The British Sundial Society

BULLETIN

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Front Cover: *Scaphe Dial at The Temple of Artemis, Ephesus, Turkey*
Photo: L. R. Matile

Back Cover: *Mass Dial, St Margaret's Church, Lowestoft, Suffolk*
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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

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EDITORIAL

The study and design of Sundials is seen in the context of both Art and Science, and we value and enjoy this versatility of interest. The first article in this Bulletin, an account of a Henry Wynne double horizontal dial, illustrates this perfectly: it is as the authors claim, a 'peak of the dial-maker's art'. Added to the aesthetic and scientific interest, we can admire the skill of craftsmanship in the overcoming the problems of the engraving: the sheer difficulty of marking those arcs. The authors have done justice to a noteworthy dial.

The editor apologises for the production of this issue later-than-usual in the month; but this delay has made it possible to include the account of the BSS Annual Conference and AGM at Yarnfield in April. An apology is also called-for to the writer of the short article on p.32 in the March issue: Chris *Parton*, not Parsons as printed. One day, perhaps, there may appear a Bulletin issue in which *no* editorial apology is called-for!

HENRY WYNNE'S DOUBLE HORIZONTAL DIAL AT STAUNTON HAROLD

JOHN DAVIS AND MICHAEL LOWNE

INTRODUCTION

About a third of all the known 17th century double horizontal dials are by the great mathematical instrument maker Henry Wynne[1]. Many of his dials were very large (around 30" in diameter), including the one described in this paper and which is perhaps the most sophisticated of all 17th century dials. As well as being a double horizontal, the dial is a moondial, a star dial and a "geographical" dial, and it includes a nocturnal, calendar tables, age of the moon tables and possibly the earliest Equation of Time (EoT) table ever placed on a dial.

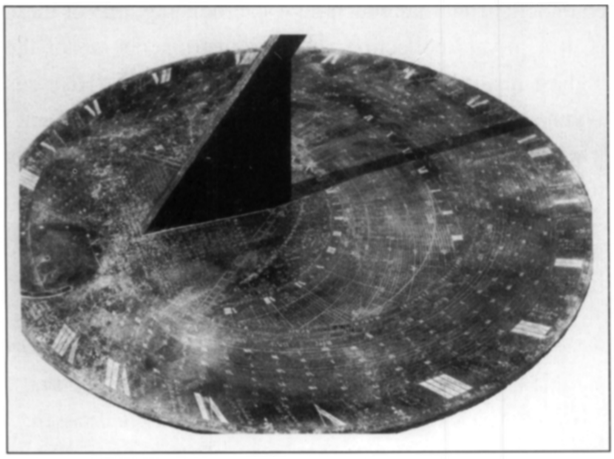


Fig.1. The original Wynne double horizontal dial. It has been dusted with talcum powder to make the engravings visible.

The dial, shown in Fig. 1, was made for Staunton Harold in Leicestershire (Fig. 2). Although it does not carry a date it is believed (see below) to have been made in 1685 and was probably commissioned by the Baronet Sir Robert Shirley (1650-1717), later to become the 1st Earl Ferrers. The Earl had been busy rebuilding and refurnishing Staunton Harold (Fig. 2i) after his father had been imprisoned in the Tower of London during the Civil War; and he spent lavishly[2] remodelling the garden and buying pictures and books for the house, so a fine sundial would have been a natural acquisition. The dial fits neatly in a sequence between two other Wynne double horizontals of similar size: the 1682 Wrest Park, Bedfordshire, dial (a replica is on display in the English Heritage garden) and the 1692 Drumlanrig Castle, Dumfrieshire, dial[3].

The 1st Earl's eldest son, also Robert (1673-99), was for a short time before his early death a Fellow of the Royal Society where he would have been exposed to the latest research results from Isaac Newton, Robert Hooke, John Flamsteed and the other prominent members. Later, the 5th Earl was a passionate amateur astronomer and in 1761 was also elected an FRS for a paper he presented on the transit of Venus. He made major changes to the gardens and buildings at Staunton Harold and is believed to have moved the dial to the position on the lawn on the Lion Front (Fig. 2ii) that it occupied until 1954. He owned a magnificent orrery and was the original purchaser (for £10 0s 0d) of the famous oil painting by Joseph Wright of Derby entitled "The Lecture on the Orrery"[4].

The 12th Earl Ferrers arranged the sale of Staunton Harold in 1954 but, sadly, died the night before. At the sale, the house was sold to demolition contractors but, some three

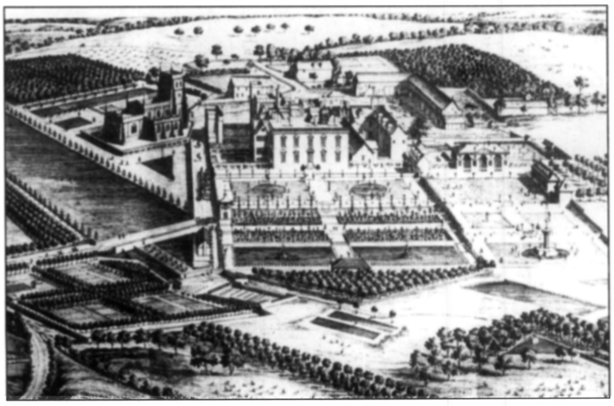


Fig.2. Staunton Harold in Leicestershire. (i) 1702 engraving by Kip of the buildings in the time of the 1st Earl Ferrers. It is believed that the dial can just be seen in the original engraving, just beyond the house. (ii) Composite photograph (2002) of the Lion Front at Staunton Harold as rebuilt by the 5th Earl and the replica dial on the pedestal, showing the appearance for the majority of the dial's life.

months later, it was purchased by Group Captain Cheshire so that it could be used as one of his Cheshire Homes for the incurably sick. The property, now a Grade 1 listed building, was put up for sale again in November 2002. The Wynne dial and its stone pedestal were moved by the present (13th) Earl to Hedenham Hall in Norfolk and then subsequently to Ditchingham Hall, Norfolk, where it remains.

Staunton Harold was surrounded by coal mines and the sulphurous coal was universally burnt in that part of the country. As a result of 250 years of rainfall in the form of a weak sulphuric acid, the dial had become badly corroded by the time it was moved from Leicestershire. In the 1970s, the Victoria and Albert Museum advised that it should be immersed in a number of weak alkaline solutions. This arrested the corrosion but, unfortunately, the engravings became far less precise and very difficult to read. The already fragile nocturnal was lost in the process. In 1985, after a period on loan to the National Maritime Museum, a respected firm of antique restorers improved the legibility slightly by mechanical treatment of the surface and an application of coloured wax. They also made a resin replica so that the original could finally be moved indoors in order to protect it from further deterioration and from the weather. It had been planned to re-engrave the replica so that the engravings could be read but without a full drawing of the dial this had not proved possible. When the present authors came across the replica dial in July 2002 it was already deteriorating badly, possibly because the resin may be on a ferrous core which is rusting and expanding. They were delighted when Earl Ferrers allowed full access to the original for a detailed study and were even happier to have the resulting drawings used as the basis for a new replica to be made, this time in solid bronze, by BSS member Tony Moss.

HENRY WYNNE

Henry Wynne served his apprenticeship under Ralph Greatorex, beginning in 1654 and gaining his freedom in the Clockmakers' Company in 1662. Greatorex was himself a maker of at least one double horizontal dial[1] and, in turn, had served his apprenticeship under the illustrious Elias Allen, the maker of the first of these dials for their inventor, William Oughtred. Wynne is credited[5] with nine apprentices, including the well-known dial-makers Richard Whitehead, Richard Glynne and Thomas Tuttell. Although Tuttell is primarily known as a clockmaker, one double horizontal dial by him is known, preserving a long line of makers in this Guild.

Wynne's premises were in Chancery Lane, London, and given as "At the Pope's Head", "Next the Sugar Loaf", "over against the Rolls" and "near Sergeant's Inn" at various stages of his career. He made all sorts of mathematical instruments but was particularly well known for his compasses and dipping needles: amongst the customers for these were John Flamsteed at Greenwich and James Gregory at the St. Andrew's Observatory. Robert Hooke is known[6] to have visited Wynne's shop on several occasions and on 26 May 1678 (some years before the manufacture of the Staunton Harold dial) he was accompanied by Samuel Pepys. Wynne is known to have made at least nine double horizontal dials, far more than any other maker. Although the one made for Windsor Castle[7] is missing (its partner there, a standard garden dial, is still in position), several of the others are listed in the BSS Register, including one at Powys Castle[8]. In addition, a further nine garden horizontal dials are known, some in private collections and one in America. He wrote a leaflet in 1682 describing the use of Oughtred's universal equinoctial ring dial which he was producing: one of these is in a private collection. All his instruments are of the highest quality. They are usually signed either "Henricus Wynne Londini fecit" (Fig. 3) or just "Henry Wynne fecit" when space was more limited. When he died in 1709 his stock was sold off .

Fig.3. "Henricus Wynne Londini fecit" - the signature favoured by Wynne on his large dials - this one from the Wrest Park (replica) dial.

OVERALL DESCRIPTION AND CONSTRUCTION

The original Staunton Harold dial (Figs. 1 and 4) is in bronze, 770mm (30") in diameter and 10mm (about 3/8") thick. The massive gnomon is a full 19mm (3/4") thick and stands a proud 592mm (about 23") along the polar style. The whole dial needs two people to lift it. The horizontal distance between the toe of the polar gnomon and the vertical style in the centre of the dialplate is 200mm. This is a larger offset than the 177mm on the slightly larger Wrest Park dial. It is likely that this design change was made to allow the vertical style to be slightly taller as, on the Wrest Park dial, its shadow does not reach the edge of the stereographic projection near the summer solstice. The gnomon is located by two large tenons of unequal size, passing though the dialplate. The tenons are currently rather crudely brazed to the underside of the plate but this is thought to be a recent repair as it would have required an oxyacetylene torch which was not available to Wynne. On the Wrest Park dial, the tenons have large rectangular holes for wedges.

The back of the dialplate has the fairly undulating surface

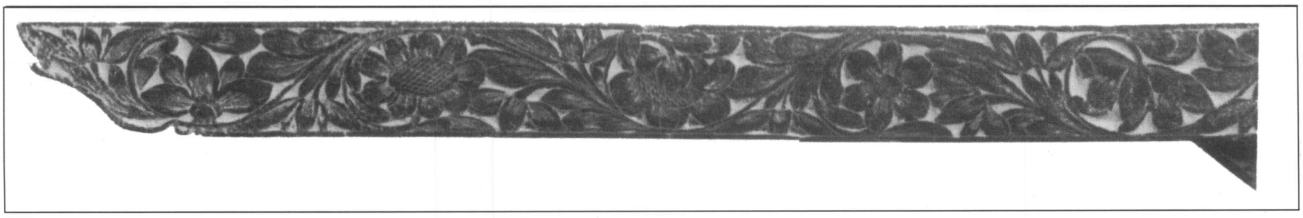


Fig.6. Part of the gnomon of the original dial (dusted with talcum powder).

typical of a hand-hammered casting which has not received the careful scraping to produce the smooth, flat surface of the dial face. It does have a minimal amount of engraving in the form of two circles representing the main chapter ring. There are two small holes which show the origins of the two polar styles but, unlike dials in thinner material, these do not penetrate through to the top surface to act as locators for the gnomon. Surprisingly, there are no holes in the dialplate for it to be fixed to its pedestal, so it rests freely in a depression in the stonework.

Even though the dial is badly corroded, it is clear that Wynne was a superlative engraver (Figs. 5, 6). The numbering and lettering is generally oriented to be read from the inside of the dial (or the south) showing its ancestry from the earlier Elias Allen dials. Later dials of this size tend to have an outward orientation of the lettering[9]. There is a wide range of lettering sizes, varying from 31 mm for the main hour numerals down to 2.2 mm for some of the tables. Wynne adopts two different fonts to cover this range, a formal Roman font for the larger letters and an italic one for the smaller ones. The complexity of the letters, sigils, fleur-de-lys and other flourishes is not as high as in the early Tudor period (e.g. the dials by Humphrey Cole) but still more ornate than the later Georgian dials.

THE STEREOGRAPHIC PROJECTION

The central area of the dial is dominated by the stereographic projection of the celestial sphere. This is 222mm in diameter and of a fairly standard format. It has lines for every five minutes of time (or right ascension) with the quarter- and half-hours dotted, and for every individual degree of declination with the 5-degree lines dotted. The 10s of the declination lines are numbered (Arabic) in several places. The two arcs of the ecliptic are shown, labelled with the zodiac sigils and dotted for each degree of solar longitude. Wynne has inadvertently interchanged the symbols for Leo (♌) and Capricorn (♑). Additional Arabic numerals along the celestial equator show the right ascension, running (0)-12 from the vernal to the autumn equinox and from 13-(24) back to the vernal equinox. The right ascension of the sun is the angular distance along the celestial equator from the March equinox to the hour circle through the sun, measured in time. Two sets of Roman numerals just outside the summer and winter solstice arcs show the time. Around the outside of the horizon circle, the names of the months are given in English (e.g. IANUARY, FEBRUARY), running clockwise. This scale is divided into individual days.

Drawing the stereographic grid would have been a major feat. The arcs for 11:55 and 12:05 have radii in excess of 17m and their centres are a similar distance off the edge of the dial. It is extremely unlikely that Wynne had a setting-

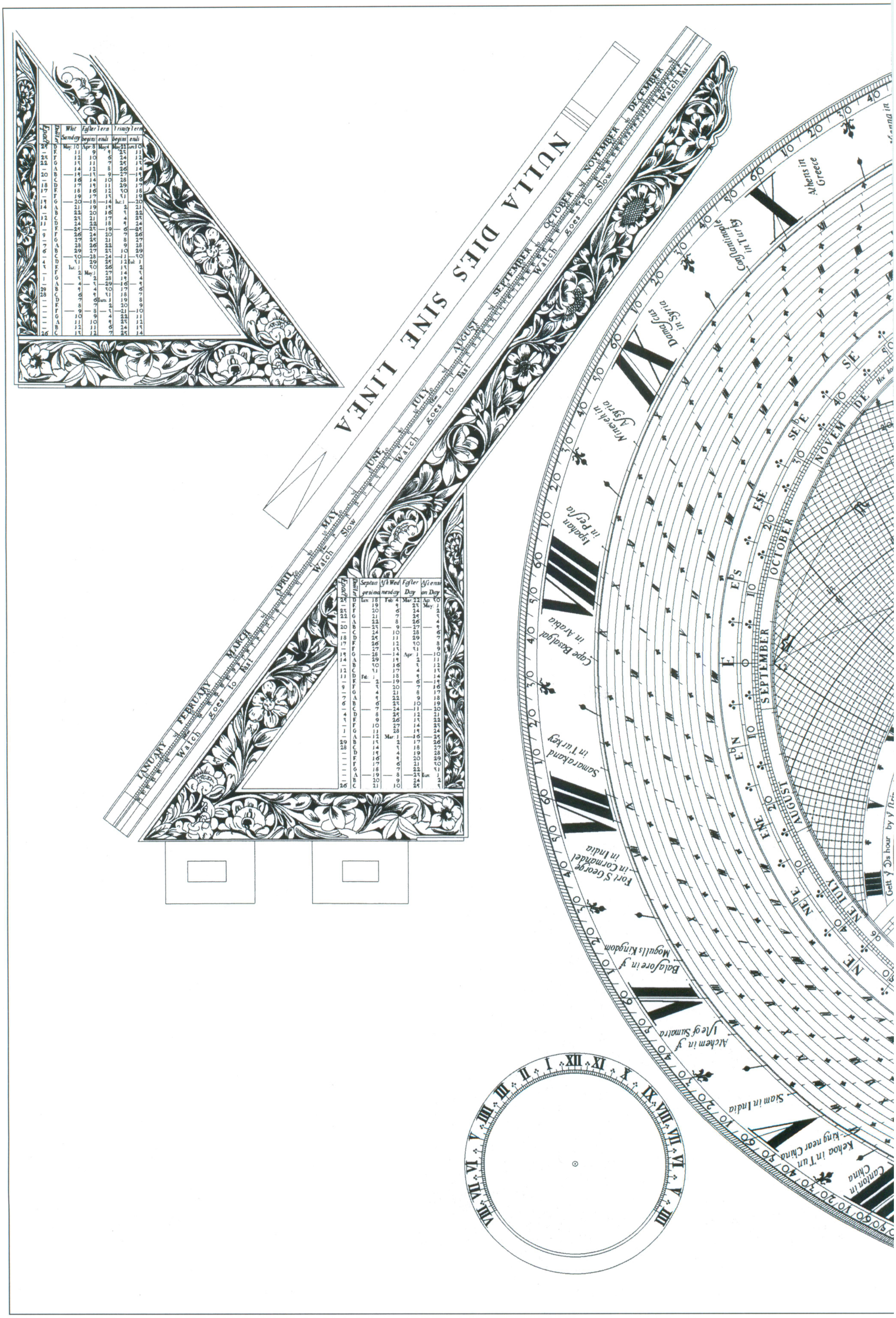
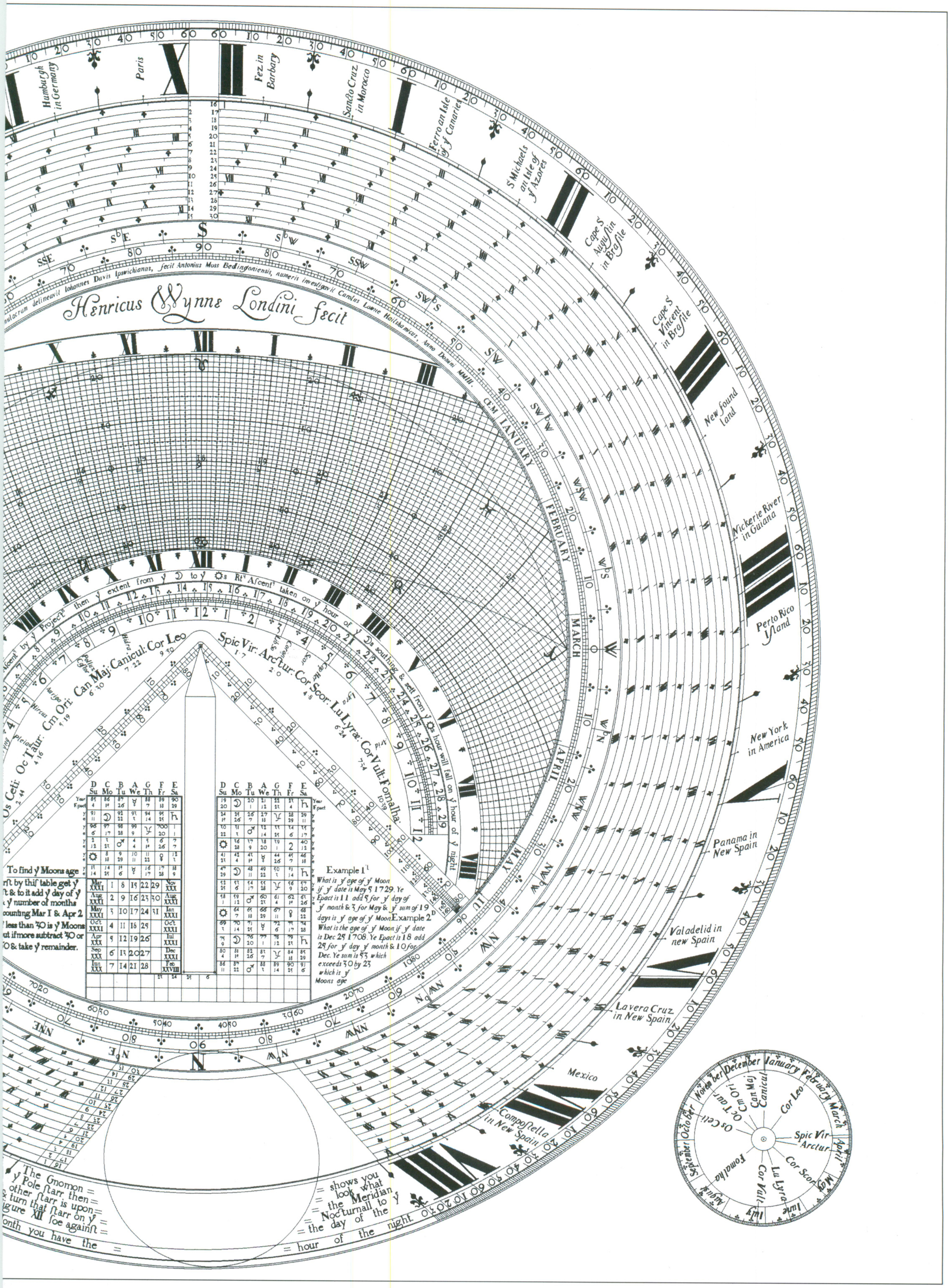


Fig.4. Drawing of the Staunton H



dial, as interpreted by the authors.

illustrated in Fig. 7. In use, the graver is fitted through the hollow hinge at A and the two outside rules are slid along the fixed dogs R and S. Positioning the dogs and finding the appropriate setting on the centre rule cannot have been easy. On many double horizontal dials, a row of dots running from the toe of the gnomon towards the south can be seen, having been used as the centres to strike the declination arcs. These are not visible on either the Staunton Harold or Wrest Park dials although the radii of the arcs would have made the use of ordinary compasses feasible.

