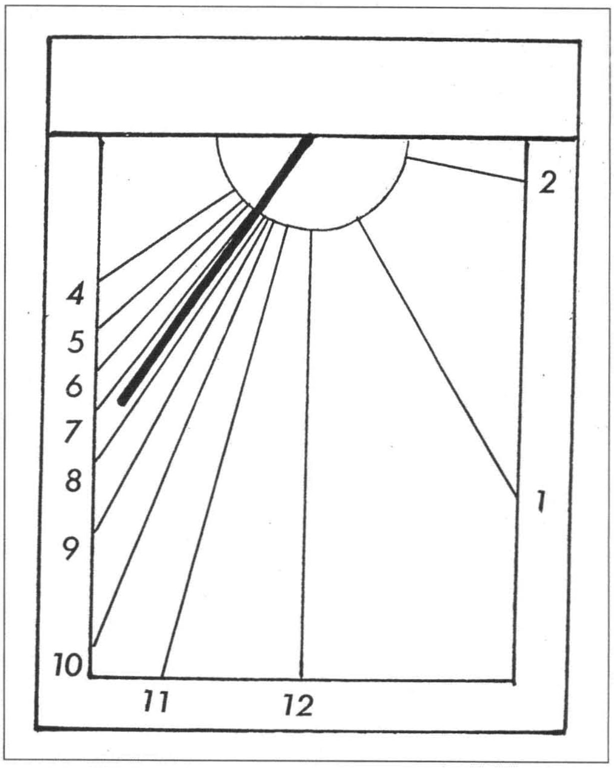


Fig. 4

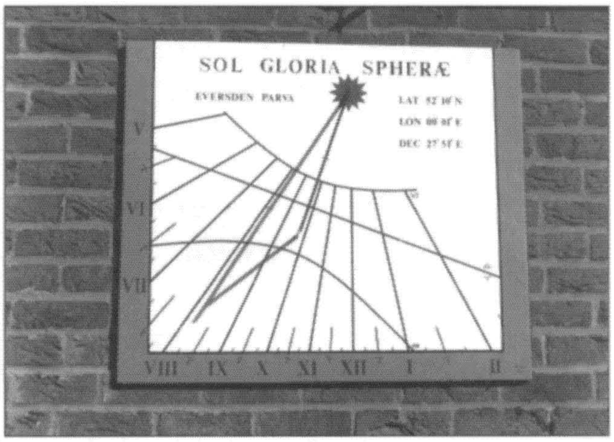
Brook Cottage
115 Whitehall Road
Chingford
London E4 6DW

RESTORATION OF A VERTICAL EAST DECLINING SUNDIAL

MIKE COWHAM

This dial, my first, was originally made in 1986. Since then, it has been continually exposed to the elements, (rain, frost and the sun's rays), and within 5 years had shown signs of deterioration. Eventually, this year, after 14 years of exposure, it was a disgrace, so a much-needed restoration was started.

Owing to the poor state of the paintwork, it was stripped to the bare wood, (marine ply), was primed, undercoated and painted from scratch. Each layer was given a light sanding to improve the adhesion of subsequent layers. A blue border was added as a background for the numerals.

