The British Sundial Society

BULLETIN

BSS Bulletin 21(iii)

September 2009

VOLUME 21(iii)
September 2009

GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics; and, by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.
2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis51@btopenworld.com*. Material can also be sent on CD or as a single-sided typescript, single- or double-spaced, A4 paper.
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4. Mathematics: symbols used for the common dialling parameters should follow the conventions given in the Symbols section of the *BSS Glossary* (available online on the Society's website). Consult the editor if in doubt or for help in laying out equations.
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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', *NASS Compendium,* 4, 23-27 (1997).

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Front cover: *The BSS Conference trip to the famous Holker Hall slate dial (after the rain!). Photo: John Davis.*

Back cover: *This 24" diameter undated Thomas Heath brass sundial with its massive 13" high gnomon stands in front of Carton House, Co. Kildare, Ireland. It bears the coat of arms of the Earl of Kildare and has a large 32 point compass rose at its centre and an 'Æquation of Natural Days' table. There are 34 place names in the chapter ring with pointers to the outside minute scale to indicate local time when it is noon in those distant places, from 'Pekin in China' in the east at 3:42am to 'St. Miguel' (Mexico) in the west at 8:19pm.*
Heath (c.1700 -1773) was one of the most important dial makers of the Grocers' Company in the 18th C (see BSS Bulletin 15(i) pp.6-13). James Fitzgerald, 20th Earl of Kildare from 1744 and 1st Duke of Leinster from 1766, died in 1773. The post-1752 Gregorian Equation of Time calendar on the dial and the pre-1766 Coat of Arms indicate that the dial was made sometime c.1752-1766. Photos: Michael J Harley.

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

BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

ISDN 0958-4315

VOLUME 21(iii) - September 2009

CONTENTS

EDITORIAL

New Author Award 2008

The winner of the Best New Bulletin Author Award 2008 could not be presented at the Conference so it was recently presented at the Institute of Astronomy, Cambridge. This is where the recipient, Robin Catchpole, works. In case there is ever a total loss of power for his hi-tech telescopes, we presented him with a replica astrolabe, as well as a certificate with calligraphy from Margery Lovatt. Robin is seen in the photograph standing in front of the 'Northumberland' telescope designed in the 1830s by George Biddel Airy, now a museum piece but still working. Airy later went on to be Astronomer Royal and it was partly through his work that Greenwich was made the Prime Meridian.

Robin's article was on the design for a Solar Pyramid. This project has undergone some setbacks and the site originally proposed has been abandoned but the originators are still hopeful of building the Pyramid at another location.

A UNIVERSAL ALTITUDE DIAL BY JOHN MARKE

MICHAEL LOWNE and JOHN DAVIS

The King George III Collection of scientific instruments in the London Science Museum contains a wide variety of instruments and demonstration pieces from a variety of sources.[1] Some of them are very sophisticated and quite well-known, such as the 'grand orerry' attributed to Thomas Wright.[2] One item which has been largely overlooked is described as a "pocket clinometer and square in a case" and is signed "J Marke Fecit".[3] In fact, the device is a universal altitude dial of a very unusual type. It is possible that the dial was originally the property of the great chemist Robert Boyle (1627-1691). The dial is described below, together with a study of how and why it works – features which we have not seen described before and which are not immediately obvious on looking at the instrument.

Provenance

The Science Museum's King George III Collection is one of the most comprehensive surviving collections of scientific apparatus from the 18th century and earlier. Its diversity is shown by two contrasting groups of apparatus. First, there is the apparatus which King George III commissioned from the instrument maker George Adams in 1761. These instruments were used by the royal family for entertainment and instruction and are expensive and elaborate. Second, there is the apparatus assembled during the 1750s by Stephen Demainbray for use in his lectures to the public. Although this apparatus was designed to demonstrate many of the same principles as those commissioned by the King, it is cheaper, simpler and more hard-wearing. The two collections came together in 1769 when Demainbray took up the post of Superintendent of the Observatory at Kew where the King's scientific instruments were housed. They were removed to King's College, London in the mid-19th century and finally to the Science Museum in 1927.