The four linear scales running from the base of the vertical style to the horizon circle (at 45°) are associated with the stereographic projection. The scale nearest to the gnomon on the west side (left side in Fig. 4) runs (90)-(0) from the centre outwards, delineated to single degrees and numbered in 10s. It is the standard scale found on most double horizontals and represents the altitude of the sun. The equation of the scale is

$$r = r_0.\cos(a)/\{1 + \mathit{sin}(a)\}$$

where a is the altitude and r_0 is the radius of the horizon circle. The scale which is paired with this runs (0)-(45) and is numbered in 10s with the 5s marked (as elsewhere on the dial) by a three-dot symbol. It matches the altitude scale at all degree points and its equation is

$$r = r_0.\mathit{tan}(z)$$

where z is the zenith angle. It is left to the reader to show that these trigonometrical expressions produce exact matches at all points!

The two linear scales on the east (right in Fig. 4) of the gnomon do not appear to be directly related to the projection. The outer one, running (0)-(90) gives the *sin* of the angle and the inner one, running (0)-(180) and matching it at all degree points, is *sin* of half the angle. The base of the vertical style is raised slightly off the dialplate allowing access to the origins of these four scales with the leg of a pair of dividers, so it is presumed that Wynne's intention was that the scales could be used in the same manner as those on a sector.

THE COMPASS

The compass runs around the outside of the stereographic projection. The first thing which is noticed is that the labels are reversed, with S in the noon gap, N by the toe of the gnomon and E and W mirrored from their geographical directions. This, of course, is done because it is intended to show the direction of the sun (or moon) from its shadow as projected from the vertical style. The innermost rings of the compass show the azimuth to half-degrees, numbered by 10s 0-90 by four, with the zeroes placed at the east and west points. This is the most common orientation of the azimuth scale (see the "Bacon" dial[18] for another example) but in contrast to the Wrest Park dial which places the zeroes on the north and south points. Outside the azimuth angle, the 32 compass points are labelled (e.g. ENE, NW^{b}N etc) and these are further divided into half-points (5.625°) and quarter points (2.8125°). There is an additional numbering of the azimuth scale in the quadrant between the SW and SE. It runs (0)-90 in both directions but with the 45° point aligned to the S (bottom of Fig. 4). The purpose of this scale, also present on the Wrest Park dial, is unknown to the authors.

THE ASTRONOMICAL AND CALENDRICAL INFORMATION

In addition to the usual properties of a double-horizontal dial mentioned above, the Wynne instrument has many other features. Prominence is given to methods of telling the time at night, by the use of the moon or certain stars. Various tables to find the age of the moon and use it for time-telling are included, but some explanation is perhaps needed to understand the use of the tables[11] before actually describing them.

The *Dominical Letter* of a year identifies the calendar dates of Sundays in that year; the letters A-G are placed in succession against the dates, starting with A on January 1. The letter which stands against Sundays is the dominical letter. No letter is placed against February 29 in a leap year, which therefore has two letters, one for January and February and another for the rest of the year. Perpetual calendars can be prepared giving the dates for days of the week if the dominical letter is known.

The *Golden Number* is a device for determining the age of the moon based on the *Metonic Cycle*. In about 432 BC the Greek astronomer Meton noticed that the phases of the moon recurred on the same day of the year after an interval of 19 years, in which there are 235 lunations. The golden number of a year represents its place in the 19-year cycle and is obtained by adding one to the remainder when the year is divided by 19. As twelve lunations take 354 days (on average) the phases of the moon occur earlier by eleven days in the course of a year. Tables are prepared which give the dates of new moon for every year number in the cycle. The day of new moon is called day one and the full moon occurs on day 14. Knowledge of the day of full moon is required to determine in advance the date of Easter Day. Different Christian communities celebrated Easter on varying days until 325 AD when the Council of Nicea fixed Easter Day as the Sunday following the full moon which falls on or next after the day of the vernal equinox, which was defined as March 21. This full moon (the Passover or Paschal moon) was to be determined by the Metonic cycle. However, the cycle is not exact, the period of 19 Julian years of 365.25 days is longer than 235 lunations by about $1\frac{1}{2}$ hours and the predicted day of full moon gradually falls later than the true moon. By the time of the Gregorian reform of the calendar in 1582 the tabular day of full moon using the golden number was three or four days late. This, together with the inaccuracy in the length of the year in the Julian calendar, was having a direct effect on the date of Easter which was tending more and more towards the summer.

The *Epact* is an improved method for finding the age of the moon, adopted for the Gregorian calendar on the change from the Julian calendar. The epact for any year is the age of the moon on the day before January 1 and runs on a 19-year cycle similar to that of the golden number. The system is more flexible in that the sequence of epacts can be adjusted to keep the predictions in line with the true moon; such adjustments are usually made in centennial years. The dates of new moon depending on the epact can be tabulated and are then used in the same way as those for the golden number. However, any tabular method of finding the age of the moon can be in error by a day or so; the complicated motion of the moon cannot be well represented by simple means. In acknowledgement of this, the moon's age from the tables is generally known as the 'ecclesiastical moon'.

THE EPACT TABLES

Tables on the dialplate alongside the gnomon give, for every year from 1685 to (at least) 1791, the epact of the year and the dominical letter. Wynne has not included the first letter of leap years but instead gives the planetary symbol for the weekday on which February 29 falls. When the dial was made Britain was still using the Julian calendar but in order to improve the accuracy of the moon's age predictions Wynne has adapted the epact method to the Julian calendar by adding the difference between the two calendars, i.e. ten days up to 1699 and eleven thereafter. He put a very similar set of tables on the Wrest Park dial, with the main table running from 1685 to 1836. However, on that 1682 dial, extra cells for 1683 and 1684 were added at the top. This leads to the view that, because the extra cells were not needed for the Staunton Harold dial, it was made in 1684/5. The actual values of epact on the Wrest Park dial (correctly) start off the same as the Staunton Harold ones but then increment by an extra day every time it reaches 29 so that it has accumulated a 7 day error by 1806. Clearly, Wynne discovered this mistake before he made the Staunton Harold dial.

Instructions are given for finding the age of the moon on any particular day. Engraved to the west (left in Fig 4) of the epact table:

> To find y^e^ Moons age
> Firſt by thiſ table get y^e^
> Epact & to it add y^e^ day of y^e^
> Month and y^e^ number of months
> from March counting Mar I & Apr 2
> so y^e^ sum if less than 30 is y^e^ Moons
> age but if more subtract 30 or
> 60 & take y^e^ remainder

Two examples of the method were put on the dialplate to the east side of the gnomon but due to corrosion are now illegible; alternative versions have been substituted. In addition to the time-keeping possibilities, the age of the moon would be a useful guide for night-time travellers to the presence or absence of moon-light.

THE MOON DIALS

Having found the moon's age, the dial has two methods of using it to determine the time of night. Just inside the main chapter ring of the polar gnomon is a series of 15 concentric circles labelled with the moon's age from one to fifteen and from sixteen to thirty. Each circle has a time calibration (hour numerals and indicators for the half- and quarter-hours) which enable the time to be read directly from the shadow of the polar gnomon cast by the moon. In an apparent attempt to compensate for the fact that the moon continually loses time against solar time (approximately 48 minutes per 24 hour day or two minutes per hour) Wynne has spaced the hour markings in each circle at intervals equivalent to 62 minutes of solar time. Unfortunately this is incorrect: in the course of an hour the moon moves 15° westward by the earth's rotation and $\frac{1}{2}$° eastward by its own orbital motion so the correct spacing is $14\frac{1}{2}$° per hour equivalent to 58 minutes of solar time, not 62.

The second method of telling time by the moon is by use of a scale which gives the time when the moon is due south (the 'southing' or meridian transit) depending on the age as found from the epact. The scale gives "The ☽s Age" running (0)-$29\frac{1}{2}$ days and divided down to one eighth days, against "The Houres *of his Southing*" running (0)-12 hours (twice) and divided to half- and quarter-hours and then to 5 minutes.

The dial instructions are written in a single arc between the hour numerals of the projection and the moon time scale:

> Gett y^e^ ☽s hour by y^e^ ſtring & Gnomon & y^e^
> ☼s Rt^q^ Aſcent^q^ by y^e^ Projectn then y^e^ extent
> from y^e^ ☽ to y^e^ ☼s Rt^q^ Aſcent^q^ taken on y^e^

hour of ye ☽s southing & sett from ye ☼s
hour will fall on ye hour of ye night.

This wording is very obscure, at least to modern eyes, in marked contrast with other lucidly-written instructions. It seems quite unnecessary to involve the right ascension of the sun in the calculation; all that is required is to add the time shown by the gnomon shadow on the outer polar dial to the time of southing, subtracting 12 hours if necessary to put the result into the twelve-hour system of time reckoning. So far as Wynne's method can be interpreted it seems that the derived time would have been the same.

The two methods are unlikely to give the same result! Apart from the error in calibrating the hourly intervals mentioned above, the two scales are based on different values for the amount by which the moon transits later from night to night (the 'daily retardation of transit'). The values from the scale of southing use an interval of 48.8 minutes (24 hours divided by $29\frac{1}{2}$ days, the average length of a lunation). The circular scales are based on 30 days for the lunation, giving daily intervals of 48 minutes; in fact both are wrong. In the course of an average lunation the earth rotates $29\frac{1}{2}$ times but the moon goes round the earth once in the same direction, so losing one revolution and returning to the meridian only $28\frac{1}{2}$ times: 24 hours divided by $28\frac{1}{2}$ gives the correct average value of $50\frac{1}{2}$ minutes for the retardation. Due to the variable speed of the moon in its orbit the actual retardation can be as little as 40 or as much as 60 minutes. From these and other causes, times found by the moon could be wrong by up to an hour or more.

The small size of the script used for the numerals on the moon-dials would make them rather difficult to read by moon-light. The full moon has an intensity half a million times fainter than sunlight and the first and last quarter-moons are nine or ten times fainter still. The human eye is not adapted to resolve fine detail at such low levels of illumination. However, when the dial was new the face could probably give an almost specular reflection if viewed at the correct angle, effectively increasing the illumination over limited areas.

THE PERPETUAL CALENDAR

Just below the table of epacts on the west side is a perpetual calendar. Much of the table is unreadable and the details have been taken from the similar one on the Wrest Park dial. It appears to show the dates of Sundays when the dominical letter is D: presumably instructions were given to derive dates for other letters and how to allow for leap years. The writing in the logical place for such instructions below the table is now unreadable and no attempt has been made to reproduce it.

THE STAR NAMES AND POSITIONS

The names of twelve stars and their right ascensions (RA) are given between the gnomon and the stereographic projection. Their details are shown in Table 1. The same twelve stars are also shown on the earlier Wrest Park dial but the later Drumlanrig Castle dial seems to use a slightly different set[12]. The RAs appear to match calculated values for epoch 1650, some of which have been substituted for unreadable values on the dial. A further twelve names in much smaller script appear alongside the arc of the moon's transit times which thereby serves the additional purpose of giving their RAs. Corrosion is bad on the east side and names here were difficult to decipher.

THE NOCTURNAL

The decision to include a nocturnal on the dial seems to have been made late in the design process. Firstly, it covers some engraving already on the dial-face; if this had not already been in position, it would have been possible to engrave the features of the lower, fixed, disk directly on the face. Secondly, the nocturnal is not on the exact centre-line of the dial but displaced approximately 10mm to the east. This meant that the moon rings could not be completely symmetrical and the labels for the age of the moon had to be omitted on the east side (although this now can only be deduced rather than actually seen).

It is unfortunate that the original nocturnal has not survived. Nocturnals were often included on other instruments: for example, see Ref 13 for one on the back of a Gunter's quadrant by Wynne's contemporary John Prujean. For the replica dial one has been designed which, although conjectural, will reproduce the features and method of use of the original. It consists of an outer fixed ring carrying times from IIII pm to VIII am (increasing anti-clockwise) and an inner rotating disc with calendar dates running clockwise. Twelve stars are indicated on this, placed so that their names are against the dates when each star is due south at midnight. To avoid overcrowding, only those twelve stars whose right ascensions are given on the dial have been included. The instructions for use are written on either side of the nocturnal:

The Gnomon shows you
ye Pole ſtarr then look what
other ſtarr is upon the Meridian
& turn that ſtarr on ye Nocturnal to ye
figure XII ſoe againſt the day of the
Month you have the hour of the night.

If the star is on or very near the meridian the derived time should be correct to within a few minutes and moreover would be in local mean time, not apparent solar time.

Stars with quoted RA					
Dial name	**Identity**	**Popular name**	**Dial RA**	**1650 RA**	**Notes**
Os Ceti	α Cet	-	2h44m	2h44m	Whale's mouth
Oc Taur	α Tau	Aldebaran	4 16	4 16	Bull's eye
Cm Ori	ε Ori	Alnilam	5 19	5 18	Orion's belt (cingulum)
Can Maj	α CMa	Sirius	6 30	6 29	Great dog
Canicul	α CMi	Procyon	7 22	7 21	Little dog
Cor Leo	α Leo	Regulus	9 50*	9 50	Lion's heart
Spic Vir	α Vir	Spica	1 7*	13 7	
Arctur	α Boo	Arcturus	2 0*	13 59	
Cor Scor	α Sco	Antares	4 8	16 8	Scorpion's heart
Lu Lyra	α Lyr	Vega	6 24	18 25	Lucida (brightest)
Cor Vult	α Aql	Altair	7 34*	19 34	Vulture's heart
Fomalha	α PsA	Fomalhaut	10 39*	22 38	

Stars by time scale					
Dial name	**Identity**	**Popular name**	**Dial RA**	**1650 RA**	**Notes**
Pleiad	η Tau	Alcyone	3^h30^m	3^h27^m	
Hircus	α Tau	Capella	4 50	4 51	Goat star
Auriga	β Aur	-	5 35	5 34	
Castor	α Gem	Castor	7 10	7 12	
Pollux	β Gem	Pollux	7 25	7 23	
Hidra	α Hyd	Alphard	9 10	9 10	
Lib So	β Lib	-	2 55	14 58	
Coron	α CrB	Alphecca	3 20	15 20	
Scor	α Sco	Antares	4 10	16 8	
Cap Her	α Her	-	5 0	16 59	Hercules' head
Lyra	α Lyr	Vega	6 25	18 25	
Arid	α Cyg	Deneb	8 30	20 29	Arided (old name for Deneb)

The dial RAs are given in $2x12^h$ format to agree with the time scale on the nocturnal.
* RAs so indicated are illegible and have been replaced with values from a contemporary Wynne dial.

Table 1. *Star names and right ascensions.*

However, if Wynne had used the same stars which appear on the dial, the selection is rather poor with gaps of two and three hours in right ascension which severely limits the chance of finding a star near the meridian at a particular time. To use the nocturnal some artificial means of illumination would be necessary, but it does not seem likely that the dial owner would venture outside with a lantern or candle to read the instrument when he could with much less effort visit the household clock!

THE DATES OF EASTER AND ASSOCIATED FESTIVALS

An abbreviated table can be drawn up for each epact giving the date when the Paschal full moon falls on a Sunday, depending on the dominical letter. From this the date of Easter Day can be derived, not only for those conditions but for any year with the same epact and a different dominical letter. On the east and west triangular sides of the gnomon Wynne has placed such a table of epacts, dominical letters and the dates of the Sunday Paschal moons. He has however mistakenly called those dates Easter Day; it is implicit in the Easter rules (and is often stated explicitly) that, if the Paschal moon occurs on a Sunday, not that day but the next Sunday is Easter. Additionally Wynne gives the dates of associated festivals (Septuagesima, Ash Wednesday, Ascension Day and the start and finish of Easter and Trinity terms) but all are seven days too early. As Britain was still using the Julian calendar the dates of Easter given by the golden number method were relevant and Wynne would have had to relate the epact to the golden number to derive his table. It is possible that his mistake arose either here or by a simple mis-interpretation of the rules. Even with this wrong identification it would have been possible to derive the

Name on dial	Time on dial	Modern name	Implied Long.	Actual Long.
Formosa Isle near China	3:45	Taiwan	122° E	121° E
Canton in China	4:15	Canton, China	115° E	113° E
Kehoa in Tunking near China	4:45	?Kontum, Vietnam	108° E	108° E
Siam in India	5:15	Thailand	100° E	101° E
Atchem in ye Isle of Sumatra	5:45	?Sigli, Sumatra	92° E	96° E
Balasore in ye Mogulls Kingdom	6:15	Balasore, India	85° E	87° E
Fort St George in Cormandel in India	6:45	Madras, India	77° E	80° E
Samarakand in Turkey	7:15	Samarkand, Uzbekistan	70° E	67° E
Cape Basalgat in Arabia	7:45	Ras al Hadd, Oman	62° E	60° E
Ispahan in Persia	8:15	Isfahan, Iran	55° E	52° E
Ninevah in Asyria	8:45	Nineveh, Iraq	47° E	43° E
Damascus in Syria	9:15	Damascus, Syria	40° E	36° E
Constantinople in Turkey	9:45	Istanbul, Turkey	32° E	29° E
Athens in Greece	10:15	Athens, Greece	25° E	24° E
Vienna in Austria	10:45	Vienna, Austria	17° E	16° E
Humburgh in Germany	11:15	Hamburg, Germany	10° E	10° E
Paris	11:45	Paris, France	2° E	2° E
Fez in Barbary	12:15	Fès, Morocco	5° W	5° W
Sancto Cruz in Morocco	12:45	?	13° W	
Ferro an Isle of ye Canaries	1:15	Hierro, Canaries	20° W	18° W
St Michaels an Isle of ye Azores	1:45	San Miguel, Azores	28° W	28° W
Cape St Augustin in Brasile	2:15	Recife, Brazil	35° W	35° W
Cape St Vincent in Brasile	2:45	Sao Paulo, Brazil	43° W	47° W
New found Land	3:15	(St Johns), Newfoundland	50° W	52° W
Nickerie River in Guiana	3:45	Nickerie R, Surinam	58° W	57° W
Perto Rico Island	4:15	Puerto Rico, W.Indies	65° W	67° W
New York in America	4:45	New York, USA	73° W	76° W
Panama in New Spain	5:15	Panama City, Panama	80° W	79° W
Valadelid in new Spain	5:45	Valladolid, Mexico	89° W	88° W
La vera Cruz in New Spain	6:15	Veracruz, Mexico	95° W	96° W
Mexico	6:45	(Mexico City), Mexico	103° W	99° W
? Compostella in New Spain	7:15	Compostela, Mexico	110° W	105° W
??	7:45	?	118° W	

The implied longitudes have been calculated using a longitude of 1° 27' W for Staunton Harold. All longitudes are rounded to the nearest degree.

Table 2. *Place names in the chapter ring.*

correct dates of Easter Day for those years in which the Paschal moon did not fall on a Sunday but the dial appears to carry no instructions for the use of the tables.

GEOGRAPHICAL DIAL

The main chapter ring of the dial has a standard set of large Roman hour numerals running IIII-XII-VIII. In most instances, the hour line is allowed to run between the numerals, rather than being incorporated against one side of a broad stroke, as became standard for later makers. A narrow scale inside the main ring is divided down into half, quarter and eighth hours, with a "spade" symbol on the half-hours. The individual minutes are shown around the outside of the chapter ring; thus they are on the periphery of the dial making them as large as is possible. They are numbered in 10s, with the figure 60 appearing on both sides of the noon gap. The half hours are indicated by an elaborate and ornate fleur-de-lys which is similar, though not identical, to that found on other dials by Wynne and also by his apprentices.

