The British Sundial Society

BULLETIN

VOLUME 13 (iv) DECEMBER 2001

Front Cover: *Lectern Polar Dial, Bollington, Cheshire: Andrew Somerville Memorial (designed and photographed by C. Daniel)*

Back Cover: *Mass Dial, St. James the Great Church, Fulbrook, Oxon (photo: A.O. Wood)*

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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

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EDITORIAL

The following pages give a comprehensive view of our member's activities: looking at sundials in Wales and in the hills above Lausanne; giving talks and lectures; laying-on exhibitions at Newbury; producing new sundial designs and reviving an old one as John Davis and Michael Lowne have done. In reading the articles we may treasure also the scraps of incidental information. Did you know that Switzerland is in a different time-zone from Britain? Or that it takes the quarrying of 7 tons of slate waste to produce one ton of useable slate? Or the meaning of the good old English word 'pottle'?

Though most of our activities are outward-looking, we occasionally have to look inwards, to see how out Society is being run. Members who were at the York meeting in May or who read the report of it in our September issue will be aware that our constitution is being overhauled by members of a 'constitution sub-commitee'. Their efforts have been skilfully drawn together by our Vice Chairman into a new draft Constitution, a copy of which will be circulated. The draft is now with the Charity Commissioners. If their approval is received in time, copies will come out with this issue of the Bulletin; otherwise with the March 2002 issue. Thereafter the Council will be happy to commend this draft to the membership, for approval at the next AGM, 2002 in Exeter.

COUNTING THE HOURS

MIKE COWHAM

It was probably the Babylonians who first divided the day or *nycthemeron*[1] into 24 hours, with 60 minutes in each. They had no mechanical clocks to provide accurate timekeeping, and relied on the time supplied by the sun's position in the sky. Their day started at sunrise, which was convenient and easy to observe. They counted their hours from 1 to 24, which was the following sunrise. Due to the changing lengths of days and nights according to the seasons, the times of noon and midnight would vary. In the summer, days could end at 14 hours, and in the winter at 10 hours. The Italians reckoned their hours similarly, but starting from sunset, again an easy time to recognise. (Note that our modern system, which starts at midnight, requires more complicated astronomical observations.)

To operate these earlier timekeeping systems a sundial with a polar aligned gnomon was not appropriate. They probably used a vertical stick, reading the time from the length and position of the shadow formed by its tip.

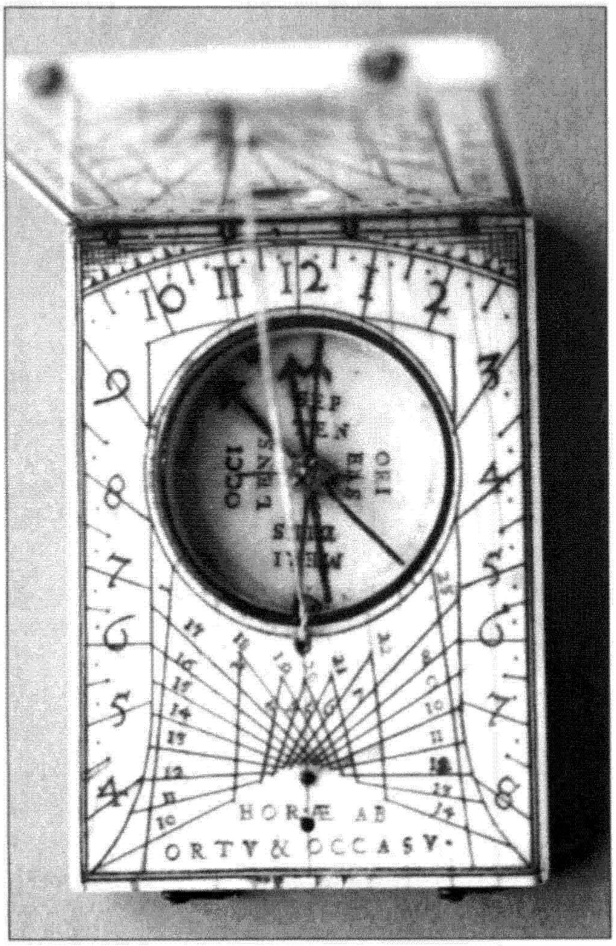

Fig.1. Ivory Diptych Dial by Hans Troschel of Nuremberg

This system of time reckoning was in use throughout much of Europe, but was phased out gradually from the mid 16th Century.

Ivory Diptych dials from Nuremberg often show Babylonian hours, *(horæ ab ortu)*, and Italian (or Welch) hours, *(horæ ab occasu)*, as well as modern hours starting from midnight. Fig. 1. They use a single short vertical pin gnomon to cast a shadow onto the calibrated scale. This scale can be appropriate for only one particular latitude. As the seasons change, so does the shadow length. Each day it will fall on a different part of each line. These dials frequently had dual scales both operating from the same gnomon. This sometimes made the scales quite difficult to interpret. Fig. 2.

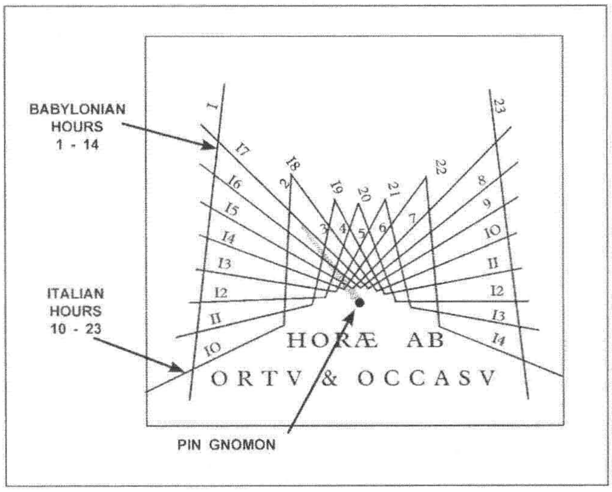

Fig.2. Babylonian and Italian Hours as marked on a Diptych Dial

From much earlier times the Arabs used a 24-hour system commencing at midnight. This was probably due to the fact that their knowledge of astronomy surpassed that of all other peoples of the known world. They needed to navigate across vast tracts of desert with accuracy, and later they crossed wide parts of the sea, colonising much of the Mediterranean basin. These feats required sophisticated navigation technology. They developed the astrolabe, probably as early as the 9th Century and their knowledge of this instrument gradually travelled to Europe, perhaps through Spain.

The Chinese and Japanese also reckoned their days starting at sunset. Their *nycthemeron* had been divided into 12 hours - or *tokis*. Each *toki* was divided into 10 buns and later the bun was further subdivided into 10 *rins*. The Japanese *nycthemeron* therefore consisted of six hours for night, and six hours for the day. Sunset was at 6 *tokis*, midnight at 9 *tokis*, sunrise at 6 *tokis* and noon at 9 *tokis*. Due to the varying length of days at different seasons, it was possible for day and night time tokis to differ by as much as 2:1.

In Japan, as in Europe in the 11th to 14th Centuries, the time was originally sounded by the ringing of a bell. Japanese lives were somewhat complicated, because the use of 1, 2 or 3 strokes on a bell was already used in their temples. They needed to find an alternative method of indicating their tokis. They therefore chose numbers from 4 to 9, avoiding the first three to save any confusion. It may seem strange to us at first but they counted their time periods in reverse. Their reasoning is probably not that strange, as they were counting the *tokis* **to** dawn or **to** sunset. It is just as logical as the way that we do it, counting hours **from** a fixed point. We often say 'twenty minutes **to** eight', and in Germany 'halb acht' is half an hour **before** eight, so in some ways we do exactly as they do. This system in Japan continued in use for several centuries, eventually being abandoned in 1873 when they adopted international timekeeping as we know it today. Their original system caused great complications when the mechanical clock was introduced. They had to find a way to indicate unequal time periods from a mechanism that was very good at recording equal periods. One solution was to have a dial scale that had moveable numerals. These could be moved every couple of weeks to suit the season. A further solution used was to have clocks with dual escapements, or at least timing weights that could be moved to a different position on the arm of a foliot escapement. These would automatically be changed in the clock between day and night periods.

With their sundials, things were a little simpler, as they could be made with a vertical or horizontal pin gnomon. A type of Japanese dial that is found quite often has a small horizontal scaphe dial with a pin gnomon. This is in diptych form, being hinged to a magnetic compass. Fig. 3. The lines on the scaphe dial show only 2 divisions either side of noon, and it is possible to see how short the days become in the winter as the sun sinks lower, throwing the shadow further up the scaphe bowl. These dials would have been very inaccurate. After the change to equal hours in 1873, these old dials and their quaint mechanical clocks were disposed of, often being sold to tourists as curiosities. These objects are now much sought after in Japan, particularly for their museums, and make increasing amounts of money. Dials made since that time have generally been of the string gnomon diptych type.

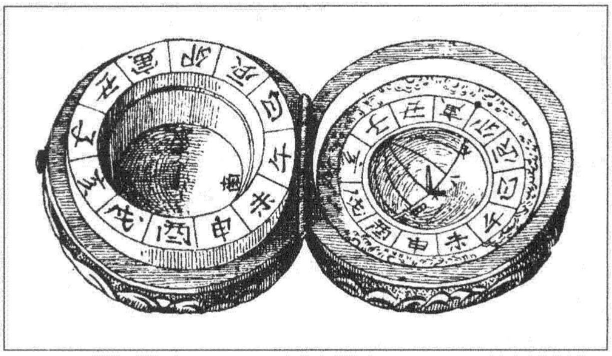

Fig.3. Japanese Scaphe Dial and Compass

HOUR MARKINGS

We are all familiar with markings on modern clocks and watches where the numerals are either Roman or Arabic. Most sundials too have used these characters to indicate the hours. Roman numerals have been the most popular until relatively recently, when the use of watches became widespread, and the man in the street needed to read them with ease.

Care should be exercised with any old numerals, as there were many variations in the form of certain characters. Those on the accompanying chart, Fig.4. should therefore be treated as a guide.

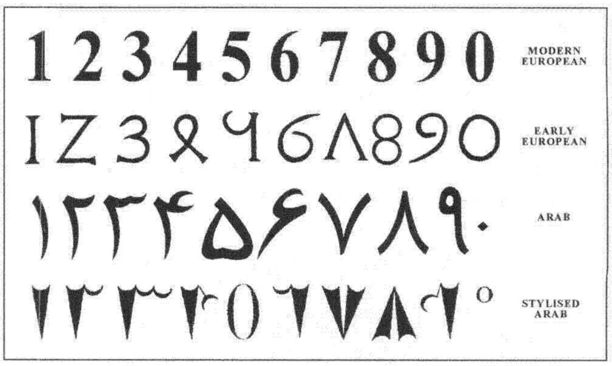

Fig.4. Comparison of Numerals

Arabic numerals have been used by us for many centuries. As their name suggests, they were derived from the numbers written by the Arabs, and many similarities can still be seen. Compare the two types, Modern European and Arab. To avoid confusion, the original Arabic numerals are here referred to as Arab numerals.

Before about 1500, the numerals used in Europe had some quite major differences to modern numerals. Occasionally, dials from this era will be found. Astrolabes, in particular, often carry the older numerals, and their study will show clearly the subtle changes made over the years as modern numerals were developed. A typical set of numerals from before 1450 are depicted as Early European. The numerals of 4, 5 and 7 are quite different to those used today. Note how easy it is to confuse the 5 with the 9. Note also how the 7 is completely inverted compared with the Arab 7 and actually looks like the Arab 8. During the following centuries, the 4 became twisted and straightened into the 4 we know today. The loops on the 6 and 9 were closed, and the 7 was rotated clockwise to make our modern 7. A number 7 more like > will sometimes be found. The rather sharp angled 2, rather like our Z persisted longer, and was still in use in Germany until around 1700. Fig. 5 shows some engraving from an astrolabe of c.1300, where these older numerals are used. Here the scale shows the days in the month of January in increments of five.

Fig.5. Engraved Numerals on Astrolabe of c.1300

Many dials (and later mechanical clocks) were made in Europe from late 17th Century destined for Turkey and other Arab states. The workers making these used stylised Arab numerals of the form shown in Fig. 4. These characters were commonly used on clocks until the mid 19th Century, and particularly on French-made pocket dials. A 'Butterfield' dial by Le Maire, Fig. 6., uses these numerals, but on the underside of its dial plate, the list of towns uses conventional Arab numerals. Note that although Arabic is written from right to left, their numerals are always written from left to right just as we write them.

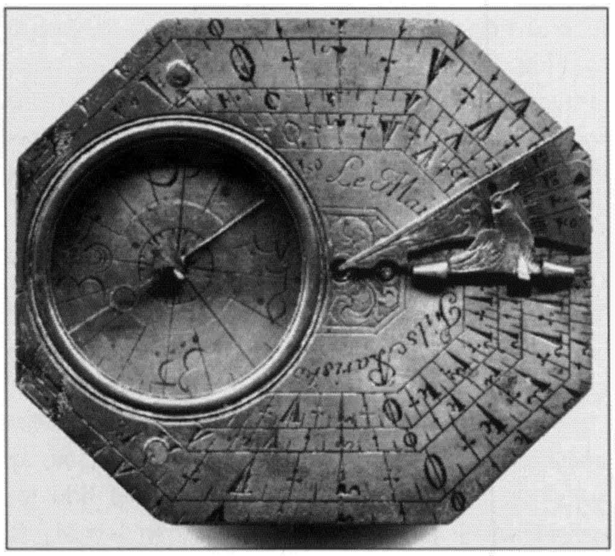

Fig.6. Le Maire Dial with Arab Numerals

Chinese, Korean and Japanese numerals are a little more complex. Each 'hour' of the *nycthemeron* is given to a sign of the Chinese zodiac. It starts with the cock at dusk (6), with the rat at midnight (9), the hare at dawn, (6) and the horse at midday (9). Later, conventional Japanese numerals were also used, but some clocks and dials carry both styles. Fig. 7.

HOUR	NUMERAL	ZODIAC SIGN	ANIMAL
6 Sunset	六	酉	Cock
5	五	戌	Dog
4	四	亥	Boar
9 Midnight	九	子	Rat
8	八	丑	Bull
7	七	寅	Tiger
6 Sunrise	六	卯	Hare
5	五	辰	Dragon
4	四	巳	Serpent
9 Noon	九	午	Horse
8	八	未	Goat
7	七	申	Ape

Fig.7. Japanese Numerals

CONCLUSIONS

It has been shown how various timekeeping methods evolved and how they were annotated on the face of timekeeping instruments.

The various numerals more commonly found on sundials have been described and related as far as possible to our modern timekeeping system.

NOTE

1. *Nycthemeron* is the Greek word signifying a full period of 24 hours. It avoids the possible confusion between 'day', meaning daylight hours, and 'day' meaning a period from midnight to the next midnight.

THE DESIGN AND CHARACTERISTICS OF THE DOUBLE-HORIZONTAL SUNDIAL

MICHAEL LOWNE

(The original version of this article which appeared in the BSS Bulletin for June 2001 contained many errors. The author was not responsible for them. This corrected and revised edition is printed by authority of the BSS Council:-Ed.)

INTRODUCTION

The seventeenth century was a time of rapid development in many branches of science, particularly those of astronomy and mathematics. Pre-eminent in this latter field was the English mathematician William Oughtred (1575-1660)[1]. Born at Eton, he was educated at Eton College and at King's College, Cambridge. After ordination as a priest in about 1603 he held the livings at Shalford and at Albury, both in Surrey, only occasionally visiting London. He took mathematical pupils and maintained correspondence with other leading mathematicians of his day which together with publications in Latin and English established his reputation at home and abroad. An engraved printing plate of a portrait of Oughtred has recently come to light[2]. His contributions to the art of gnomonics included the design of the 'horizontal instrument' and the 'double-horizontal sundial'.

COMPARISON OF THE TWO INSTRUMENTS

It is necessary to distinguish between the two related but separate instruments. The first version (the horizontal instrument) was devised early in the seventeenth century. It is portable and consists of a plan of the sky on a horizontal plane, delineated with hour circles, parallels of declination and ecliptic arcs with date scales enabling the sun's declination to be found for any day. There is a scale of altitudes around the rim and a centrally-pivoted alidade also carrying an altitude scale. In use the instrument is suspended vertically by a ring at the top and held edge-on to the sun so that the shadow of a central pin falls on the outer altitude scale. The reading from this is then transferred to the alidade which is rotated until the altitude coincides with the declination of the sun for that day. The time can then be read at this coincidence point and the times of sunrise and sunset can also be determined. Instrument makers such as Elias Allen became aware of the instrument and made fine examples, although no printed information was available until 1632[3] when a pupil of Oughtred, William Forster, translated and published Oughtred's Latin manuscript which also included a description of his 'Circles of Proportion', a circular slide-rule.

The double-horizontal sundial is a fixed-dial development of the portable horizontal instrument. There are two sets of graduations on the baseplate, the more usual variety with time-marks corresponding to an inclined polar gnomon, and another set with a central vertical gnomon and graduations which are a plan of the sky in the same format as the earlier instrument. Having a vertical gnomon this part of the dial operates from the azimuth of the sun, that is to say the bearing of the point where a vertical line through the sun meets the horizon. The essential difference between the two instruments is therefore that the one operates from the altitude and the other from the azimuth of the sun. Both are made for a specific latitude and require knowledge of the sun's declination as the third parameter. Descriptions of the double-horizontal dial and its uses were given by Oughtred in pamphlets issued in London in 1636[4] and later editions.

Studies of the dial by A J Turner[5] and F W Sawyer[6] have been of assistance in the preparation of this article. Turner gives details of an acrimonious dispute between Oughtred and Richard Delamain, also a mathematician, who claimed priority in the invention of the circles of proportion and the horizontal instrument. A reprint of Oughtred's 1636 description and uses is provided by Sawyer.

It appears that the first double-horizontal dials were made by Elias Allen but they were soon produced by other instrument makers. Few of the dials are dated but from the known dates of the makers it seems that the dials were not in vogue for very long, the last known example being made by Benjamin Scott in about 1713.

DESCRIPTION OF A DIAL

The surviving double-horizontal dials are now three hundred or more years old and where they have been left *in situ* are quite possibly patinated or eroded and difficult to decipher[7]. One well-preserved example is a very fine dial by John Seller which is now in a private collection. Seller was not only an instrument maker: he was a cartographer and held the appointment of 'Hydrographer to the King' over three or four reigns. Figure 1 is a view of his dial (which is made for latitude 51½°N) showing the inclined polar gnomon and tucked underneath it the shorter vertical gnomon. The long polar gnomon is necessary to ensure that the shadow reaches the outer graduations when the sun is high in the sky. The fillet around the gnomon base would interfere with the operation of both dials at low solar altitudes and suggests a

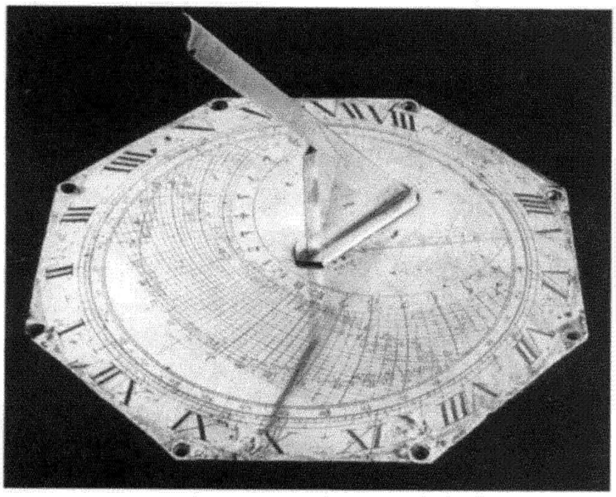

Fig.1. Double-Horizontal dial by John Seller

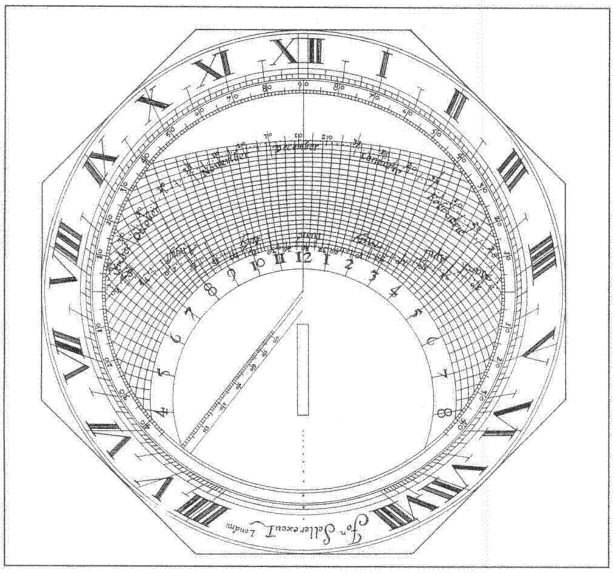

Fig.2. Dial-plate of the Seller dial

later repair or replacement. A face-on drawing of the dial-plate is shown in Figure 2: here the Roman numerals and time graduations (divided to five-minute intervals) relating to the polar gnomon are seen around the periphery. Inside these are the graduations of the azimuth dial which enable a number of astronomical quantities to be derived from the shadow of the vertical gnomon. The shadow-casting part of this gnomon is chamfered to a sharp vertex: there is then no need for a discontinuity in the graduations at noon to allow for the gnomon thickness as with the polar dial. However, the azimuth dial reading is limited by the vertex angle of the gnomon. In the Seller dial (and others) this is about 30°, so that if the sun is within 15° of the meridian the shadow will be cast, not by the vertex, but by one or other of the edges of the V, giving incorrect readings. This will occur between about llam-lpm in midwinter and 11.30am-12.30pm in midsummer, in the latitude of the British Isles.