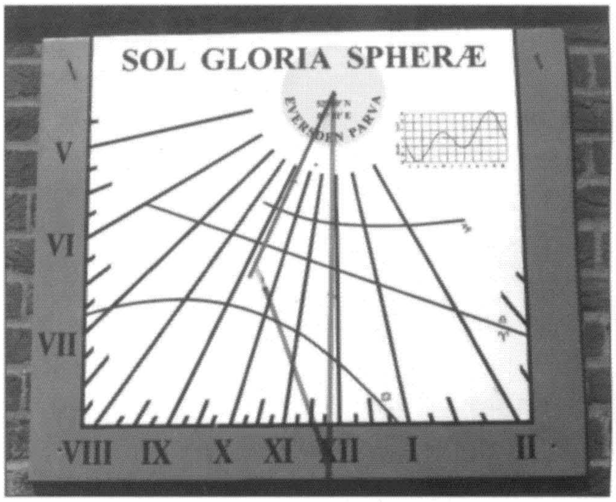


The 1986 Dial

The original layout drawing of the dial still existed. It was made by geometrical methods, full size, on a sheet of drawing film. But in 13 years the memory grows dim, and was there perhaps a later drawing....? Therefore I decided to do the drawing all over again. The first step was, as before, to consult the excellent book **'Sundials: Their Theory and Construction'** by Albert Waugh. This showed me how to go about the task. This time I wanted to include a $\frac{1}{4}$" gap in the scale to allow for the thickness of the gnomon. Therefore I drew the dial in two halves with this $\frac{1}{4}$" split in it. This later made things very complicated. The alternative would have been to cut the drawing, pasting in a $\frac{1}{4}$" gap, or move the drawing by $\frac{1}{4}$" in the appropriate place. Needless to say, there were more wrong lines on the drawing than right ones. Persistence eventually paid, and a correct? drawing was finally achieved.

The lines for the Equinox, Summer Solstice and Winter Solstice also proved difficult. I decided to add these to the same drawing. ***This was a mistake.*** They are better done on a separate sheet, to be added later, but by the time that I was really convinced of this, I had nearly finished.

The next task was to transfer the lines to the plain painted board. This was accomplished by pricking through the drawing with a compass point to leave faint marks on the paintwork. The hour lines were then drawn in with a black marker pen. (I should have used a red pen under the red lines used for the Solstices and Equinox because the dense black lines still showed through two coats of red paint!!) To paint the lines, I used some 7mm tape, stretched tight, which I centred over the drawn lines. It was yellow tape, (intended for transformer insulation), and semi-transparent so that I could verify that the alignment was correct. I then took two further pieces of the same tape, placing these carefully either side of each of the first tapes. With the original strip removed, it was a simple matter to fill in the gap between with two good coats of paint. When dry the masking strips were removed. In this way regular line widths were achieved. The only possible problem with this method is that if the masking tapes are not well pressed down, paint can creep underneath, giving a ragged edge. At the points of intersection of lines, there was a greater tendency for the paint to creep underneath. A sharp scalpel was needed later to tidy up the ragged edges.



The 1999 Dial

The next step was to consider the lettering and numbering. On the original dial I had used gold paint for the Sun's image at the foot of the gnomon and for the numerals. This had quickly discoloured and had been the first to peel off, so an alternative was considered. Gold leaf would be best, but I had no experience with this, and had no instructions for applying it. (I decided to leave this until the next re-paint in 2012?) Therefore a bright yellow was chosen as an alternative. The Sun's disk was painted in yellow, but yellow over blue for the numbers did not seem a good idea. It would need at least two coats or it would soon look green. Painting the numerals once was bad enough! On the original dial, the black lines had stayed the longest, so I decided to paint the numerals in black. This still gives a reasonable contrast against the blue background.

The signwriting was my biggest challenge. The first step was to generate the characters using a computer. This was done, full size, on plain paper. To transfer them to the dial surface, a pencil was scribbled across the back of the print to act like carbon paper. I discounted the actual use of carbon paper due to the difficulty of holding it steady during use. The letters were then transferred from the paper to the dial surface by tracing their outlines with a fine ball point pen. Finally they were painstakingly painted with a series of very fine paint brushes.

As a final thought, I decided to include a graph showing the Equation of Time. This too was computer drawn, using Waugh's tables, and was transferred by the same methods as the letters - but how should I paint the thin graph lines? The eventual solution was to use a drawing pen charged with slightly thinned black paint. However, I found that the thickness of the line depended on the velocity of the pen, so extreme care was necessary. The small lettering needed great skill, a fine brush, much patience and the aid of a strong headband magnifier. The Equation of Time curve, in red, was itself painted freehand.

The dial is now complete, and will be varnished in the near future. I have delayed varnishing to give the paint time to harden. It also makes it easier if I have to make any corrections. The dial has been placed on the wall and I am now happy with the accuracy of the hour lines. I just need to wait for the 1999 Summer Solstice to check on the Solstice line. If this is correct, then I will assume that the Winter solstice line is also correct.