Between the hour numerals, on the quarter and three-quarter

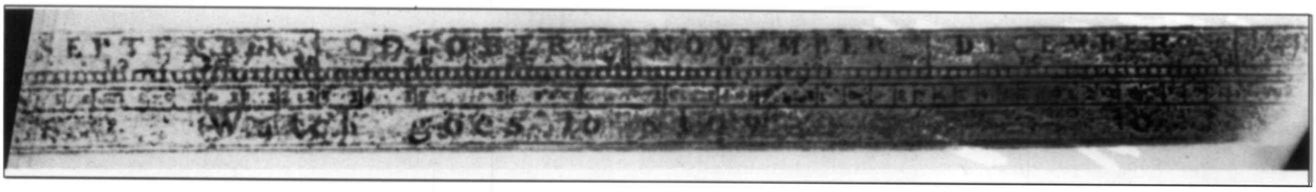


Fig.8. A digitally-enhanced negative photograph of the least-corroded part of the EoT scale on the gnomon.

hours, are the names of (probably) 34 world-wide locations (Table 2), making this a "geographical" dial. Several of the names, especially in the evening hours, are difficult or impossible to read. The dial may thus be regarded as the prototype for the "Grocers'pattern" dials[9] which became so widespread over the next three-quarters of a century. Wynne made other geographical dials (such as those at Euston Hall and Wrest Park) having complete chapter rings for each location, in the position occupied by the moon rings on the Staunton Harold dial. On the Drumlanrig Castle dial, he used two dedicated rings to show the times of noon for 50 locations[12], in the style later adopted by Thomas Wright. The names of the places used on the various dials are not in general the same. Clearly, on the Staunton Harold dial, some were chosen simply because they had (or were believed to have) the right longitude for the time on the dial. Thus although places such as "*Athens in Greece*" are a natural choice, "*Balasore in yͤ Mogulls Kingdom*" or "*Nickerie River in Guiana*" took much effort to read and to locate on a modern map. Table 2 shows that Wynne's longitudes were generally within a degree or two of the correct values and also confirms that he made the proper allowance for the longitude of Staunton Harold.

GNOMON AND EoT SCALES

The gnomon is literally covered by engraving on all surfaces (Fig 6). The rectangular calendar scales on both sides of the main triangular area have already been described. Surrounding these tables are superb floral borders (perhaps sunflowers or daisies?) engraved in deep relief. Similar, though not identical, borders can be seen on the Wrest Park double horizontal and also the Windsor Castle garden dial though in these cases they surround coats of arms and a pierced monogram, respectively.

On the underneath edge of the tail of the polar gnomon is a motto running top to bottom:

NULLA DIES SINE LINEA

which may be translated as "no day without lines" or, more freely, as "another day, another line". This motto has been found on other dials, for example the stained glass dial originally at Wendon Lofts, Essex. It is likely that very few casual viewers of the dial ever notice this motto.

The most exciting part of the gnomon is the fact that it has an Equation of Time scale running the full length of the top edge (Fig. 8) and reading from bottom to top. Assuming that the dial was made in 1685, this could well be the earliest extant EoT scale on a dial (the 1675 Wynne dial at Kinnaird Castle is sometimes claimed[19] to be the earliest but the table was added about a century later[14]). The position, believed unique, means that the scale is just 17mm high but around 550mm wide. It is now badly corroded, especially near the bottom, so that only some of the values can be read. The scale gives the months, named in full and divided to individual days with the 10s numbered. Then there are numbered tick marks for each minute of EoTand finally the legends "Watch goes to Fast (Slow)" (sic). Just visible at the maxima/minima of EoT, amongst the minute numerals, is faint evidence that the excess number of seconds has been recorded, although the values cannot be read with certainty. Thus, at an early stage of development, all the features of the EoT scale on high quality dials for the next century are found.

Careful study[14] of the EoT values which can be read leads to a strong indication that the source of the data that Wynne used was the same as that printed by Thomas Tompion in 1683 as a table for pasting inside his longcase clocks, and also engraved on one of his sundials[15]. Certainly, the values do not match the very earliest tables of Flamsteed or Huygens. Robert Hooke was working closely with Tompion on a spring driven watch and meeting him almost daily[16], and is known[17] to have given him an equation table on 13 December 1674 (although the original source of the table is unknown). Since Wynne was also in contact with Hooke, it seems likely that he also had access to the same data.

CONCLUDING REMARKS

It may be of interest to examine how many of the features of the dial can still be used, more than three hundred years after the original was made. Obviously the polar dial is still operational and so is the azimuth dial if ten days are added to the date scale to compensate for the change to the Gregorian calendar in Britain. The tables of epact and dominical letters are of course out of date but if the epact of the current year is known the age of the moon can be found by Wynne's method and the moon dials will work as accurately (or rather inaccurately) as before. The star right ascensions have been altered by precession and are now about 15 minutes later than the 1650 positions leading to a corresponding error in times found by the nocturnal.

There is no doubt that the Staunton Harold dial represents a peak in the dial-makers art, combining well established astronomy with the latest research results and much artistic flair. Despite the occasional mistakes in its design, it formed a prototype for succeeding generations of dial-makers.

Acknowledgements

The authors are pleased to thank the following people for their help in preparing this article: The Earl and Countess Ferrers, Christopher Daniel, John Fox, Leicester Record Office, English Heritage, Michael Cowham, George Huxley.

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SUNDIALS FOR THE BLIND

A. A. MILLS, P. STAPLETON AND J.P.D. HENNESSY

One tends to think of the sundial as purely a visual instrument, useful only to the sighted observer. Yet back in the 17th century the Jesuit priest Francis Hall ('Linus') was seeking to make a 'sundial for the blind' by utilising the heat of the Sun. He arranged a spherical flask filled with water to throw a crude solar image upon a ring of metal figures, with the expectation that a blind person would be able to feel the hottest numeral. This dial was part of a formidably complex and fragile assembly, and had only a short life before it was destroyed by aristocratic vandals of the period.[1-4]

We wished to make a dial accessible to both blind and sighted visitors that utilised solar energy alone. This ruled out models employing electronic signalling of the hour[5,6] – although utilising solar cells could perhaps be argued as meeting the criterion! We felt that the principle pioneered by Hall held potential for modern development.

The standard sundial utilises only the visible solar radiation, but some 35% of the total available energy falls in the infra-red (Fig.1). A blackened surface absorbing throughout the spectrum will experience maximum heating,

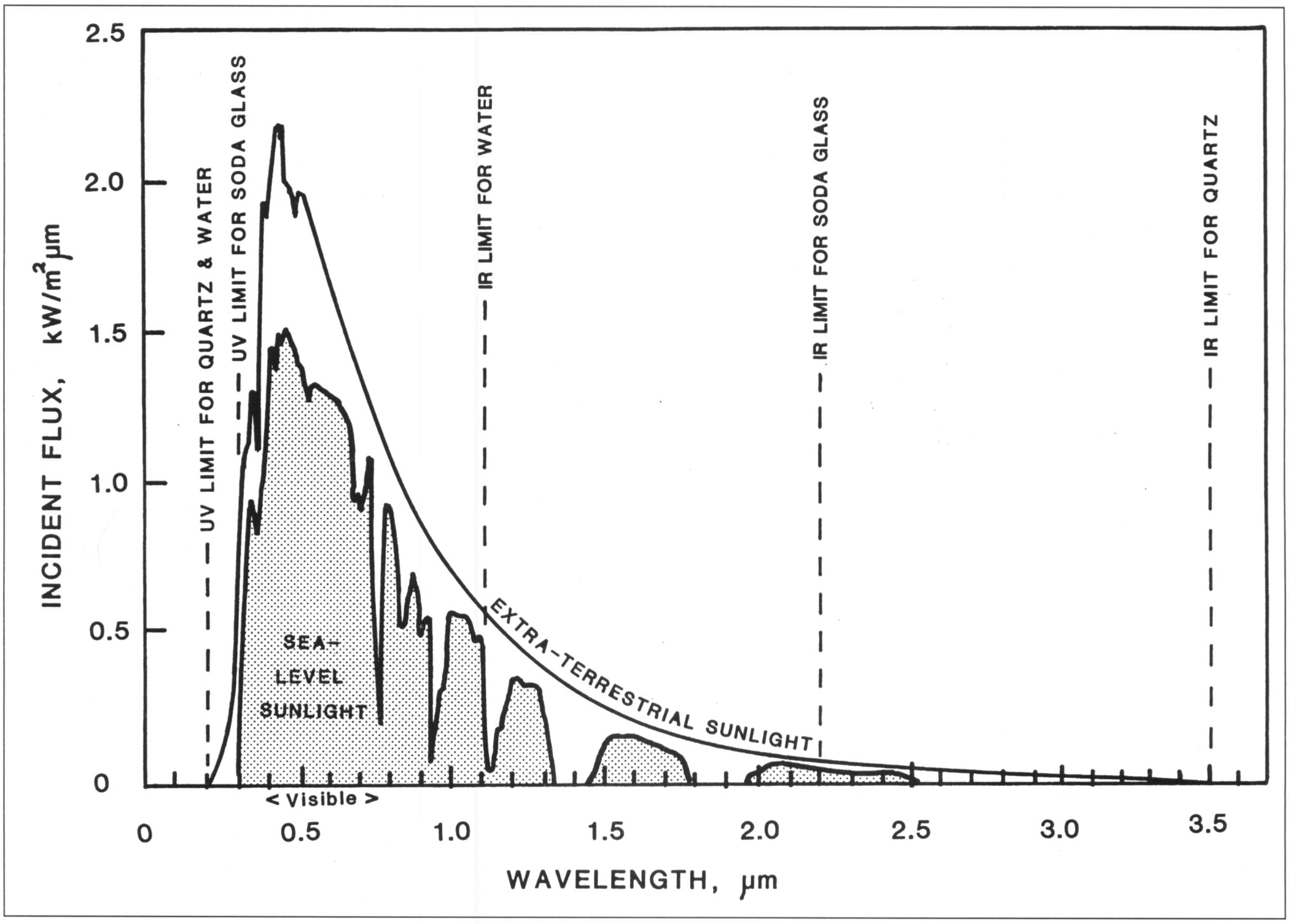

Fig. 1.

its temperature rising until the incoming energy is balanced by conductive losses plus energy re-radiated in the long I.R. This phenomenon is utilised in burning glasses and mirrors, much used in past centuries to attain high temperatures.[7] The continuous motion of the Sun across the sky usually necessitated manual guidance of such a solar furnace, but was ingeniously overcome by the spherical lens in Hall's design. The same stratagem is used in the Campbell-Stokes sunshine recorder, where a solid glass ball concentrates the heat of the Sun sufficiently to scorch a record upon a paper scale. With a sphere of glass or other transparent material of refractive index around 1.5 this scale must be positioned about half the radius of the sphere from its outer surface.[8] Soda glass or Perspex are better than flasks of water, for they transmit further into the I.R. and do not run the risk of freezing in winter.

PRINCIPLE

It seemed to us that replacing the metal figures or paper scale in the above instruments with an array of blackened bimetal strips would produce a better sundial for the blind, for differential expansion consequent on heating causes this material to bend. Small pegs at the outer ends of the strips could therefore be arranged to protrude through holes in a band marked with embossed Braille numerals. For the sighted user, light could be focussed on a translucent hour scale.

PRACTICAL FORM

An early prototype embodied a sphere and coaxial cylinder of the same diameter, turned together from a single block of Perspex. However, the heating produced by the sphere proved to be too localised and intense. A revised version employed a simple cylinder of Perspex, 100 mm in diameter by 83 mm long, to focus the Sun's light and heat into a line, again at about r/2 (25 mm) from the polished surface of the cylinder (Fig.2).

Thanks to the courtesy of Kanthal Ltd[9] a length of their 127 R09 LE bimetal strip was available, measuring 19 mm wide by 0.3 mm thick. The constituent Ni/Fe alloy foils had been so intimately rolled together that it appeared a single metal. Pieces 52 x 9 mm were guillotined from this stock, rounded brass pegs riveted on, and the assemblies chemically blackened. They were then secured at 7.5° intervals around a PTFE ring as shown in Fig.3. The visual scale was illuminated by light from the lowermost portion of the Perspex cylinder, an intermediate screen of the semi-reflective film sold for application to windows removing excess light and heat.

Fig. 2.

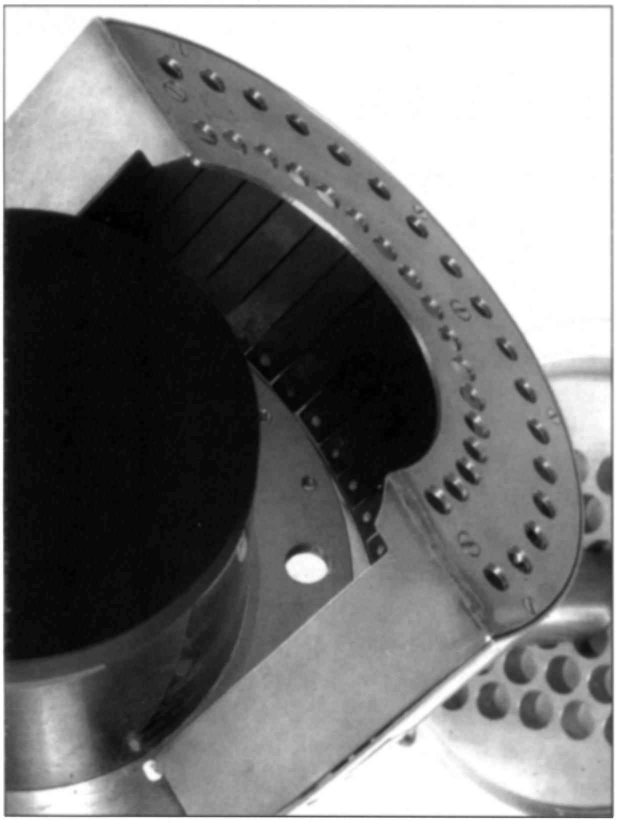

Fig. 3.

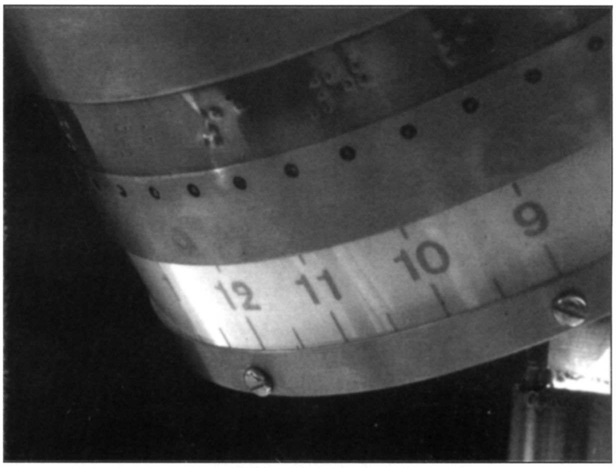

Fig. 4.

When set with the axis of the cylinder pointing approximately towards the celestial pole, it was found that the appearance of a clear Sun sufficient to throw definite shadows caused the appropriate peg to protrude (Fig.4). A snag has been discovered though – the ferrous-based bimetal metal alloys are very susceptible to rusting on exposure outdoors. A maraging grade of stainless steel bonded to aluminium alloy should be more resistant to corrosion – it has been used for high quality saucepans! Meanwhile, the existing dial has been sited in a sunny conservatory.

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READERS' LETTERS

ANOTHER LEADED-IN GNOMON?

I was interested to see the letter from John Lester in 'Readers' Letters' in Bull.BSS. 15 p.17 entitled 'A Leaded-in Gnomon'. The letter added support to the article by Christopher Daniel on the Dinton Church sundial (BSS Bull 14 iv, 2002.)

I believe that there may be a further example in existence, to be found in the churchyard of St. Nicholas Church at Landwade in Suffolk. Although there is not a complete gnomon there, the top of an octagonal sectioned column carries two separate pieces of metal, both being embedded in lead. The two pieces are aligned together and set at right-angles to one of the faces of the octagonal top. Perhaps these pieces of metal were the fixing lugs of a gnomon. Interestingly, these two pieces are currently aligned in an E—W direction, the smaller of the two being closer to the west-facing edge of the octagonal top. If these pieces were indeed fragments of a dial gnomon, perhaps the whole column has been moved in the past, and incorrectly repositioned by 90° from the N—S direction. The column stands on a large square base on the south side of the church. Although the column is plainly old and well-worn by time, there do not appear to be any markings engraved on the plinth top. Perhaps this adds further evidence to support the conjecture of a 'free-standing' gnomon on early horizontal dials, as put forward by our chairman.

Landwade Church is in an 'estate setting', adjacent to Landwade Hall, about 3 miles north-west of Newmarket. Although the church is normally locked, the keys for access may be obtained from Landwade Hall. The church is featured in 'England's Thousand Best Churches' by Simon Jenkins. It is well worth a visit, just to view the magnificent memorial tombs to members of the Cotton family who held the estate from the 15th to the 19th century, apart from being in a gracious English parkland setting.

The photograph shows the leaded-in fragments.

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A SUNDIAL ON A PUBLIC HOUSE

Back in 1994 whilst I was talking with the late Charles Aked, he mentioned that he had never come across a sundial on a Pub! So I have kept my eyes open for one ever since. The one I have found is on the front of the Red Lion Inn, in the village of Hernhill opposite the green and St Michaels church. The dial-- which has the date of the building, 1364 AD, above it-- is on the south facing front wall of the pub, and has a wrought iron gnomon mounted directly on the white painted plastered wall, with an arc of roman numerals below.

The enclosed photographs were taken around noon; the gnomon would appear to be at a too shallow angle for accurate time keeping.

On the opposite side of the road in St Michaels Church Yard there is a well made horizontal sundial, with a notice commemorating eight local men who in 1838 were followers of a local rabble-rouser known as Mad Thom, or Sir William Courtenay. They were shot dead in nearby Bossenden Wood by soldiers sent to arrest them.

Hernhill is a lovely small village set on a hill, inland to the south of Whitstable in Kent. There is an old manor house and a row of 15th century cottages with the traditional village green.

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'ASTROLOGER' AT PALERMO

I was surprised to read in an article on the meridian line in Palermo Cathedral, published in the March 203 issue of the Bulletin, that Piazzi, its designer, is described as an astrologer.

Not so. Guiseppi Piazzi was in fact an outstanding astronomer, Director of both the Palermo and Naples observatories, discoverer of the first minor planet Ceres, and compiler of important star catalogues. He was elected Fellow of the Royal Society and was the godfather of Charles Piazzi Smyth later Astronomer Royal for Scotland. Piazzi was certainly very capable of laying out an accurate meridian line.

R. H. Chambers
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DA14 4SB

{The writer of the article reports that the use of the word 'astrologer' is a direct quotation from the English-language guide-book of the cathedral. It seems likely that this was a mistranslation from an Italian guide-book, by a translator unaware of the pejorative overtones of this word in English; and that 'astronomer' would have been the appropriate translation of the Italian.

A note from John Heilbron, author of the book 'The Sun in the Church' mentions that his book includes two coloured pictures of the Palermo meridian. He mentions also that there is another slightly later meridian line in Sicily, built by the Danish astronomer Peters, for the cathedral at Acireale, halfway up Mount Etna. - Ed.]

COALBROOKDALE SUNDIAL PILLAR

In the churchyard at Little Wenlock Shropshire, a horizontal dial is mounted on top of an ornate cast-iron pillar. An enquiry to Mr John Powell, the Librarian at the lronbridge Gorge Museum verified my supposition that it might have been made by the Coalbrookdale Company Limited in the 19th century. He kindly sent me a copy of a catalogue entry (q.v.) from Ca. 1880 showing this pillar which he thinks may have been in production even before that date. [This is apparently the only reference in the company's catalogues to sundials so it must be concluded that the cast-iron dials currently on sale at the Museum of Iron's shop, with their incorrectly angled gnomons, are not based on original models].

SUNDIAL PILLAR.

51 ins. high, 9¾ ins. sq. at top.
Prepared for but *exclusive of Dial.*
Plain painted ... ... **106/-** each.

Both Mr Powell and I would be interested to know whether anyone else has encountered other examples of this pillar and would be grateful for information.