THE AZIMUTH DIAL

The shadow of the vertical gnomon on the dial face is diametrically opposed to the azimuth of the sun: the dial plan is therefore turned through 180° with respect to the sky. Immediately inside the polar dial time graduations is a circle centred on the foot of the vertical gnomon. This represents the horizon and is divided to degree intervals of azimuth and labelled every 10°. The zero points are to east and west and the numbers increase until they meet at 90° at the south point. North of east and west they again increase but only to 40° on each side. These are the northerly limits of sunrise and sunset at the summer solstice and further graduation is unnecessary.

Running across the dial from east to west is an array of curved arcs with some thicker than others. These represent the path of the sun across the sky depending on its declination, the angular distance north or south of the celestial equator. They are not labelled but it is easy to see that the central thick line is the equator and others are spaced at two-degree intervals (only 1½° for the outer interval from 22° to 23½°) with thicker lines at 10° and 20° north and south. The thick lines are not shown on Figure 2.

Crossing the declination lines are others labelled with Arabic numerals from 4 in the east through 12 in the north-south line to 8 in the west. These are hourly time-lines and each hour is divided into quarters. Some dials have declination arcs for every degree: the dial by Thomas Tuttell shown in Figure 3 is one example. The time scale on the Tompion dial at Hampton Court[8] is divided to five-minute intervals.

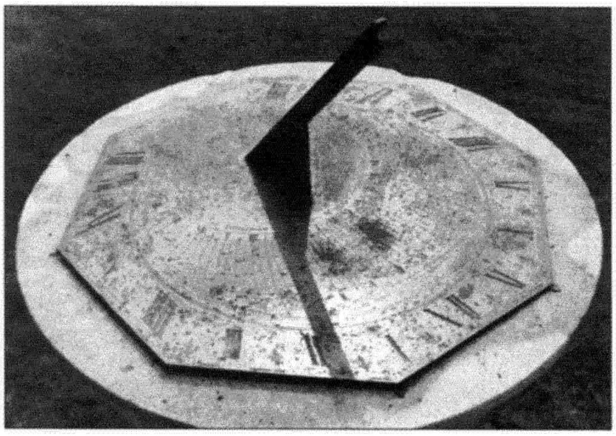

Fig.3. A dial by Thomas Tuttell

Two arcs meet the azimuth circle at the east and west points and curve round to touch the declination lines at the extremes of ±23½° on the north-south line. These show the annual path of the sun through the sky (the ecliptic) inclined at 23½° to the equator, the tilt of the Earth's axis of rotation relative to the orbit (the obliquity). They carry a scale of dates, divided to individual days and labelled for the 10th, 20th, and last day of the month. The declination of the sun for every day of the year is thus indicated, but individual days between the 5-day markers are shown only schematically on Figure 2. The solstices (sun at 23½°) are shown as June 11 and December 11, and the equinoxes (sun at 0°) as March 11 and September 13, ten days earlier than our present reckoning. When this dial was made in the late seventeenth century Britain was still using the Julian calendar, at that time ten days behind the reformed Gregorian calendar we now use.

A diagonal scale running from the gnomon point to the NE horizon is an almucantar for determining the altitude of the sun. It is divided to degrees and labelled every 10°.

THE USE OF THE DIAL

Much astronomical information can be found from this construction and the shadow of the vertical gnomon. By reading the azimuth scale where it is met by the shadow (or its extension if it doesn't reach that far) the sun's azimuth can be determined. If the date is known the time can be found by locating the date on the ecliptic scale, noting the corresponding declination (probably between two lines) and following that declination round until it intersects the gnomon shadow. The position on the hour scale of this intersection shows the time. In a reverse procedure, the declination and approximate date can be found be taking the time from the outer dial, transferring this to the corresponding inner dial time-line and noting the declination where this crosses the gnomon shadow. Following this back to the ecliptic gives the date. This method of finding the date is not very sensitive: the maximum rate of change of the sun's declination (at the equinoxes) is only 0.4°/day. At the solstices the declination changes very slowly and remains effectively at the same value for several days at a time. Some dials, notably the late example by Benjamin Scott, have the scale of dates at the ends of the declination arcs. A few dials do not carry a date scale: for these it is necessary to use the time derived from the outer dial as explained above to find the declination.

Having found the declination of the sun, the line can be followed to the horizon circle at east or west side. This will give the times of sunrise and sunset by reading the time graduations at those points. The azimuth at rising and setting can also be found from the horizon circle. The times of sunrise and set can of course be found for any day of the year, not just the current date, by following the appropriate declination line to the horizon.

The altitude of the sun is found by setting one point of dividers upon the derived position of the sun at the declination-gnomon shadow intersection and the other on the foot of the vertical gnomon. Transferring this distance to the almucantar scale enables the sun's altitude to be read off.

These properties are demonstrated by the simplified drawing of the south-west quadrant of the azimuth dial in Figure 4, with just sufficient detail to show the principle. A diagonal line represents a gnomon shadow which indicates a solar azimuth of 50° south of west. Suppose the date is February 13: this day-mark on the ecliptic curve gives the declination as –10°. Following this line to its intersection with the shadow shows the time to be just after 2.30pm, say 2.32. In Table 1 these and other quantities derived from the dial by the above methods are compared with values calculated for that azimuth and date.

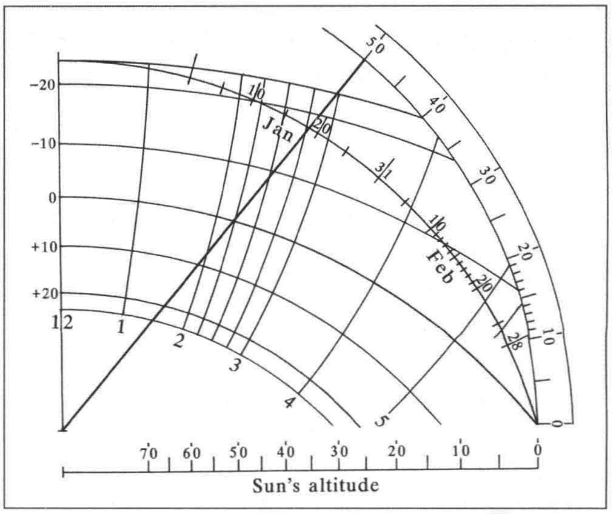

Fig.4. To illustrate the use of the azimuth dial

TABLE 1

Quantity	Derived from dial	Calculated
Declination	-10°	-9.9°
Time	2.32pm	2.3lpm
Sunset	5.9pm	5.l0pm
-at azimuth	16°S of W	16.0°S of W
Sun's altitude	20°	20.5°

As is traditional in gnomonics, the effects of atmospheric refraction are ignored in the time and azimuth of sunset. The agreements between the calculated values and those derived from the dial are most satisfactory!

In the 1636 description Oughtred gives no less than twenty possible uses of the dial, although some of these are rather repetitious. In addition to those already mentioned, it is possible by use of the azimuth scale to determine the declining angle of a wall, either with the dial unmounted or permanently fixed. In the latter case a horizontal board is used with a line drawn perpendicular to the wall. The shadow of a plumb-line as it crosses this line is marked off. Then, says Oughtred, "run instantly to the dial" and take the reading of the sun's azimuth. This angle, if drawn relative to the marked position of the plumb-line shadow, shows the north-south line. The angle between this and the perpendicular to the wall gives the declining angle.

By imagining the dial to represent the hemisphere of the sky which is below the horizon, the duration of twilight and the depression of the sun can be found.

Another quantity (apparently not envisaged by Oughtred) which can be deduced is the right ascension (RA) of the sun, the angular distance along the celestial equator (measured in time) from the March equinox to the hour circle through the sun. This can be obtained by ignoring the time figures and counting the hours and minutes forward along the equator from the equinoctial points to the hour line containing the required date, starting the count at 0 hours at the March equinox and 12 hours at that of September. As the sidereal time is defined by the RA which is due south on the meridian, the sidereal time at apparent noon is equal to the sun's RA. Adding 12 hours to this (strictly 12 hours 2 minutes) will give the sidereal time at midnight. A dial by Elias Allen now in the Science Museum and illustrated by Turner[5] has subsidiary small figures along the 0° declination arc to facilitate determining the RA of the sun in this way. It also gives the RA of twelve bright stars to the nearest quarter-hour. These include 'Great Dog', 'Lion's heart', 'Bull's eye' and 'The Goate', respectively Sirius, Regulus, Aldebaran and Capella. There is 'A Moone Dial' consisting of small Arabic numerals just inside the Roman numerals of the polar dial and a table of ages of the moon and corresponding hours to correct the dial reading. The presence of the moon dial implies that the star table is also intended as a means of telling the time at night. I am not suggesting that the wakeful owner should venture out in his nightshirt to consult his dial by candle-light; it would be simple to memorise the midnight sidereal time and the RA of a few stars which transit in the hours of darkness at that season. By observing the position relative to the meridian of a star of known RA an estimate of the sidereal time can be made. The difference between this and the midnight sidereal time will give an approximate figure for the solar time.

Other dials, notably some of the large instruments made by Henry Wynne, also carry moon-dials and the RA of some stars.

THE SELF-SETTING PROPERTY

The combination of polar and azimuth dials implies that the instrument is self-setting: by rotating it in a horizontal plane until both dials show the same time it will in principle be correctly oriented in the meridian. Although Oughtred makes much use of this property he does not mention the limitations of determining the orientation in this way. The crucial factor is the error in the orientation which will be caused by a small difference between the times shown by the two dials. From practical tests I find that the mutual agreement of the time readings cannot be judged to better than a minute. Even such a small difference will introduce an orientation error whose extent is strongly dependent on the hour-angle of the sun at the time of the operation and is also affected by the sun's declination and the latitude. Figure 5 shows the relation between the hour-angle of the sun and the orientation error, the angle through which the dial can be rotated to either side of the true position before a difference of one minute between the dial readings can be detected. It is drawn for latitude 52°N and two declinations, +20° and –20°. Looking at the +20° (summer) line, the orientation error for one minute difference between the dial readings cannot be less than about ½° and then only if the sun is at least four hours off the meridian. At smaller hour angles the error builds up very rapidly and it would be useless to try to obtain an accurate setting if the sun is within about 2½ hours of meridian passage. In winter (-20°) it is hardly possible to obtain a satisfactory orientation at all. The latitude dependence is such that at 58° the error is about 50% greater than shown in Figure 5 but is only about half as much at 40°.

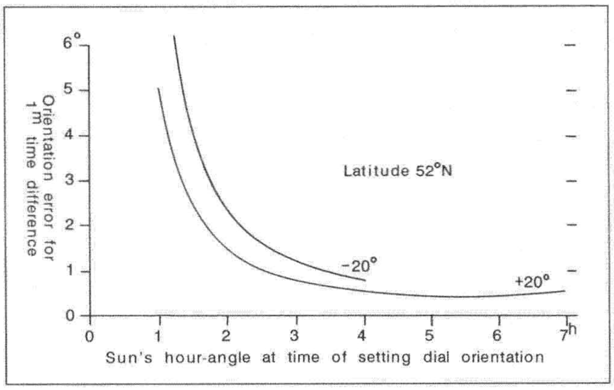

Fig.5. The orientation error for one minute time difference

Any error in the orientation will of course have an effect upon the time-keeping of the dial. Broadly, an error of one degree in the orientation will cause an error of four minutes in the indicated time. Even at the most favourable time of setting the orientation the time error caused by one minute difference between the dials will be about 2 minutes. The error rises rapidly under unfavourable conditions and the dials could be as much as twenty minutes wrong if orientation is attempted with the sun near the meridian. Matters can be improved by rotating the dial first in one direction and then the other to find and mark the two positions where a time difference can be detected. The mid-point of the two marks will provide a fair indication of the true orientation if the sun is not too close to meridian passage.

THE MAP OF THE SKY

In common with all map-makers Oughtred was faced with the problem of depicting part of a sphere (in this case the complete visible hemisphere of the sky) on a plane surface. The resulting flat map is termed the projection of the sphere and many types of projection have been devised. All involve some distortion in representing a sphere on a plane, and it is a question of selecting the best projection for the particular purpose. The one used by Oughtred is known as the stereographic projection (Greek *stereos*, solid, *graphein*, to write). In the 17th century this was much used for terrestrial and celestial maps, such as those by Cellarius[9] sometimes reproduced as calendar illustrations. It suffers from distortion and large variation of scale, but for the present purposes these defects are not significant and the projection has other properties which make it ideal for this application. One of the useful properties is that circles on the sky project as circles on the plane, except for great circles passing through the origin, which project as straight lines. This contrasts with the gnomonic projection used in polar-gnomon plane dials, in which great circles project as straight lines and small circles appear as conic sections. (Great circles are those whose plane passes through the centre of the sphere: all other circles are small circles. For example, on the Earth meridians of longitude and the equator are great circles and parallels of latitude are small circles.) Another useful property of the stereographic projection is that angles on the sky are reproduced on the map, in the sense that the tangents to the arcs of projected lines at their intersection meet at the same angle as the corresponding arcs on the sky: this is of use in a geometrical delineation of the dial. Except in the case of the horizon the centres of the circles on the map do not coincide with the corresponding centres on the sky and the necessary centres and radii to draw them must be found by calculation or geometric construction. In Figures 1 and 2 the row of small pits on the line of the gnomon are some of the centres from which the declination arcs were struck.

The principle of the stereographic projection applied to the case of a horizontal dial-plate is shown in Figure 6. The circle NZSO represents the meridian with Z the zenith and O the opposite point, the nadir. NESW is the dial plate in the plane of the horizon and ZCO is the vertical through its centre. A position on the sky is shown at P and ZPF is the vertical arc through P meeting the dial plane at F. The angle NCF is the azimuth (A) of P from north. The nadir O is the origin of the projection and a line joining PO cuts the plane NESW at Q which is called the stereographic projection of P. As Q lies in the line CF, the azimuth of P from the north point is exactly reproduced on the dial by angle NCQ.

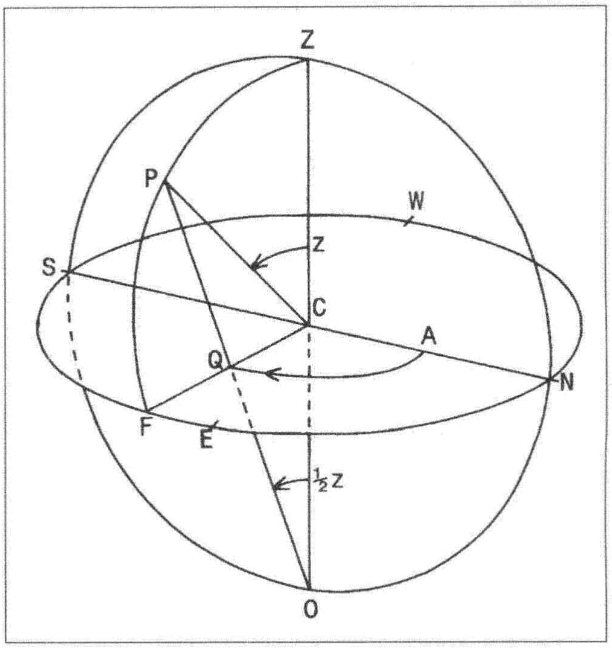

Fig.6. The principle of the stereographic projection

By joining CP, the angle ZCP is the angular distance of P from Z, called the zenith distance (z) of P. The triangle PCO is isosceles (PC=OC, both radii of the circle) so the angle COQ is $\frac{1}{2}z$. Triangle OCQ is right-angled at C, therefore the distance CQ is proportional to $\tan\frac{1}{2}z$. At the horizon $z=90°$ and $\frac{1}{2}z=45°$ whose tangent is 1, so if R is the chosen radius CF of the horizon circle on the dial the distance CQ is $R\tan\frac{1}{2}z$.

In the following formulae and those of the next section, the symbols used are:

Latitude	ϕ
Sun's hour-angle	h
Sun's declination	δ
Obliquity of the ecliptic (23.44°)	ε
Radius of the horizon circle on the dial	R
Radius required to draw a projected circle	r

The rectangular coordinates x and y on the projection are referred to the meridian and the prime vertical, the great circle which passes through the zenith from the east-west points of the horizon. Both circles project on to the dial as straight lines as shown in Figure 7. In astronomical usage, x increases to the west and y increases to the north so, remembering that the dial plan is rotated by 180° and taking the centre of the dial as the zero-point, the signs of x and y

appear on the dial as in Figure 7. (Sawyer[6] uses the opposite sign convention for y.)

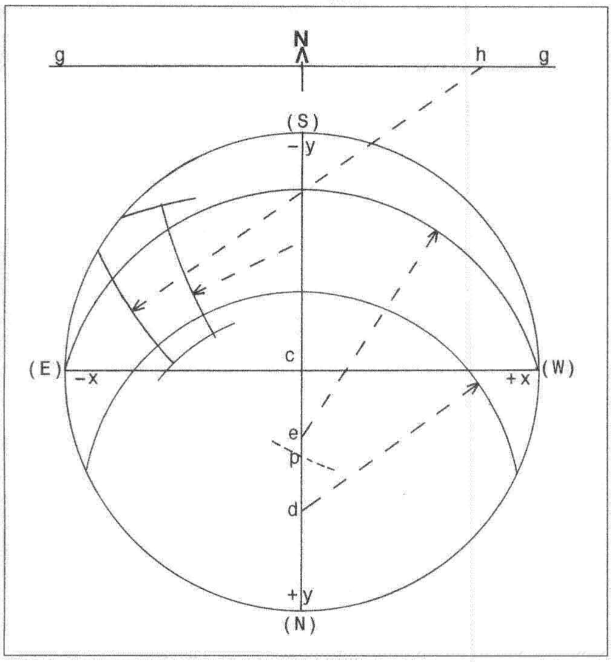

Fig.7. Delineating the azimuth dial

Any point on the sky (defined by its hour-angle and declination and the latitude), can be plotted from the general formulae:

$$x = \frac{R(\cos\delta.\ \sin h)}{(1+\sin\phi.\ \sin\delta + \cos\phi.\ \cos\delta.\ \cos h)} \qquad 1.$$

$$y = \frac{R(\cos\phi.\ \sin\delta - \sin\phi.\ \cos\delta.\ \cos h)}{(1+\sin\phi.\ \sin\delta + \cos\phi.\ \cos\delta\ .\cos h)} \qquad 2.$$

DELINEATION OF THE STEREOGRAPHIC PROJECTION

An interesting challenge to a present-day dial-maker would be to build a modern version of the double-horizontal dial. My own effort (somewhat simplified and made only in chipboard and plywood) is shown in Figure 8. The early dial-makers most probably used geometrical methods for the delineation but in these days of computers (or even pocket calculators) it is a simple matter to calculate the necessary details.

The arcs of the projected declinations and the two ecliptic curves are symmetrical on either side of noon, so that their centres lie on the meridian (x=0) line. In Figure 7 a declination arc is shown centred at d and one of the ecliptic arcs centred at e.

The centre of a declination arc is given by:

$y = R\cos\phi/(\sin\phi+\sin\delta)$ 3.

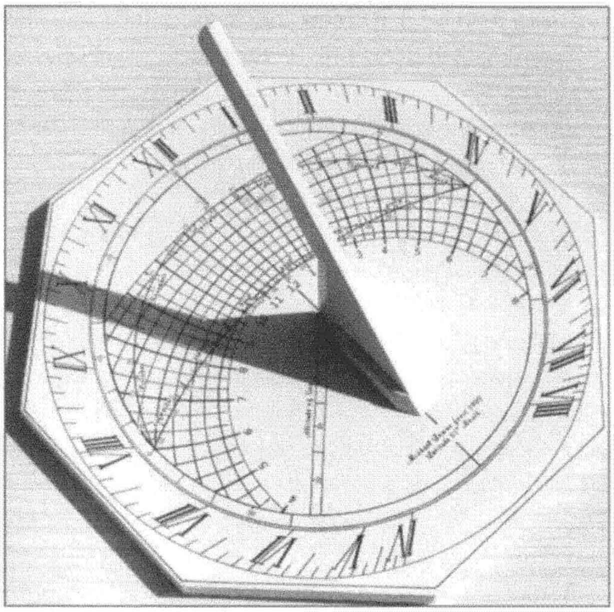

Fig.8. A modern double-horizontal dial by the author

The radius required to draw the arc is:

$r = R\cos\delta/(\sin\phi+\sin\delta)$ 4.