There is still a fine sanded finish on the dial's surface, but this should be invisible when the dial is eventually varnished.

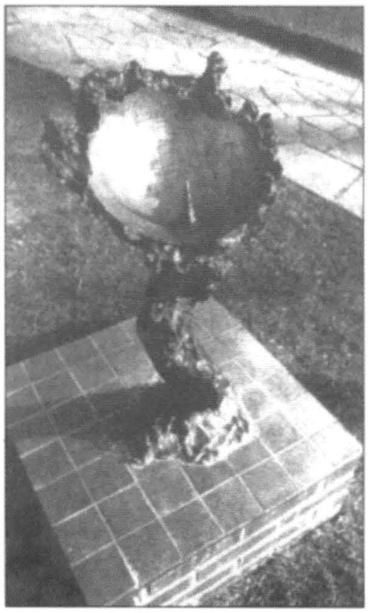
PO Box 970,
Haslingfield,
Cambs,
CB3 7FL.

Lieut.Commander Richard (Dick) Andrewes DSC.R.N.

Members who knew Dick Andrewes will have been sorry to hear of his death last year. Dick had attended many of our meetings and designed a unique dial for his house at High Beech in Essex and an analemmatic for the nearby Conservation Centre. However he was best remembered for his support and work for the Horniman Museum where he delineated the scaphe dial, part of the Museum's Sundial Trail. The picture shows the dial and as can be seen the bowl is part of a sphere, but its organic shape gave Dick no data line from which to work. It is typical of his ingenuity that he overcame the problem by rolling a marble in the bowl to its lowest point on which the pin gnomon now sits.

Dick had an eventfiil life and was awarded a DSC for his wartime naval service. When he retired after further service in India, he, as a very mature student, took a degree in Mathematics. His enthusiasm for sharing his knowledge with others was much appreciated by fellow captives when he was a prisoner of war and much later when he patiently explained the mysteries of dialling to local BSS members. Dick Andrewes will long be remembered by us as a quiet unassuming family man - a true gentleman.

D.A.Y.



Scaphe Dial, Horniman Museum, designed by Dick Andrews

SOME EARLY SUNDIALS OF NORTHUMBRIA

FRANK AND ROSEMARY EVANS

Introduction

The north east of England is quite rich in Anglo-Saxon dials, mostly from North Yorkshire. The early dials of Northumbria, by which is meant the two ancient counties of Northumberland and Durham, are fewer and perhaps less well known. They are not without interest, however, and in particular the dial at Escomb in county Durham, dating from the seventh or eighth century, is of signal importance.

We have examined and attempted to classify some seventeen dials. While it has been difficult to date them there seems to be a sequence of designs from Escomb onwards and we have categorised these designs into the following local types:

1. The earliest (Figs. 1 & 2). Here the dial plate is carved in relief on an elongate stone. The plate is semicircular with a projecting sculpture over it. The edge of the semicircle is ornamented with stone ropework in a two-stranded twist. Time lines are tides, set at 45° and 90° to the noon line.

2. A simple semicircular dial plate carved on an oblong stone (Fig. 3). Both the dial plate and the time lines may be engraved or in relief. Time lines may be tides, double hours or possibly decimal.

3. A full circle drawn round a central gnomon hole, not on a special dial plate. There may or may not be regular lines radiating from the gnomon hole. We know of one such radiating line which has been lost since 1903 and it is likely that radiating lines were always present in some form on this type of dial in the past.

4. Crude scratch dials, more or less irregularly laid out and drawn on any convenient stone. Although so poorly made they appear to be the most recent.

The dials

Type 1.Two are known from the region. They are at Escomb and at Dalton-le-Dale.

Escomb (Fig. 1). NZ189301, Landranger sheet 92.
This famous dial is situated some 6m above the ground on the nave wall of an Anglo-Saxon church which has been dated variously as between 670 and 690 AD, 650 and 700 AD, and "eighth century". The church has been little altered since. It is claimed in a guide booklet of the church to be the earliest sundial in its original place in the UK. The dial has been written about several times and was most recently considered by an incumbent of Escomb, the late Nicholas Beddow[1], who believed that the key to its interpretation "lies in Saxon mythology, to a period before the emergence of the cult of Valhalla and the Viking Gods." The dial has also been discussed by Cramp[2] and appears in Mrs. Gatty's "Book of Sun-Dials"[3]. The dial semicircle is estimated at 55 cm by 27 cm.