John Lester.
24 Belvidere Road
Walsall, West Midlands, WS1 3AU

CELESTIAL RING DIAL

HEINER THIESSEN

Would you like to be able to read your sundial both at day and night time, even with the Moon merely peering through the clouds? This equatorial dial can be read with sunlight, moonshine as well as with the twinkle of a fixed star of your choice. It is intended to be an educational precision instrument (with a tolerance of +/- two minutes) that tracks the hour angle of the Sun, not only when it is visible in the sky but also when it has sunk below the observer's horizon.

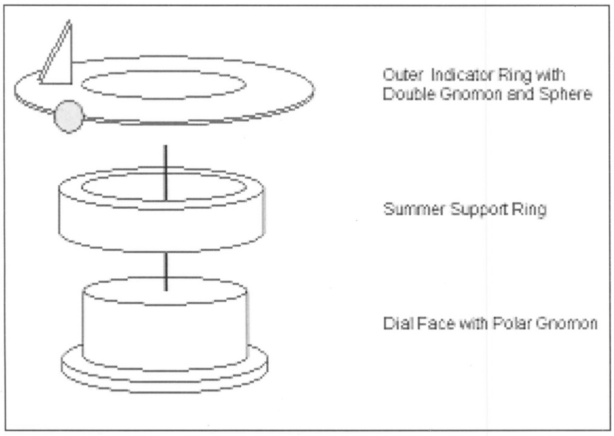

Fig. 1. The components of the Dial

WHAT ARE THE COMPONENTS OF THIS DIAL?

The dial consists of

1. a fixed circular dial face, representing the equatorial perimeter of our planet and showing the time markings for all 24 hours of the day.
2. an indicator ring, featuring the 360 degree marks of the celestial sphere, which it represents. The latter slides around the former, thus simulating the apparent motion of the heavens around planet Earth.
3. a summer support ring, fitting tightly around the circular dial face and designed to provide two distinct levels of operation for the mobile indicator ring:
   a) the summer level which raises the top of the indicator ring to the same height as the dial face itself and allows readings on the surface of the equatorial dial face.
   b) the winter level (without support ring) which reduces the height of the indicator ring by some 30mm, allowing readings on the outer cylindrical surface of the dial face. (see Fig. 1: Parts of Celestial Ring Dial)

The circular dial face with its perpendicular brass gnomon, pointing to the celestial North Pole, is slanted to the horizontal at the observer's co-latitude angle, thus being in the equatorial plane, and showing Roman numerals for all 24 hours of the day as well as time markings at 5 minute intervals. The correct slant of the dial face is achieved with the aid of a wooden plinth which has been cut at the correct angle for its location. The summer support ring rests on the outer bottom rim of the dial face thus bringing the top of the indicator ring to the level of the dial face. This support ring should be removed during the 'winter' period, i.e. from the autumn to the spring equinox. (see Fig. 2: Winter and Summer Reading)

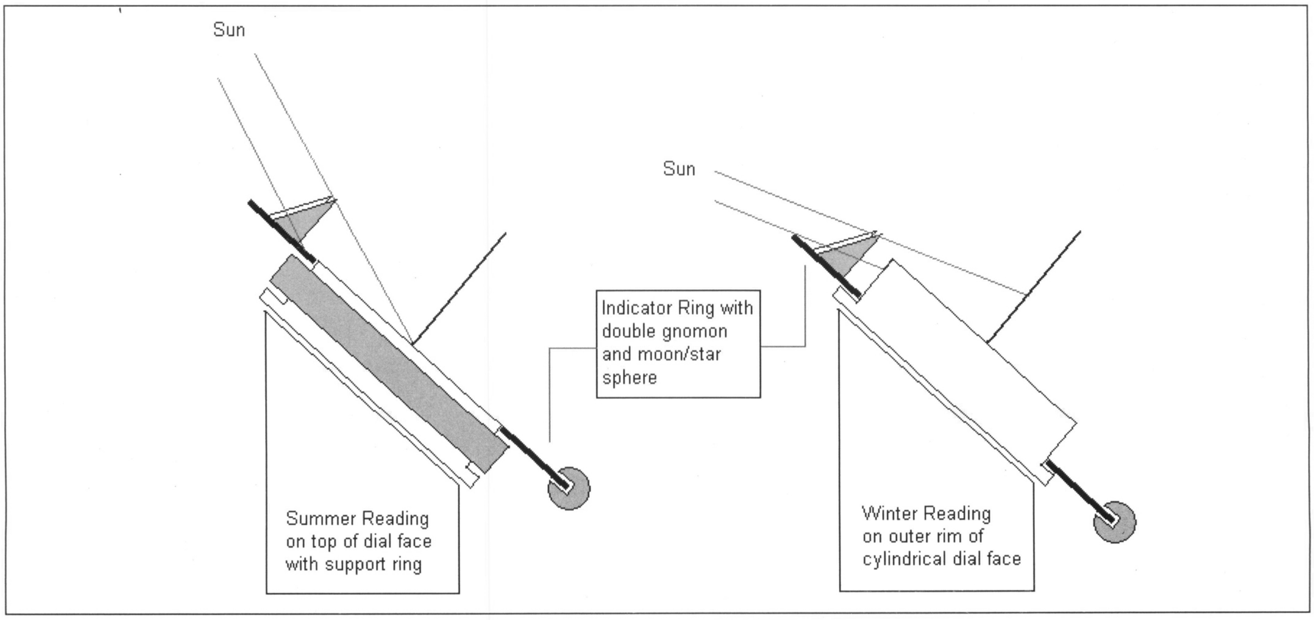

Fig. 2. Arrangement of the dial for Summer and Winter

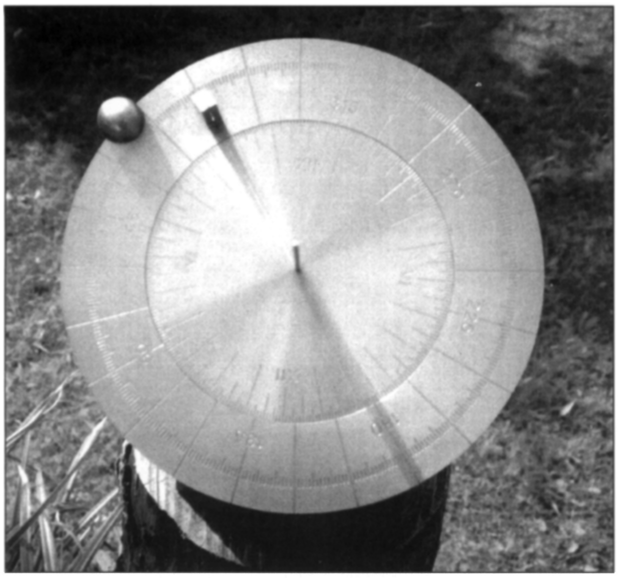

Fig. 3. Light-beam hits polar gnomon at 10 a.m.

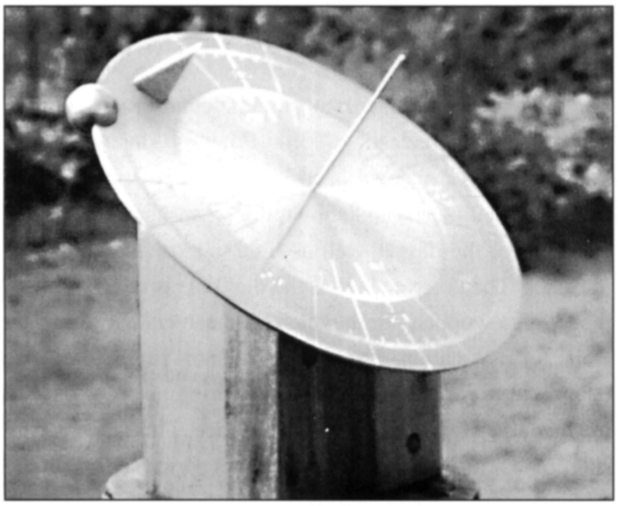

Fig. 4. Dial on its plinth cut at latitude angle

The mobile 'celestial' indicator ring with double gnomon and Moon/Star sphere, slides clockwise around the dial face and lies in the same equatorial plane. This indicator ring shows degree markings from 0 to 360 at one degree intervals with the centre slot of the double gnomon being permanently positioned on the 0/360 degree line. The double gnomon consists of a solid brass triangle of 50mm height and 10mm thickness with a 0.5mm gap cut through the centre of its thickness. As a result we see two triangles of 4.75mm thickness positioned in parallel, one to the left and one to the right of the Zero degree mark on the indicator ring. The triangular shape of the double gnomon itself is not relevant for L.A.T. readings as it is not its shadow but its light that measures the progress of time. Its shape was chosen for engineering reasons.

The Moon/Star Sphere is a solid brass ball of 30mm diameter and slides around the outer rim of the indicator ring through 360 degrees with the aid of a groove on the underside of the indicator ring. The sphere can slide freely, but it can also be locked into position with the help of an Allen screw (and key) on its underside. (see Figs. 3 & 4: Photos of the Celestial Ring Dial, Fig. 5: Attachment of Moon/Star Sphere)

WHAT CAN THIS DIAL DO?

It reads Local Apparent Time (L.A.T.) by sunlight, but it can also tell the hour by moonshine or by the progression of a chosen fixed star.

WHY DOES IT WORK?

It was the objective of this design exercise to make a dial that simulates the apparent movement of the heavens (mobile indicator ring) around the perceived 'terra firma' of planet Earth (fixed dial face). In analogy to the Earth's grid system of longitude and latitude lines, the celestial sphere has been similarly mapped with co-ordinate lines of declination (latitude) north or south of the celestial equator and Right Ascension (RA) in analogy to terrestrial longitude with its 'Zero' reference at the First Point of Aries, which is the Sun's position at the vernal equinox.

For day-time readings, the 'celestial' indicator ring, simulating the heavenly sphere in its apparent westward motion, tracks the hour angle of the Sun. With the Sun being the only point of reference for day-time readings, the double gnomon - in its proper alignment with the Sun - will read its hour angle, i.e. the distance of arc on the celestial equator, east or west of the local meridian. This is either measured in degrees (15 degrees = 1hour) or more conveniently in time (24 hours = 360 degrees). The dial presented here is merely a variant of the traditional equatorial dial, with the 'celestial' indicator ring tracking the Sun throughout the day and reading off L.A.T. on the fixed dial face. Hence its name.

The design also helps to visualize that an L.A.T. reading of 10:00 a.m. represents local noon at all locations 30 degrees east of the observer's meridian. Equally, 12:00 L.A.T. indicates local midnight some 180 degrees east or west of the observer's meridian. The keen dialist could even be tempted to calculate his local solar time at which the new day and thus to-morrow's calendar date kicks in on the other side of the globe, as local midnight hits the international date line at 180 degrees longitude.

For night-time readings, the 360 degree markings on the 'celestial' indicator ring become all important. While the Sun's position is associated with the 'Zero' degree line (position of double gnomon), all other degree markings on same indicator ring *refer* to RA, i.e. the longitudinal co-

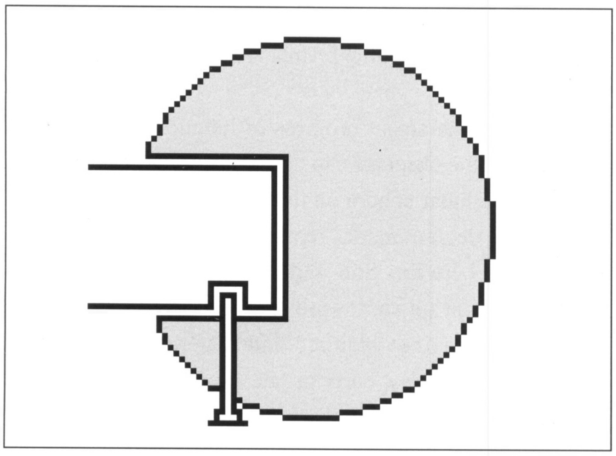

Fig. 5. Fixing of lunar sphere to rim of indicator ring

ordinate on the equatorial plane, measuring the angular distance along the celestial equator from the First Point of Aries at Zero degrees to the hour circle of any heavenly object we might wish to use for our readings. However, the degree markings on the 'celestial' indicator ring do not represent the longitudinal RA itself, but the calculated *difference*, between the RA of the Sun and the RA of the Moon or between the RA of the Sun and the RA of any chosen fixed star at the time of observation. Once this difference in RA has been calculated and the model sphere has been moved to the appropriate degree marking on the 'celestial' indicator ring, it becomes possible to track the hour angle of the Sun, even when it has sunk below the observer's horizon. By aligning the correctly positioned model sphere with the celestial body in the sky and the polar gnomon on the dial face, the hour angle of the Sun can be deduced by the position of the double gnomon on the Zero degree line, which now reads L.A.T on the fixed dial face. (see Fig.7: Alignment with Moon or Star) As the night progresses and the observer wishes to take additional readings, the indicator ring has to be moved in clockwise direction, thus simulating the apparent westward rotation of the celestial sphere.

HOW DOES IT ALL WORK?

In order to read L.A.T., the observer slides the indicator ring clockwise around the inner disk, until the double gnomon is perfectly aligned to the hour angle of the Sun and a narrow shaft of light, passing through the 0.5mm gap in the double gnomon itself, will not only point to the correct time, which is engraved on top of the equatorial dial face, it will also reach the very centre of the dial face which is the root of its perpendicular brass gnomon. The double gnomon's height of 50mm is sufficient for the line of light to reach the centre of the dial face and to climb the polar gnomon some short distance, even at the highest solar declination of 23.5 degrees at the summer solstice. As Fig. 3 illustrates, the polar gnomon itself is not strictly necessary for summer day-time readings. It is sufficient, to see the line of light to be perfectly aligned with the centre point of the dial face.

During the winter period (i.e. from autumn to spring equinox) the double gnomon's shaft of light can be read off on the outer rim of the dial face. The narrow strip of light will also bounce off the cylindrical surface at the top end of the polar gnomon, thus confirming accurate alignment. All this is made possible by removing the summer support ring on which the indicator ring slides through its 360 degrees during the 'summer period'.

It is also possible to read L.A.T. without direct sunshine. As long as the position of the Sun is somehow visible, even through modest cloud cover, the observer can align the polar gnomon of the dial with the centre gap of its double gnomon and the Sun itself. The double gnomon should now point to local solar time on the dial face. Precision will depend on the quality of alignment, but the procedure enables the dialist to read L.A.T. without blue skies.

READING TIME BY MOONLIGHT

The lunar sphere on the outer rim of the indicator ring can be moved through 360 degrees during the period of one lunation. The time from one New Moon to the next is of an average duration of 29 days, 12 hours, 44 minutes and 3 seconds. During this period the Moon moves through more than 360 degrees as it has to re-align itself between Sun and Earth for the next New Moon, while the Earth itself has travelled approximately another 1/12 of its annual orbit round the Sun. As a result the Moon moves through an average arc of 13.2 degrees per day, or approximately 0.55

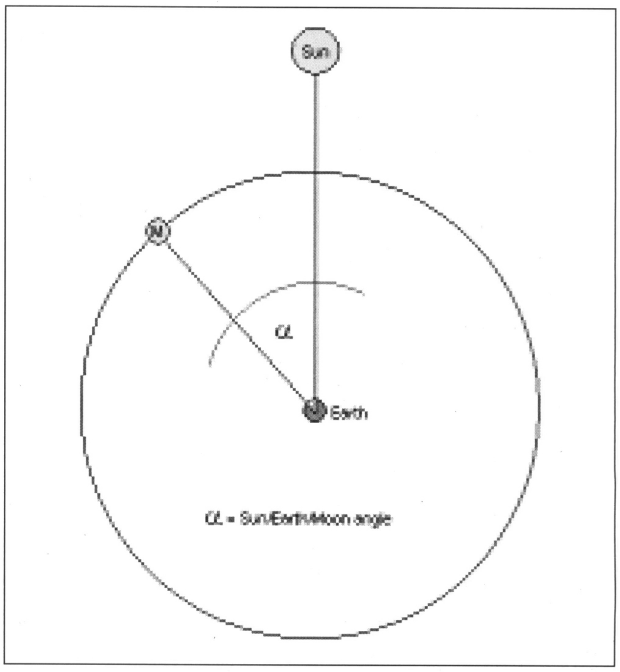

Fig. 6. Sun/Earth/Moon angle

degrees per hour. A rough rule of thumb suggests: the Moon moves the distance of its own diameter in about two hours.

However, as a result of the eccentricity and inclination of its orbit, the actual velocity of the Moon changes constantly. Variations between two transits may range from 38 to 66 minutes, while the average time gap between two transits is 50min 30secs. The best way forward to read L.A.T. by Moon light is by employing the Sun/Earth/Moon angle (see Fig. 6: Sun/Earth/Moon Angle). This angle is the difference of the RAs of the Sun and the Moon and thus of the hour angles of the Sun and the Moon at the time of observation.

Here is a sample of the values for Sun/Earth/Moon angles for the 21 June 2003:

2003-06-21 12:00 GMT-89.32 deg.
2003-06-21 14:00 GMT-88.49 deg.
2003-06-21 16:00 GMT-87.66 deg.
2003-06-21 18:00 GMT-86.83 deg.
2003-06-21 20:00 GMT-86.01 deg.
2003-06-21 22:00 GMT-85.19 deg.

While positive and rising values refer to a period from New Moon to Full Moon, negative and declining values, as above, indicate a waning Moon. Comprehensive data for such Moon readings (for day and night at 2 hourly intervals) can be found at www.obliquity.com. The Sun/Earth/Moon angles on this website have been calculated by Dr. David Harper at Obliquity Consulting, UK using the same methods as those employed in the production of The Nautical Almanac.

According to the actual progress of lunation at the time of observation, the observer can now consult the source above and slide the lunar sphere on the outer indicator ring to the appropriate degree mark, representing the difference in hour angles between Sun and Moon. The observer now points the Moon sphere towards the real Moon in the sky. A Moon shadow is not required and readings can be taken both at night and day, early or late in a lunation. A simple alignment between the dial's polar gnomon, the centre of the moon model and the real satellite in the sky is sufficient. The double gnomon on its Zero degree mark on the 'celestial' indicator ring should now indicate L.A.T. (see Fig.7: Alignment with Moon or Star)

Sun/Earth/Moon angles are shown as either rising from zero to 360, or like above, as rising from zero to 180 and falling back from -180 to zero. Although the GMT times for Sun/Earth/Moon angle values of 90, 180 and -90 degrees can be loosely associated with the First Quarter, Full Moon and Third Quarter of the Earth's satellite, the Moon's inclination to the ecliptic by up to 5 degrees can mean, that the ephemeris times for Quarter and Full Moons (which are measured in degrees of longitude along the ecliptic), may not necessarily coincide perfectly with the former. It is therefore important for Moon readings to be guided by 'differences in RA' or 'differences in hour angles' which refer to the plane of the celestial equator and not by published times for Quarter and Full Moons which refer to the ecliptic plane.