The two ecliptic arcs require different centres and radii. For the March-June-September arc:

$y = R/\tan(\phi-\varepsilon)$ 5.

$r = R/\sin(\phi-\varepsilon)$ 6.

and for the September-December-March arc:

$y = R/\tan(\phi+\varepsilon)$ 7.

$r = R/\sin(\phi+\varepsilon)$ 8.

The centres of the hour lines (as at h) lie on a straight line g-g which is parallel to the x-axis. For this:

$y = -R\tan\phi$ 9.

The centres and radii of the arcs are given by:

$x = -R/(\cos\phi.\tan h)$ 10.

$r = R/(\cos\phi.\sin h)$ 11.

Lines which are separated by 12 hours have the same centres and radii. The hour lines need only be drawn over the range covered by the declination arcs between +23.5° and –23.5°, or down to the horizon if –23.5° is below the horizon at that point, as can be seen on Figures 1 and 2 and indicated on Figure 7. It will be found that lines close to the meridian are nearly straight, with centres at considerable distances from the dial centre-line. If the radius required is more than can conveniently be handled by compasses or trammels, it is possible to calculate the x,y positions at intervals by the general formulae (1,2), plot the resulting points and join them with a suitable curve.

Some of the formulae for the radius r may give a negative value: this may be ignored and the absolute value taken.

In delineating the dial, various checks can be made. The arc for the equator (δ=0°) should pass through the east and west points of the horizon, as will the two ecliptic arcs, which should also touch the limits of declination (±23.44°) on the meridian. Although it is not necessary to extend the hour lines beyond the range of the declination arcs, they should pass through the projected pole of the sky which is on the meridian and at $y=\tan\frac{1}{2}(90-\phi)$, p in Figure 7. The arc for 6 hours hour-angle (h=90°) is centred at x=0 and should pass through the east and west points of the horizon.

It remains now to put the scale of dates on the ecliptic arcs. The distance along the ecliptic traversed by the sun during 24 hours varies, due to the elliptical nature of the Earth's orbit around the sun and the resulting variations of orbital velocity. The average daily motion of the Sun is 59 arc-minutes, but when the Earth is closest to the Sun (at perihelion) in early January it is 61'/day and at its furthest (aphelion) in early July it is 57'/day. If the mean and true sun are taken as together at perihelion, three months later the sun is 1.92° (or nearly two days' motion) ahead of the position it would occupy if the Earth's orbit were circular. The sun then drops back until at aphelion mean and true positions again coincide. After three months the sun is 1.92° behind the circular motion position.

The x,y coordinates of the sun on the dial for each day can be derived from the true longitude of the sun, its angular distance along the ecliptic from the 'first point of Aries' at longitude 0° where the ecliptic intersects the equator at the March equinox. Throughout the leap-year cycle there are small variations in the daily longitudes, but for the present purpose these are disregarded and average values taken. It is convenient to use the midday values of the longitude which is calculated by applying a correction for the elliptic motion to the longitudes found from the average daily motion of the sun of 0.9856°/day (=360°/365.25 days). The longitude (averaged over the leap-year cycle and adjusted to allow for the leap-year differences) on December 31 at midday is 280.1° and at the present time the Earth is at perihelion on January 3. The sun's longitude L is given by:

$$L = 280{\cdot}1+0{\cdot}9856d+1{\cdot}92\sin(0{\cdot}9856(d-3)) \qquad 12.$$

where d is the day of the year: January 1=day 1, February 1=day 32 and so on. February 29 is ignored.

The x,y coordinates of the daily points are given by:

from March 21 to September 22 (L 0° to 180°)

$$x = R\cos L/(1+\cos(\phi-\varepsilon).\sin L) \qquad 13.$$

$$y = -R\sin(\phi-\varepsilon).\sin L/(1+\cos(\phi-\varepsilon).\sin L) \qquad 14.$$

and from September 23 to March 20 (L 180° to 360°)

$$x = R\cos L/(1-\cos(\phi+\varepsilon).\sin L) \qquad 15.$$

$$y = R\sin(\phi+\varepsilon).\sin L/(1-\cos(\phi+\varepsilon).\sin L) \qquad 16.$$

The daily points for the sun's position should of course lie along the pre-drawn curves for the ecliptic.

The almucantar operates from the zenith distance (z) of the sun but is graduated for the altitude (a): $z = (90-a)$. Radial distances from the foot of the gnomon are given by:

$$r = R\tan\tfrac{1}{2}(90-a) \qquad 17.$$

The height of the vertical gnomon should be not less than half the radius of the horizon circle. This constrains the placing of the root of the polar gnomon and at low latitudes may result in an excessive distance from the dial centre.

DELINEATION BY GEOMETRICAL METHODS

As mentioned earlier, it is possible to delineate the dial by geometrical construction and it seems most probable that the seventeenth century dials were made that way. Sawyer[6] has given full details and it is not proposed to repeat the explanation here. Briefly, the principle is that the projected arcs, if drawn as complete circles, would intersect the meridian line in two points, generally one above and one below the horizon. The centre of the arcs must lie midway between the projections of these two points and the radius is half their separation. The line of the centres of the hour arcs is at the mid-point of the projections of the north and south poles and the centres are found by drawing lines from the pole at the appropriate hour-angles to meet the line of centres. From these points the arc radius is the distance to the pole. A major difficulty with the geometric method is that some of the projected points lie at considerable distances from the centre of the dial, necessitating the use of a large setting-out table. Such an item would have been common in an early instrument-maker's workshop.

How the scale of dates was inserted on the ecliptic is not known: one method would have been to plot the tabulated right ascension of the sun for each day along the ecliptic arc using the hour-lines, the reverse of the procedure mentioned earlier.

THE EXISTING DIALS

Table 2 is a list of known dials, listed by maker and showing the date where this is known (or in some cases an inspired guess), the material and dimensions, the present location and other brief details. It cannot be taken as complete: early sundials are still being discovered and other double-horizontal dials may be among them.

Table 2

Elias Allen, (fl 1606-1654):			
Undated	Brass, 12" octagonal	Museum of the History of Science, Oxford	
Undated	Brass, 12" octagonal	National Maritime Museum, Greenwich	
Undated	Brass, 12" octagonal	Science Museum, London. Latitude 51½°N	a.
Bacon (? maker or owner)			
Undated	Brass, 13" square	Not known. Lat.51°56'. Eq. of time table	b.
Hilkiah Bedford, (fl.c 1656-1680, d1689):			
1668	No details	St Andrews.	
Jacob Clark:			
c1680	Brass, octagonal	National Museum of Scotland Edinburgh	
c1700	Brass, octagonal	National Museum & Gallery Merseyside	
Croft, Ilminster:			
Undated	Bronze, 14½" square	Somerset, SR3949 Gnomon not original	
Daniel Delander (1678-1733):			
Undated	Bronze, 24" diam	Northamptonshire. SR3607 Lat. 51½°N	
Ralph Greatorex, (1625-1712):			
Undated	Brass, square	Private collection	
Stephen Gray:			
1699	Brass, 12" square	Kent. SR4123	
Benjamin Scott (fl 1712-1751):			
c1713	Brass, 20½" diam	Paris	
John Seller (fl 1658-97):			
c1680	Brass, 8½" octagonal	Private collection. SR3121 Lat. 51½°N, Figures 1 & 2.	
Henry Sutton (working 1649, d1665):			
1658	Brass	Not known	
1659	Square	Not known. Broken gnomon	c.
Thomas Tompion (1638-1713):			
1690	Brass, 20½" diam	Hampton Court. SR2119	
Thomas Tuttell (working 1693, d1702):			
c1700	Brass, 15" diam	Kent, Figure 3. SR3539	

Henry Wynne, (fl 1654-1709):

1682	Brass, 30½" diam	English Heritage SR2125	d.
c1690	Brass	Grafton Hall	
c1690	Brass	Powys Castle	
c1690	Brass, 36" diam	Norfolk. Lunar table, equation of time.	
c1690	Brass, 27" diam	Not known	e.
1692	Brass, 33" diam	Dumfriesshire. Lat 56°N. Spiral moon dial. SR0897	f.
1695	Brass	Not known	
Undated	Brass, circular	London	
Undated	Brass, 16¼" octagonal	Sussex. Gnomon missing	

Anon:

mid 17c	Brass, 13" octagonal	Illinois	
Undated	Brass, octagonal	Kent, SR0001	g.

MODERN DIALS:

Michael Lowne:

1999	Chipboard and plywood 10½" octagonal	Sussex. Lat.51°N. Figure 8

John Davis:

2000	Brass, 12" octagonal	Suffolk. Lat.52°4'N.
2000	Brass, 13" square	Norfolk. Replica of 'Bacon' dial.

NOTES TO TABLE 2:

a. This is the dial described in the text, with moon dial and star positions.

b. The date scale is on the horizon at the ends of the dec. lines. Advertised for sale in Spring 2000 for $4950.

c. Sold at auction for £920[10].

d. A replica of this dial has been made for use at Wrest Park.

e. Sold at auction for £11500 in 1990.

f. A recent photograph has appeared in a BSS *Bulletin*[11].

g. This dial has the stereographic plan to the south of the gnomon. It is apparently read from alidades which can be pointed towards the sun, thereby duplicating the function of the shadow of a vertical gnomon.

The notation SR is the entry number in *The Sundial Register*, 2000[12].

More than half the 17th and 18th century makers listed are represented by only one dial. It has been suggested that possibly some of these solitary examples were made by instrument-makers' apprentices at the conclusion of their indentures to demonstrate their capabilities.

ACKNOWLEDGEMENTS

The photograph and drawing of the Seller dial in Figures 1 and 2 were kindly provided by the owner of the dial. The major part of the list of surviving dials was supplied by Mr Christopher St J H Daniel: other information was provided by Mr J Moir, Mr M Kenn and Dr J R Davis. I am indebted also to Mr Daniel for the photograph of Figure 3 and for much technical help and encouragement. Miss R J Wilson provided biographical details of some dial makers.

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24 Ditchling Way
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East Sussex BN27 3LU

WALES, 2001

DON PETRIE

"Croeso i Gymru"

Welcome to Wales! The 2001 Wales Sundial Safari began on Saturday, September 1. After a frustrating day dealing with train delays and missed connections, Jackie and I were happy to be greeted by David Young, our tour organiser, who immediately whisked us off from Llandudno Junction to our home base for the week - the Glen Aber Hotel in Betws y Coed. This is a relatively small family-run hotel in the heart of the Snowdonia National Park in North Wales.

One of the first things one notices is the language on the signs. Wales is bilingual and any language that has people or place names with over 50 letters and few vowels is rather formidable.

Betws-y-Coed gets its name, meaning "prayer house in the woods", from the 6th century Bede House on whose site the present 14th century St. Michael's Church now stands. The village is located in a superlative setting surrounded by dense woodland and magnificent mountain country enhanced by rivers with their waterfalls and ancient bridges.

We met for dinner in the hotel dining room and renewed acquaintances with old friends and met several new ones. A total of 34 people were to participate in the tour. After dinner there was a brief orientation meeting during which David outlined the plans for the upcoming week.

On Sunday morning we started out in typical sundial hunting weather - cloudy and a slight drizzle, which later improved to cloudy. We travelled down the Valley Conwy to the nearby market town of Llanrwst to see one of only three sundials on bridges in the British Isles. This famous Inigo Jones bridge is locally called the "Bridge of Shouts" because it is so narrow and humped that drivers would shout to find if anyone was coming from the other side. This bridge was built in 1703 and was the only bridge to survive when an upstream dam broke in 1926. The dial is a plane horizontal one on the north side of the centre span of the bridge. It is circular and about 10" in diameter with a thick long gnomon. There is a plaque below it reading, "This dial was placed here to commemorate the tercentenary of the bridge. August 27, 1936."

After coffee at a 15th century house whose Welsh name means 'Beyond the Bridge', we continued north to the walled town of Conwy, acknowledged as a World Heritage Site. It was known in medieval times as "the strongest and fairest town in Wales". Its strength lay in its castle and town walls. The whole 1.3 km long wall with its 22 towers and 3 gateways is completely preserved. Built simultaneously with the castle, it is unique in Wales. Castle Conwy was built by Edward I King of England, as one link in a chain of mighty new fortresses, one day's march apart, in his military campaigns to conquer Wales. As one of the key castles in the English monarch's "iron ring", Conwy is "incomparably the most magnificent". Building of it was started in 1283 and completed in a mere 5 years at a cost of £1500, (£ 12 million today). Its imposing grey battlements form a stark contrast to the colourful scene of the town and busy harbour with its yachts and fishing boats. A magnificent view of the complete walled town and Conwy estuary is seen from the castle's Chapel Tower (106 steps!). Also impressive is the suspension bridge completed in 1826 to replace the ferry, previously the only means of crossing the river. It is considered to be Thomas Telford's engineering and architectural masterpiece.

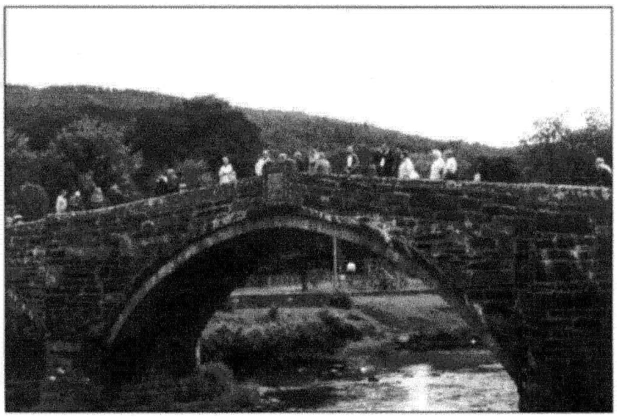

Fig.1. On the Bridge of Shouts, Llanrwst: sundial and diallists (DP)

Our first stop was at the 1765 church of St. Mary and All Saints. Here is a horizontal sundial on an elegant stone pedestal. The circular bronze dial is badly pitted. It was made by Meredith Hughes and so is about 200 years old. Also in Conwy our sight-seeing included Plas Mawr, the finest surviving Elizabethan gentry town-house in Britain, built about 1580 and carefully restored; and 'Britain's Smallest House' down on the waterfront, a mere 3.05m high and 18m long.

In the afternoon, we stopped at Bodnant Gardens in sun and cloud. This house, belonging to Lord Aberconway, is now leased to the National Trust. Its 80 acres, consisting of a

Fig.2. Heliochronometer, Bodnant Garden (MC)

terrace around the house and an expanse sloping down to the River Hiraethlyn, were laid out in 1875. On the terrace is a heliochronometer made by Pilkington and Gibbs at the beginning of the last century. It was in working order but its accuracy is made questionable by a wobbly mounting on a very elaborate pedestal. Also, on the terrace step is an unnamed and undated horizontal sundial. It is a plain circular dial with no motto or other embellishment

On Monday, we again had damp and cloudy start but the day gradually cleared. We made our way southwards along the twisty road through the Lledr Valley and up over the Crimea Pass to Blaenau Ffestiniog, formerly a major centre for slate mining. Now, it is surrounded by mountains of waste slate workings that threaten to engulf the town. Each ton of usable slate had produced seven tons of waste!

Past the town of Harlech with its famous castle, we came to the village of Dyffryn Ardudwy. In the churchyard cemetery is the tomb of G.Griffiths (died 1844), his first wife Clarissa (died 1859) and his second wife Ann (died 1863). On the top of their vault is a slate cross dial-the only cross dial reported in Wales. It has an approximately 2 ft. long shaft which is cracked but the markings are clearly legible.

Then we travelled north to the famous Italianate village of Portmerion, This fascinating mish-mash of architectural styles from around the world revealed some new feature every time you turned around. It was designed with marvellous ingenuity by Clough Williams-Ellis to fulfil his boyhood dream of building his own ideal village. He wanted to demonstrate how a naturally beautiful location could be developed without spoiling it. There are two sundials in Portmerion. One is an armillary sphere about 15" in diameter sitting atop a 10 ft. pillar. Thus, it would be difficult to read; but that doesn't matter because its gnomon points to the south! Around the stone base of the pillar is inscribed "In gratitude to William Willet" (originator of British Summer Time) - appropriate for Portmerion! The other is a basic horizontal sundial properly oriented to north but not level and it has no gnomon. It is about 8" in diameter and is nicely engraved with an 8-point compass rose and a very interestingly designed equation of time. The dial is held over its head by one hand of a cherub of sorts.

Fig.3. Portmerion: Sundial held by the hand of a cherub of sorts (DP)

The weather continued cloudy as we travelled around Tremadog Bay and had panoramic views of its beautiful beaches. We passed through Portmadog, from where much of Ffestiniog's slate was shipped, to arrive at the whitewashed village of Clynnog Fawr in Caenarfonshire. There, a 17th century church dedicated to St Beuno stands on a much older foundation dating from A.D. 606. In the churchyard stands one of the oldest sundials in the British Isles. Its vertical stele has a dial carved in the Celtic fashion

- the only one of its kind in Britain. It is similar to many of the ancient dials of Ireland - not far across the channel at this point. The carving is fairly simple with lines only for the 3rd, 6th, and 9th hours - these having forked ends. The stele is a red granite slab about 4½ ft. tall and 4" thick with slight shoulders for the upper ends of the carved semi-circle.

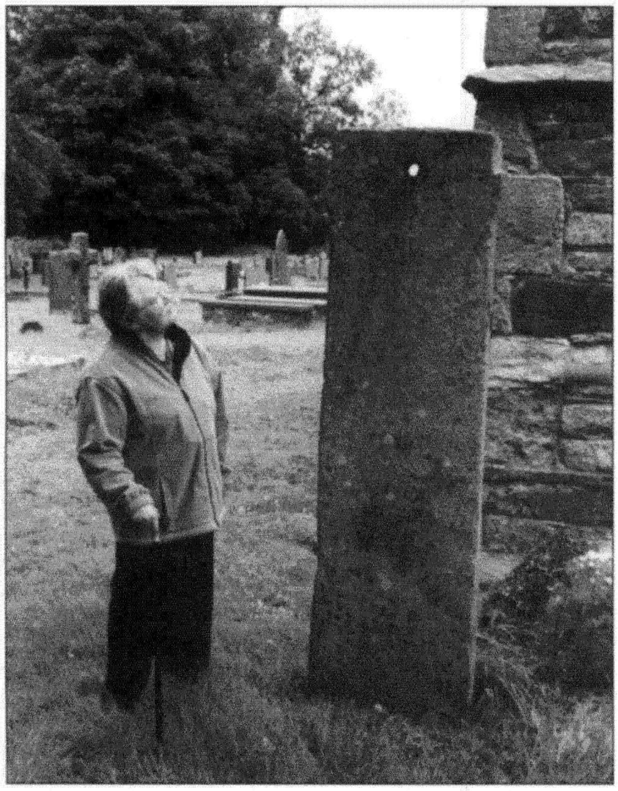

Fig.4. Celtic dial at St. Beuno's Church, Clynnog Fawr (DB)

The gnomon is missing from its quite large hole. Although its origin is unknown, this important dial was discovered in the bridge of a nearby mill stream and installed in its present site in 1930.

Another scenic ride home to our hotel took us past Caernarfon Bay and the site of a Roman ruin dating back to 78 A.D. After dinner, we were treated to a slide presentation by Douglas Bateman about his design, construction, and installation of a rare form of sundial - a meridian or noon dial. It is in the form of an analemma etched on glass for viewing from the interior of the main entrance to the new central administrative building of the Defence Evaluation and Research Agency at Farnborough. This was followed by an audience participation entertainment in which each person was to substitute sundial terms in popular songs, books or poems; and for which each received a Canadian postage stamp depicting a pillar sundial.

On Tuesday, we awoke to a bright sunny sky with scattered clouds. We soon had a brief shower and the sky then cleared as we set off for the seaside town of Colwyn. There, in the house of T.R.W. Cowell, a retired doctor, we saw a marvellous large slate horizontal sun and moon dial. This dial was discovered by our Chairman, Christopher Daniel, who gave a brief discourse about its history and use. The dial - in perfect condition - was produced by a relatively unknown dial maker in 1803 for a latitude of 53° N. It is exquisitely carved on a piece of slate 30" square and about 2" thick. A series of concentric circles represent the age of the moon from new moon and a series of concentric spirals lead to the hour markings. These lines are marked by carved dots rather than numbers, which gives a less cluttered appearance as well as being easier to identify at night. The sun time is determined by the shadow of an iron gnomon on the usual hour markings to a 5 minute accuracy. Around the outer edge is an equation of time, and there are two inscriptions.