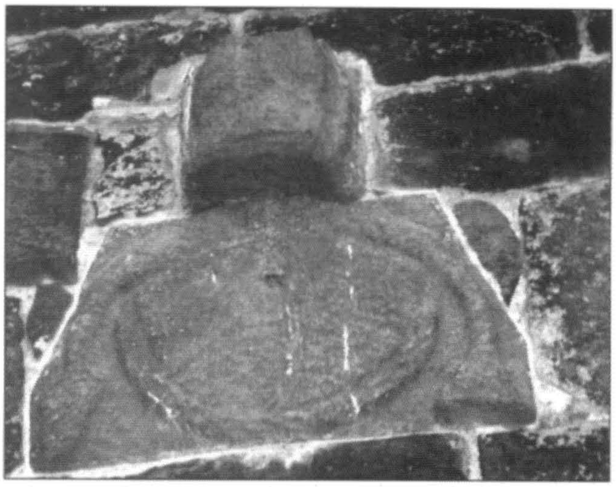


Fig. 1. The pre-Viking dial on the seventh or the eighth century church at Escomb.

On a panel in the church porch the following appears: "The trapezoidal shape seems to have been intentional. Although now very weathered, the whole dial appears to have been finely carved in relief, with a serpent or fish-like creature over the upper edge. The head is seen from above and the triangular tail encloses a worn triquetra (triple-knot). The body seems to have been ornamented with v-shaped incisions, while the lower edge is surrounded by a simple two-stranded twist. It is difficult to tell whether the block above the dial, which is probably an animal head, is part of the scheme or a later insertion...

"the dial at Escomb has as a square style hole coated with lead and there are four divisions to divide the daylight hours. The ornament on it is similar to (a carving on the Saxon stone cross in the church porch) and the frid-stool at Hexham, where the twist and triquetra are also found. Such a simple form of ornament is difficult to date. Similarly the animal has parallels in Irish and Pictish metalwork and manuscripts, and the v-markings on the body are very similar to ones on mounts from St. Ninian's lake treasure, but again it is difficult to assign a precise date. However, the influence seems to be Celtic.

"The presence of the sundial in the wall does seem to indicate that it may have served a small monastic community at Escomb."

David Scott, in a personal communication, has suggested that dials such as this were not intended as time-keepers at all but rather as symbols of life on earth, the dials being usually mounted some distance above the ground, causing the observer to raise his eyes to heaven. This may help to explain the remarkable 6 m elevation of the dial.

Dalton-le-Dale (Fig. 2). NZ408480, Landranger sheet 88. This is a dial previously overlooked or misunderstood, although correctly figured as pre-Conquest (but without further comment) by Cramp[2]. It has been confused in the literature with the curious eighteenth century dial on the inner north wall of the church nave[3, 4]. The Anglo-Saxon dial here considered is set over the porch ridge in a nave wall dated by Pevsner[5] as "early thirteenth century", so it has clearly been moved at some time. It is badly eroded and in view of its antiquity and importance is in urgent need of protection. The dial plate is in the form described above for early dials, the semicircle, cut in relief, being estimated at 55 cm diameter. Above the semicircle the stone is much eroded and fragmented, but there may at one time have been ornamentation here in the style of Escomb. At the edge of the semicircular dial plate there is further very badly eroded relief work but careful examination reveals it to be the remains of a double stranded rope twist surrounding the plate, again in the style of Escomb. There appear to be five tide lines, the sunrise, noon and sunset lines being clear, the others faint.

Type 2. There are four dials known under this heading, perhaps only Pittington surviving in its original position.

Fig. 2. The pre-Viking dial repositioned on a thirteenth century church wall at Dalton-le-Dale.