The Marke dial is part of a sub-set of the King George III Collection known as the Boyle Collection. This Collection contains a number of mathematical models and books, and was incorporated into the King George III Collection in 1770. A manuscript catalogue dated 13 March 1770 lists the dial as Item No. 35, "a square brass scale plate in a case". Robert Boyle was a physicist and chemist who carried out many experiments on air, vacuum, combustion and respiration.

This collection of instruments should not be confused with the extensive set of papers owned by the Royal Society and known as the Boyle Papers.[4] These papers predominantly comprise Boyle's extant remains but, between his death in 1691 and their arrival at the Royal Society in 1769, they were the subject of serious depredations, and they also gained a certain amount of material that seems to have belonged not to Boyle but to two men through whose hands the papers passed: his executor, John Warr, and the nonconformist minister, Henry Miles, whose widow presented them to the Royal Society. Amongst the Boyle Papers are three engravings which are proofs and counterproofs of a double horizontal dial signed by John Marke and dated 1667. The relationship between these engravings, which were described in the September 2008 *Bulletin,*[5] and the altitude dial has not been established but the possibility that they both belonged to Boyle is quite good.

Fig. 1. The embossed leather case of the Marke quadrant.

John Marke

John (Johannes) Marke (c.1641- after 1673) was originally from Northampton and was apprenticed to the great Henry Sutton. He started his apprenticeship in 1655 in the Joiners' Company although he also became a Brother Clockmaker in 1667. Like his master, from whom he took over when Sutton died of the plague in 1665, he could work in brass, silver, ivory or wood and made the whole range of mathematical instruments of the time. His premises were at the Golden Ball in the Strand, near Somerset House. He made instruments for both Robert Hooke and John Flamsteed but he is probably best-known for the instruments he made for James Gregory to equip the new St Andrew's Observatory when he came to London in 1673 on a purchasing expedition. These included a new plate for the latitude of

Fig. 2(a) The clinometer side, (b) one of the sights, (c) the signature and one of the sliders.

St Andrews (56° 25') to fit to the Humphrey Cole astrolabe (already a century old) which is still in the St Andrew's Museum. The stereographic projection on that instrument is a testament to Marke's skills.

Sutton was an accomplished mathematician as well as a practical instrument maker with a reputation for delineating scales with the best accuracy of the time. He was, for example, capable of deriving the requirements for the projections on a Gunter's quadrant – then newly developed – without significant guidance and he was also responsible for major developments in the features of the double horizontal dial. It seems that Marke was a star pupil with at least some of Sutton's attributes.

Dial Description

The instrument is a combined clinometer and altitude sundial, double-sided, one side carrying the clinometer and the other the sundial for determining the time from the measured altitude of the sun. Made in brass, the dimensions are 5 × 4½ inches (129 × 115 mm) and around 2 mm thick. It still has its original gold-embossed leather case shown in Fig. 1. The instrument is capable (within limits) of operating at any latitude. When it was photographed for Ref. 1, its surface was streaked with old lacquer but this has evidently been cleaned off since, leaving it highly polished and difficult to photograph.

The description of the dial in Ref. 1 describes the scales but does not attempt to say how they should be used. The authors do, however, suggest that the scales are similar to those on a quadrant by Abraham Sharp, now at Bolling Hall.[6] A recent investigation of that instrument shows that the similarity is superficial and the functions are quite different.

The clinometer side is shown in Fig. 2. It carries the signature "*J: Marke Fecit*" but no date. The altitude scale runs 0-45[°] along the base, 45-90[°] up the right-hand side and is divided to degrees and halves. Visible near the top at the ends of the line carrying the signature are two sighting apertures (Fig. 2b) enabling the sun's altitude to be found. Not, one hopes, by actually looking through the holes but by allowing the light passing through one to fall on the other. Originally there would have been a plumb-bob on a thread suspended from a small hole opposite the 45° corner. A uniform scale at the left side runs from 0 to 10 and is divided in tenths and twentieths of the units.