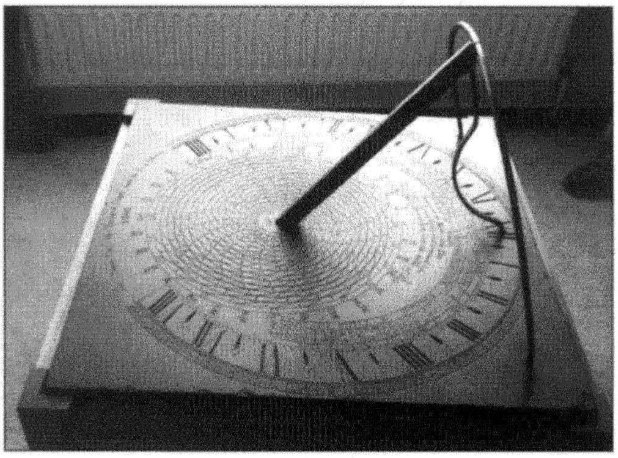

Fig.5. Sun-&- Moon Dial by Isaac Morris, Colwyn (DB)

One reads, "Sun and Moon Dial. The Trigon of Ecliptic made by Isaac Morris". The other is, "Hereon bright sol glorius ray, Points out the minutes of the day, And lunar globe with borrowed light, Will show when the time of night". The dial's owners have had it mounted in a solid wooden frame of coffee table height so that it can be more easily examined and appreciated. Isaac Morris (1764 - 1848) "delighted in making dials". He produced several, one of which is recorded to be in the National Museum of Wales. There are references in several books to his remarkable skills of which this dial is an excellent example. From Colwyn Bay, the coach took us to Bodrhyddan Hall, home of Lord Langford and his family. The original gray stone building was probably built by Lord Conwy during the 15th century and substantial parts of it still exist. It is now basically a 17th century house with 19th century additions by the famous architect, William Eden Nesfield. It has been in the same family since it was built over 500 years ago. The Queen Anne Revival style front of the house faces just south of west. On its gable end above the large dormer is a vertical declining sundial dated 1874. It has gold lettering on a blue background and has a motto- "DVM.SPECTAS.FVGJO" (While you watch, I flee). It is surrounded by decorative carving and above it is a large Spanish pilgrim's scallop. This is topped by a carved pelican - a feature of the family crest.

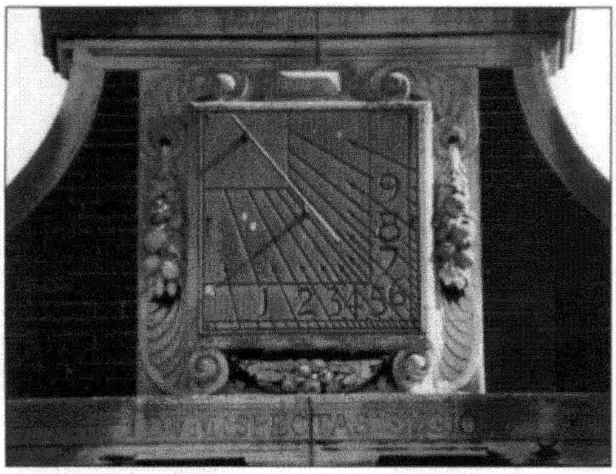

Fig.6. Bodryddan Hall: declining vertical dial (DB)

One enters the garden past St. Mary's Well, an octagonal wishing-well house of dressed stone dated 1612 and bearing the name Inigo Jones. The well is a symbol of birth, and the path then leads towards a sundial which is a reminder that time is slipping away, and thence to a bell representing life's end. The 8" square horizontal sundial is badly eroded so that the inscription and most of the numbers cannot be made out It is atop a 4 ft. stone pedestal with the letters "I K H" and the date 1637 carved on the south-west side near its top. The upper half of the gnomon is broken off.

We then proceeded along the shore of Conwy Bay to Bodelwyddan Castle, spectacularly set in the rolling parkland above the A55 expressway. The castle has been occupied since 1461 but its owners never seemed to prosper and it has changed hands several times, eventually ending up under the ownership of the Clwyd County Council. Through the Council's unique collaboration with the National Portrait Gallery, the building has been restored to its former glory as a Victorian Country House. The rooms have been authentically refurbished to reflect various periods and interior design styles thus placing the major collection of Victorian portraits, photographs and sculptures in realistic historical settings. The large formal gardens include a maze, an aviary, and a sundial. This is a bronze horizontal dial about 12" in diameter sitting on a graceful but deteriorating tall pedestal. The dial is in very good condition with nicely engraved numerals and a central compass rose but no motto or equation of time. There are three outer rings - one with 10 minute gradations and two rings marked every 2 minutes. These two rings are overlapping to allow time readings to one minute accuracy. The words "Troughton" and "London" are inscribed at the base of the gnomon; this indicates that the dial was probably made in the 1780's. It was, however, found in a fish pond in 1970 and placed in its present site in 1993.

Our bus took us across the Denbigh Moors giving us great views of the Welsh pastoral countryside and heather moorland and with mountains visible far on each side of our route. In the village of Pentrefoelas we visited the workshop of Nick Canfield, a local sundial maker. Here, we saw examples of various styles of pedestals made from different types of stone. He had a few of his dials in brass and slate to show us as well as a price list. Then, it was down past the source of the River Conwy and back to our hotel.

Wednesday was a day-off from the tour, to do as we pleased - resting, shopping, exploring, visiting, etc. Most of our group took advantage of David and Lilli Youngs' invitation to visit their 300 year old Welsh cottage. Margaret Stanier volunteered to lead the hardier souls on a one hour hike up to the cottage from Betws-y-Coed. This we did in cloudy weather with intermittent drizzle. The cottage - "Aberllyn", (mouth of the lake) - is a small partially restored building in a remote forest setting and, a its name suggests, near a mountain lake 700 feet above sea-level. David showed us his working Pilkington and Gibbs heliochronometer which we could take apart to examine its mechanisms. He also demonstrated his unique spiral equatorial sundial. Coffee, cookies and delightful Welsh cakes were supplied by Lilli before we made our way back down to the hotel. Other members chose to visit "Aberlynn" by car in the afternoon. After dinner on Wednesday, we were treated to a talk by Paul Parker - editor of "Clockwise Around Wales - A horological miscellany". He was introduced by Christopher Daniel who had written three of the articles in the book. Mr. Parker gave us an interesting outline of the history of the

Fig.7. At Aberllyn: guests of the Youngs (DP)

Griffith family, - a clock-making dynasty in Wales begun by Richard Griffith who was born in about 1755.

Thursday - again cloudy for our long bus ride to the eastern border of Wales. The trip started on a very twisty section of the A5 with several hairpin turns going up and down hills. There was vista after vista of rolling hills and farms with their networks of hedges and dry stone walls and the occasional village nestled in a valley. Our route took us along the steep north side of the Tanat Valley which separates the Berwyn Mountains from the rolling Montgomery Hills to the south. From our coach we could look across the lkm.wide valley or almost straight down at times to the valley floor 150m. below us. We finally arrived at Powis Castle in Welshpool, Prince Charles' residence when he visits Wales. Begun about 1200 on a rocky outcrop as a fortress by Welsh princes, it is a handsome red-sandstone mansion that now contains "the finest country house collection in Wales". There are displays of Indian works of art and treasures collected by Clive of India and his son Edward.

Our group was invited to see a special sundial on the private terrace and, fortunately, by this time the weather had cleared to bright sunny intervals. Indeed, the dial is special! The round pedestal and heavy base are of stone and contain 3 sundials. There is a vertical dial with an iron gnomon on the south side and two recessed polar dials on the east and west sides. These two dials each have a brass plate installed to form the sharp edge of the style which resists deterioration. On the upper surface, a 1680 double horizontal sundial in excellent condition is embedded in a slate surround. Unfortunately, the long ($13^{1}/_{2}$") bronze gnomon is bent. The dial plate has very fine engraving of its lines and numerals, and includes a 32 point compass rose and an azimuth scale around its outer border. Also engraved is "Henricus Wynne Londini fecit" and "Cherbury Lat.$52^{d}\,37^{m}$"

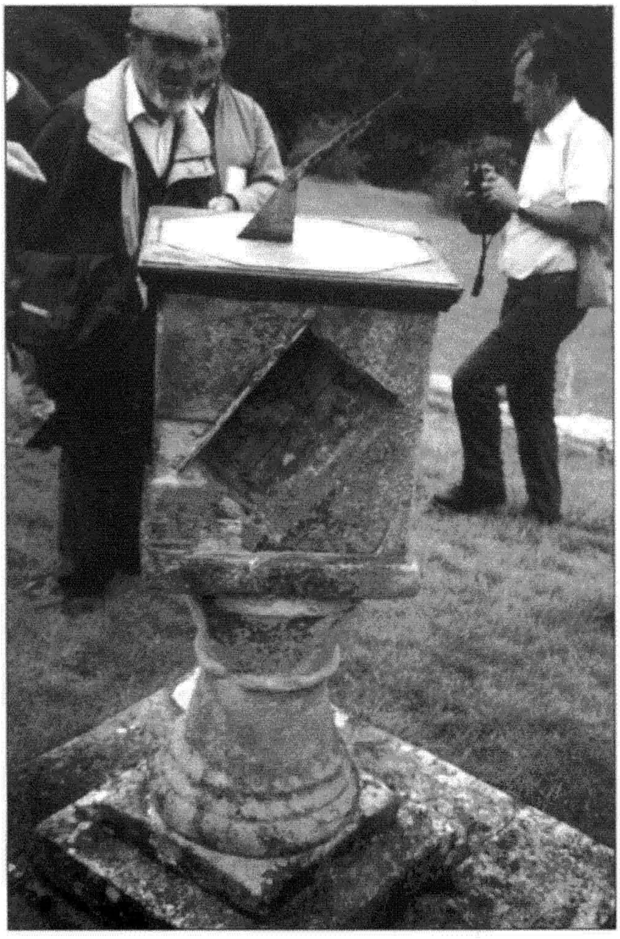

Fig.8. The Double-Horizontal dial at Powys Castle (DP)

The large garden has been laid out in the Italian and French styles. The grounds contain many lead statues, an orangery and an aviary on the terraces as well as an informal woodland wilderness overlooking the Severn Valley. Towards one corner of the garden is a horizontal sundial made by John Bennett in 1760-70. It is 24" in diameter on a multi-pillared pedestal about $4^{1}/_{2}$ ft. tall. The circular dial plate is about 1" thick solid brass with deeply engraved Roman numerals to mark the hours and fine engraving to mark its other features. An outer ring divides the hours into 1 minute intervals and another into 5 minute intervals. There is a table showing the length of days throughout the year and a 40 point compass rose in the centre of the dial. Below the gnomon is engraved "Bennett, Crow Court Soho, London" and a coat of arms south of the gnomon with the inscription "UNG.JAY.SERVIRAY" medieval French for "I serve but one". A very heavy brass gnomon 16" long is mounted on the dial plate. Members borrowed a step-ladder from the topiary-cutters nearby, to get a top view of the dial plate for photography. A third dial just outside the entrance to the castle is badly deteriorated and aptly described as 'scruffy'.

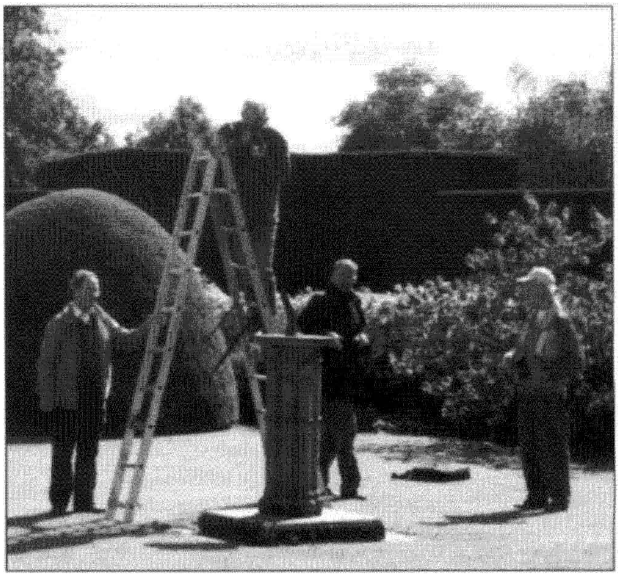

Fig.9. The Bennett Sundial, Powys Castle Garden (CM).

Fig.10. a & b Marrington Hall Lodge Sundial (MC, DP)

After lunch, we headed off to Marrington Hall (owned by the Earl of Powys) to see a sundial originally erected for the Lord of the Manor, and now to be found in the gate-keeper's cottage garden. This multiple dial is considered to be one of the best examples of this type of dial in the world. The dial is clearly dated 1595.It is beautifully carved and contains 11 component dials -horizontal, vertical, polar, and 3 equinoctial scaphe dials. The 5 ft. 2" stone pedestal is embellished with numerous emblems and symbolic devices. On its top is a small circular horizontal dial of the now common garden variety. It is decorated with a simple sun image and is thought to be the earliest dial of this class to be still in situ. Carved on the chamfered edge around this dial is "so this day; fleeth away; these shades do flee; from day to day". On the north side of the column, is carved an effigy taking up half of the shaft and above it "VT.HORA.SIC.VITA" (as the hours, so is life). On the south side are three dials and the inscriptions "DEUS MIHI" (My God) and "FVI.UT.ES.ERIS.VT.SUM." (I was as thou art.Thou shalt be as I am) - this among carvings of a death's head and crossed bones.

On a happier note, we then went to Sweeney Hall for English Tea. This "new fair house in Sweeney, a handsome pile of buildings" was erected in 1640 but only the pillars of the entrance gates and supporting wall remain. Sweeney Hall was described in an 1855 book as "a handsome mansion built of freestone, and beautifully placed in the midst of a well timbered park". It was sold in 1969 after 300 years in the same family. Their motto "Dread Shame" is incorporated into the stained glass crest above the front entrance. The Hall is of classic design with a large entrance hall and rooms leading off. It is beautifully furnished, and, the tea was good!

On the way home, David Young gave us an outline of Thomas Telford's life and his achievements in the building of churches, canals, and roadways. One of his major accomplishments was the building of the road from London to Holyhead, now the A5 on which we seemed to spend a lot of time. At no place does the road's grade exceed 20%, an amazing feat considering the mountainous terrain we experienced in North Wales. This road also included the world's first iron suspension bridge, which crosses the Menai Strait.

Friday - surprise - cloudy and wet! We travelled westward along the steadily climbing A5 towards Ynys Mon (the Isle of Anglesey). This took us through Llanberis Pass in the Snowdonia Mountains and along the Nanffrancon, a typical U-shaped valley carved out by a glacier 10,000 years ago. We arrived at St Llecid's Church at Lfanllechid in the pouring rain (known by the locals as Welsh mist). Needless to say, the sundial in the cemetery got little attention! This was too bad because it is an excellent dial to see. The 34" diameter dial is carved on a thick square slate slab that is offset on a 4 ft. pedestal made of slate blocks. It has a 15" long iron gnomon. The dial plate is finely carved and contains a 32 point compass rose and hour numerals from 4 am. to 8 pm. subdivided to 5 min. intervals. It is inscribed " Lat.53° 20' " and " Rob Pritchard, Willm Pierce, Wardens *1795*, N Wilson fecit". Outside the dial in each of the four corners of its surround are carved decorative daffodils.

Our sodden group continued on across Telford's suspension bridge to the town of Beaumaris ('Beautiful Marsh') to visit another castle. Beaumaris Castle was to be Edward I's masterpiece in the "iron ring" of castles he built in North Wales to stamp his authority over the Welsh peoples. Like the others, this castle was located at a site that could be supplied from the sea. Building began in 1295 but money and supplies ran out before this castle could be completed. Nonetheless, it is an awesome sight, regarded by many as the finest of all the Edwardian castles in Wales. Its perfectly symmetrical concentric "walls within walls" design, involving four successive lines of fortifications, was state-of-the-art for the late 13th Century. The town walls of Beaumaris have been almost completely destroyed.

By afternoon, the weather had cleared to provide some sunny periods. We were able to find the sundial hidden in an unkempt, overgrown circle of rosebushes in the St Mary's Parish churchyard. Hardly worth the effort, it is a small 8" 'modern" square dial which includes a basic 4 point compass rose and the motto "Sine Umbra Nihil" etched on a copper plate. The half hours are each subdivided into four parts. The gnomon had been mostly twisted off but its remainder is correctly aligned. The 30" high pedestal is made of stones and does appear to be quite old.

After some more Beaumaris sight-seeing we took a buffet lunch at Gazelle Hotel on the sea front. We then headed back to the mainland and to the Llanberis valley, to see the Dinorwig Power Station. It houses the world's fastest response generator. It uses water which flows from an upper lake through the turbines to produce the electricity, and then falls to a lower lake. The output of electricity can be brought to full capacity within 30 seconds when needed to add power to the grid Then, during off-peak times, the water is pumped back up the 1800 feet to the upper lake. The power station is built inside Elidir Fawr mountain under the site of the previous largest slate works in the world. Inside the mountain are 16 km. of tunnels and the world's largest man-made cavern - twice a long and half as wide as Wembley Stadium - a truly awesome sight.

This was our last evening together. After dinner, Douglas Bateman presented David and Lilli Young with a fine brass 'Spot-On'sundial, and a bouquet of flowers, as a memento of our tour and in well-deserved recognition of their efforts, in organising our week. We then all participated in a well-conducted quiz about sundials fiendishly arranged by Mike Cowham. For sundial afficionados, this was a very humbling experience.

Fig.11. 'Thank you, David and Lilli!' (DB)

Thus ended the Wales 2001 Sundial Safari - an exceptionally good week. While there were not a lot of sundials, those that we did examine were noteworthy, - quality rather than quantity. Also, getting to know some of the history of Wales and to see many of its attractions and its beautiful landscape made our visit well worthwhile. The Welsh language - that's something else!

A thank you is due to all those who supplied the bits and pieces of information that have been used to compile this report.

The photographs accompanying this report were kindly supplied by Doug Bateman, Don Petrie, Carolyn Martin and Mike Cowham.

Author's address:
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462 Millard Street
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L4A 8A8 Canada

READERS' LETTERS

'TIME' AS SUN TIME

It seems that the sundial is never free from the undeserved criticism that it rarely indicates correct time. Stand with an observer at a dial and wait for the routine: a glance at his wristwatch, followed by a check of the dial will nearly always prompt the comment that the latter is 'nearly correct' or something similar. I long to say 'No, despite the split-second regularity of your quartz crystal watch, it is *that* time which qualifies as only approximate'!

It is of course the ordinary sundial that is the true marker of the sun's passage and with which the dial will always be in step. I think we have become somewhat brain-washed into accepting mean time as 'real' time whereas it is merely a modern day convenience. Nevertheless, the diallist, though aware of this, often strives to convert the hour angle lines to indicate G.M.T. and B.S.T.

Am I alone in finding this obsession rather odd? As I see matters, although we have mean time information all about us, it is not so in respect of our local solar time. This being the case, it assumes a special importance and interest, and hence I feel dials should be marked accordingly.

So, other than for specialist cases, I say no more meddling with longitude and/or equation of time corrections, but delight in the humble dial. This will indeed give us the real time that in the final analysis governs our lives. It indicates the moment of local noon so that a morning is the same length as the afternoon and takes in its stride the fact that in nature no one day equals the next.

P.D.Briggs
The White House,
Radcliffe Road, Cropwell Butler,
Nottingham, NG12 3AG

'TIPPLE TIMES: SPECIFICATIONS'

Quite recently a BSS Bulletin reader asked me for specific details of my 'Tipple-Times Sundial' shown in the BSS Bulletin 11, 37 (1999), and displayed in 1999 at Dunchurch Lodge at the BSS Annual Conference (See Fig.1).

The specific details may just be of interest to other members and are as follows:

1. The gnomon is a standard 75cl, Australian, white-wine bottle, filled with water and with the labels removed. It has an external diameter of 77mm and acts as a convex lens, held in place by foam distance-pieces, suitably arranged.

BSS Celebrates 10 Years, 1989-1999. Display by Maurice Kenn at Dunchurch Lodge, including 'Tipple Times' Sundial

2. The dial is a standard plastic double-walled(so-called) wine cooler. Its height is 232mm; the mean external diameter is 123mm, although the vessel tapers slightly; and the internal diameter is of the order of 97mm.

3. Tracing paper covers about half (180° or so) of the outside of the wine-cooler. 'Tipple Times' are marked as follows:

(a) 'Gin and Tonic Time' (G & T) at 12 noon; and

(b) 'Sundowner Time' at 6 p.m. for the equinoxes, and at 6 p.m. for the Summer Solstice at 52° N. The markings are essentially in ink but with pressed-on numbers and lettering.

Maurice J.Kenn,
38 Corkscrew Hill,
West Wickham, Kent , BR4 9BB

RICHARD TOWNELEY

I would like to offer this short note of appreciation for your publication of the excellent article by Tony Kitto 'Richard Towneley and the Equation of Natural Days', in BSS Bulletin Vol. 13 (ii). The article researches and reports some of the details and events that led to the understanding of what we now call the Equation of Time. I have always thought that such an account would be very interesting to most diallists and very appropriate if printed in the Bulletin.