Staindrop. NZ131206, Landranger sheet 92.
The dial is hard to discover and hard to read. It is inside the church on the nave side of the twelfth century chancel wall[5], to the north of the chancel arch and some 6 m above the floor. It is clear that from an earlier external location it has been reused as a building block in the wall, where it has been mounted upside down. It is placed next to the north wall of the nave and is partly obscured by this latter wall.

The dial plate contains a semicircle raised in relief and estimated to be some 40 cm in diameter. Three tide lines remain, the sunrise and sunset lines not being visible. The noon line is crossed near its outer end.

Hart (Fig. 3). NZ470351, Landranger 93.
This dial is again inside the church, being built into the south side of the west wall at eye level, where it may be examined in detail. The wall is apparently Norman. There is known to have been an Anglo-Saxon church here and the dial was doubtless moved during medieval alterations; it is slightly damaged in one corner. The oblong dial plate, 45 cm by 26 cm, is inscribed with a 40 cm diameter semicircle and the full complement of nine half-tide lines. The dial is carefully made and the time lines are in relief, half-round in section, the half-rounds having a diameter of 2 cm. The whole is cut from a single stone. There is a second medieval dial on the church porch which is clearly of a later date (see below).

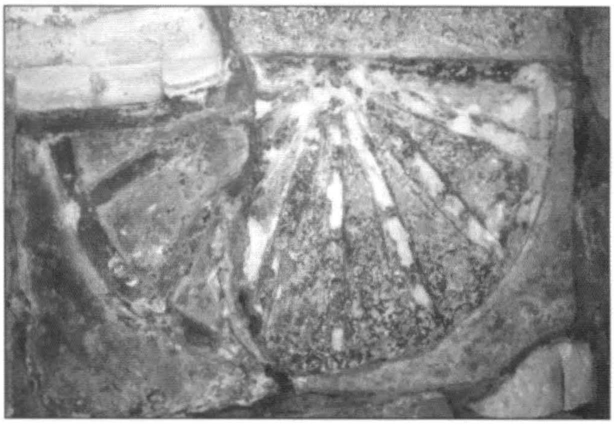


Fig. 3. The post-Viking dial built into the interior of a Norman church wall at Hart.

Middleton St. Lawrence. NZ348124, Landranger sheet 93. This dial is currently in a box locked in the church vestry. It was formerly not at this church, which is the Victorian parish church of the town of Middleton St. George, but was taken down from the much older church named Middleton St. George which, confusingly, is beyond the small settlement of Middleton One Row, a mile to the south east (NZ366117). The stone is in two parts, with the middle part missing. The details are crudely engraved and on the lower part consist of the bottom part of a semicircle with eight surviving time lines and on the upper part what appears to be the remains of a rough pentangle. The semicircle is not true and the time lines, if extended into the missing portion, would not meet at a point. An information card accompanying the dial contains the suggestion that the dial is decimal but this is far from clear and more work on the construction remains to be done.

Pittington. NZ328436, Landranger sheet 88.
This dial is illustrated in Gatty[3] but much of the detail she showed a hundred years ago is lost or hard to see, although photographs have confirmed what is not clear to the naked eye. The dial is above a buttress on the south wall of the nave, 3.3 m above the ground. There are remains of Anglo-Saxon windows above the north aisle[5] and since the south side lacks an aisle the wall bearing the dial may also be, in part or all, surviving Anglo-Saxon and hence the dialís original location. The dial is formed on a dial plate, now cracked, 54 cm by 32 cm with an engraved near-semicircle of 49 cm by 28 cm. There are six time intervals (seven time lines), and these are sometimes referred to as double hours. Each time line once bore a pock mark half way along its length and a small oblong decoration at its end, resting outside the semicircle; these are largely eroded, but the cross on the noon line remains clear.

Type 3. There are six dials known of this type in Northumbria.

Darlington. NZ273141, Landranger sheet 93.
Mrs. Gatty[3] describes this dial as being built into a wall of the choir, whether externally or internally she does not say. It is now displayed, free-standing, against a north pillar within the nave and upside down compared with Mrs. Gatty's illustration. There are six concentric circles with both cardinal and intercardinal tide lines across the diameters. The curious cross mark referred to by Mrs. Gatty is now hardly visible but shows in a photograph.