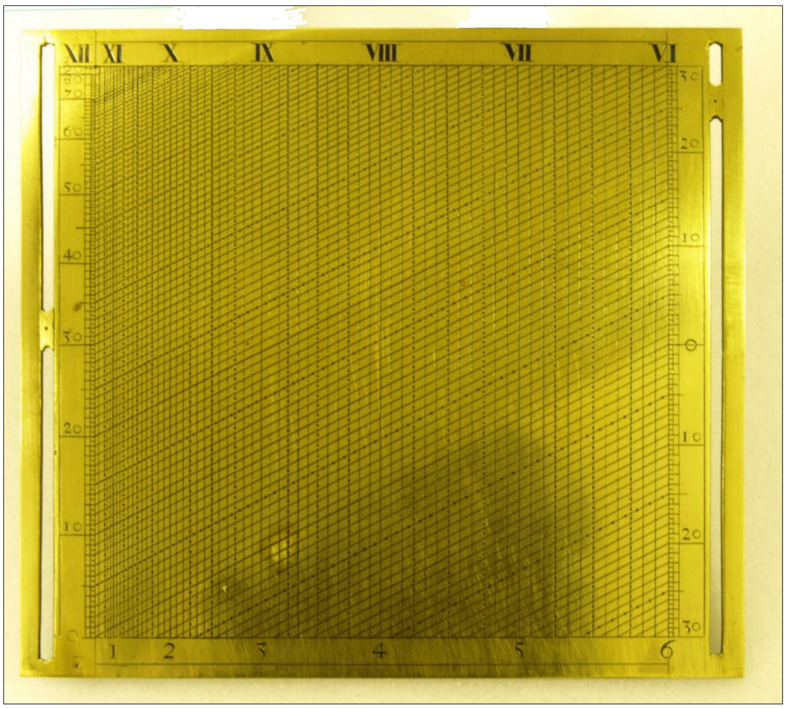

Fig. 3. The sundial time-finding side.

The altitude dial side is shown in Fig. 3. The scales are numbered but it is left to the user to know what they represent. The hour scales are along the top and bottom of the working area, morning hours in Roman numerals VI to XII at the top and afternoon hours in Arabic figures 1 to 6 at the bottom. They are spaced as the cosines of the hour-angles, the angular distance of the sun from the meridian, with the zero at the right-hand side. The upper and lower scales are joined by vertical lines at intervals of five minutes of time. The side scales are of the sines of angles, 0-90 on the left and 30-0-30 on the right, each being divided to degrees and halves. Sloping lines join corresponding points on these scales at intervals of one degree: where there are no corresponding points the lines are drawn parallel. Identifying dots are placed at the intersections of half-degrees and the hours and half-hours, and on the sloping lines at the 5-degree positions midway between the 5-minute intervals on the hour lines.

Visible from both sides are small sliders (Fig. 2c) in parallel slots which would enable a thread (now missing) to be stretched between the two sine scales on the time side. They have no function on the altitude side.

Basic Operation

The side scales are scales of the sines of altitudes. The left scale is for the sine of the meridian (noon) altitude and the right that for the altitude at 6am or 6pm (± 90º hour-angle), which in the northern hemisphere is positive for northern declinations and negative (below the horizon) for southern declinations. The zeroes denote altitude 0° on both scales and the sloping line joining them represents the horizon.

In the polar spherical triangle formula linking latitude (φ), declination (δ), hour-angle (h) and altitude (a):

$$\sin a = \sin\varphi.\sin\delta + \cos\varphi.\cos\delta.\cos h$$

On any one day and latitude, δ and φ are constant, so $\sin a$ is linear with $\cos h$ and a plot of $\sin a$ against $\cos h$ is a straight line, representing the change of altitude with hour-angle throughout the day. This is set on the dial by adjusting the sliders so that the thread is laid between the points on the side scales corresponding to the sines of the meridian altitude and of the altitude at h = 90°. As the sloping straight line between the zeroes on the side scales represents the horizon, the vertical distance between this and any other parallel line will represent the sine of a constant altitude. The point of intersection between thread and an altitude line will indicate the time, am on the upper or pm on the lower hour scale.