The article gives us an insight in to the difficulties encountered in all such pioneering scientific investigations, where there is a background of potentially unreliable supporting instruments (if they exist at all) whose inaccuracy can mask the very effect under investigation. Even the scope of the problem is uncertain; just imagine how difficult it would have been if the earth's rotation had not been constant.

Funding was also a great problem and it is fortunate that there were rich educated men like Richard Towneley and Jonas Moore who shared the curiosity and who would generously support such costly and uncertain experiments and then publish the results without reservation. Scientific progress was dependent then on a few individuals.

This important article is particularly enlightening in that it emphasises the contribution to Flamsteed's work made in Lancashire at Towneley Hall. It draws together many individuals with familiar names and then connects them on the same contemporary stage. I found the chronology particularly helpful. I hope that many members have shared my enjoyment and interest in this piece by Tony Kitto.

Graham Aldred
4 Sheardhall Avenue
Disley, SK12 2DE

NOTES FROM THE EDITOR

FOR SALE

Bronze Sundial, 12 inch, by G.Adams, London. Superb untouched condition. Lovely green patina. Plain, but elegant and totally original example by this famous maker. £950 From: Mr. L.Borrett, 15 Knoll Road, Sidcup, Kent, DA14 4QT (Tel:020 8302 2916)

NATIONAL MARITIME MUSEUM

Members living in or near London and having an enthusiasm for Astronomy may be interested in this note: *Exploration of the Solar System.* The Open Museum at the National Maritime Museum will be running a two-day course on the Exploration of the Solar System, on Friday and Saturday, 14th and 15th June 2002, in the Museum's Lecture Theatre, 10.30am-4.15pm. In recent years, telescopes and space probes have surveyed the fiery surface of Venus, the deserts of Mars, the moons of Jupiter and Saturn, and the ancient comets on the very edges of our solar system. This course will examine these exciting discoveries, and consider where space exploration will venture in future. Speakers include Dr. Michele Docherty, Imperial College; Prof. Alan Fitzsimmons, Belfast; Dr. D. Hughes, Sheffield; Dr. C. Murray, Queen Mary College London; Prof. Colin Pillinger Open University; Dr. Sara Russell, Natural History Museum; Dr. Duncan Steel, Salford; Prof. Fred Taylor; Oxford. For further information, phone 020 8312 6747 or consult the Museum's web site www.nmm.ac.uk

WRONG COUNTY

The new Armillary Sphere sundial described in the September issue of the BSS Bulletin, page 127, was erroneously described as standing in Cheadle, Cheshire. This should have been Cheadle, *Staffordshire*. Apologies to all concerned.

ARMENIAN CHURCH SCRATCH DIAL

In reference to Shaul Adam's article on p.91 in the September issue, we have been asked by M.Arnaldi to say that the scratch dials which he noted in Armenia and in Italy had 11 sectors, not 13 sectors as stated in the article.

ITEMS FOR REVIEW

The editor is glad to receive new books about sundials or sundial-related topics, and can usually find a reviewer willing to write a review of such books. She cannot however undertake to receive, note or comment on any other sundial-related objects, such as models, toys, jewellery, or clothing. People engaged in selling, promoting or distributing such items cannot make use of the Bulletin for these purposes. Small advertisements can be accepted on payment of the appropriate fee.

FACSIMILE REPRINTS OF DIALLING BOOKS

The North American Sundial Society is sponsoring a series of facsimile reprints of rare works on Dialling under the title 'ShadowCatchers'. These maybe obtained either as hardbound books, or as digital download, or on CD. The first four titles in the series are:

Samuel Foster: *The Art of Dialling, 1638;* Samuel Foster: *Pothuma Fosteri, 1652;* William Emerson: *Dialling, or the Art of Drawing Dials on all Sorts of Planes Whatsoever, 1770;* Gilbert Clerke: *The Spot-Dial, Very useful to shew the Hour within the House, 1687.*

Further particulars and an order form from Fred Sawyer, 8 Sachem Drive, Glastonbury, CT. 06033 USA.

NEWBURY 2001

Terrorist attacks such as occurred in America on September 11th can filter down to affect all civilised endeavours, even sundial meetings. The (fortunately) large attendance (46) at Newbury included one member who, along with many others, had been unable to reach Montreal for the North American Sundial Society (NASS) Conference due to plane cancellations. Can we hope that International Societies like ours can play a small part in restoring friendship and sanity to the world?

Members of the BSS at the Mary Hare School for the Deaf, Newbury, 22 September 2001

On a happier note, it was good to meet up with many old and quite a few new members at Newbury. The morning talks began with Richard Fleet, of Newbury Amateur Astronomical Society (NAAS), presenting his ingenious computer software *GRAPHDARK*. Unlike us, stargazers don't like the sun and the program's main display shows the times when we can avoid the pollution of sun (and moon) light for the next 700 years. This may not bother some of us!

Next, Piers Nicholson talked about the development of his *Spot-on-Sundial*, designed as a serious alternative to the garden centre product. Much thought was given to problems of alignment, vandal-proofing and instructions. The dials cover a range of latitudes from Newcastle to New Orleans, and we wish Piers well with his venture.

The afternoon session began with Tony Baigent's *Sundial Seekers Companion*. Inspired by old-time ships' surgeons' kits and the like, Tony has made a fine monogrammed and partitioned case containing all his dialling needs. His wife being an habitué of jumble sales, Tony amusingly described her acquisitions for him: binoculars (20p) and nail brush, as well as his own bargains: Chinese Swiss army knife (*"£1, sir"*) and an amazing height finder made from curtain rods... Great stuff.

Peter Ransom followed with an introduction to the *Walking Man* statue in Andover that he worked on with artist Claire Norrington. Tree shadows forced Peter to alter the intended south facing dial, held above the man's head, to an east and west pair, so gaining him an extra entry for the Register! He hopes in future to lay out a ground line inscribed with some of the places the man would pass through on his circum-ambulation (and natation) of the world. A neat idea.

Next, Tony Wood talked briefly about horizontal mass dials found in Scotland and Norway. It would be unfair to elaborate here, as an article on the subject is planned, which promises to be most interesting.

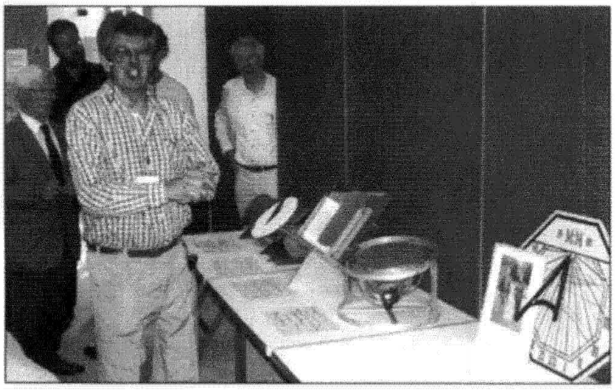
Finally, Michael Maltin showed us the progress he has made restoring the early 18th century horizontal dial that he had shown us last year. Authorities such as the British Museum were unable to provide advice on restoration so he experimented himself. His careful use of clock cleaner (Horolene?), waxing and rubbing with wet and dry paper have greatly improved it. We hope to see the finished job next year.

The exhibitions were stupendous. This year the participants visited each in turn while the exhibitor enthused. John Moir started the ball rolling by demonstrating his rainbow (sun)dial. Since last year's meeting he has produced an analemmatic dial based on a bow and arrow, for Robin Hood Estate in East London, a gnomon cone opposite Newark Castle showing a river of time, and a model for a proposed "armillary octahedron".

Next to him John Foad demonstrated a hemispherical dial made from a transparent dome to protect birds' nuts from squirrels. Here one moves a finger to get its shadow on a calibrated interior base then reads off the time indicated by the finger. We learnt how to draw arcs of great circles on the surface of hemispheres with a minimum of fuss!

Our secretary, Doug Bateman told us about the BSS library in Nottingham and David Pawley advised us of where to park! Doug later also showed the BSS leaflets that are sent to enquirers about sundials. He was followed by Glen Holmes who showed an octagonal dial he had brought along for advice, as there was no evidence of a gnomon having been fixed. He also brought an astrocompass and literature on using it. The latter disappeared very quickly! Go to
http://www.navismagazine.com/demo/b29/navigator-astrocompass
to get your own copy!

Michael Isaacs then displayed a vertical south dial. The MM of the date served a dual purpose, standing for Michael and Mary. One thinks that this year (MMI) would also be suitable for them! David Pawley had been trawling the boot sales again, this time showing what we thought might be a homemade planetarium projector stand. He also had bought a sun-compass, and showed how he tested a horizontal dial for 13°N in England by mounting it on an inclined plane before forwarding it to Barbados. The lectern dial, made by Peter Lamont, that David bought at York had been restored and was displayed.



David Pawley describes some bargains. Michael Isaacs' dial is at the right.

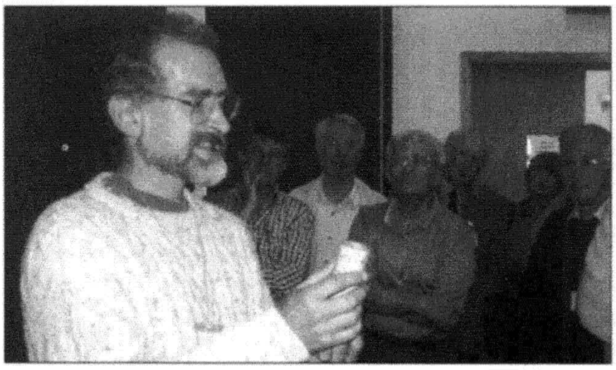
John Singleton talked about the Singleton Brothers' equation of time wheel (with 58 and 63 cogs) as well as the horizontal dial for use anywhere in the UK, and described in the September 2001 Bulletin (vol. 13 iii). We accepted the tilting from top to bottom to get the gnomon at the correct angle, but there was some debate on the east-west tilting to deal with longitude. (The consensus was for rotation about the style.)

Desmond Quinn demonstrates his nocturnal. Ben Jones' dial supports Desmond's elbow!

Nobody went to sleep when Desmond Quinn talked about his nocturnal dial. He questioned how people could use them efficiently with a handle rather than a plumb bob, and was convinced that it was well nigh impossible to see Polaris through the small central hole held to the eye. He demonstrated his improved model.

Ben Jones displayed two beautifully crafted dials - a slate horizontal and a finely carved vertical. We were very impressed with his album of work.

Back into the main room again for Chris Lusby Taylor to demonstrate his Perpetual Georgian Calendar. Reminding us all of the inside of a toilet roll we were bowled over when it told us that 22 September 2001 was indeed a Saturday. Graham Stapleton confirmed this fact a couple of minutes later with his hexagonal cross-section calendar slide rule.



Chris Lusby Taylor is watched carefully as he proves 22 September 2001 is a Saturday

Tony Wood brings something new each year. This time it was three mindbender puzzles. Gloucestershire Clocks, Gloucestershire Sundials I and II were on sale for £2 each. Featuring pictures of what you would expect, there are 12 pieces in each set that have to be arranged in a 4 by 3 array to form complete pictures wherever two sides meet. He also talked about the *Mass Dials of Lincolnshire* CD-ROM that has been produced.

Peter Ransom showed a dessert dish that featured a sundial, and promised (tongue-in-cheek) jelly and ice cream served in them for callers. He has been busy programming a Texas Instruments graphing calculator to produce an analemmatic dial (complete with central scale). With a vertical gnomon made from an opened out staple he can now use this to tell the time (if he has a compass), or find north (if he has a watch). He reckons that he would be lost without his calculator!

David Young then told us about the planned sundial safari in Austria, and demonstrated his electronic biscuit box sundial. With light sensitive diodes this can tell the time to the nearest 15 minutes and can be set to BST by the flick of a switch.

Rogers Turner Books had their wares on display, and what a lot to drool over! With new and old books for sale, many members were sorely tempted. One good reason for coming without one's spouse I suppose!

Outside Don Bush demonstrated a 66-element dial in the shape of a helix. Fortunately we had a bit of sun to show how to orientate it. He also showed us a vertical analemmatic where the horizontal gnomon remained fixed and the vertical dial plate moved to ensure the gnomon was in the correct position for the time of year.

It was a great day out. Our thanks go to David Pawley for organising it all; to Tony and Sally Ashmore for helping him on the day and previous evening; and to everyone who attended and helped to make such a fantastic event.

John Moir and Peter Ransom

BOOK REVIEW

Origin and Use of Church Scratch-Dials, by T. W. Cole, Pierhead Publications Limited, PO Box 145, Herne Bay, Kent CT6 8GY, ISBN 0-9538977-1-0 £3.00 post free.

Still priced at fourpence (on the cover) this is a facsimile reprint of the 1935 booklet which was one of three covering the history of scratch dials. The other booklets cover additionally the construction of scientific dials and a classification. Their subject matter overlaps considerably and the reprint booklet, containing, as it does, a listing of dial locations, is the most useful for today.

The front cover photograph of Litlington (Sussex) has been replaced by a sketch, presumably to catch the eye better, and maybe because it is virtually a scientific dial anyway and not a typical scratch dial.

Cole is one of the authors who produced what are regarded as the standard works; like Horne who used Somerset and Green who used Hampshire, Cole has Worcestershire and twenty sketches from that county appear at the beginning.

The history of scratch dials is well covered with an explanation of canonical hours and abbey or monastery service times. The text does not refer back to Saxon dials although their role is fully described in one of the other booklets. Consequently the listing of 1300 churches includes Saxon dials. Also included are transitional dials which Cole describes. He appreciates the difficulties of 'numbers-round-the-edge' dials and the problems of determining their dates and relationship to the later scientific dials. Again, some of these early scientific dials may be listed amongst the scratch dials.

The listing itself covers all English counties. Interestingly Lancashire is a complete blank and is still very much a 'desert': Lincolnshire's numbers however have much increased - from 51 locations to around 137. It is a pity he did not list Yorkshire by Ridings, as they apparently differ greatly in dial populations.

'Listed by Cole' is still a good starting point for dial recorders and comparison with more up to date records should prove interesting. There is an intriguing list of non-church dials on barns, castles and other places, I suspect they may be hard to track down, certainly I've had no luck with the one local one he quotes. Outside England there are five noted in Normandy (now considerably augmented) confirming that continental origins are a possibility.

At a current cost of £3.00 (180 times the 1935 price) it is still worth carrying round to make sure we miss nothing, or at least make a thorough search.

A.O.Wood
(Mass Dial Group)
Churchdown, Glos.

Sundials: An illustrated History of Portable Dials, by Hester Higton (Philip Wilson) 2001, pp136 , price £29.95)

This attractive book is the first that is devoted almost entirely to Portable Sundials. It covers virtually all of the types of dial to be found today. Previously, descriptions of portable dials have generally been included in books of Scientific Instruments or have been confined to one type of dial, e.g., The Ivory Sundials on Nuremberg by Penelope Gouk.

The book by Dr. Higton is lavishly illustrated with all but the line drawings in full colour. It is written in an easy-reading style and will be appreciated by the newcomer as well as the expert. Alongside the descriptions of the various types of dial are brief histories of the social, political and ecclesiastical developments that go with the period of a particular type of dial.

The book is divided into eight basic chapters plus an Introduction, Glossary and Bibliography. The contents of each Chapter are as follows:-

'Pillars and Rings'. In this chapter the subject ranges from early Egyptian and Roman dials to later Pillar and Ring dials. An interesting Roman find, a pillar dial, is examined in particular detail.

'Higher Altitudes'. The dials covered here are the Quadrans Vetus, Regiomontanus, Navicula and Chalice dials.

'The Sun Encompassed'. The origins of the Compass explained and how it was used with portable dials. It also explains why the gnomon of a dial should normally be parallel to the axis of the Earth.

It covers Cruciform dials, Signet Ring dials and dials of the type found in the Mary Rose. In 'A Cautionary Tale' the details of a dial dated 1552 are discussed and an opinion formed that it is actually a fake.

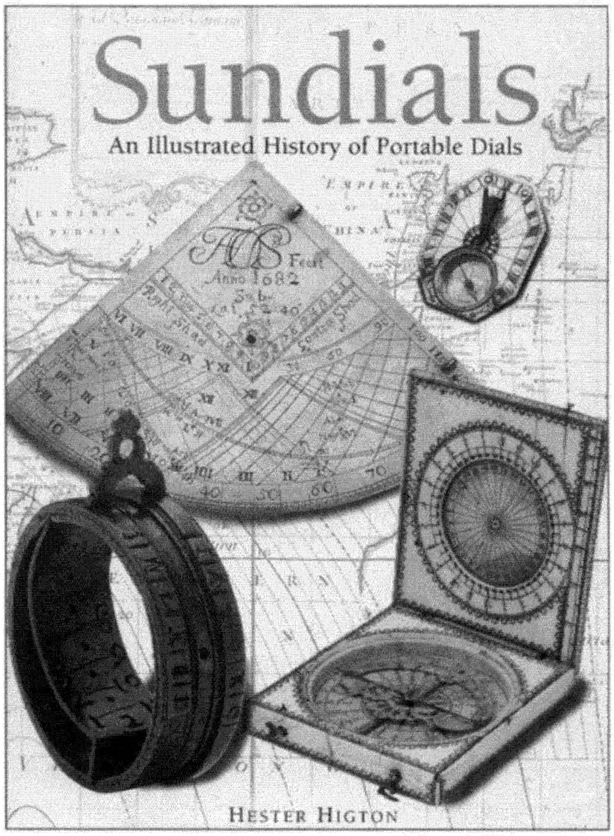
'Multiplications'. This chapter describes how the mass production of dials started, particularly with reference to the workshops of Nuremberg and Augsburg. The chapter has some good photographs of ivory diptych dials. Early dials from London also feature in this chapter with details of the rise of the Guilds and the Instrument Making trade in London.

'English Accents'. The new trade in London is described and histories given of the more famous English Mathematical practitioners whose efforts were directed towards the art of dialling. It describes Quadrants, Nocturnals, the Double Horizontal dial, and the Universal Equinoctial Ring dial.

'A Continental Selection'. Three areas of Europe are cited, viz., Dieppe, Paris (Butterfield dials) and Augsburg. It describes some very beautiful dials, particularly those made in Paris.

'Watching the Time'. This chapter shows how the sundial eventually gave way to the pocket watch in the 19th Century. It covers some of the mass produced dials leading up to that time. A section explains the working of the Pocket Watch and it concludes with precision time marking instruments such as the Dipleidoscope.

'The Sun Eclipsed'. This final chapter shows dials of a later period, when they had become no more than novelties. It gives details of some of the famous collectors of the last 150 years. Finally it gives brief details of some of the dials that have been made as replicas or even outright fakes.



The book has been well written and is useful for its social history and for its explanations of how each type of dial works. The inclusion of watches and their escapements seems to me to be a little out of place in a book of Sundials. Such details have been recorded many times elsewhere. The book itself is not without its errors, and two in particular need to be corrected if the book ever goes to a second edition.

A Schissler compendium is shown, the lid of which is captioned as a 'vertical dial'; the adjacent text uses the same description. However, it is clearly a horizontal dial with numerals increasing clockwise and going beyond the VI calibrations both morning and night.

The other error concerns the Universal Equinoctial Ring dial where the author clearly states that this type of dial overcomes the problem of knowing which side of noon the reading is. This type of dial *does not* give this information and can easily be misread around the time of noon.

The book has generally been well laid out although the inclusion of pictures without Figure numbers can at times be a little confusing. In most cases the picture is on the same page as the text but in a few cases it has to be overleaf and may cause a few problems for the reader.

There are some printing errors that need to be tidied up. On one page, the blank area surrounding a picture has been allowed to protrude over about 10 lines of adjacent text making comprehension somewhat difficult. In one case 2½ letters at the beginning of a line are lost. In another place there are some faint colour spots on a page. Having checked a second copy it proves that this error is on the basic printing plate. There is one illustration, that of the Canterbury Cathedral dial, that is of rather low resolution making the image somewhat blurred.

Hester Higton's book is certainly one that everyone interested in Portable Dials will want to have in their library. Its pictures, in general, are clear and the text supports them well

Mike Cowham
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THE "BACON" DOUBLE HORIZONTAL SUNDIALS

JOHN DAVIS AND MICHAEL LOWNE

INTRODUCTION

The double horizontal dial, originally developed by William Oughtred in the early 17th century, is rightly regarded by gnomonists as one of the most interesting and useful of all the dial types. Its layout and construction have been described in modern articles[1,2]. Only a relatively small number of double horizontal dials are known, having mostly been made by the most skilled British scientific instrument makers in the 17th and 18th centuries. The makers of most of the extant dials listed[1] are reasonably well known. However, the original "Bacon" dial which is the subject of this article first became known to the authors when it appeared for sale in America[10] in 2000 and its maker, date and original location all remain unknown. It is an intriguing dial for many reasons, and has prompted the construction of a near-replica for a member of the present-day Bacon family.