Hart. NZ470351, Landranger sheet 93.
As well as the dial within the church there is a double circle surrounding a gnomon hole on right pillar of the south porch. No hour lines are visible.

Brancepeth. NZ224378, Landranger sheet 93.
There is a simple incised circle around a gnomon hole on the westernmost buttress of the thirteenth century south wall. No hour lines are visible. This dial would certainly have been overlooked without the note by Mee[4].

Hamsterly NZ127309, Landranger sheet 92.
On the left pillar of the south porch which is of apparently medieval date, the top 45 degrees or so of a simple circle surrounding a shallow gnomon hole, the rest eroded away. A search of several minutes preceded its discovery and its existence would have remained hidden without the word of Mrs. Gatty[3].

Rothbury. NU058017, Landranger sheet 81.
There are two dials here of similar type.

(1) Between the two easternmost buttresses of the south side of the chancel a double circle with cardinal lines cut from the gnomon hole to the inner circle. The upper line from the gnomon hole is no longer visible but was clearly illustrated by Dixon[7] giving an indication of the rapid erosion of modern times.

(2) On the easternmost buttress of the south side of the chancel, a circle with 16 diameter lines accurately cut. The portion of the church on which the dials stand is dated by Pevsner[6] as thirteenth century.

Type 4 There are five dials of this type so far discovered, all in Northumberland.

Bywell. NZ049614, Landranger sheet 87.
On a stone close to the easternmost nave buttress there are five fairly clear time lines. The two close to the noon position do not exactly line up with the style hole and the whole marking is crudely cut. Pevsner[6] dates the nave as Early Norman.

Bolam. NZ092826, Landranger sheet 81.
Beside the inner door and partly obscured by the east wall of the south porch, four rays from a scratch dial extend faintly and crudely downwards and to the left. Since the south doorway is thirteenth century 6 and the porch, although later, is also medieval, we are looking at a dial of about this date.

Bothal. NZ240866, Landranger sheet 81.
Two scratch dials.

(1) On the easternmost buttress of the south nave, framed within a slightly inaccurate rectangle, a series of rays around a gnomon hole. There were perhaps originally 24 equally spaced intervals forming a circle but several of the upper ones are lost. Pevsner dated the wall to the thirteenth or fourteenth century[6], while the remnants of medieval glass in the windows has been dated by heraldic features to the fourteenth century (L. C. Evetts, pers. comm.)

(2) Again on the nave wall and just east of the south porch are three irregular lines extending leftwards and downwards from a gnomon hole, which is in mortar. The stone to the right of the gnomon hole is of different rock and bears no marks. There has possibly been some reconstruction here.

Bamburgh. NU178350, Landranger sheet 75.
Scratched directly onto a building block inside the crypt, on a north wall, near its east end, are some simple diameters, slightly irregularly laid out. The work appears to be progressing towards full lines at intervals of $22^1/_2°$ with short intervening lines, but there are many gaps. There is no surrounding circle and the gnomon hole is unbored. It is difficult to provide an explanation for this dial or its location. It may have been moved from an earlier site, it may be a practice dial or, as has been suggested, it may be of symbolic significance connected with a saint's day[8].

Discussion
The Type 1 Escomb dial is long established as very early Anglo-Saxon and the Dalton dial, although now mounted on a post-Conquest wall, must, by its construction, have a strong claim to be of a similar period. The Type 2 dials which succeed these early dials lack their ornamentation while retaining the semicircular form. They are on the whole carefully made but with varying time markings, which further suggest a lack of continuity with the Type 1 dials. It is proposed that these later dials may be dated as post-Viking, succeeding in time the ravages of the Viking raids. The ninth century was a turbulent period for the north east of England, not so much for the impact of the Viking invasions as for the earlier sacking of monasteries. Much of Northumbria remained unconquered by the Norse invaders, only the southernmost part of Durham succumbing, but raiding had a considerable effect on monastic life, particularly in the first part of the ninth century[9].This is reflected in the sharp diminution of written records from the Northumbrian chronicles at this time and it is likely that, as with record keeping, sundial making dwindled away as the monasteries and their associated monastic occupations declined. We place the Type 2 dials at a period of revival following this unsettled time, perhaps beginning with the tenth century as the Norse tide slackened under Saxon pressure from the south. These dials in their turn were to suffer with the Norman rebuilding, being displaced or discarded from the new churches, as happened, for instance, at Hart.