Detailed Operation

The first step is to derive the altitudes to set the thread on the side scales. As $\sin a$ is linear with $\cos h$ it follows that $\sin a$ at 6^h is the mean of $\sin a$ at 0^h and $\sin a$ at 12^h hour-angle. In other words $\sin a$ at 6^h is half the sum of the sines of the altitudes at upper and lower meridian transits. Calling these U and L respectively and the altitude at 6^h E:

$$U = (90-\varphi+\delta)$$

$$L = -(90-\varphi-\delta)$$

$$\sin E = ½ \{\sin U + \sin L\}$$

$$\sin E = ½\{\sin(90-\varphi+\delta)-\sin(90-\varphi-\delta)\}$$

The same result can be obtained from the polar triangle formula by putting $\cos h = 0$:

$$\sin E = \sin\varphi.\sin\delta$$

which can be expressed:

$$\sin E = ½\{\cos(\varphi-\delta)-\cos(\varphi+\delta)\}$$

and converted to sines:

$\sin E = ½\{\sin(90-\varphi+\delta)-(\sin(90-\varphi-\delta)\}$, as before.

Note that L will generally be negative and E may be positive or negative depending whether δ has the same or opposite sign to φ. For southern latitudes take φ as positive and reverse the sign of δ.

In use, the instrument requires differing procedures depending on whether the declination is positive or negative:

For positive declinations:

1. Calculate U and L from the formulae above (U will be numerically greater than L).

2. With dividers measure off L on the left scale from 0.

3. Set one leg of the dividers on the value for U and the other leg lower down on the scale, thus subtracting $\sin L$ from $\sin U$ and forming the value $(\sin U - \sin L) = 2\sin E$.

4. Leaving one foot of the dividers on the value for $2\sin E$, open them to put the other foot on the zero of this scale.

5. Rotate the dividers through 90° about the zero to measure off $2\sin E$ on the horizontal base line.

6. Follow the sloping line which intersects the base at this point up to where it intersects the right-hand scale. The slope of these lines is two horizontally to one vertically, thereby dividing $2\sin E$ by two to give $\sin E$.

7. Set the dividers on the intersection point on the right scale and the zero point and mark off the same distance above centre to give $\sin E$ above the horizon. Alternatively, read the degree scale and transfer this reading to the upper part of the scale.

For negative declinations:

1. Calculate U and L as before (L now greater than U):
2. Measure U on the left-hand scale from zero with the dividers.
3. Set one leg of the dividers on the value for L and subtract the value for U to form $2\sin E$ which is negative.
4. Transfer $2\sin E$ to the lower horizontal scale as before and follow up the sloping line to intersect the vertical scale at $\sin E$. This will be correctly placed below the zero point.

In the case when $\delta = 0$, $U = L$ and E is also 0 as may be seen from sunrise and sunset being at the east and west points of the horizon.

To set the thread to the $\cos h : \sin a$ values and find the time:

1. By adjusting the sliders, stretch the thread between the value of $\sin E$ just found and the value of $\sin U$ on the left hand scale. The height of the thread above the 0-0 horizon line then represents the value of $\sin a$ changing with $\cos h$ throughout the day. Once this has been done the setting is valid for that day, or perhaps several days at the solstices when the declination is changing only slowly.

2. Measure the sun's altitude on the clinometer side by means of the sights and plumb-bob hanging vertically.

3. On the left-hand scale, take this altitude setting and follow up the sloping line at that point. The line is parallel to the horizon and represents a constant value of $\sin a$.