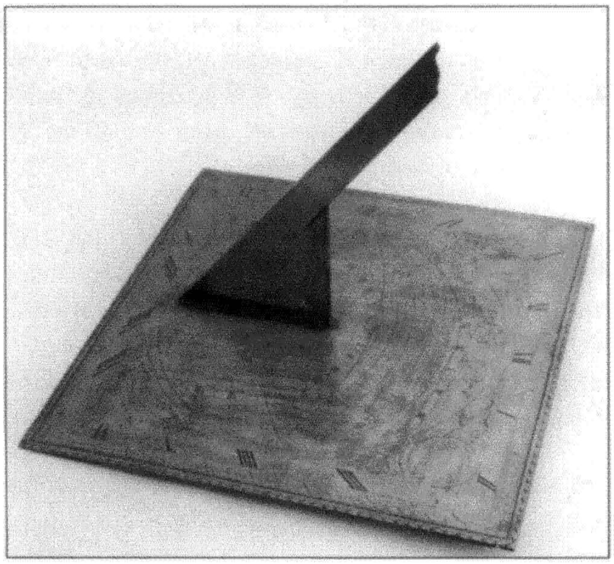

Fig.1. The original "Bacon" double horizontal dial. (photo: D. Coffeen)

THE ORIGINAL BACON DIAL

The original dial is shown in Figure 1. The brass dial plate is approximately 13 inches (330 mm) square and the characteristic double horizontal gnomon is mounted so that its toe is quite close to the southern edge of the plate. This permits the maximum height for the vertical style although it does rather cramp the main hour scale near sunset and sunrise. The only direct clues to the origin and manufacture of the dial are the name "BACON", the latitude 51° 56' engraved to the south of the gnomon and a coat of arms. There are no dial makers called Bacon in the Directory of Scientific Instrument Makers[3], which lists all of the craftsman makers known to have made this type of dial - many of them descending in a master-apprentice relationship from Elias Allen, who made the first dials for Oughtred himself[4]. Of the three Bacons who are listed, the earliest worked around 1805, which is too late for our dial.

The format of the name, with just a surname and no place or "fecit" descriptors, suggested that perhaps Bacon was the name of the first owner, rather than the maker. However, the set of arms to the north of the stereographic grid is not one which has ever been associated with a known Bacon family. They may be "blasoned" (i.e. described in heraldic language) as *On a Bend ermined, three Leopards' Heads.* This description matches the arms of Sir William Stephenson, who was Lord Mayor of London in 1764, but his will gives no hint that he owned property at the appropriate latitude. It also matches the arms used by the Victorian actor Charles Kemble, having originally been granted to George Kemble of Wydell, Wiltshire, in 1602. The Venerable John Kemble (1599-1672) was executed for saying mass at the family property of Pembridge Castle near Welsh Newton, Herefordshire. The latitude of the castle is 51° 52.1', well within the measurement tolerance of the time to the dial latitude. Research into the possible connection is ongoing.

Maker	Dial location	Azimuth scale origin or style	Main numerals orientation	Declination date scale	
				Horizon circle	Ecliptic
"Bacon"	USA	E/W	Inward	Clockwise	Zodiac, clockwise
Elias Allen	Science Museum	E/W	Inward	None	Months, clockwise
John Seller	Private collection	E/W	Inward	None	Months, clockwise
Henry Wynne	Confidential	N/S, and compass	Inward	Clockwise	Zodiac, clockwise
Henry Wynne	Drumlanrig Castle	32 pt compass	Inward	Clockwise	-
Henry Wynne	Sotheby's catalogue	N/S	Inward	Clockwise	Zodiac
Benjamin Scott	Paris Museum	E/W	Outward	Anticlockwise	Zodiac, anticlockwise
Henry Sutton	?		Inward		
Daniel Delander	Stanford Hall	32 pt compass	Outward		
?	Boughton Monchelsea	32 pt compass	Inward		on alidade

Table.1. Showing the style and scale orientations of some known double horizontal dials.

The dial has a square main chapter ring, with the Roman numerals orientated to read from the centre of the dial ("inward" in Table 1). This is the form used by many early English makers (for example, Elias Allen) and contrasts with that used by Benjamin Scott in his famous c1715 dial[5] where the numerals are arranged to be read from its periphery ("outward"). In general, the numerals are aligned along their hour lines but this is not so for those along the southern edge, which are very elongated by the close proximity of the origin. The dial is delineated in minutes, with three-dot markers for the five-minutes and other markers for the quarters and half-hours. On such a relatively small dial, this leads to the need for some very fine engraving. Surprisingly, there is no noon gap to allow for the thickness of the gnomon, causing time errors and a discontinuity of about six minutes in the time readings at noon. This oversight has been corrected on the replica. The azimuth scale is centred on the base of the perpendicular style, in the physical centre of the dial plate, and is of the four times 0-90° type, with the origins at the East and West points. It shows half-degree increments. Although East/West appears to be the most common choice of the origins for the azimuth scale on a double horizontal dial, at least two examples are known, by the famous maker Henry Wynne[7], with North/South origins.

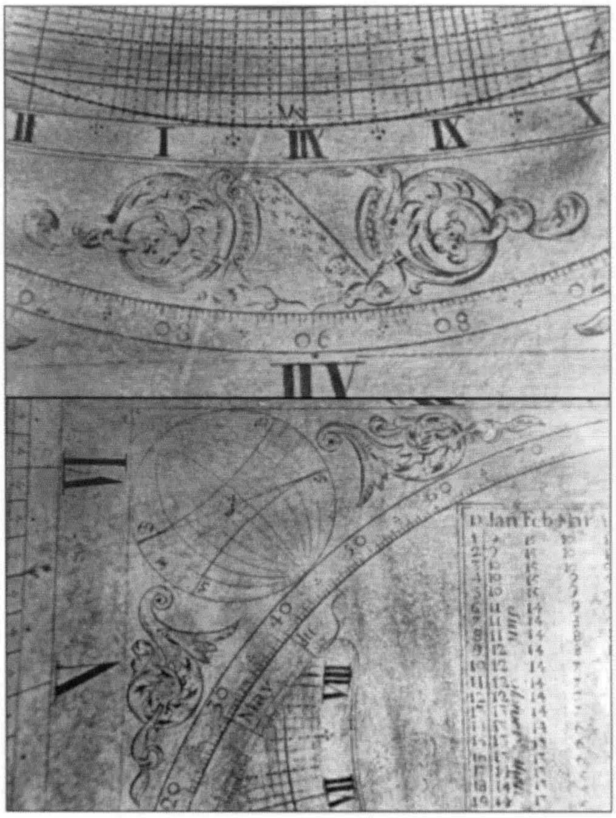

Fig.2. Details of the original "Bacon" dial, showing (top) the coat of arms and part of the stereographic grid and (bottom) the South-East spandrel and part of the Equation of Time table. (photo: D. Coffeen)

The stereographic grid is a demonstration of the engraver's prowess, featuring lines for every degree of declination and 5-minutes of time. The quarter-hours, and the 10°s of declination, are marked by dots which neatly fall in the gaps between the lines running in the other direction. The two arcs for the ecliptic feature dots for every day of the year, with the dates identified by signs of the zodiac engraved over the grid, running clockwise round the arcs. The dates are further identified by a non-linear calendar scale running around the outside of the horizon circle, with each day shown and every fifth day with a three-dot marker. This calendar scale was not used by Elias Allen and John Seller on their dials. Henry Wynne did place the dates around the horizon circle on some of his dials but when Benjamin Scott did so, the months ran anticlockwise round the circle. The styles of the markings of the various double horizontal dials are summarised in Table 1. This table is by no means complete, but it is clear that there is a wide variety of styles and conventions so that it is difficult to use these features to identify a maker.

THE SPANDRELS

The designs in the four spandrels initially appear to be interesting engraving flourishes but on closer inspection turn out to be one of the most intriguing features of the dial. All the designs are based on stereographic projections: in spite of their small scale the accuracy is sufficient for their features to be determined. They are intended to be read from the centre of the dial and are inclined at 45° to the cardinal directions. They are shown in a reconstructed form in Figure 3.

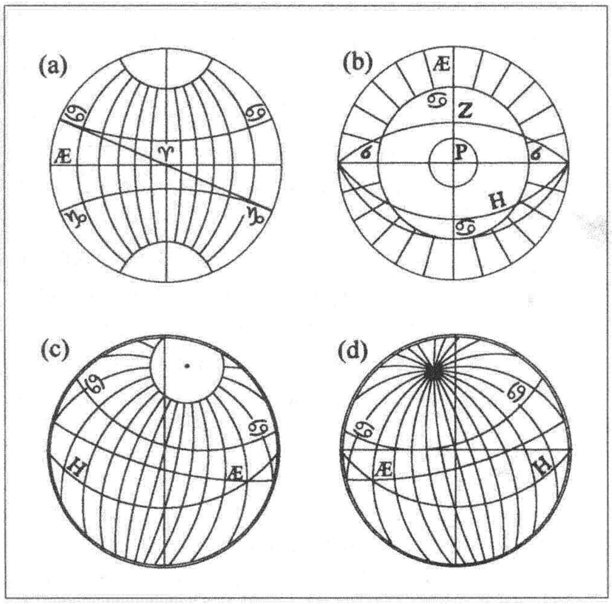

Fig.3. Diagrams of spandrels (a) south east, (b) south west, (c) north east, (d) north west. The individual plans are rotated a multiple of 45° so that the centre of the dial is at the bottom of each drawing. The drawings show the "corrected" projections for the replica dial.

In the south-east corner of the dial plate is a projection of the sky centred on the "First Point of Aries" (♈ in Figure 3a and also labelled with ♎, the "First Point of Libra", 180° opposite). The straight line "Æ" is the celestial equator. The tropics of Cancer (♋) and Capricorn (♑) are shown and a line tangential to these is the ecliptic passing through ♈. Hour circles at 15° intervals are drawn between two arcs at about 10° distance from the poles: these arcs have been altered on the replica dial to represent the arctic and antarctic circles.

In the south-west corner, the projection is centred on the north pole of the sky (P in Fig. 3b) with the arctic circle around it. The periphery is the equator, labelled Æ. The stronger line running from the east and west points (labelled 6 for 6am and 6pm) is the ecliptic meeting the central line at the summer solstice, ♋. The tropic of Cancer at declination 23.5° is shown and is also labelled ♋ on the opposite side. Hour lines radiating from the pole appear from this declination circle to the equator. The mark resembling a backwards (on the original dial only) "Z" is taken to indicate the zenith at latitude 50°, not very different from the dial latitude of 51° 56'. A curve running from east to west through Z is the "prime vertical". Another east-west curve on the opposite side is labelled "H" and is probably intended as the northern horizon of Z, but it is not in the correct place, being only 80° from Z instead of 90°. This position has been corrected in the replica.

The other two projections in the north-east and north-west corners (Figs. 3c and 3d) are more difficult to interpret. They are contained within double circles and are projections centred on 18° north declination (or latitude: they could be intended as terrestrial plans), and are inclined to the 45° line to the dial centre by about 15°. They show the equator Æ, and the tropic of Cancer ♋. Hour lines at 15° intervals meet at the pole on the north-west plan but stop short at a radius of about 13° from the pole on the north east plan. Some aspects are not very accurately drawn: the tropic is misplaced and the hour line spacings are rather irregular. Each has a curve labelled H, apparently the horizon for a more northerly latitude, 52° on the north-west plan and 56° on the north-east. The horizons are inclined to the central meridian by 15° (or one hour of time). It seems that the plans are drawn for 18° latitude (approximately that of Jamaica, for example) and horizons relevant to locations in Britain have been superposed, but the time or longitude difference is not understood. The double circles around the edge might possibly indicate that two latitudes are depicted. It seems most probable that these two plans had significance to the original owner of the dial, but this cannot now be determined. They have been copied on the replica dial with the drawing errors "corrected".

THE EQUATION OF TIME TABLE

The area around the base of the gnomon is dominated by the large Equation of Time table, with one column for each month and an entry, in minutes only, for every day. The presence of the table strongly suggests that the date of the dial is after 1672, when the first proper EoT table in England was published by John Flamsteed[6]. The dates of the maxima and minima show that the table is calculated for the Julian calendar, as indeed are the equinoxes on the stereographic grid. This implies that the dial was made before 1752, when England legally adopted the Gregorian calendar. The presentation of the EoT in the form of a table is inefficient in terms of space on the dial plate and engraving effort. This might suggest that the dial dates from towards the beginning of the 1672 to 1752 period, as the neater circular arc format was introduced (in London) by Thomas Tompion and Henry Wynne by the 1690s.

Comparison of the dial table has been made with two contemporary tables, that of Flamsteed (1672)[6] and one prepared by (or for) Thomas Tompion[9] in 1683. Direct comparison between these two tables shows that they can differ by more than 20 seconds, the Flamsteed values being larger numerically than those of Tompion. The greatest discrepancies occur around the times of the solstices and equinoxes and can be ascribed to the use of different values for the eccentricity of the Earth's orbit around the Sun. Flamsteed has used a value of 0.0173 and Tompion 0.0166: the true value is part-way between these two at 0.01685 and perhaps was not accurately known at the time. Although the one-minute resolution of the Bacon table makes the comparison difficult (and it is not helped by the Flamsteed tabulation being in degrees of solar longitude rather than calendar dates) the discrepancy makes it easier to determine which one is most likely to apply to the Bacon dial. A very simple test is to inspect the range of dates which are covered by the maximum and minimum values. From January 24 to February 5 (Julian) the dial shows the EoT as +15 minutes and in the Tompion table those values which exceed $14^{m}30^{s}$ (and so round up to 15m) run from January 25 to February 6, 13 days in each case. However, Flamsteed's values exceeding $+14^{m}30^{s}$ cover 18° of solar longitude, effectively just over 18 days. Similarly, at the October minimum, the dial figures and the rounded Tompion value of -16m each cover 18 days, whereas the rounded Flamsteed values cover 22° or over 22 days. The greater extent of the Flamsteed ranges is explained by the excess of Flamsteed values over Tompion. Mathematical analysis shows that overall the Tompion table is a much better fit to the dial values than that of Flamsteed. The evidence leads to the firm conclusion that the Bacon dial table, if not directly derived from the Tompion one, is based on much the same parameters. Perhaps this choice was based on the difficulties that instrument makers had in interpreting Flamsteed's longitude-based table.

The location of the EoT table on the dial plate precludes the inclusion of an altitude scale, usually found running diagonally from the foot of the vertical style. This suggests that the dial was intended for timekeeping purposes, rather than astronomical ones.

In principle, the accuracy with which the dial was originally delineated could be assessed by measuring the radii and centres of the stereographic arcs. This would be possible only with direct access to the dial. Working from photographs, the best that can be done is to measure where the declination arcs meet the horizon circle, using the in-built azimuth scale. These points correspond to the azimuths of the astronomical (true) sunrises/sunsets, which may be calculated exactly and compared to the dial values. This has been attempted for the dates where the photographs allow reasonable measurements. A standard deviation of 0.13° for the sunset azimuth errors for declinations from +13° to +23.5° was obtained, but it is unclear how much of the apparent errors is due to the photographic measurement technique.

THE BACON CONNECTION

"Bacon" is quite a common English surname so it is not possible to be certain which particular family originally owned or made the dial. However, it would have been an extremely expensive item when it was new, and its scales would have been decipherable only by an educated person, so it is likely to have been a family of high standing. The most famous of the Bacon families is that which descended from Sir Nicholas Bacon, born in Kent in 1510 but who later moved to Norfolk and became a member of Queen Elizabeth's Privy Council. Sir Nicholas' second son of his first marriage (Sir Nathaniel) married Anne, the daughter of Sir Thomas Gresham, founder of the famous Gresham College. His second son by his second marriage was Sir Francis Bacon. The Bacon family included several MP's for Norfolk constituencies and for Ipswich, and had many ancestral homes, mainly in East Anglia.

The 51° 56' line of latitude for which the dial was made just clips the south of Suffolk before passing though Essex, Herts, Beds, Bucks, Oxon, Glos and Herefordshire, and on into Wales. So far, no ancestral Bacon home has been found to correspond to this line. This reinforces the conclusion from the coat of arms that "Bacon" does not refer to the owner. Thus at the moment, the history of the dial remains mysterious.

THE REPLICA DIAL

With the current revival of interest in double horizontal dials, the making of a replica of the Bacon dial was an interesting challenge, especially as the original is no longer in its home country. Good photographs of the original were available, so it was possible to produce a computer-aided design (CAD) drawing (Figure 4) starting from careful measurements and scaling of the photographs. Although care was taken to preserve the feel of the original design, there are several important areas where the design was purposely changed. The main change is the latitude of the dial; whereas the original was made for 51° 56' North, the replica was accurately delineated for 52° 31' North, to suit its new home in Norfolk. Another major change was to the EoT table, where the original values were substituted by modern ones (averages for the period 2000-2049) in the Gregorian calendar. Next, the heraldic arms on the original were replaced by those of the modern Bacon family. Although double horizontal dials, as scientific instruments, did not usually carry mottoes, one was included on the replica with the wording:

Time is the greatest innovator

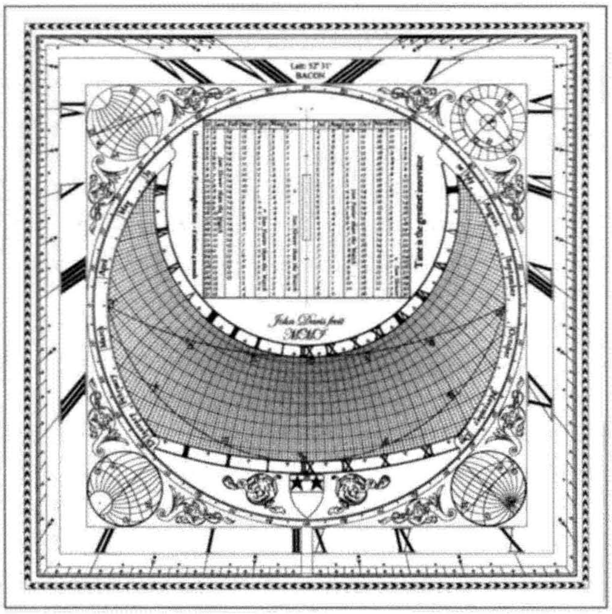

Fig.4. A computer aided design (CAD) drawing of the replica dial.

This is a quotation[8] from the great Tudor statesman and philosopher of science, Sir Francis Bacon, and so is particularly apt. The change from local to Greenwich time for everyday time-keeping has occurred since the original dial was made and this has been reflected by the addition of a simple equation giving the time correction for the longitude of the dial's intended location. Finally, the replica is signed and dated by the maker, as is customary - a practice which would have saved much confusion had the original maker followed it! The lettering on the replica dial is in computer generated fonts which give it a period feel although they are not strict reproductions of the original.

The replica dial (Figure 5) was manufactured by photolithography and wet chemical etching of the brass

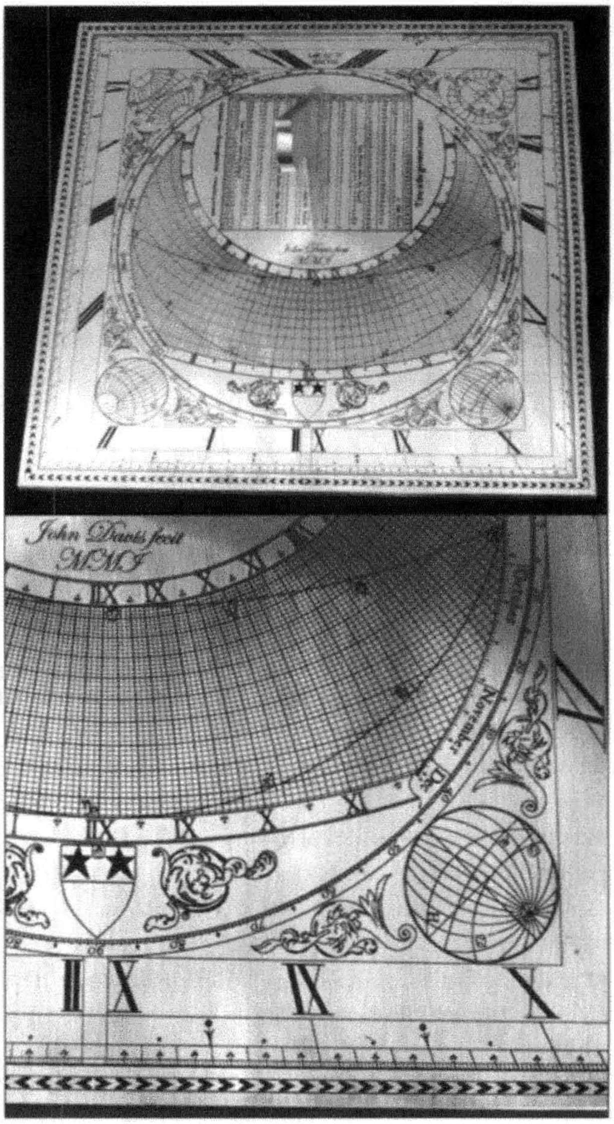

Fig.5. The replica "Bacon" dial, showing (top) an overall view and (bottom) details of the North-West spandrel design and the Bacon coat of arms.

plate, whereas the original was of course made by skilled hand engraving. This produces some differences in the style of the lines produced. The photomask was home-produced using an inkjet printer and, combined with a dry-film, negative photoresist, gave a minimum printed linewidth of 50 microns (approximately two thousandths of an inch). Wet chemical etching is an isotropic process so, as the etching progresses, the etch gradually undercuts the photoresist and widens the lines as they increase in depth. This limits the fineness of the lines that can be achieved for a given depth and in practice a minimum linewidth of 150 microns was achieved on the finished dial. The etching was performed in the standard ferric chloride solution, in a bubble-agitated vertical tank at 40° C. Because the flow of etchant is naturally reduced in the narrow lines, where the undercut resist reduces turbulence, etching is slower in the fine features than it is in the larger open areas. This fortuitous effect gives the differential line depth that a hand engraver would achieve by using a larger graving tool and more force in these areas. However, whereas the engraved line would have a "V" profile, the etched one is more like a "U". The major difference between the two techniques is in the larger areas, which are flat-bottomed when etched but made up of a number of parallel Vs when engraved. The engraving on the original dial would almost certainly once have been wax-filled but this is not now apparent. On the replica, the lines were filled with black enamel paint and the brass surface given a fine satin finish with a rubberised texturing block. It has been left in an unsealed state so that it can weather naturally.