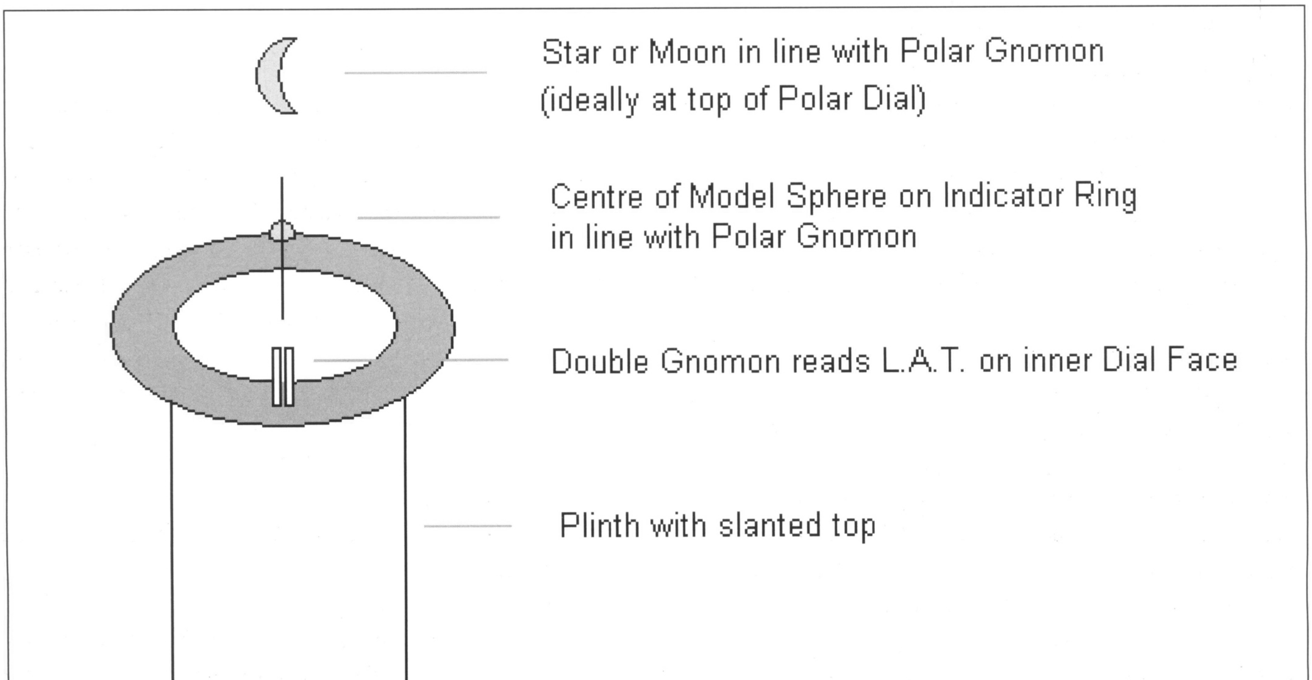

Fig. 7. Lining-up of gnomons, lunar-sphere and moon

The principle of corrections for EoT, longitude and summer time applies. Precision of Moon readings can be limited as the Moon itself is a fast mover on its orbit round its rotating mother-ship and the position of the model lunar sphere on the dial needs to be up-dated regularly by approx. 1.1 degrees for every two hours. It is perhaps worth remembering that the model Moon travels anti-clockwise on the outer indicator ring as the lunation progresses, while the indicator ring itself slides in clockwise direction throughout day and night.

With the model sphere in its correct position on the outer indicator ring and the double gnomon on the correct L.A.T. mark (GMT +/- EoT, longitude, and BST corrections) , the dial can also be of assistance to locate the position of the real Moon in a cloudy night sky, or even during day time, when the waxing or waning Moon may appear to be less prominent.

The keen critic however might suggest with some degree of justification that all this appears to be a little 'circular', as one requires to know the time of observation (to work out the difference in hour angles) in order to read the time by Moon light. And this is perfectly true: the dial merely mirrors the positions of Sun (double gnomon) and Moon (Moon sphere) throughout the entire lunation and helps us to marvel at the beauty of our relatively 'local' astronomy. One might perhaps argue that this exercise is not merely about reading time but more so about closely tracking our nearest heavenly neighbours, with the help of a constantly clockwise and thus westward moving indicator ring.

READING TIME BY STAR LIGHT

Fixed stars are much more predictable in their apparent movement than the Earth's satellite, but the same principle applies as for reading L.A.T. by Moon light. The observer chooses a fixed star with a sufficiently low declination, that is visible throughout the entire period of observation. S/he then finds the appropriate Sun/Earth/Star angle with the help of a planisphere. (Read current RA values for Sun and fixed star on the outer rim of the planisphere with its 360 degree markings and work out the difference) This calculated angle is also the difference between the hour angles on the equatorial plane of a chosen fixed star and the Sun and changes by approx. 1 degree per day, gradually diminishing as the Sun progresses on its path on the ecliptic. The sliding sphere on the outer indicator ring, now representing your chosen fixed star, moves in clockwise direction, as does the indicator ring itself.

One full (sidereal) rotation of the Earth takes 23 hours, 56 minutes and 4 seconds. This is the time that it takes for a star to return to a given point in the sky. On the other hand, the average time from one solar noon to the next is 24 hours. As a result, we can see a particular star at a given point in the sky 3 minutes and 56 seconds earlier every night. This means that between consecutive midnights the observed star will appear to have moved westward by approx. 1 degree. (360 degrees : 365.242199 days per average year = 0.986 degrees per day) In 15 days the star will have moved westward by approx. 15 degrees. (14.785 degrees to be precise)

At the spring equinox 21/22 March the Sun's position on the ecliptic is at the 'First Point of Aries', or at Zero degrees of RA. The fixed star Sirius in Canis Major on the other hand is 'fixed' at 101.2 degrees of RA. As a result, the difference in hour angles between the Sun and Sirius at the time of the spring equinox is exactly 101.2 degrees, i.e. 101.2 minus 0 degrees .

The observer moves the model sphere to the 101 degree mark and points it to its real counterpart star in the sky, again aligning the dial axis (polar gnomon), the centre of the star model sphere and the heavenly object itself. The double gnomon should now read L.A.T. (see Fig.7: Alignment with Moon or Star) On the following night of observation the difference in hour angles would be reduced to 100 degrees.

Throughout the year, three or four such fixed stars have to be chosen, to be able to read L.A.T. by starlight. The author has selected Sirius in Canis Major (for December to April), Spica in Virgo (for April to July) and Altair in Aquila (for August to November).

GMT AND BST

The dial model could be further enhanced by fitting a smaller mobile Dial Disk through the polar gnomon onto the top of the permanently fixed Dial Face. This smaller disk could be adjusted on a daily basis for EoT, Longitude Correction, as well as for Daylight Savings Time or even for another chosen Time Zone. As a result, the observer would be able to additionally read GMT/BST, or even US Eastern Time if preferred, by observing the narrow shaft of light, cast by the double gnomon and falling onto the time markings on the smaller mobile disk.

THE POLAR GNOMON

The polar gnomon (or the axis of the dial face) has the following functions:

1. It aligns the Moon or any chosen fixed star with the centre of the model sphere on the indicator ring for night time readings.
2. It aligns Sun and centre gap of the double gnomon for

overcast day-time readings.

3. It confirms the precision of day-time L.A.T. readings, when the narrow shaft of light, emanating from the double gnomon finally hits the polar gnomon itself and bounces off its cylindrical surface. This applies to both, summer and winter readings.
4. It would be possible to take winter day-time readings, merely with the shaft of light from the double gnomon bouncing off the top end of the cylindrical surface of the polar brass gnomon. This could be done, even without removing the summer support ring.
5. The shadow of the polar gnomon itself , which has a 3mm diameter, is less precise than the narrow shaft of light emanating from the double gnomon and its use for L.A.T. readings is not recommended.

ENGRAVING

The centre of the Dial Face will be engraved with the Greek Motto:

ΕΚ ΤΟΥ ΚΟΣΜΟΥ ΦΩΣ. It means: The universe brings light.

Or literally : Out Of Cosmos Light.

MAKERS AND DESIGNER

The dial has been made by APM Precision Engineering, Horndean, East Hampshire. Engravers were R&T Industrial Engravers, Havant. The outer indicator ring (280mm diameter) is laser cut. Dial face and outer ring are made of stainless steel (marine grade 316S) . Double gnomon, moon/star sphere and polar gnomon are solid brass. Dial design by Heiner Thiessen.

SUNRISE AND SUNSET

... and finally, here is a genuine question, which I would like to share with the readership: I wonder whether anybody might be able to suggest a way to read times for sunrise and sunset, without adding greatly to the furniture of the dial. I would be pleased to hear from you.

ACKNOWLEDGEMENTS

My thanks go to John Moir who has been very helpful in providing me with the theoretical foundations on the movements of the Moon. I am equally grateful to Dr. David Harper from Obliquity Consulting, UK who has very kindly supplied the time series on 'Differences in Hour Angles between the Sun and the Moon'. Dr. Harper has also lodged these time series on his website, for the benefit of the BSS readership. And finally I would like to thank Ted Howells from Chichester Planetarium who very kindly checked the astronomy of the dial before I spent any real money.

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A 17th CENTURY CHURCHYARD DIAL

JOHN DAVIS

This simple horizontal dial (Fig 1) sat largely disregarded in the churchyard of St. Mary's Church, Weston Colville, Cambridgeshire, for nearly 350 years. Then a moment's vandalism snapped off the gnomon. Fortunately, decisive action by the churchwarden prompted the vandal to return the missing gnomon. Then, via the good offices of the Bulletin Editor, I was lucky to be able to visit Weston Colville in late July 2002, to study the dial and subsequently to repair it. It is of sufficient interest that it is now kept in a safe place, away from further harm.

The dial, dated 1665 and signed "Thomas Soame", is some 177 mm square and only about 1mm thick. It is very much a provincial piece and not one made by a London mathematical instrument maker. Thomas Soame was probably the donor and not necessarily the maker. He was buried in the churchyard and his tombstone, with his coat of arms, reads:

> "Here lieth the body of Thomas Soame gent.
> Late of Hundon in Suffolk who died Jan 28 A.D. 1670
> in his 82nd year"

He is believed to have been a Royalist in the Civil War and this may explain why he moved from the neighbouring county of Suffolk, which was largely for the Commonwealth. The parish records for Hundon show several Soames at that period, mainly as farmers. The 1639 Ship Money Returns show a Thos. Soames charged 13s 6d, suggesting that the family was relatively well off.

Fig. 1. General view of the dialplate. Note that the dial has been sprinkled with talcum powder to enhance the engravings - in real life, the whole dial is very dark.

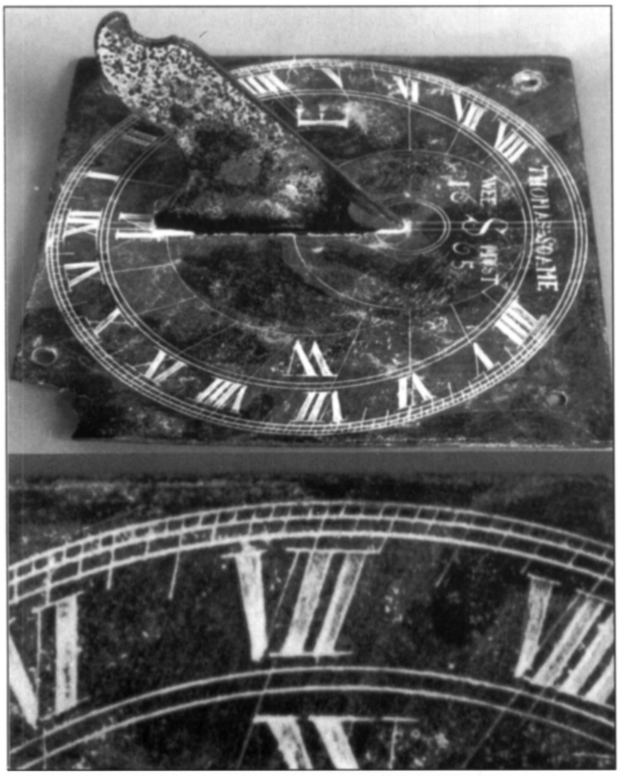

Fig. 2. (Top) View of the dial showing the curious hooked gnomon. (Bottom) A view of the chapter ring showing the neat sixteenth-hour divisions.

The dial has the motto "WEE MVST" with the "Dy-all" being left implied only by the dial ("We must die all"). This was quite a popular motto of the time, especially as 1665 was a plague year, although Soames himself survived another five years. Some of the engraving on the dial is rather naïve, with the lettering being of uncertain height, the diagonal of the N on the compass being reversed and the E being oriented differently to the other directions.

At first sight, it appears that the hours are divided into 5-minute sub-divisions. On closer inspection, however, it is seen (Fig. 2) that each quarter of an hour is neatly divided into four, giving sixteenths of an hour (3.75 minutes) and making the dial of particular interest as a transitional one. Earlier dials in the Tudor period and early 17th century were rarely divided into periods shorter than a quarter of an hour. By the end of the century, the best London dials[1] made for regulating longcase clocks were divided to individual minutes and carried fractional hours only as a secondary scale. It seems unlikely that the residents of a country district would have ordered their lives in such small time increments and I have yet to find a contemporary term for sixteenth-hours.

In contrast to the rather haphazard engraving of the lettering, the delineation of the dial is very good. Two small dots near the toe of the gnomon define the origins of the two style edges and the hourlines pass accurately through the correct one. The noon lines, with noon gap appropriate to the width of the gnomon, are accurately at right angles to the 6am - 6pm line - not always the case for provincial dials of this period. Fig 3 gives an error analysis of all 256 divisions and shows a high level of accuracy, almost comparable to that of a London mathematical instrument maker. The best-fit latitude of 52° 0 ± 5 is very close to the latitude of Weston Colville at 52° 8 N although it is perhaps fortuitous that this is near a whole number of degrees. The peaks in the error profile of Fig 3 show some tendency to being at 7.5° intervals of hour angle, i.e. on the hours and half-hours. This suggests that these lines were put in first and then the intervals were subdivided. The natural symmetry of the hourlines (am to pm, and before and after 6:00 am/pm) does not seem to have been exploited by drawing continuous lines through the two origins. The method by which the dial was laid out is thus unclear. Certainly, the modern method of trigonometrical calculation and a protractor would have been inappropriate, and geometrical constructions would have been time-consuming with so many divisions. This leaves the possibility that the layout was achieved by means of dialling scales, as invented in 1638 by Samuel Foster[2], put on a ruler in 1657 by George Serle[3] and described more recently by Sawyer[4].

The gnomon tapers from being about 3mm thick at the style edge to around 6mm thick at the back. It is thought that the hook shape near the tip is purely decorative: there is no sign that a plumb-bob was ever hung from it. The gnomon was

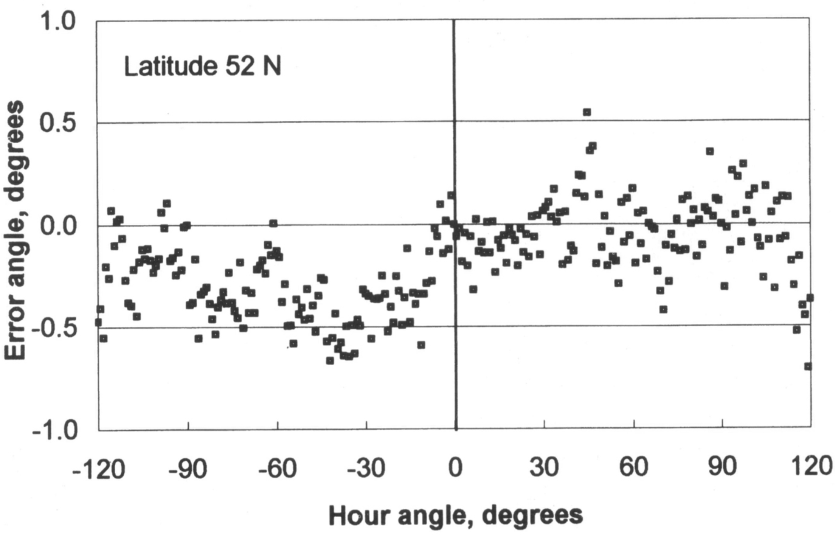

Fig. 3. Error analysis of the divisions. The best-fit latitude of 52° 0' was determined by minimising the least-squares of the errors. The standard deviation of the errors is 0.22°. The error angle is defined here as the angle of an hourline measured on the dial minus the theoretical value.

originally held in place by three tenons passing though slots in the dialplate and then swaged over. One of these tenons broke off when the gnomon was vandalised. As the dial is no longer subjected to weathering, the gnomon was repaired by means of hidden stainless steel screws and a brass spreader plate. This left the broken tenon unused, so it was available for compositional analysis. X-ray fluorescence measurements by the British Museum show that the material contained the elements shown in Table 1, so that it is somewhere between a "leaded brass" and a bronze. An earlier (probably 1595) churchyard dial was recently described in the *Bulletin*[5] and its composition[6] shows it to be much closer to a modern brass with a lead content of only 0.5% and 1.9% of tin. The earlier material is believed to be imported Flemish brass but the origins of the Weston Colville material have not been established. Its relatively low copper content when compared to typical bronzes often used for making the highest quality dials may be why the patina on the dial is very dark, with relatively little of the greenish speckles often associated with old dials. The very clean Cambridgeshire air, with little industrial pollution or sea atmosphere, has probably prevented much build-up of sulphates or chlorides. As a result, the dial is generally in excellent condition.

Element	Symbol	Amount (% by weight)
Copper	Cu	75
Zinc	Zn	11
Lead	Pb	10
Tin	Sn	3

Table 1. Composition of the gnomon, as determined by x-ray fluorescence. Trace amounts were also found of arsenic, antimony, nickel and silver.

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THE SUNDIAL AT NOVODEVITCHIY CONVENT IN MOSCOW

E.TH. THEODOSSIOU & V.N. MANIMANIS

Abstract

The European Astronomy Conference (JENAM 2000), held in Moscow in early June 2000, gave us the opportunity to visit the historical capital of Russia. The local organising committee successfully arranged for several guided visits to interesting places. Besides the Kremlin, the Red Square and the Gagarin's Square, we visited the historical monastery of Novodevitchiy Convent with an exquisite vertical sundial, which we describe in relation with the historical and architectural context of the city in which it is placed.

Key words: *Moscow, Novodevitchiy Convent, sundial, Gagarin's Square*

1. Moscow

Moscow lies in the vast green gentle valley of the River Moskva, which crosses it from one edge to the other. The city is structured along five concentric rings and a number of axles extending from the center towards the edges. This structure signifies the successive stages of Moscow's historical development and evolution, and also stresses the importance of the central point, the Kremlin.

The historical center and heart of this city of 9 million inhabitants is the fortified complex of the buildings of the Kremlin, in Kitay Gorod. This complex is built upon the low but strategic hill of Borovidskiy, on the north bank of Moskva. The area it occupies forms a rough triangle of 70 acres surrounded by a tall wall. As it is known, *Kreml* in Russian means a central fortress, a central fortified sector of a city. During the reign of Ivan III (1462-1505) the 'Italic Kremlin', built in the late 15th century, was fortified by a continuous wall with ramparts, 2250 metres long, made of red bricks. The thickness of the wall is 4 to 6 m and its height ranges from 9 to 21 m. It has 19 towers each of a different style, and five architecturally wonderful gates. Along the Kremlin's eastern wall is the largest square of the city, the famous Krasnaya Plosatch (Red Square). Fortified monasteries east and south protected the access to the city from these directions; and one of them is the Novoedvitchiy Convent.

A most impressive sight in Moscow is the huge complex of the Moscow State University, the M.V. Lomonosov University, built from 1949 to 1953. The University bears the name of Mikhail Vassilievitch Lomonosov (1711-1765), a poet and a scientist, a proponent of the education

Fig. 1: The Kremlin as seen from the Balshoi bridge on Moskva. From the left, the SW tower, the Great Palace and the Kremlin's Cathedral (right). The brick-red wall attracts the attention.

of the masses and an enemy of superstition. Besides his role as the first great reformer of the Russian language, Lomonosov contributed to the development of the natural sciences, reorganised the Academy of Sciences and made the plans for Moscow's first university (1755), whose building is at the centre of the city.

2. The religious history of Moscow

The Russians became acquainted with the Christian religion in 860 A.D. In the middle of the 10th Century (AD 957), Princess Olga of Kiev visited Constantinople and was baptised under the name Elene. Later her grandson Vladimir (972-1015), sovereign of Kiev and allied with the Byzantine Empire, married Anna the sister of the Byzantine Emperor Vassilios II, and became a Christian. This caused the immediate christianization not only of Kiev's Russia, but also of the other sovereignties of the Russian land (Novgorod, Suzdal, etc.).

Moreover, the Russians adopted the Cyrillic alphabet for the writing of their old Slavonic language, but also for the gradual acquaintance with all the religious and other literature of the rich Byzantine cultural heritage.

The earliest reference to Moscow dates from the 12th century (AD 1147); the city is cited as the residence of the nobleman Yuri Dolgoroukiy, sovereign of Rostov and Suzdal (NE Russia). Moscow became the religious centre of all Russians in 1326, when the bishop Peter, whose seat was in Vladimir, settled in Moscow after the fall of Kiev.