The Type 3 dial at Hart is clearly later than the Type 2 dial there, since the latter is rebuilt into a Norman wall and the former is on a later porch. It may be fair to generalise from this that simple circles, shallowly inscribed and with or without time lines, are more recent than the robust and carefully formed semicircles typical of Type 2. The absence of time lines within some of the circular dials requires explanation, but it may be that they have eroded away, as in the case of the Rothbury dial.

The few crudely scratched Type 4 dials of the region are all in Northumberland. It is likely that there are others to be found, perhaps also in County Durham. Dating them is difficult. We have dates of the stonework on which they appear, both from early Norman times and from the thirteenth century. It seems that, although generally later, the period of their creation overlaps that of the dial circles of Type 3.

Conclusion
Northumbrian dials of the period considered are greatly varied in style but appear to decline steadily in the delicacy of their construction from the eighth century to around the fourteenth. For interval frequency and accuracy of timekeeping, albeit in seasonal hours, the dials of Pittington and Hart, both of the tenth or eleventh century, are especially noteworthy. The dials of these and earlier centuries particularly call for conservation as antiquities.

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DERIVATIONS

K.H. HEAD

Theoretical Derivation of the Equation of Time

I was impressed by the article on 'The Sundial Clock' by P.D.Briggs (February Bulletin), especially his ingenious use of Meccano to 'adjust' for the Equation of Time. I wonder if he could provide details of his mechanism?

I had already derived the Equation from examination of the two sinusoidal curves given by Wilson[1]. The equation follows.

If the Day Number, starting from 1 on 1st January (many diaries give this number), is denoted by A, the correction (ET), in minutes, to allow for the Equation of Time is given approximately by the relationship

$$ET = 8\sin(0.9856A) + 10\sin[1.971(A + 10)]$$

The coefficent 0.9856 is the angle through which the earth moves in its orbit round the sun in one day, and is equal to 360/3655.25 degrees; and 1.971 is twice that number.

This relationship is shown graphically by the curved marked ET in Fig.1 Values derived from the above equation are close enough for most practical purposes to those given in published tables e.g. by Waugh[2].

Theoretical Derivation of Declination

I find it surprising that of the several books on sundials that I have consulted, none gives an equation for the declination of the sun throughout the year. If it is assumed that the orbit of the sun is circular, it seems to me that the declination D is given by the equation

$$D=\sin^{-1}[0.398\sin\{0.9856(A-80)\}]$$

in which 0.398 is the sine of the angle of the ecliptic (23.44°) and A is the Day Number as defined above.

This relationship is also shown graphically in Fig.1, by the curve marked D. These values are also very close to published data e.g. Waugh[2].

References

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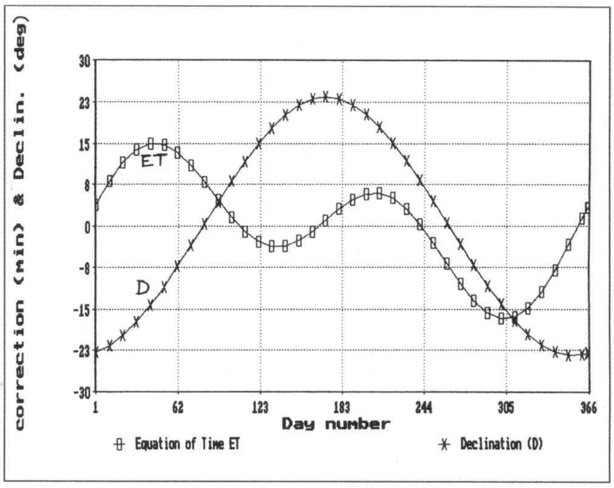

Equation of Time Graph


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