The presence of the EoT table means that the gnomon cannot be buttressed without obscuring the table and hence its fixing is not as mechanically solid as it might otherwise be. On the original dial, it is presumably held in place by a hand-cut tenon passing through the dial plate and pulled tight by tapered pins through it. Modern machining methods, such as the availability of brass screws and steel taps, not to mention milling machines, allow a better-engineered solution of a milled slot and counterbored brass screws. The back of the replica, which is 6 mm thick, has been left flat so that the dial may be simply mounted on its pedestal with silicone or epoxy and without disfiguring screws.

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ACKNOWLEDGEMENTS

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Wales, 2001. Viewing Sundials
(photo: MC)

THREE JERSEY SUNDIALS

DAVID LEVITT

INTRODUCTION TO JERSEY

Jersey is the most southerly of the British Isles and sits in the English Channel within sight of the French coast. The Island (excluding its own offshore islets) is contained within the rectangle defined by the corners 49°16'N, 2°16'W: 49°09'N, 2°00'W so that, allowing for the Equation of Time, sundials are about eight minutes behind UTC. Politically the Channel Islands enjoy a considerable degree of independence in their internal administration, including taxation arrangements. This stems back to King John who, in 1204, lost his territories in Normandy and Brittany but decided to retain the Channel Islands. Since then privileges and concessions have been granted and confirmed by the English Crown to reward and encourage the islanders to remain loyal in the face of considerable hostility from the French. Today the main industries in Jersey are international finance, tourism and agriculture. The population of about 90,000 occupy an area of around 45 square miles, which may seem fairly crowded. In fact people are concentrated in a few areas and large sections of the Island are peaceful and unspoiled.

The Société Jersiaise, founded in 1873, is dedicated to the study of the Island, in particular its history, language, geology, natural history and antiquities. The Société has some records of sundials, mainly in the context of old Jersey houses. There may be up to 40 sundials of interest although many have been lost over the years. I have started to record each dial, in as much detail as possible, for the BSS Fixed Dial Register and also for the Société Library. Of the dozen investigated so far there are three, which I found particularly interesting.

A DIAL WITH EQUATION OF TIME INDICATOR

St Brelade's Church is on the west of the Island, at one end of the popular St Brelade's Bay. The south facing vertical sundial, see Fig. 1a, is on the wall above the vestry porch. This is just a few yards from the ancient Fishermen's Chapel. The dial is on a grey rectangle (probably limestone) with a rod gnomon of bronze. There are hour lines from 6 am to 6pm with 15 minute divisions. The hours are marked, in roman numbers, from VII to V. Below the dial is the date 1837 and above the dial the motto:

L'HOMME EST SEMBLABLE À LA VANITÉ, SES JOURS SONT COMME UNE OMBRE QUE PASSE

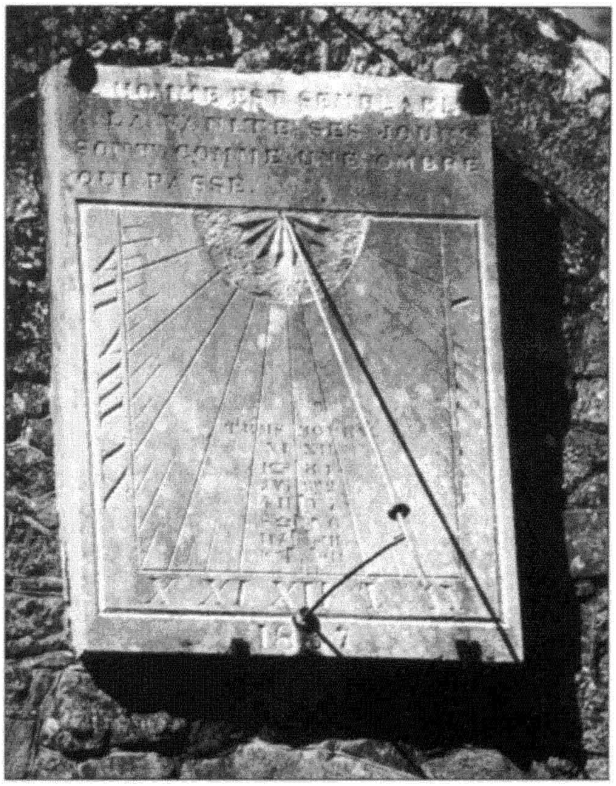

Fig.1a. St Brelade's Church, Jersey. South Facing sundial with Equation of Time indicator. The object on the gnomon is a decorative boss that has come away from the fixing point of the gnomon.

This is a quotation from Psalm 144 v4 in the French translation of the Book of Common Prayer, which was authorised by Charles II for use in the Channel Islands.

The unusual, possibly unique, feature of this dial is the arrangement for showing local mean time. The almanacs in use in Jersey in 1837 (almost all in French) contained simplified astronomical tables, which included 'Tems Moyen', or mean time. In the almanacs figures were shown for the time on the clock when the sun was at midday, so that a clock could be corrected by reference to a sundial or a noon mark. This was achieved by printing 'XI' and the minutes and seconds when the sun was fast (e.g. sun noon at clock time 11:55:30). When the sun was slow 'XII' with minutes and seconds was printed (e.g. sun noon at 12:04:30). This convention was transferred to the dial, even to the extent of contracting 'Tems' which was abbreviated from 'temps' to fit in the tables. On the dial, straddling the noon line, an abbreviated extract from an almanac is engraved, in round minutes, together with the 12 signs of the zodiac. (See Fig.1b.)

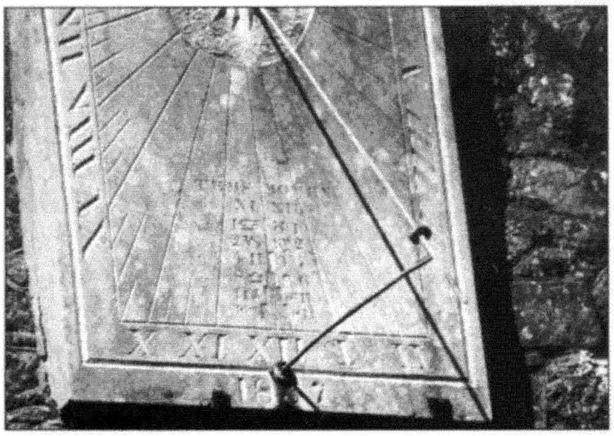

Fig.1b. Central part of the sundial of St. Brelade's Church, to show widening of noon line, zodiac signs, and minutes of correction.

The noon line has been widened by the number of minutes marked for each adjacent zodiac sign. The appearance of the noon line is like the profile of a very thin asymmetric stepped pyramid. The normal assumption, which I first made, would be that when the shadow falls on, for example, the displaced noon line beside Aries ♈, then it should be noon on the clock. This is apparently not the case, except for the first two signs, Cancer and Taurus, ♋ ♉. To correct a watch, at the start of a zodiac house, one must observe noon by the shadow on the centre of the noon line, ignoring the displacements, and set the watch time to the number of minutes before (from the XI column) or after (from the XII column) noon on the watch.

The indicated adjustments at the start of each house of the zodiac fit the Equation of Time curve, as shown in Fig.1c, with the exception of Cancer and Taurus which have been transposed. It is hard to resist the conclusion that the designer of the sundial intended that the displacements on the noon line should give a direct reading of local mean time on twelve days of the year; but for that to work, he should have reversed the whole columns.

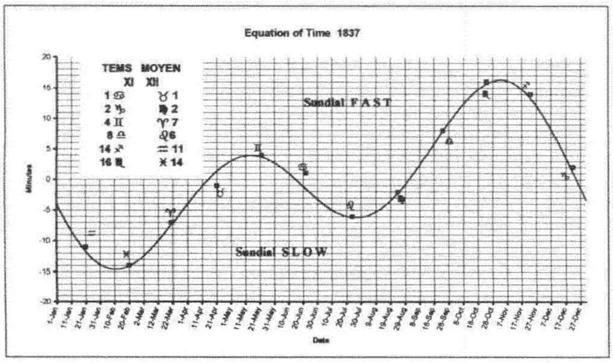

Fig.1c. Graph to show the Equation of Time for 1837 with the adjustments shown on the St Brelade's sundial. The values for Cancer and Taurus have been transposed. Inset is a diagram of the engraving on the sundial.

I have examined the Church records, held at the Jersey Archive, covering the period around 1837 but found no reference to the sundial.

A SUNDIAL WITH A CHEQUERED HISTORY

Royal Square, St Helier is in the centre of the Island's capital. Traditionally it was the market and the place where proclamations were read and news discussed. On the Picket House, which is a brick building on the north side of the Royal Square, is the most spectacular of Jersey's sundials. See Fig. 2. It is a vertical declining dial carved and painted on limestone and fits into a space formerly occupied by a window. Numerals, both Arabic and Roman, run from 8am to 7pm with hour lines, half hour and quarter hour marks. As there are obstructive buildings not all of the hours actually receive a shadow.

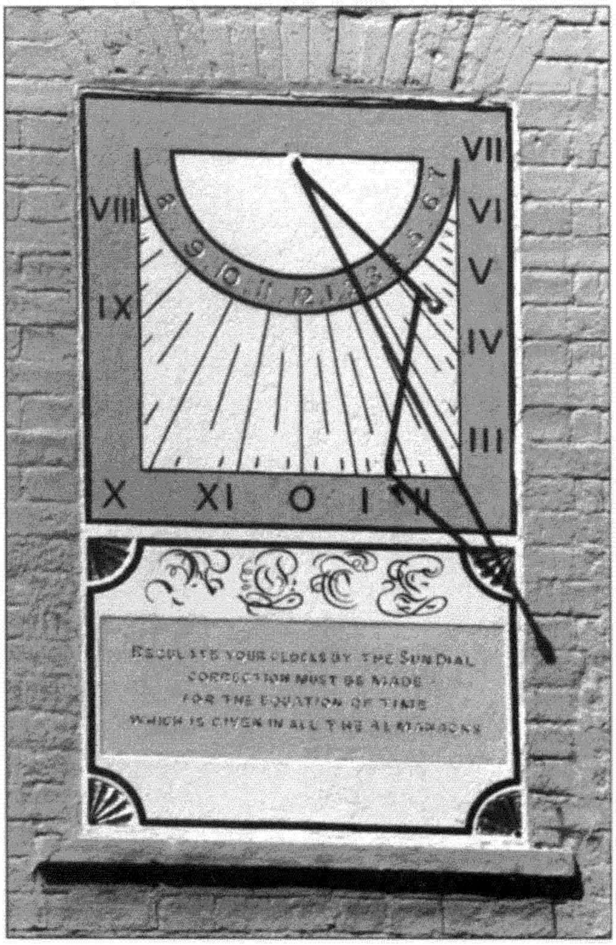

Fig.2. Royal Square, St. Helier, Jersey. A declining vertical sundial from about 1825. Photographed at 1435 UTC on 8 August 2001. The shadow should indicate 2.22pm. Note the angle between the 2.30 line and the shadow, which may indicate that the gnomon was not correctly replaced. This effect is not apparent for much of the time.

Below the dial are carved the following instructions:

REGULATE YOUR CLOCKS BY THE SUN DIAL
CORRECTION MUST BE MADE
FOR THE EQUATION OF TIME
WHICH IS GIVEN IN ALL THE ALMANACKS

Above these instructions there are four ornate letters. The interpretation of these seems to have been lost by a system similar to 'Chinese Whispers' when the sundial was repainted on numerous occasions over the years.

The dial is believed to date from the mid 1820s and was made by a Jerseyman, Elias le Gros. It is interesting that the language of the instruction is English as French was then used for all official purposes. It has been assumed that the dial was intended for the British garrison and English residents and visitors.

Mr le Gros was a mathematician, teacher of navigation, cartographer and civil engineer. In 1834 he was awarded £200 to make an engraving of the map of the town of St Helier, which he had surveyed, and some complimentary remarks were made in the States of Jersey about his talents[1]. He was a man with wide interests who invented a floating chair for use in shipwrecks, and proposed theories on atmospheric pressure and lunar influence[2]. Sadly, in 1859, appeared the last of many references to Mr le Gros in the local press. The Royal Court certified that he had lost his intellect and sent him to the hospital. He broke his ankle trying to escape and was consigned to the infirmary for treatment[3]. Nothing further is known about him, not even when he died or where he was buried.

In 1875 there was an impassioned plea from the *Chronique de Jersey* to restore the 'Quadrant' in the Royal Square. There had been a dispute between the civil and military authorities over the tenancy of the Picket House. As a result the military had obliterated the sundial with plaster and paint. The editor appealed to the Lieutenant Governor to have the sundial restored immediately. It is from this report that the installation date of the dial has been derived as the article starts (in French): *'About half a century ago a scholarly Jerseyman ... placed on the wall of the guard house in the Royal Square a Quadrant indicating the time by the sun, which cannot lie[4]'.* After a gap of thirteen years the Chronique was able to report that the restoration of the sundial (then described as 'le Cadran Solaire', rather than 'le Quadrant') was almost complete. There had been great difficulty in deciphering the inscription, which had been filled in with cement. The gnomon was shortly to be fitted and when that was done the appearance would be more like a sundial than a funeral monument[5] (a Mr Carter re-carved the text and his family name is still carried by a firm of monumental masons in the Island).

During its replacement of 1888, or at some subsequent restoration, the gnomon appears to have been fixed slightly below the true 'centre' with the result that the shadow does not always fall along the time lines. This is illustrated in Fig. 2.

From 1926 to 1997 the Picket House was leased to the National Westminster Bank and its predecessors. The States of Jersey are now responsible for the building and the sundial. There is little information on the restoration and maintenance of the dial since its dramatic rebirth in 1888. Whoever was responsible carried out an excellent job. The only thing missing is a plaque to the memory of Elias le Gros who has no other memorial.

JERSEY'S OLDEST SUNDIAL?

A possible Mass Dial completes the trilogy. In 1989 a carved stone was reported to the Société Jersiaise as a primitive sundial. The stone, which is on private property, is almost entirely buried in the ground at the top of a steep bank. The face, 33cm by 31.5cm, is approximately horizontal. The stone extends at least 38cm into the ground and may have been a quoin stone.

There are three lines, which appear to radiate from, but are not joined to, a 2cm diameter circular hole. The 'radii', about 20° apart are not absolutely concentric with the hole, which contains the rusted remains of an iron rod. There is no obvious sign of lead or other fixing material. Some damage has occurred, towards one corner of the stone, leaving an irregular shallow depression. (See Fig 3.)

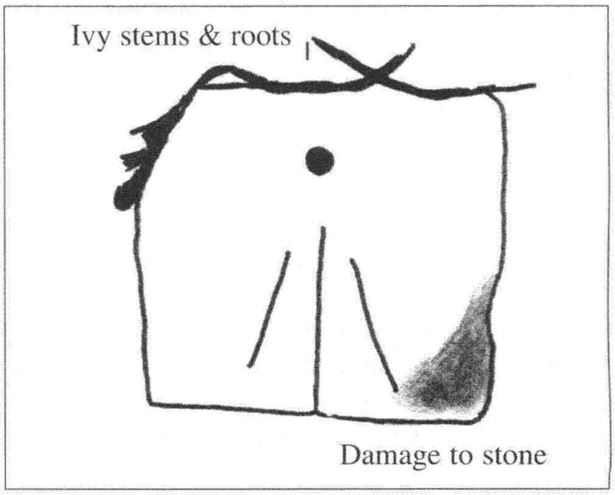

Fig.3. Sketch of possible Mass Dial in Jersey taken from a photograph with limited definition. Only the surface (now horizontal) is visible, the rest of the stone being buried in the ground

Encouraged by Mr A O Wood of the Mass Dial Group I suspended my initial doubts that this could be a time measuring device and consulted Dr John Renouf about the stone itself. Dr Renouf is the authority on the geology of Jersey and he has an extensive knowledge of the working of stone in the Island throughout the ages.

He has advised that the stone is a weathered coarse granite, almost certainly from the Island. The surface of the rock shows evidence of degradation through granules weathering loose over time. This indicates a very near surface source for the rock from which the block has been fashioned and a mediaeval origin is quite consistent with this. Deep-quarried granite was not available until centuries later. The main features cut into the granite have retained their overall shape and form though it is likely that the granulation of the surface has somewhat blurred the sharpness of the original cuts. A date in the region of 1100AD (the start of Mass Dials) is fully compatible with this physical evidence although not proven. An old weathered block could have been made use of at any time but this seems to be unlikely[6].

If this is a Mass Dial it presumably came from a religious establishment in Jersey where it was mounted in a wall facing south with the central line vertical beneath the iron peg. In the twelfth and thirteenth centuries there were, in addition to the twelve parish churches, a large number of chapels and priories. These were suppressed in the Reformation of the mid-sixteenth century and sold. Although I have found no historical record of any chapel in the immediate vicinity of the stone, it is reasonable to speculate that the stone came from such a source within the Island.

The purpose of the dial raises an interesting point. With a span of 40° centred on the (assumed) noon line it seems that each of the two intervals indicated would, at some times of the year, be less than one hour in duration. This is hard to reconcile with the usual Canonical Hours of Terce and Nones (mid-morning and mid-afternoon). Perhaps some other significant time was being indicated.

UNANSWERED QUESTIONS

My first steps in sundial recording and research have given rise to some intriguing questions, some of which remain unanswered. I should be interested to receive any comments on the three dials described as well as particulars of any other instruments similar to the St Brelade Equation of Time indicator.

ACKNOWLEDGEMENTS

My thanks to Mr M R de la Haye for allowing access to the Mass Dial and to Dr John Renouf for his geological assessment of the stone.

REFERENCES

1 *Chronique de Jersey* (8 Feb 1834)
2 R.S. Cox: 'Maps and their makers' *Bull. Société Jersiaise* **22 pt2** 221-223 (1978)
3 *Nouvelle Chronique de Jersey* (1 June 1859)
4 *Chronique de Jersey* (9 June 1875)
5 *Chronique de Jersey* (5 May 1888)
6 Dr John T Renouf: Personal communication (2001)

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RAILWAY TIME (2)

JOHN WALL

Readers may recall a short piece which I contributed to the Bulletin - Volume 12(i) for February 2000, under the heading 'Railway Time'. There I recorded a trophy, now in the National Railway Museum, in the form of a sundial awarded by the British Transport Commission for punctuality. The account concluded: 'I would be interested to learn of any functional sundials on railway property, now or in the past'. To date, surprisingly, there has been no reply to my plea. Ironically, however, I myself came across a second example this year whilst on holiday in Switzerland, seeking out noteworthy sundials and steam railways. It was almost literally on the doorstep of my Hotel des Alpes in the village of Glion, high above Montreux on Lake Geneva. The hotel is distinguished by having its own halt on the Rochers de Naye mountain railway, which is why I chose it in the first place.