In 1472 the Great Prince of Moscow Ivan III Vassilievich (1462-1505) married Sophia-Zoe Palaiologina, the niece of Byzantium's last emperor. Because of this marriage, he considered himself the successor of the Byzantine Empire, which in 1453 had succumbed to the Moslem Turks; he adopted for his armorial bearings the Byzantine two-headed eagle and introduced the Byzantine rituals in the Russian Church. Thus, the eagle of Ivan's coat of arms became two-headed, and the Prince declared himself the inheritor and successor of Byzantium. Moscow became the 'Third Rome', the Rome of the Czars (the new Caesars). A few years earlier the Russian Orthodox Church had declared its independence from Constantinople (1458), giving as a reason the attempt of the Byzantine Church to sign their union with the Roman Catholic Church at the Synod of Florence (1439). As a result, after the fall of Constantinople in 1453, Moscow was the only free seat of a Patriarchate of the Eastern Orthodox Church. For Russia, Orthodoxy formed the emotional and ideological background of the union of the Russian territories into a strong European power.

During the reign of Ivan IV the Terrible (1547-1584) there appeared in Moscow the first stone churches, for example the churches of the Dormition and of the Annunciation in the Kremlin. The prototypes of these churches, during the reign of Ivan III, were made of wood, as were the churches of Vladimir. In this same century the onion-shaped dome

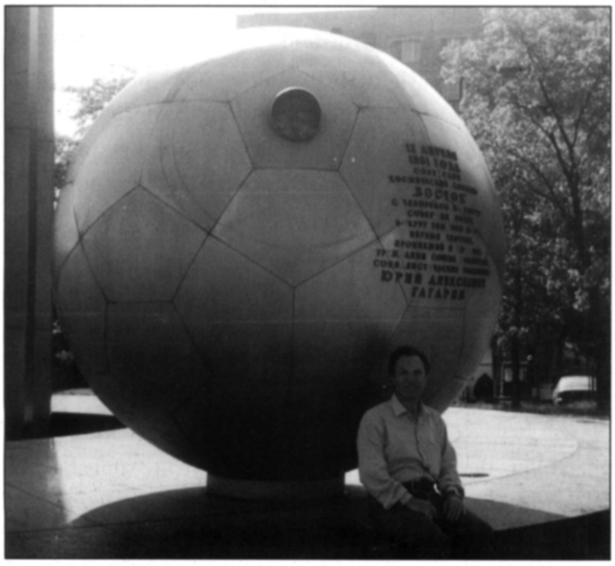

Fig. 2: One of the authors (E. Theodossiou) at Gagarin's Square in Moscow in front of a replica of Vostok I. This is the spacecraft in which Gagarin circumnavigated the earth in 1961.

Fig. 3: E. Theodossiou with Professor Telemachos Kalvourides of the National Technical University of Athens; they are standing under the exquisite sundial of the fortified monastery Novodevitchiy, situated close to Moscow's Kremlin. The shadow indicates the hour the photograph was taken (3 p.m., III).

was combined with pyramid-shaped endings and formed the characteristic outline of the Russian churches. Among them was the Kremlin's Cathedral of Christ the Redeemer.

3. The vertical sundial at Novovitchiy Convent

The local organising committee of the Conference successfully arranged a guided visit to interesting places. One of them was the Gagarin's Square with a huge statue of the cosmonaut Yuri Gagarin and a replica of Vostok I (Fig. 2).

We visited also the historical monastery of Novodevitchiy Convent with an exquisite vertical sundial. The architectural complex of Novodevitchiy Convent (= Convent of the New Virgins), built in 1524 in the greater Moscow area (55°45' N, 37°35' E) next to the River Moskva and near the stadium, bears the marks of architectural evolution. The traditional architectural canon of the five-domed church coexists with decorative elements of Western baroque. In Novodevitchiy Convent there are the graves of writer Anton Tchekhov and of Princess Sophia.

As in several cases of European churches and monasteries, in Novodevitchiy Convent, on the building immediately after the entrance there is a vertical sundial. This sundial is simple but nevertheless impressive, since its white colour forms a vivid contradiction with the red colour of its building, a brick-red similar to that of the Kremlin walls, only slightly lighter in order to resemble the colour of the central church in a Byzantine monastery, a colour symbolizing the Resurrection. At the same time, the colour of the sundial's plate fits with the white window frames and shutters, as well as with the white columns and gutters, thus forming a red-white ensemble. White and red are the two colours of the Easter (Fig. 3).

On the white semicircular plate of the vertical sundial (diameter 2.25 m) there are carved two concentric semicircles of smaller diameter (182 and 74 cm). On the ring formed between the two external peripheries are carved the hours with Roman numerals (height 16 cm) from 8 a.m. (VIII) to 7 p.m. (VII). Each one of the 12 carved hours is accompanied by the respective hour line, while the half-hour intervals are marked with ticks 6 cm long and the quarter intervals are marked with smaller ticks.

The sundial's gnomon is a plain iron rod at the center of the semicircles, supported, continental-style, by two iron supports, which may be angled in order to avoid casting confusing shadows.

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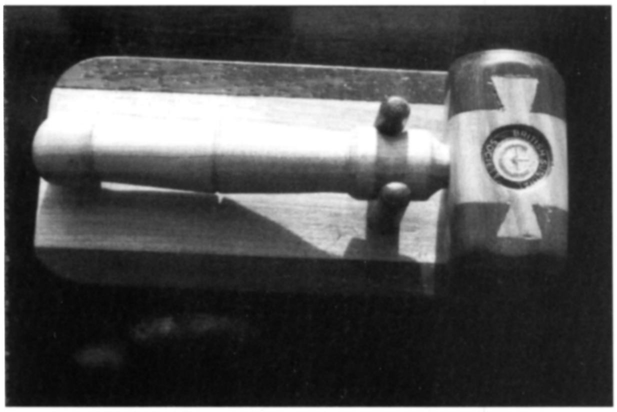
THE GAVEL: A NOTE FROM THE CHAIRMAN

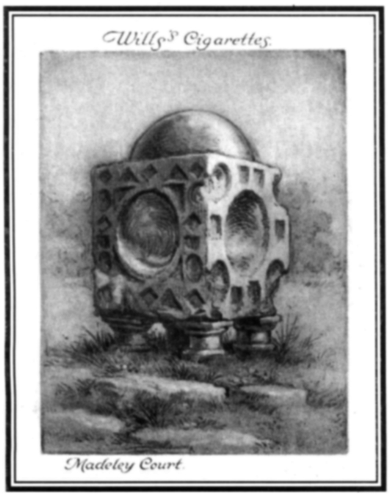
Dr John Lester has kindly made and presented a gavel to the Society, to enable the Chairman to call for order on official occasions, especially at the annual conference dinner, when proposing the usual toasts, and at the customary auction.

The gavel is constructed of two different contrasting kinds of wood, namely cherry and padauk (which comes from Burma). These are cleverly cut and dovetailed in a seemingly impossible manner, such that the warm red colour of the one wood stands out against the light sand colour of the other. Let into the upper side of the mallet is the Society's distinctive metal badge. When not in use, the mallet sits neatly between two pegs on a wooden matching base, on the underside of which the maker's initials and the date 2003 are incised. (The accompanying photograph does not do justice to the work; but does give some idea of what the gavel looks like.)



Dr John Lester is to be congratulated on a beautiful and skilful piece of craftsmanship, which should be of long-standing benefit to the effective running of the Society. He was able to witness the first successful 'trials' of his gavel at the recent conference at Yarnfield. The Society is much indebted to him, as in particular is the Chairman, who thanks him very much for this splendid and useful gift.

C St J. H. Daniel



BOOK REVIEWS

Biographical Index of British Sundial Makers from the Seventh Century to 1920 by Jill Wilson. British Sundial Society, Crowthorne, England, 2003. ISBN 0 9518404 4 4. pp117, £10

The latest publication of the British Sundial Society is the very welcome compilation by Jill Wilson of nearly 1,000 biographical entries on British sundial makers. The 117-page book is presented in the same format as the Society's Bulletin and will be well suited to stand with the Bulletins in your bookshelf

There is a minimum of general discussion in this book, with nearly every page dedicated to index entries. The book is divided into 5 sections by date period. There are 34 entries for the 7th through 16th centuries; 182 for the 17 th century; 388 for the18 th; 222 for the 19th and early 20 th centuries; and finally 85 undated entries. Each section is arranged alphabetically and there is a final overall alphabetical listing of names to complete the work. This final index would benefit from having page numbers included in addition to the current listing only by section.

This is definitely a valuable resource for anyone interested in the history of dialling or in tracking down a particular maker or designer of a sundial. It is the result of many years' work, but it does leave room for some improvement and expansion. The current edition contains text only; one can hope that a subsequent edition might include some illustrations of the makers or their dials.

It would also be helpful to have a detailed discussion of the criteria that were used to determine inclusion in the index. Is this a list of known makers of dials? Or does simply writing a book on the subject qualify someone for inclusion? Since the title clearly refers to sundial makers, I was surprised (and pleased) to see an entry for Samuel Foster, who was a superb theorist, but not a maker of dials. In reading the biographical entry I found the suggestion that there is indeed a dial at least tentatively attributed to Foster. Bravo! I then checked William Leybourn, printer, surveyor, and teacher; he is someone for whom the index states, "no dial by him appears to have been recorded. However he may have been the designer...." Further check showed that Gatty, Eden and Lloyd are all included, only for their role in compiling the folksy Book of Sundials. An earlier example is Geoffrey Chaucer, who published a work on the Astrolabe and included shadow time examples in the Canterbury Tales, but who is not known as a maker of sundials.

So it would appear that authoring a book suffices; but if such is the case, then there are many missing entries to the index. Examples include Thomas Edwards who published a dialling text in Oxford in 1692 and also designed an astrolabe, double horizontal and analemma - all of which were made by instrument maker Jean Prujean, who is included in the index. Another example is John Wybard, a 17th century physician and mathematical practitioner who published an interesting hook on lunar horology.

If we focus only on makers, then there are also several missing entries. For example, John Aubri was evidently producing Bloud-type dials in 1680, but he is not in the index. Nor is Christopher Brookes, an instrument maker and son-in-law of the famous William Oughtred; Brookes made a new form of quadrant in 1649.

In this regard, the author has noted that, "since this is the first list of British Sundial makers to be produced, it is certain that many names and sources must have been overlooked.... However, this is where readers can help. If you know of a maker or of the existence of a signed dial not recorded here, please pass on the information."

This is a perfect invitation for the second edition. I would also encourage readers to amplify on some of the information given. For example, John Doherty has only the line, "Known to have made a horizontal dial" (with no source listed). This follows two excellent lengthy discussions of Edward John Dent and Charles Wastell Dixey. And surely J.H. Lambert (1728-1777), a great German mathematician, cartographer and diallist deserves either to be taken out of the undated list or to be eliminated on the basis of nationality.

Major resources such as E.G. Taylor's Mathematical Practitioners volumes and Gloria Clifton's Directory of British Scientific Instrument Makers are included in the list of sources, but it is not clear how the present volume should be positioned with respect to them. The Biographical Index clearly overlaps (albeit incompletely) with these larger works but perhaps does a better job of including diallists who might not qualify as 'instrument makers', such as the quarryman Joseph Angus who made several dials for his own cottage and garden in Crawleyside, Durham. The index covers a much longer period than any of its source references, but it strangely (to the reviewer at any rate) omits many of the names that the source texts would lead one to think should be included. This work is also uniquely able to draw on the considerable database of signed or attributed dials in the BSS Register, thus providing entries for otherwise unknown makers such as J. Saul, T. Bishop, J. Bexon, James Dawson and Willliam Mead.

Perusal of the index entries has surprised me with tidbits of previously unknown information or references on several of the names which hold a particular interest for me. I would anticipate that most BSS readers would share in the same experience if they take the time read through the index rather than simply shelving it for the sake of future reference.

This is an excellent resource for BSS members. It is to be hoped that the membership will partner with Jill Wilson to flesh it out even further in subsequent editions.

Frederick W Sawyer III
Glastonbury, CT., USA

Biographical Index of British Sundial Makers from the Seventh Century to 1920, by Jill Wilson; BSS, 2003, ISBN 0 9518404 4 4. Card covers, A4, vi+ 117 pp.

In familiar yellow-covered format this book will instantly be recognised. After introductory pages of preface, introduction, abbreviations, and bibliography, the main body of the work lists about a thousand makers alphabetically by surname within each of five sections by date; pre-1600, the 17th and 18th centuries, 1801 to 1920, and finally those to whom no date is given. An index allows the reader to determine in which period to look in case of doubt. I would have found a purely alphabetical arrangement simpler, especially in cases where the maker's career spanned one of the date boundaries. The entries range from a single line to a whole column.

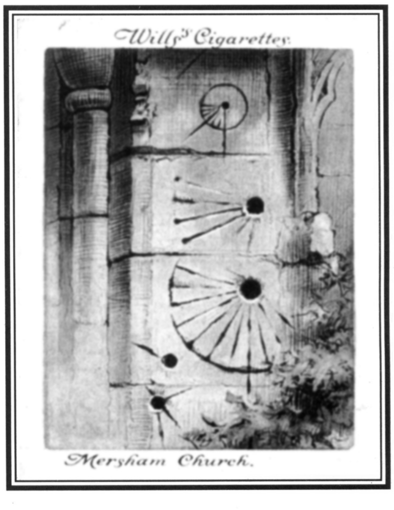
The term "maker" is used somewhat elastically, for the list includes some who wrote on dialling (Geoffrey Chaucer ...) or have only a documented connection (Gilbert White ...) as well as carvers or suppliers of plinths. Again, John Leach who restored SRN 3015, is listed; he was Mayor of Tenby and I suspect not really a maker.

I feel this must be clearly recognized as a first edition of the work for although it is undoubtedly valuable many improvements could be made. Some likely printed sources have not been cited (including several books devoted to specific makers, for example Ferguson, Samuel Roberts, Tompion, and the Adams family), and books on regional clockmakers could provide additional information and enlarge on or confirm that given. References to the "Guild of Clockmakers" should rather be to the "Clockmakers' Company,,.

There is evidence that the entries have not kept up to date with a most important and growing source of information, the Sundial Register. In general records later than about SRN 3350 (first reported in 1996) do not seem to have contributed to the work and this is a great pity. For example: under Duppa Jenkins, SRN 0474 is listed at Shrewsbury, as in the 1995 Register, rather than at Clifford in Hereford and Worcester as corrected in the 2000 edition.Under "Harper & Son" is mentioned a dial at Ovibury; this should be Onibury and was listed as SRN 3461 in the 2000 Register. These appear to highlight a more general difficulty: the information flow from the Register is only summary and it would seem that there is no simple way of reflecting added data and corrections resulting from later reports.

Despite these criticisms, there is no doubt that this is a very useful book. It concentrates in a convenient and inexpensive form a large part of the sundial-related information to be found in wider and costly sources like Clifton, Taylor, and the Dictionary of National Biography as well as adding much more. Much labour is involved in producing a large factual list and it is inevitable that errors will be present, and that it will never be complete. It is therefore to be hoped that it will be improved in subsequent editions and no doubt this will be greatly aided by feedback from the readership. For myself, I regret that my own misunderstanding of the position of Register reports already made led me not to contribute data more directly to the author, and perhaps I am not alone in this. All those with an interest should acquire this book for use as ready reference, and if they are in a position to check or improve any entries - such as Register reports, specific dials, or particular makers - on which they have special knowledge, and then actively suggest corrections and more information for the next edition, they will assist the author in her contribution to the wider availability of useful information.

Andrew James,
Winchester, Hampshire



BSS ANNUAL CONFERENCE, YARNFIELD, APRIL 25-27 2003

TONY BELK

The Yarnfield Park Conference Centre was a very attractive venue with modem accommodation, large comfortable lecture and exhibition rooms, a good restaurant and plenty of room to sit and chat. It was good to make new friends and greet friends of long standing in such a congenial environment. Our secretary, Doug Bateman, opened the conference proceedings with an amusing insight into the electrochemical hazards that sundials have to endure. With the help of a jug of plain water he demonstrated that a sundial made of a variety of metals could not only tell the time (when the sun was out) but also generate enough electric power to drive a rotating vane when the sun was not shining. So the sundial is of value in the rain and in the shine.

The Camino de Santiago has been used by pilgrims for 1200 years and the scallop shell is their badge. Piers Nicholson took us along the pilgrim route from St Jean Pied de Port in France to Santiago de Compostella by means of the varied sundials along the route. They were ancient and modern, on shops, churches, cathedrals, nunneries and in gardens. One would not do the walk simply for the sundials as there are rather few dials and they are not in terribly good condition. The whole journey is 480 miles and we were shown dials and other items of solar interest along more than half of it, including three modem dials in San Sebastian and Biarritz. We wait with interest for Piers to complete the rest of the journey.

Bill Gottesman described a novel design of sundial which was billed as a "watch" accurate dial using focussed light. A 6 mm wide strip of cylindrically curved glass is used to reflect a focussed strip image of the sun on a cylindrical surface on which the reflector lies. The image of the sun is 2 minutes of time wide and this at present sets the accuracy of the dial to 1 minute, the dial being marked in individual minutes. A helical dial scale is used with its axis parallel to the earth's rotational axis and a video image showed the movement of the sharply focussed strip image. Latitude setting is by an ingenious arrangement of wedges of a sphere which can be rotated to cover a range of 23 to 51 degrees. An equation of time and daylight saving scale slides within the main scale. A method was described which, based on three accurate time readings taken in one day, allows fine adjustments to the alignment of the dial to make it accurate through the day and year. A further modification proposed for the future is to use two reflectors and the sharp dark shadow between the two strip images will give an accuracy of 15 seconds.

Fred Sawyer introduced us to a French engineer and mathematician Paucellier (1832-1913). He made his name by conceiving the first method of drawing a straight line without having a ruler to follow.(Lord Kelvin said it was the most beautiful thing he had ever seen) He went on from this to design sundials with a style pointing in an arbitrary direction using only straight lines for the hour lines and solstice and equinox lines. The time is read where the gnomon's shadow and day line cross, rather like an analemmatic dial. We were shown the formulae that allow the design of such a dial with any direction of gnomon and any dial plane. It is possible that such a design may be used

Fig. 1. Conference Members

in California on a suspension bridge where the carriageway is due north-south. The inclined pillar that supports the bridge does not lie along the celestial axis so a Paucellier design will work. He showed designs with styles pointing in various directions including vertical, east-west horizontal and north-south horizontal and a 45°style declining by 45° and indicated that in all the designs the hour lines do not all cross at a point. A design is possible with two sloping gnomons which will be self-orienting during the middle hours of the day. Finally he pointed out that the reciprocal of a straight line is a circle and Paucellier produced another series of sundial designs where every line was a circular arc. Altogether a very interesting collection of very unusual sundial designs.

Charles de Boer described the "puzzle" sundial situated in Gnosall, a village some eight miles from Yarnfield. It was installed in 1721, before we adopted the Gregorian calendar, for the price of £2.00. At the foot of the gnomon there is a series of five semicircular scales which Noel Ta' Bois first pointed out in "Clocks" in March 1988. Two have 10 at the centre and four sets of 31 or 30 markings but not evenly spaced. Another has 0 at the centre and a set of 23 markings on either side, and the final two have 6 at the centre and are marked from 4 to 8 or 8 to 4. These last three give the times of sunrise and sunset against the sun's declination for the latitude of Gnosall, 53° north. He hoped that the assembled BSS community might come up with a solution to the puzzle of the outer two rings. He also described a modern sundial which has replaced the old one which is now preserved on the vestry window sill.

The Andrew Somerville Memorial Lecture was given by Prof John North with the title "Chaucer, Holbein, and the shadow of Good Friday". He chose as a motto for the lecture "Umbra Versa" - shadow on a wall or the tangent ratio in trigonometry. Chaucer in "Canterbury Tales" makes three mentions of reading the time by the length of the sun's shadow, a method based on work by medieval monastic scholars. The time given in the Parson's Prologue is 4.00 pm on April 11-17 which includes Good Friday. We were shown a horoscope for 4.00 on Good Friday 1400, the year in which Chaucer died. The first full edition of Chaucer published in 1532 had a Holbein woodcut on its cover. One year later Hans Holbein the younger produced the 80 inch square painting of Jean de Dinteville and Georges de Selve, "The Ambassadors" which Prof North proposed was a religious allegory and not merely a riddle about the nature of time. It is one of the finest examples of renaissance portraiture and almost certainly represented 11 April 1533, Good Friday, when the sun's elevation was 27° The cylinder dial on the table indicates a date in mid April and the gnomon indicates a time of a few minutes to 4.00 pm.