Glion was first made accessible to tourists in April 1883 when a funicular railway was built up the mountainside from the suburb of Territet on the lakeside east of Montreux. This was so successful that in July 1892 the proprietors completed a rack and pinion railway (train à crémaillère) from Glion to the very summit of the Rochers de Naye at 2045 metres (6710 feet). Fearing that they might be shunted up a siding, the hoteliers of Montreux promoted a rack and pinion railway from their city to Glion which

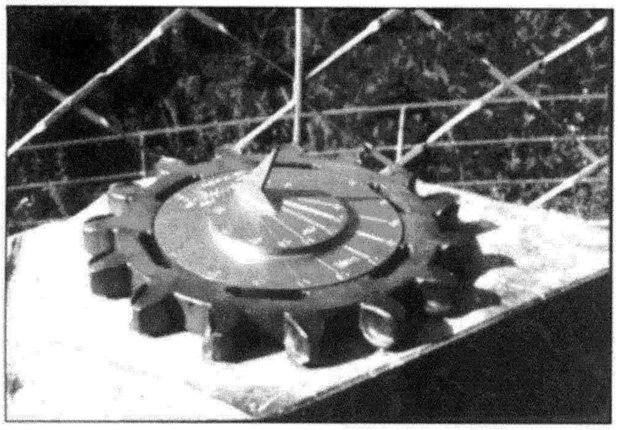

Fig.1. Anniversary Sundial; of the Rochers de Nay Mountain Railway at Gilon, Montreux, Switzerland.

was opened in April 1909, effectively by-passing the funicular, which. however, still operates from Territet. The total length of the line is 10.5 kilometres with a maximum incline of 220% ! It remains one of the highest, steepest and most scenic railways in Europe.

When the proprietors of the Montrex-Territet-Caux-Rochers de Naye Railway (MTCR) came to commemorate the centenary of the Glion-Rochers de Naye stretch in 1992 they hit on the happy notion of commissioning two identical sundials: one to be located on the platform at Glion station close to the terminus of the Territet funicular, and the other further up the line at Caux. The second choice was because (in the words of the promotional literature) 'the Rochers-de-Naye Railway still uses steam. In Summer, an old steam locomotive, sweating blood and tears, sets its con-rods a-pulsing up the stretch from Caux to Naye. Those nostalgic steam-train lovers will be delighted to find all the charm of the Belle-Epoque'.

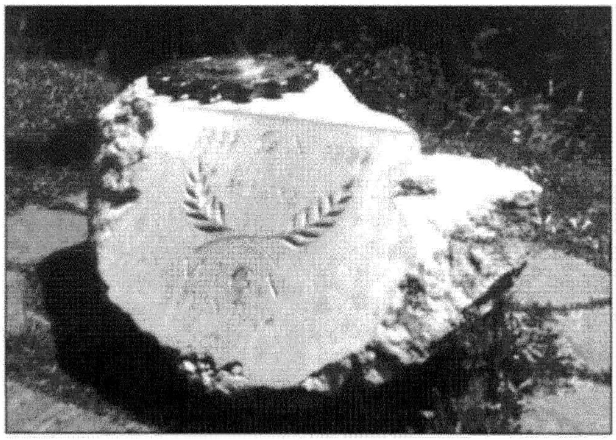

Fig.2. Anniversary Sundial of the Rochers de Nay Railway at Caux.

The two horizontal sundials, 2 feet in diameter, are made of shining golden bronze. In each case the circular sundial proper is surrounded by a representation of a cogwheel from the traction of the rack and pinion railway. At the top, above the gnomon, is inscribed the graph for the Equation of Time. There are two sets of hour lines, the inner set on a raised circular disc is marked 'été' for summer and the outer set is marked 'hiver' for winter. Each sundial is set on a rough-hewn block of sandstone on the face of which is inscribed the legend:

1892 GN 1992
100 ANS

(A sprig of laurel)

MT G N 5 JUIN 1992

I can think of no better way to commemorate such an important milestone in the history of a mountain railway. My only disappointment was that on every one of the many occasions when I passed through Glion en route to or from the Hotel Halt one stop further up the line, the stationmaster chose to time the departure of the train not by reference to the sundial but to an electric clock nearby.

There is, for me, a rather embarrassing postscript to this account. It is a good example of the obvious, ignored, staring one in the face. The incorporation of summer and winter hour-lines led me to suppose that, like us, the Swiss have embraced 'Summer Time' and put their clocks forward by one hour in the Spring and back by one hour in the Autumn. If we assume that the Swiss and the British do so simultaneously, and always on a Sunday, I reckoned that our times should coincide throughout the year. Yet on all of my flight itineraries (in July and August) there is a difference of one hour, plus or minus, depending on whether one is flying out or returning. Why? To my shame I pestered a most helpful young lady from the Swiss Travel Service on the telephone for an explanation, and she finally confessed that she was equally baffled. (In passing, she did not understand initially what a 'sundial' was, but eventually introduced me to its pleasing Swiss/French equivalent 'Cadran solaire'). In the instant that I rang off I remembered that the United Kingdom and Switzerland lie in adjacent time-zones which differ by one hour. So although we both change from 'Summer Time' to 'Winter Time' and vice-versa together, our clocks (and sundials) will always differ by the same amount - one hour. I can only plead in mitigation that memory-loss is also a function of time, and advancing age.

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MORTAR FOR A VERTICAL SUNDIAL
A SEVENTEENTH CENTURY RECIPE

ANDREW JAMES

INTRODUCTION

I was recently shown an interesting eighteenth century reference to sundials in a curious context. Richard Neve, (Philomath), included in his "The City and Country Purchaser, and Builder's Dictionary: or, the Compleat Builder's Guide", a recipe for mortar suitable for making a flat ground or plane on which to draw a vertical dial.

The text is shown in Figure 1 and the title page of the work in Figure 2. Both are taken from a facsimile reprint (c. 1970) of the second edition of 1726.

M O — M O

been ſteeped and well mingl'd, by which a Salt is communicated to the Water, binding the Clay, and making it fit to abide the Fire

Some Metaliſts uſe a kind of *Mortar* to plaiſter over the in-ſides of their Veſſels, (for refining of Metals) to keep the Metal from running out: And this kind of *Mortar* is compounded, and made of Quick-lime, and Ox-blood, the Lime being beat to Powder and ſifted and then mix'd with the Blood, and beat with a Beater

The Glaſs-makers in *France* uſe a ſort of *Mortar* (for plaiſtering over the in-ſides of their Furnaces,) made of a ſort of Fuller's-earth, which is gotten from *Beliere* near *Forges*, which is the only Earth in *France* that has the Property of not melting in this exceſſive Heat. And 'tis of this ſame Earth that the Pots are alſo made which will hold the melted Metal for a long time

7. *For Sun Dials.*] An exceeding ſtrong and laſting Mortar to make a Dial-plain on a Wall, may be thus made: Take Lime and Sand, which temper with a ſufficient Quantity of Linſeed-oyl; this ſpread upon the Wall, will harden to the Hardneſs of a Stone, and not decay in many Years. *Note*, If you cannot get Oil, you may temper your Lime and Sand with ſcum'd Milk, (but Oil is better) and this will laſt ſix times as long as the ordinary Plaiſter made of Lime and Hair with Water.

I have known a very ſtrong and tough Mortar (for a Sun-dial-plain,) made in this manner. To about five or ſix Gallons of Brook-ſand, (which was dry'd on an Oaſt, and ſifted through a fine Splinted-ſieve.) there was put as much, or rather more Sifted-lime, and a Gallon of Boreing (or Gun) Duſt ſifted alſo; all which was wet and temper'd well with 6 or 7 Gallons of Scum'd-milk, and about a Pottle of Linſeed-oil. This was laid on the Wall firſt, well wet with Milk; but the Workman found much Trouble to ſet it ſmooth, by reaſon it dry'd ſo very faſt; but by keeping it often ſprinkl'd with Milk, and ſmoothing it with the Trowel, it at laſt ſet with a very ſmooth and ſhining Surface. But notwithſtanding all his Care, it (as it dry'd) crack'd pretty much; which I fanſie might proceed from the want of Hair in it: It did alſo blow in Bliſters, tho' the Lime were ſifted; and therefore I fanſie, that if the Lime had been prepar'd as it is in *Freſco Painting*, it might have been prevented.

8. *Extraordinary good for Floors, Walls, and Ceilings.*] If you temper Ox-blood, and fine Clay together, and lay the ſame in any Floor, or plaiſter any Wall, or Ceiling with it, it will become a very ſtrong and binding Subſtance, as I have been told, (ſays my Author) by a Gentleman Stranger, who affirm'd to me, That the ſame is of great uſe in *Italy*.

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Fig.1. The recipe (mortar, entry 7)

To aid deciphering, the recipe is given below, in partly modernised spelling. Note that the present writer accepts no responsibility for its use!

For Sun Dials

An exceeding strong and lasting Mortar to make a Dial-plane on a Wall, may be thus made : Take Lime and Sand, which temper with a sufficient Quantity of Linseed-oil; this spread upon the Wall, will harden to the Hardness of a Stone, and not decay in many Years. *Note*, If you cannot get Oil, you may temper your Lime and Sand with scum'd Milk, (but Oil is better) and this will last six times as long as the ordinary Plaster made of Lime and Hair with Water.

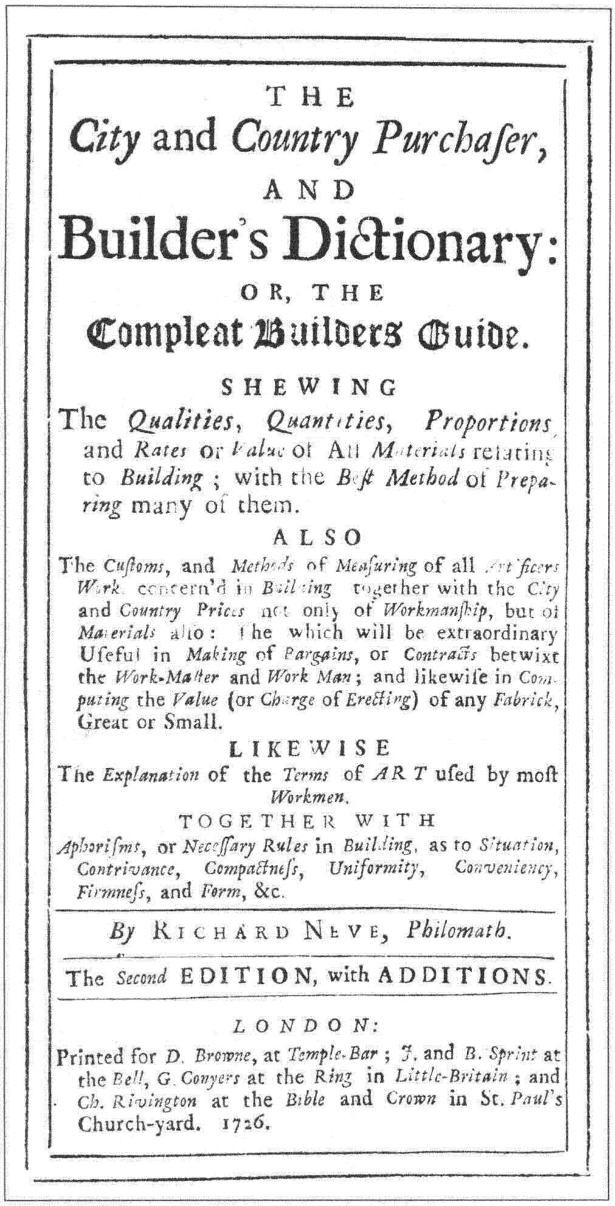
I have known a very strong and tough Mortar (for a Sundial-plane,) made in this manner. To about five or six Gallons of Brook-sand, (which was dried on an Oast, and sifted through a fine Splinted-sieve,) there was put as much, or rather more Sifted-lime, and a Gallon of Boring (or Gun) Dust sifted also; all which was wet and tempered well with 6 or 7 Gallons of Scum'd-milk, and about a Pottle of Linseed-oil. This was laid on the Wall first, well wet with Milk; but the Workman found much Trouble to set it smooth, by reason it dried so very fast; but by keeping it often sprinkled with Milk, and smoothing it with the Trowel, it at last set with a very smooth and shining Surface. But notwithstanding all his Care, it (as it dried) cracked pretty much; which I fancy might proceed from the want of Hair in it: It did also blow in Blisters, though the Lime were sifted; and therefore I fancy, that if the Lime had been prepared as it is in *Fresco Painting*, it might have been prevented.

NOTES

A Pottle was an old measure equal to half a gallon. As to "scum'd milk", scummed means skimmed. Presumably the Boring Dust was effectively iron dust: one wonders whether it would not later give trouble by oxidising within the mixture. The *Oxford English Dictionary* gives "gun dust" as meaning "the metallic dust produced by the boring of cannon" giving just two citations, both from this book (in the 1703 edition), the second being this very passage.

THE AUTHOR

Details of Richard Neve's life seem unclear, though he almost certainly died before 1726 when this second edition



THE
City and *Country Purchaſer*,
AND
Builder's Dictionary:
OR, THE
Compleat Builders Guide.
SHEWING
The *Qualities*, *Quantities*, *Proportions*, and *Rates* or *Value* of All *Materials* relating to *Building*; with the *Beſt Method* of *Preparing* many of them.
ALSO
The *Cuſtoms*, and *Methods* of *Meaſuring* of all *Artificers Work* concern'd in *Building* together with the *City* and *Country Prices* not only of *Workmanſhip*, but of *Materials* alſo: The which will be extraordinary Uſeful in *Making* of *Bargains*, or *Contracts* betwixt the *Work-Maſter* and *Work Man*; and likewiſe in *Computing* the *Value* (or *Charge* of *Erecting*) of any *Fabrick*, Great or Small.
LIKEWISE
The *Explanation* of the *Terms* of *ART* uſed by moſt *Workmen*.
TOGETHER WITH
Aphoriſms, or *Neceſſary Rules* in *Building*, as to *Situation*, *Contrivance*, *Compactneſs*, *Uniformity*, *Conveniency*, *Firmneſs*, and *Form*, &c.

By RICHARD NEVE, *Philomath*.

The *Second* EDITION, with ADDITIONS.

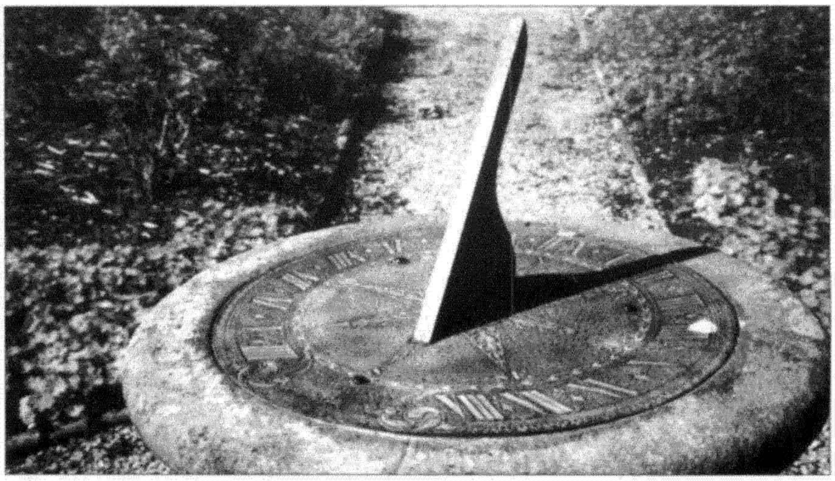
LONDON:
Printed for *D. Browne*, at *Temple-Bar*; *J.* and *B. Sprint* at the *Bell*, *G. Conyers* at the *Ring* in *Little-Britain*; and *Ch. Rivington* at the *Bible* and *Crown* in *St. Paul's* Church-yard. 1726.

Fig.2. The title page of the 1726 edition

was published, corrected probably by John Ozell. The first edition of Neve's Builder's Dictionary was published in 1703 and was an entirely new type of architectural book; much material was brought together from different sources and arranged alphabetically. An enlarged third edition came out in 1736. I have not yet traced this passage, but I believe that it appeared in the first edition, so it may reasonably be taken as essentially seventeenth rather than eighteenth century.

ACKNOWLEDGEMENTS

Thanks to Michael and Polly Legg for showing me this, and to David and Charles Limited for permission to use extracts from their facsimile reprint.



Dial in a garden of Bodelwyddan Castle, N. Wales - photo: Don Petrie or which has been submitted for publication,

GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the Bulletin on the subject of sundials and gnomonics; and by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language will not normally be accepted.

   Articles may vary in length, but the text should not exceed 4500 words, about three-and-a-half pages in the Bulletin. When writing about a fixed dial or mass dial in Britain , authors are encouraged to ensure that the dial has been, or will be, placed in the Register of Sundials (See inside back cover for address of Registrar.) If you are uncertain about the recording, please insert a note in italics at the end of the article to give the dial's approximate location: for example, *The sundial described in paragraph 3 is in Derbyshire, Taddington village, Lat. 53°14 ' Long.1° 46'*

2. Format: The preferred format for text is typescript, single-spaced or double-spaced, A4 paper; or on disc, 'microsoft word' or 'ASCII', with one printout.

3. Figures: For photographs, black and white prints as large as possible up to A5 size; colour prints are also acceptable if they show sufficient contrast. Slides and transparencies are also acceptable. Drawings and diagrams should be in clear black lines on white paper. If sending figures on disc, they should be saved as TIF or JPEG. Each figure illustrating an article should carry on the back the author's name and a number indicating its relative position in the text. (Fig.1, Fig.2 etc) Captions for the figures should be written on a separate sheet in numerical order. They should be sufficiently informative to allow the reader to understand the Figure without reference to the text.

4. Notes are best avoided: it should be possible in a short article to incorporate into the text all the background information which the reader needs, to understand the article. If notes are used, they may be referred to, in the text, as (Note 1), (Note 2) in brackets; then listed at the end of the article, after the 'Acknowledgements' and before the 'References'

5. Acknowledgements: These should be as brief as is compatible with courtesy.

6. References: Sources are referred to in a text by a superscript number. They are listed in numerical order under the heading 'References' at the end of the article. If the same source is cited several times in the article, use a superscript number and complete reference on the *first* occasion only. On subsequent occasions, simply insert the author's name in brackets in the text of your article, adding *(if necessary)* the date or page or figure number. Avoid further superscript numbers, and do not write *loc.cit.* or *ibid.* in the reference list.

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

   If you simply wish to give a short list of books associated with the subject of the article, this may be given at the end of the article under the heading 'Bibliography', using the convention as given for 'Books' above.

7. The address of the author will normally be printed at the end of the article, unless the author, when submitting the article, expresses a wish that this should not be done.

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British Sundial Society

ELEVENTH ANNIVERSARY CONFERENCE, HELD AT THE ROYAL AGRICULTURAL COLLEGE AT CIRENCESTER

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14 Michael Isaacs, Berkshire
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24 Sally Hersh, West Sussex
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27 Irene Barrett, London
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29 Doreen Bowyer, Kent
30 Alan Smith, Manchester
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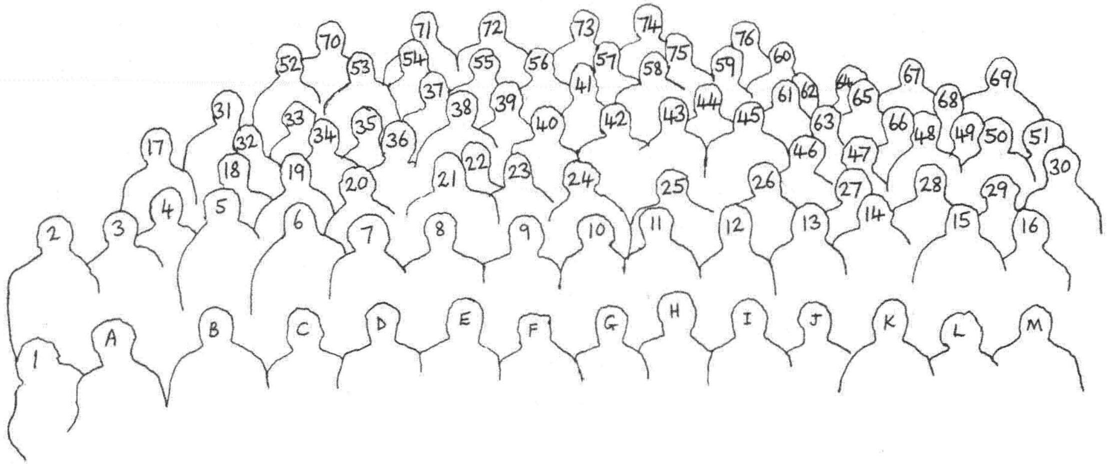
32 John Lester, West Midlands
33 Roger Bowling, Cheshire
34 Alfred Brown, Manchester
35 Jackie Holland, Illinois
36 Tony Moss, Northumberland
37 Gordon Hendry, Dumfries & Gall.
38 Tony Ashmore, Berkshire



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40 Walter Wells, Leics.
41 Graham Stapleton, London
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43 Dorothy LeConte, Guernsey
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45 Richard Mallett, Bedfordshire
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64 Valerie Cowham, Cambridgeshire
65 Andrew Ogden, Co. Kildare
66 Mary Belk, Wiltshire
67 Desmond Quinn, Essex
68 Donald Bush, Nottinghamshire
69 ???
70 John Hayden, London
71 ???
72 Jack Bromiley, Merseyside
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