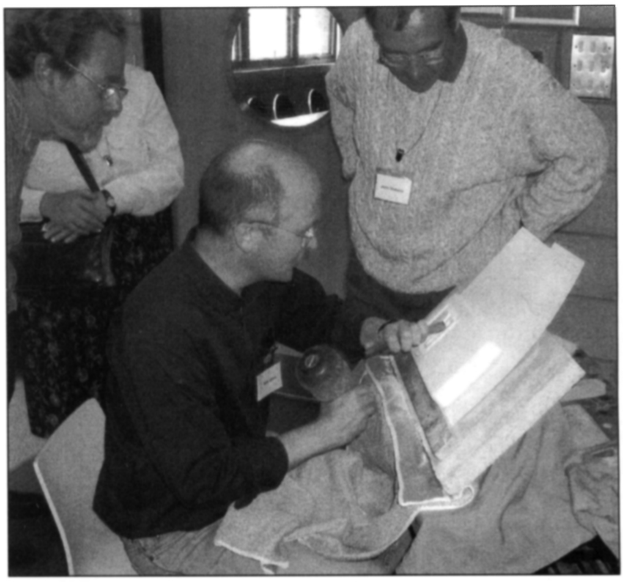


Fig. 2. Stone-cutting workshop

A line at 27° can be drawn across the picture from the silver crucifix at the top left through the gnomon of the polyhedral dial on the table. The axis of the extended skull image also is at 27° and where these two lines intersect is the position from which the skull image should be viewed. In 1528 Holbein also drew a portrait of the Bavarian astronomer Kratzer, who almost certainly provided Holbein with the scientific data for "The Ambassadors". This portrait also includes some of the same instruments as "The Ambassadors". To add to the religious symbolism 27 is 3 to the power 3 (the trinity) and the hymn book is open at a famous Luther hymn. The tablecloth is an Armenian Christian pattern and the pavement is an exact half scale replica of that in the sanctuary of Westminster Abbey. If the horoscope for Good Friday 1533 is compared with that for Good Friday 1400 they are found to be very similar because they are separated by seven lunar cycles of nineteen years, providing another link between Chaucer and Holbein and Good Friday.

Coach trips were made either to Shugborough or to the Gladstone Pottery Museum. The weather was kind and both visits were considered to be very successful. In the evening after the Conference Dinner we had the Auction. The items for sale were mostly from the estate of the late Neville Rodber, a BSS member of long standing. Our Chairman acted as auctioneer and the bidding produced some surprises and amusement and a result with which the Treasurer was happy, even though some items did not reach their reserve price.

The Sunday morning was mainly filled with workshops. The dial recording workshop enabled Patrick Powers and Tony Wood to remind the members of the current developments in recording. To assist in this an attractive newsletter had been produced. The topics covered included digital photography, better recording techniques, encouragement to use the register and choose how the next edition, due in 2004, should look. The slate cutting workshop, run by Ben Jones, attracted considerable interest among many members who were able to get some hands on experience under the eye of an expert.

The declination workshop run by John Davis discussed how the declination of a wall could be determined despite the natural obstacles that occur. These may be no sun, high wind, or even no daylight. Mike Cowham's "How to spot fakes, forgeries, reproductions and restorations" workshop introduced the dial detective's kit. Protractor, micrometer, magnifier, camera and computer are basic requirements, plus no doubt some time spent examining dials of known provenance. First assess the material, whether it is of uniform thickness and hammered flat from the rear. Next: Is it engraved, punched or etched? Is the gnomon made in the same way as the plate? Is the dial signed? Finally, Was the gnomon screwed to the plinth? Was it wrenched off and is it correctly delineated? In future, dial thieves should beware, as BSS members will be much better informed and prepared.

As usual the Aunual General Meeting was a very business-like affair, assisted by all the reports which had been available for members to read throughout the conference. And finally to conclude the formal proceedings Allan Mills gave us a brief history of trigonometry, the properties of the triangle - in Greek trigonon. The Egyptians knew that the sum of the angles of a triangle was 180 ° and the 3, 4, 5 method of drawing a right angle. For the Greeks, Pythagoras generalised the formula with the well known square on the hypotenuse. They were also interested in constructions based on the circle, chords and angles subtended at the centre. Greek science and medicine were preserved for many centuries by Islamic scholars who also invented algebra. Al-Battani, a tenth century Arab prince, and a famous astronomer and mathematician, was responsible for the translation of the ancient texts. We heard why the tangent ratio is so called and that it is also called umbra or shadow as it is the length if shadow of an upright of unit length. The sine, however, is a mistranslation of the early form although non-mathematicians may have less friendly definitions.

The conference was again a most pleasant and worthwhile opportunity to discuss and learn more about the many and varied interests and abilities of the BSS membership, sometimes in a formal and sometimes a relaxed manner, and encouraged us all to come again next year.

MINUTES OF THE 14th ANNUAL GENERAL MEETING OF THE BRITISH SUNDIAL SOCIETY HELD AT THE YARNFIELD CONFERENCE CENTRE, STAFFORDSHIRE, 27 APRIL 2003

1. The meeting was opened by the Chairman, Christopher St J H Daniel, at 12.30pm. About 60 voting members were present.

2. Apologies were received from Julian Lush, A James, George Wyllie, Piers Nicholson, Peter Ransom, and Martin Jenkins.

3. The minutes of the special meeting to adopt the new constitution, held immediately prior to the 13th Annual General Meeting held in Exeter on 21 April 2002 (which had been published in the Bulletin, September 2002, pp101) were adopted, as proposed by J Davis, and seconded by P Walker. The archive copy signed by the Chairman.

4. The minutes of the 13th Annual General Meeting held in Exeter on 21 April 2002 (which had been published in the Bulletin, September 2002, pp95-100) were adoped, as proposed by M Stanier and seconded by J Lester. The archive copy signed by the Chairman.

5. There were no matters arising.

6. Secretary's Report

The Secretary's main roles are liaison with the general public, organising the annual conferences, and the supporting administration.

Liaison. Since the last AGM I have dealt with 98 enquiries by letter and a small number by telephone. Quite a number have sought advice about setting up dials and information about dials in their possession.

Conference 2003, 25 - 27 April. This, the 14th conference, is being held in the Yarnfield Park Conference Centre, Staffordshire. A total of 66 have booked and this is a large fall in numbers compared with the last 3 years. Quite a few are having a 'gap' but many have already indicated an interest in the Oxford conference. [NB, the numbers above were as of 2 weeks before the event: late bookers and day delegates brought the actual total to 75.]

Conference 2004, 16-18 April. As a reminder, we have chosen St Anne's College, which has a compact site with the lecture theatre, accommodation and dining room all quite close together. The planning sub-committee comprises C Daniel, Margaret Stanier, Jill Wilson, Mike Cowham, Patrick Powers, Ian Wootton, and Dr Jim Bennett, Director of the Museum of the History of Science. Planning is well advanced with offers of papers already, and instead of having an open afternoon for the public (which would have required manning of exhibits and a lot of effort) there are likely to outings to Blenheim and two dial makers' workshops.

Constitution and Council meetings. At the last AGM the up-dated constitution was adopted. One of the changes was to have a smaller Council, and so far, no problems have been experienced.

Leaflets and lectures. The main colour leaflet has been reprinted, and the dial makers and book list leaflets have been updated with minor changes. Members continue to give talks to all sorts of organisations, but we do not keep a count of the number given. One significant event was representation for two days at National Science week at Greenwich in March, although this was more of a static display with a few dials to attract attention.

There were no queries, and the report was adopted.

7. Treasurer's Report (The statement of accounts is at the end of these minutes.) The Treasurer added comments about the report, which had been copied to all conference attendees. He reported that the financial state of the Society is healthy. The accounts are following the Charity Commission's convention. In year 2001 there was an excess of income over expenditure of about £8000 due to the prepayments for the Exeter conference, whereas 2002 appears to show a deficit. This is due to the Exeter expenditure falling in this year. The Treasurer added that conference events are budgeted to avoid a loss, and modest contingency of 5% is added to the conference price. Exeter, however, had exceeded this figure, showing an 8% gain.

The report was adopted and the master copy signed by the Chairman, who then thanked the Treasurer for his diligence and hard work during his three years in office.

8. Reports from individual members of Council and Specialists

Advertising: Mike Cowham. This has been a very slow year for advertising in the Bulletin and Newsletter. It was hoped that we would have received some Classified adverts from Members with small wants or things that they wish to sell. The cost of this is very reasonable.

Many of our potentially larger customers, ie, auction houses, realise that our Society has very few collectors of higher value items and due to their own economies have had to cut back on what they see as less productive advertising.

It is unlikely that we will ever attract large quantities of advertising and the costs of actively seeking it will probably outweigh any returns. However, it is a useful facility and will attract occasional users. For the moment the most cost-effective results are achieved by sending our Rate Card to each potential customer annually.

For anyone planning advertising we are normally able to offer a quick and cost-effective setting service. For example, the advertising flyer from Cotswold Auctions was a last minute request. The copy arrived by e-mail, was set for them by return, and approved in a very short time. Copies were then delivered direct to our Cambridge printers with only hours to spare.

Reference Library: Graham Aldred. Two books are with Ian Wootton for repair. One recent new acquisition is "Time in Rutland" by Robert Ovens & Shiela Sleath. Because the books have some significant value they are covered for fire risk under the whole library's policy, but for theft, it is a case of 'self insurance' where the Society carries the risk. Consideration is being given as to how best to publicise the library as a balance between benefit for members and the risks associated with too wide a coverage.

Restoration: Graham Aldred. There had been two enquiries with regard to vertical declining dials in need of restoration. Both owners have been given lengthy advice and sent a BSS Makers List. They have been encouraged to contact again if they require further help and advice.

One dial is on Mount Zion church above Hebden Bridge, it was overprinted with numerals of value and position as would be found on a clock face, with 6 o' clock where noon should be! The incised numerals below the paint, however, are correctly named and positioned. The owners are well resourced to implement a replication with some dialling advice and permission from English Heritage and various Church Authorities. The other dial is located in Horton in Ribblesdale, Settle, a vertical decliner, not even a shadow of its former self, lacking both gnomon, numerals and hour lines, and therefore in need of some considerable reconstruction.

Mass Dial Group: A.O.Wood. Preparation for compiling the Mass Dial Register is going ahead. We have a new computer and the database is ready for testing. The first counties should be entered shortly. Two formats will be used:

a. One dial per page, with a picture. b. A short format entry for each dial of 2 or 3 lines and no pictures. It is probable that format (a) will only be available on CD.

A large number of reports have been received including some from records compiled in the 1920s and 30s (G. S. Amos, Norfolk). Collections should be acknowledged from Frank Poller, Harry Sunley, Mike Cowham and Lyn Stilgoe. The continuing efforts of the NADFAS Church Recorders should also be acknowledged. The website pages have also inspired a few reports and sometimes an attached photograph. Photographs in digital form are currently under review, at the moment they are discouraged owing to processing costs but obviously we shall need to find accommodation for this format.

The discovery of two dials with dates (rather late ones) inscribed together with reports from France of over 400 dials may result in new thinking about dating and origins. Additional reports from Israel and Norway add weight to a theory of continental origins.

It is hoped, in the coming year, to compile Registers for a number of counties, the Lincolnshire Dials of Bob Adams form a basis and guide for our expected format.

Thanks to all recorders and colleagues for their help over the past year.

Editor: Margaret Stanier. Four issues of the Bulletin of the BSS, 44 pages each, have appeared since the last AGM. This has not been without difficulty, and the editor always has an anxious time in the weeks before an issue is due, wondering whether it will again be possible to fill this number of pages, with appropriate variety. The editor is always delighted to receive material of any relevant kind, especially from people who have not previously sent anything for publication.

As to other publications, we are very happy to see that the 'Biographical Index of British Sundial Makers' has at last appeared; the author Jill Wilson must be warmly congratulated. This is a work of which the Society can be proud. Two copies of the 'Index' have been dispatched to reviewers, one on each side of the Atlantic. The second edition of 'Oxford Sundial' is now in press. It will include three new sundials and one repainted dial face, since the first edition.

The long awaited index of the Author and Title for the Bulletins from 1989 to 2001 appeared during the year, and particular credit must be given to Andrew James for drawing it all together.

The new edition of 'Make a Sundial' by Jane Walker is well under way and should be available some time this year.

Membership: Kevin Barrett. There have been fewer new members this year - 27 new members since last April (3 of which are reinstatements). The bulk of 5 yearly memberships have run their course this year resulting in some loss of members with 11 falling away. There has been a drop in UK and American numbers. We have instituted a scheme to pay in cash via the direct cash method which has worked well, especially in Europe. It is intended to promote this again next year as it works well. We also now have more Standing Order payers which is easier to collect and saves the Society postage costs.

General Membership statistics: current membership is 538, down from 609 last year.

The database is being improved to accommodate various requests by adding extra fields to improve membership management. Revised Membership Application and resubscription forms are being developed to assist in reducing the stationary and postage costs.

Fixed dial register: Patrick Powers. Work on reducing the large backlog of entries for the Register has continued during the year despite a few difficulties with the Society's PC.

In the year, the backup arrangements for the data held on the database have been upgraded and now a copy of all data is automatically made daily and held on a totally separate hard drive. This is in addition to the continuing practice of maintaining normal backups on CDROM and of course the back-stop practice of maintaining six monthly backups which are held off site.

A small change to the recording policy has been agreed by the Council. This will permit individual collections of dial information, for example such as may from time to time be bequeathed to the Society, to be recorded in the Register without the necessity for the collection to be physically broken up and distributed within the main body of the archives.

The Register is a form-based archive which uses a database to record the salient details of dials and because of this, recording forms and photographs cannot currently be accepted by e-mail or other electronic means. Nonetheless and in the light of the continuing improvement in digital photography and digital data processing, consideration is currently being given to ways in which we may be able to accept such information in the future.

The printed edition of the 2000 Register is now out of print but a new edition is currently being planned for 2004. Because of the much increased numbers of entries and photographs that this new edition will have, the exact format has not yet been decided.

A second edition of the out of print Bulletins CDROM has been issued in the year after one more printed edition of the Bulletin went out of print. Having these out of print editions on CDROM means that *all* issues of the Society's Bulletin are always available to all Members.

A fifty percent reduction has been achieved in the past year in the number of dials on the database which have no recorded map location. This greatly enhances the value of the Register and of course this will be reflected in the forthcoming new edition.

Work has continued on the development of a sister database for use in Mass Dial recording. It is hoped to be able to have this operational shortly.

Finally can I repeat what I say every year, that the information in the Register is available to *all* Members not just those who do a stalwart job of recording them? Please do get in touch if I can be of assistance in answering any query you may have or if you wish to record a dial and have not done so before.

Exhibitions: David Young. A small display, with supporting dials and leaflets, had been given at the Antiquarian Horological Society's 50th anniversary conference in Keble College, Oxford. Similarly, a display had been given at the National Science Week in the Royal Observatory, Greenwich. John Moir and Doug Bateman had been in attendance for the two days. At another event, Christopher Daniel had represented the Society at a seminar run by English Heritage on the general topic of conservation. A number of small organisations were also represented.

The BSS Web site: Peter K Scott. The BSS web site is being maintained and kept up-to-date, with the relatively minor addition of a slide show. The site remains an important part of the Society's infrastructure supplementing the already established methods of communication with members. Many of our newest members have been recruited as a direct result of visiting the web site. The site continues to attract complimentary remarks about its appearance and content, but nevertheless, constructive suggestions are always encouraged.

Internet: Piers Nicholson. In the year ending 31st March 2003, Sundials on the Internet had 676,000 page accesses. Visitors were recorded from some 170 countries starting with the USA, UK and Canada, and ending with Vanuatu, San Marino, and Montserrat.

The most popular pages, after the home page, are: a list of picture links; setting up a sundial; the Equation of Time; commercial makers of sundials; new public sundials; an introduction to sundials; the various kinds of sundials; sundial computer programs; book list.

The sundial trails are collectively very popular too, with the Cambridge, London Thames, Poland, East Sussex, and Toronto at the head of the list.

The support of the British Sundial Society towards this major educational site is gratefully acknowledged, and it work is in hand to further improve the links and counter-links between Sundials on the Internet and the BSS web site.

Newbury 2002: Peter Ransom & David Pawley. Never mind the Costa Brava - Newbury once again showed that it is unequalled in providing fine weather on demand. Well over 40 members (45 actually signed in), old friends and new, spent much of the day on September 28 enjoying gossip and sundial chat outside, only coming indoors for the short talk sessions.

There were talks by Tony Baigent (who cemented memories of sundials firmly in the minds of the younger generation), Peter Ransom (Simpsons, symmetry and sundials with software), Martin Jenkins (who recorded 23 French fancies in Saint-Veran), Michael Maltin (with astrocompasses and his superb models that his fan club wished to handle), David Brown (with dirt cheap laser equipment), Kevin Barrett, (about the membership), Margaret Stanier, (with a picture and article plea), and Doug Bateman (Austrian tour details and thanks).

There was a tour of the exhibits when we all went round what was on display, hearing the exhibitors talk about their expositions. We heard from Barry Waltho (Credit card sun compass and window dials), Bill Hitchings (A 19th century horizontal dial by Cary), Donald Bush (Horizontal dial and a nice Foster-Lambert dial), Heiner Thiessen (The "Sunrise" dial), John Moir (Armillary Octahedron, Book of Hours (combined double cycloid and double polar) and more!), Mike Shaw (An equatorial remote-sensing fibre optic dial and a neat device for finding E.O.T and Longitude adjustments), David Ellis-Jones (A 19th century Richard Melvin dial), Silas Higgon (The improved azimuth dial), David Brown (a stone-carved Berossos (or Hemisphericum) dial), John Davis (A large horizontal based on a pattern by the Grocers Company, a double horizontal dial, and a selection of small portable dials), David Young (The BSS's trip to Cornwall), Martin Hinchcliffe (A display of his '1034 miles by sun compass' journey that he sailed from Pitcairn to Marquesa), Tony Baigent (His instrument box, a machine for finding the declination of a wall and concrete dials), Tony Wood (picture, china dials and the Elmley Castle multiple dial), Peter Ransom (Sundial ephemera and craftwork featuring dials), Pat Briggs (Meccano equation of time machine).

There was also an astrocompass display. Some members had brought their astrocompasses to form what is thought to be the largest display of astrocompasses.

David Pawley is the inspiration behind and organiser of the Newbury meeting. We cannot thank him enough for all he does in getting this show on the road, so we are not going to try! We also thank Wendy for helping with the set up on the Friday evening.

Publication sales: Margery Lovatt. A new price list is in course of preparation, ready to circulate with a` Bulletin during 2003. We may have been undercharging on postage and thus making a small loss on certain items. It is suggested that the new price list should be printed on green paper, to make it conspicuous, and superseding previous lists. Orders for the 'Biographical Index' have already been received. One complete set of back issues has been sold; there are 8 other complete runs available.

8. Election of Officers

Chairman, Secretary and Treasurer. The Chairman (C Daniel) and Treasurer (John Davis) had been proposed and seconded by I Wootton and J M Shaw. The Secretary (D Bateman) had been proposed and seconded by M Cowham and A James. There being no other nominations the Chairman declared those proposed duly elected.

Members of Council. M Stanier, K Barrett and A Wood had been proposed and seconded by I Wootton and J M Shaw. G Aldred and P Powers were proposed and seconded by M Cowham and A James. There being no other nominations the Chairman declared those proposed duly elected.

Checking the accounts. The Treasurer recommended that Mr A R Ashmore being nominated for checking the accounts. Proposed by M Stanier and seconded by I Wootton, Mr Ashmore was duly elected.

Co-opted members. Last year P Nicholson and D Young had been co-opted to provide expertise on the internet, exhibitions and tours. The Chairman stated that both are likely to be co-opted for the coming year.

10. Any other business David Young led the appreciation for what was considered to be a successful conference and enjoyable weekend. The Chairman responded by thanking all the speakers.

The Chairman wished to give thanks to Ian Wootton for his considerable efforts in binding the sundial registration sheets and photographs, the minute books, and repair of books in the library. Thanks was also given to John Lester for his gift of a gavel (duly demonstrated).

The Chairman emphasised that the Society is always ready for new blood in the management of the Society. The fact that Council is well staffed at the moment should not deter anyone from expressing an interest.

Reminders were given about next year's conference in Oxford, and the Newbury event will take place as usual in September.

The Chairman concluded by reporting that following the death of Lord Perth last November he is corresponding with a potential new Patron.

The meeting was closed at 12.45pm.

D A Bateman, Honorary Secretary

BSS, ACCOUNTS FOR YEAR ENDED 31 DECEMBER 2002

STATEMENT OF FUNDS (£)

Year ending 31 December	**2001**	**2002**
Current account balance	599.06	5,742.86
Deposit account balance	16.19	16.27
Charities Office Investment Fund	30,744.78	24,572.56
TOTALS	31,360.03	30,331.69
Change in flinds during the year	8,055.21	(1,028.34)
Income received during the year	50,383.61	30,825.73
Expenses incurred during the year	42,328.40	31,854.07
Excess of income over expenditure during the year	8,055.21	(1,028.34)

INCOME	**2001**	**2002**	**EXPENSES**	**2001**	**2002**
Subscriptions	11,904.44	12,198.32	Bulletin	11,192.39	11,500.47
FICO	1,569.48	1,702.15	Officers	3,89~.87	2,683.70
Sub4otals	13,473.92	13,900.47		15,084.26	14,184.17
Events	31,673.00	14,384.90	Events	23,846.67	15,696.25
Sales:					
Books etc (ML)	2,163.29	933.00	Books etc	836.07	584.56
Education (JW)	556.00	310.50	Education	272.90	288.41
Advertising (JC+MC)	160.20	210.00	Advertising	0.00	47.00
Misc (DY)	50.00	20.00	Misc	0.00	0.00
Sub4otals	2,929.49	1,473.50		1,108.97	919.97
Donations	130.84	39.00	BH Lib	200.00	155.05
Auction	1,003.85	00.00	BHF	155.00	0.00
interest	1,159.27	1,027.86	Archivist	597.47	0.00
Misc	13.24	0.00	Internet	508.63	532.13
			Insurance	184.74	231.00
			Somerville	76.50	45.50
			Dial Reg	487.76	0.00
			Misc	78.40	90.00
Sub4otals	2,307.20	1,066.86		2,288.50	1,053.68
TOTALS	50,383.61	30,825.73		42,328.40	31,854.07

STOCKS HELD AT YEAR END

Bulletins	2,968
Author Index	82
Postcards	3,160
Sundials of Australia	2
BSS Glossary	21
A Celebration of Cornish Dials	3
The Ancient Sundials of Ireland	9
Cambridge Sundials	170
Oxford Sundials	12
Make a Sundial	11
BSS Binders	74
BSS Ties	5
BSS Lapel Pins	83
CD-ROM Out of print Bulletins	9
CD-ROM Mass Dials of Lincoinshire	I
Sundial Constructor Disk	4

Notes to accounts

1. The accounts are prepared on a payments and receipts basis. That is, money is booked when it is received or spent. This is in line with the Charity Commission's guidance.

2. The year-end flinds are held in approved investment accounts as well as a current account. The current account is high due to payments for Yamfield (AGMiConference) being received in the latter part of December. They also include £935 which represents fliture subscriptions paid by members under the five-year scheme and £871.44 in the Andrew Somerville Memorial Fund.

3. The management accounting figure for the excess of income over expenditure is £2,600 rather than a loss of £~ ,028.34. This allows for pre-payments on the Exeter AGM and five-year payers.

4. Events are priced not to make a loss.

5. Stocks are valued at nil as it is difficult to see that they would have any value in the event of the Society being wound up. This does not impact our cash flow.

6. The value of the BSS Library is not shown. A valuation is being sought.

Treasurer: G P Stancey 11/2/03

Checked by: AR Ashmore 11/2/03

27/04/03

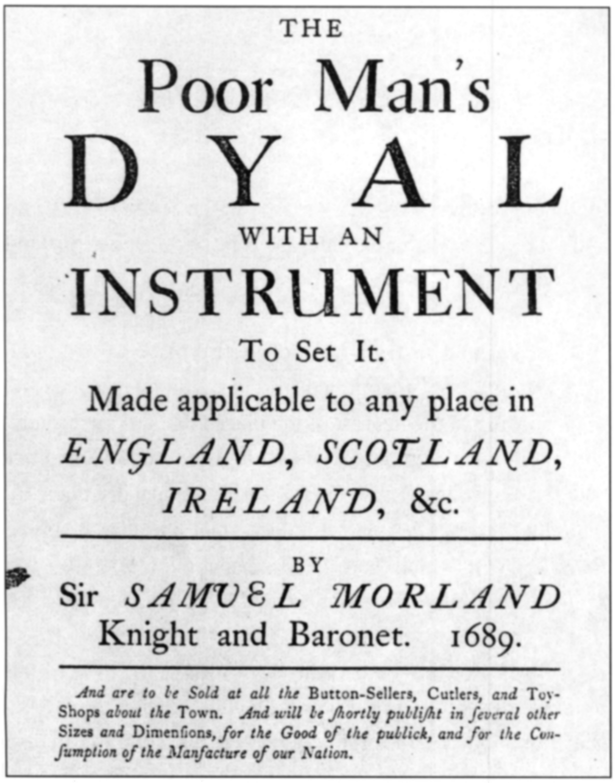
THE POOR MAN'S DYAL

JOHN FOAD

Most of the horizontal dials that have come down to us from days gone by are rather grand, and we can be pleased of course that they have survived. Church horizontals, even when quite plain, have been an endangered species for a century or more, because they are so unprotected. Simple dials in private hands will have been dispersed with other household effects over the years, and often discarded as valueless. The surviving dials in private ownership tend to be found where a family has remained in one residence for generations, and where the intrinsic quality of the dial has ensured its survival.

So we know quite a lot about the design, and the designers, of the more elaborate dials, but less perhaps about any cheap everyday instruments that may have been made. One insight into the nature of the simpler dials of the seventeenth century can be found in a little booklet, "The Poor Man's Dyal", published in 1689.

The author was Sir Samuel Morland, a man of many parts. By talent and by inclination he was a mathematician, and evidence of his turn of mind appears in his work on cryptography, published in 1666, and in his projected work on "The Quadrature of Curvilinear Spaces". However since this translates in modern terms as "Squaring the Circle", it is as well that he was dissuaded on this occasion from publication!


THE
Poor Man's
DYAL
WITH AN
INSTRUMENT
To Set It.
Made applicable to any place in
ENGLAND, SCOTLAND, IRELAND, &c.

BY
Sir *SAMUEL MORLAND*
Knight and Baronet. 1689.

And are to be Sold at all the Button-Sellers, Cutlers, *and* Toy-Shops *about the* Town. *And will be ſhortly publiſht in ſeveral other* Sizes *and* Dimenſions, *for the Good of the publick, and for the Conſumption of the Manfacture of our Nation.*

Fig. 1. Title page

But Morland was also a strongly practical man, and turned his mind to a wide range of problems. He developed Pascal's arithmetic engines, publishing details of two such calculating machines of his own design; he had a patent on a metal fire hearth; he invented the speaking trumpet or "Tuba Stentoro-Phonica", for use "as well at sea as at land"; and late in life, he turned his hand to gnomonics, designing a small cheap dial for the mass market of the day, of which more later.

But he began his adult life as a diplomat, siding initially with the Parliamentarian cause. Cromwell sent him as an envoy to Sweden, and later to Switzerland. His mission there was to free the Protestant Waldensian sect of the Piedmont from the persecution of the French, and he acquitted himself well in his work. He spent a number of years in Geneva, researching the history of the Waldenses, but when he eventually returned to England, he found himself more closely involved than he would have wished in the realities of domestic politics. He encountered intrigue and violence, far from his taste, and became a witness to the barbarism that followed on the certainty of a righteous cause. Dr Hewitt was "trepanned to death" in his sight (and hearing!). On another occasion, eavesdropping unintentionally on the planning of a plot to murder the future Charles II, he escaped death at the poniard of Oliver Cromwell only by feigning unconsciousness.

Concerned then for the safety of the King, he rejected his own Parliamentary principles, and devoted himself from that time to working towards the Restoration. The eventual accession of Charles to the throne marked the major change in Morland's life, from diplomat to engineer. Charles supported him (if inadequately and erratically) in his work on hydraulic projects, which were to occupy his time for the remainder of his working life. He designed and built engines for pumping water from pits, and for raising water for domestic purposes, using new and ingenious machines involving the power of explosives, as well as more traditional pumping methods. He championed the use of steam power, not only for hydraulics, but also for marine propulsion, a century before James Watt.

He was acknowledged as an exceptional engineer, but he had no private income. His experiments and machine building drained all his small resources, and he had to fight continually for the means to cover his expenses. He did not enjoy the struggle, and by the age of sixty four, he had had enough. He declared that his one wish was to live thenceforward in retirement and spend his life "in Christian solitude".

One of the projects with which he filled his later years was the design and manufacture of the sundial mentioned above. He called it the "Poor Man's Dyal", and it was a small cheap instrument "to be sold at all the Button-Sellers, Cutlers, and Toy-Shops about the Town". The dial is not illustrated in his book, but we can get a fair idea of it from his notes. It took the form of a circular horizontal, about four inches in diameter, made of block tin. It had full length lines and Roman numerals for the hours; halfs and quarters were marked, but there was probably no other furniture. He also made "an Instrument to set it". Again we can only reconstruct this from his description of its use. It must have consisted of a small circular plate, with the circumference divided and marked in four equal intervals; and with a central vertical shadow-casting pin. These two instruments were sold with his short booklet, extracts from which are given below.

The booklet starts by describing the use of the instrument to set the dial, finding an East-West line by noting the positions of morning and afternoon shadows of equal length.

The second section gives the adjustments needed for use at different latitudes, with the extent of the "packing" needed under the North or South side, for 85 locations around the British Isles.

Finally, he rants against the "brazen fac'd founder" who has pirated his dial in pewter, and what is worse, made it with a totally inadequate gnomon, that will never tell the time accurately.

The whole booklet runs to only five pages, much of which is taken up with the list of towns. The extracts below make up, in fact, almost the whole of his text. A few obvious printing errors have been corrected here.

The original book is entitled "The Poor Man's Dyal, with an Instrument To Set It. Made applicable to any place in England, Scotland, Ireland, &c. By Sir Samuel Morland, Knight and Baronet. 1689"

A facsimile was made in 1886 by Richard B Prosser, and issued in a print run of just seventy five copies. One is in the British Library in London, and the City Library at Nottingham holds another. The only copy of the original text resides, or resided, according to Mr Prosser, in the Archiepiscopal Library at Lambeth.

Here follow extracts from "The Poor Man's Dyal ..."

TO SET THE DYAL

First, set the small Instrument upon any Level place, where the Sun comes two or three hours before, and as many after Noon, and by the 4 Marks at the bottom, make the 4 points (A, B, C, D) and by those Marks make two Lines, (A, C) and (B, D) crossing each other in the Point (O.) Then mark the point (E) where the shadow of the Pin terminates in the Forenoon, And having from the Distance (OE) described a circle, watch in the Afternoon, when the shadow of the Pin cuts the Circle in the point (F) for the line (EF) is a true East and West Line; And the Hours of (VI) and (VI) upon the Dyal, being placed upon the said Line, the Dyal is truly set.

DIRECTIONS

For *London*, or any place within 20 Miles, the Dyal must be placed exactly Level; But for the following places, the North-side of the Dyal (where is the Hour of (XII)) must be elevated higher than the Opposite, or South-side, as is hereafter exprest, which every Carpenter and Joiner knows how to perform,

IN ENGLAND

BEDFORD, about 1 twentieth part of an Inch.

...

Buckingham, 3 hundredths.

...

Carlisle, 1 fourth, or a quarter.

...

[and so on for 71 places North of London in England, Wales, Scotland and Ireland.]

For the Places hereafter mentioned, the North-side of the Dyal must be lower than the South-side, *viz.*

[and here follows a list of 14 places in the South of England and "the Islands" (being Guernsey, Jersey, Lindy, Portland and Wight).]

If it be required to fix any Dyal in any place of *England, Scotland*, &c., not mentioned in this Catalogue, it must be set according to the nearest of the places that are mentioned, and it will serve without any sensible Error, and much better than those ordinary Brass Dyals, which are usually made by ignorant Apprentices and Journey-men; Or that Cobbled *Pewter Dyal*, which was lately made by a *Brazen-fac'd Founder*, in Imitation of this *Poor Man's Dyal*, and deserves at least, by way of Transposition, the Name of *That Man's Poor Dyal*; For tho' he had the Wit to make a Circle of the same Diameter, and to set off all the Divisions of the Hours, Halfs, and Quarters from the other; yet the Style is so False and Defective in all its Parts, that it is not to be mended by one, who knows nothing of a *Dyal*: Yet, notwithstanding, in one thing he is to be commended, that he has made the Hour-Lines so short, that the Shadow, of the False *Gnomon*, will not so easily discover his Errors. Besides, he has carefully filled up the Vacancies in the middle of he *Dyal*, with the Points of the Compass, which are only proper for an Upright Style, and clogg'd the Tail of it with five leaden Bells, within a pair of Rams-horns, to ring aloud the praises of his Sheeps-head, for attempting to Imitate or Counterfeit another Man's Contrivance, without being able to perform it like an Artist: Forasmuch as any person who has the least

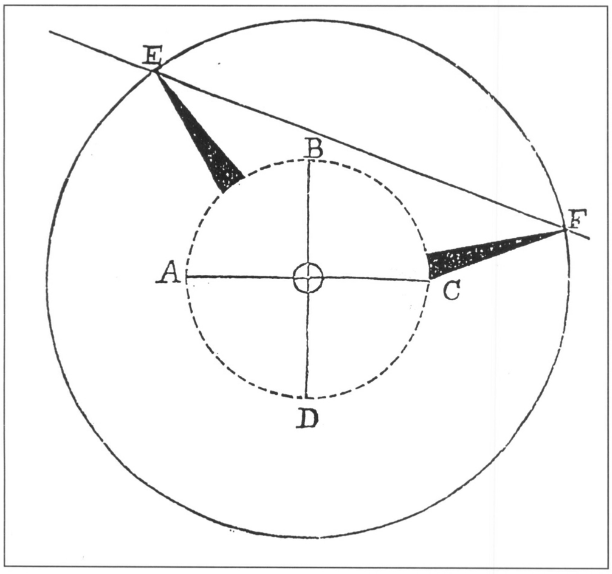


Fig. 2. To set the dyal

knowledge of those matters, will soon distinguish between the true Original, (which was first Calculated, and afterwards Exactly Delineated by Sir *Samuel Morland's* own hands, and the Molds of the Style, which is the principal part of the *Dyal*, carefully Contrived and Corrected) and that ignorant Founder's Counterfeit, and Ill-contrived *Dyal*, to which he has put a Date of 1690, to let the World understand that it was none of his own Contrivance, but that he did Counterfeit one that was made before, *viz.* in 1689. And of which the Style comes False out of the Mold, and by Cutting and Scraping is made Ten Times worse.

If by Accident in sending about, or otherwise, any of these *Dyals*, or the Stiles of them being but Block Tin, shall happen to be Bent; Then with the help of a Square, or for want of that, of a quarter of a Sheet of any paper folded up in a double fold, (which makes an exact Square) it may be bended back, and set right again.

F I N I S

REFERENCES

Sidney Lee (Ed):
. Smith, Elder & Co, London, 1894 "The Poor Man's Dyal"

Author's address:
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Ulcombe, Kent, ME17 1EX

A DOZEN DIALS: A WARWICKSHIRE WALK

JOHN LESTER

[John Lester is experienced at combining a day's outing in the country, on foot or by car, with a sundial-seeking excursion. This Guided Walk has already been enjoyed by enthusiasts for its ancient buildings, history and scenery; the sundials are a bonus!---Ed]

The walk begins at the junction of A3400 and B4439 in Hockley Heath. (Landranger 139 , MR SP 153 726) and the distance is 5 ½ miles.

At the junction there is a war memorial in the form of a sundial (SR 1842) mounted on a tall pillar. It is unusual in that it has three faces on the sides of a vertical prism, and it has survived the years since its erection in 1921 very well. The inspiration for it may well have come from the Ash family who gave nearby Packwood House to the National Trust. From the dial, walk along B4439 and in a few yards descend to the towpath of the Stratford on Avon Canal (built between 1793 & 1816) continuing past a drawbridge, beneath a brick bridge with a winding hole beyond, to

Fig. 1. Dial at Packwood House

arrive at a second drawbridge. Cross this and walk past Drawbridge Farm keeping to the left margin of a field. In the next field aim for its far left corner and then walk the length of a narrow field to cross a stile and walk with a stream on the left until it is possible to cross it by a plank bridge. Climb the slope towards the church of St.Mary the Virgin, Lapworth, seen ahead. Parts of this church date from Norman times but it is mostly of the 13th century. Climb the steps into the churchyard and note the unusual detached tower and the west ("Galilee") porch. On the south wall of the nave are two mass dials, one in imminent danger of flaking off and disappearing. By the blocked-up priest's door in the chancel is a possible gnomon hole which may have marked the site of a third dial.

Fig. 2. Wall dial of 1730, St. Giles Chruch, Packwood

Leave the churchyard by the way you entered and turn right along the lane. At the crossroads beyond the canal bridge go straight ahead along Grove Lane until a footpath is seen on the right just beyond the Dower House. Cross the stile and follow a line of marker posts, noting the view across the lake to Packwood House. After the next stile keep to the left margin of two fields and pass to the left of a bungalow to reach a lane. Turn left here towards Packwood House. As you approach note the topiary garden on your left which is said to represent The Sermon on the Mount. Soon, three of Packwood's sundials become visible : a vertical south (dec 10° E, SR 0986), a vertical east (dec N, SR 0984) bearing the motto "Orimur Morimur" and a vertical west (SR 0985) bearing the motto "Septem sine Horis" Of this latter motto Mrs Gatty says "The meaning of this bald inscription must be that there are in the longest days seven hours (and a trifle over) in which the dial is useless." To the west of the house a cube dial (SR 1964) of 1667 stands in a circular wabe. At present all the Packwood dials are in need of repainting but moves are afoot to persuade the National Trust to undertake this.

On leaving the garden, cross the road and climb some semicircular brick steps leading to the avenue and follow it as far as a transverse belt of trees. Here turn left, and keeping the trees on your right pass through a gate, cross a stream in the next field by a footbridge to arrive at a lane. Here turn right and after about 100 yards take a footpath on the left which crosses the field ahead. In the next field cross a culverted stream and turn right to enter the churchyard of St.Giles, Packwood. The church has a nave and chancel of ca 1300 while the tower, which bears a vertical sundial dated 1730 (SR 1425) was built around 1500. There are three mass dials on the church, the most distinct of which is on a buttress to the west of the porch. Another is on the wall of the nave east of the porch while a fragmentary one can be seen at the side of a chancel window. There is also a possible gnomon hole on a buttress. In the north-east corner of the churchyard is a fine cube dial (SR 3986) which is a memorial to members of the Ash family of Packwood House.

On leaving the churchyard by the western gate the traces of a horizontal dial can be seen on a grave. Follow the drive from the car-park to the road where turn right and then left at a T-junction. A few yards beyond another junction take a footpath on the left and keep to the left hand margins of two fields. Cross a footbridge and in the next field turn left to a second footbridge. Cross this and walk along the right hand edge of the field to a gap at its far end. Beyond this keep to the left hand margin of the next field to cross a stile and a plank bridge into a narrow strip of woodland. Immediately after crossing a second plank footbridge near the end of the wood turn right to cross a stream and walk with the hedge on your right to reach a road. Turn right here for a short distance to rejoin the canal towpath by the drawbridge and continue , passing beneath the A3400, to arrive at the Wharf Tavern where the completion of the walk can be celebrated.

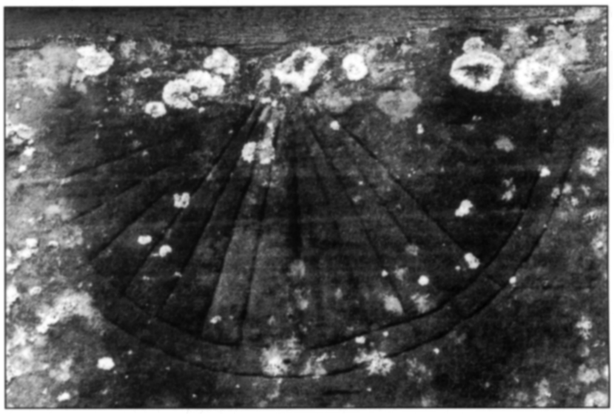

Fig. 3. Mass Dial on a buttress, St. Giles Church

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