4. Where the altitude line intersects the thread indicates the time, am on the upper Roman numerals or pm on the lower Arabic numerals. It is also possible to derive the times of sunrise and sunset from the point where the thread meets the horizon line.

It is noticeable that the instrument has no table of the sun's daily declination throughout the year, although there is space where the maker could have chosen to engrave one in the blank area of the clinometer side. Possibly it was provided with a printed sheet of instructions which could have included a table of declinations.

The procedure outlined above for deriving $\sin E$ is rather cumbersome and subject to error, but appears to be the only possible method using the dial itself. However, if there was an instruction sheet this could also have carried a simple nomogram for finding $\sin E$ directly from $\sin U$ and $\sin L$.

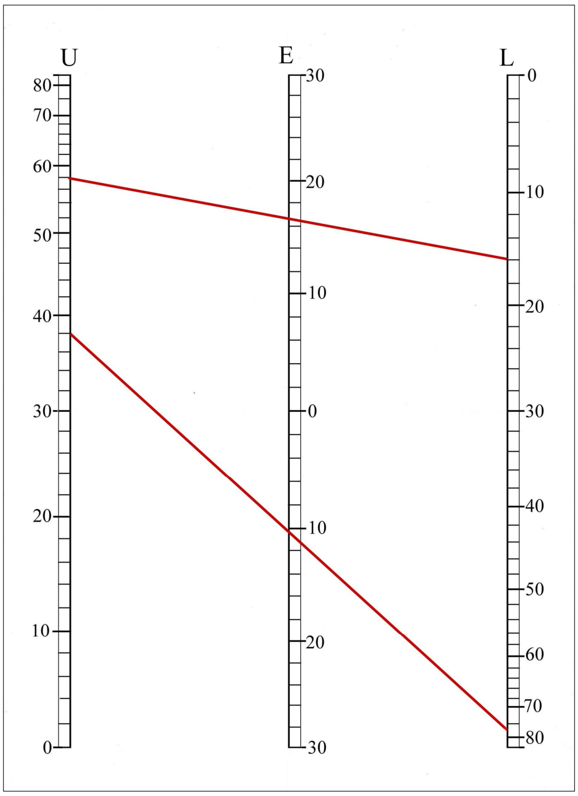

Fig. 4. A nomogram for deriving $\sin E$ from $\sin U$ and $\sin L$.

A scheme for this is shown in Fig. 4, in which a straight-edge is laid between the values of U on the left scale and L on the right. The reading of E is found where the straight-edge crosses the central scale and can be transferred to the dial scale. It will indicate directly whether E is positive or negative, to be inserted above or below the zero on the E scale. Two examples are shown on Fig.4 with the straight-edge settings in red.

Examples of Use

An example of the use is given on the drawing of the sun-dial in Fig. 5 (simplified to show 2° intervals in altitude and 10 minute intervals in time). The latitude is 53° and the declination +21°. The construction lines to form $\sin E$ from $\sin U$ and $\sin L$ via $2\sin E$ and the $\cos h$:$\sin a$ line joining the values for $\sin U$ and $\sin E$ are shown in red. The sloping lines for three solar altitudes are shown in blue.

Two of the altitude lines (for 55º and 31º) intersect the $\cos h : \sin a$ line on the diagram enabling the time to be read directly but the third intersection for a low altitude of 13º falls off the scale to the right (as shown by dashed lines) and indicates that the time is earlier than 6am or later than 6pm. This is dealt with by measuring with dividers the distance between the intersections of the $\cos h : \sin a$ line and the altitude line on the $\sin E$ vertical and transferring this above the $\cos h : \sin a$ line. Following down the sloping line from this point to the intersection with the $\cos h : \sin a$ line will give the time, now with am on the lower time scale and pm on the upper. This construction is shown on Fig. 5. The intersection of the $\cos h : \sin a$ line with the 0-0 horizon line will show the times of sunrise and sunset, but in this case it also falls off-scale to the right: with a positive declination they too are earlier than 6am or later than 6pm. To find

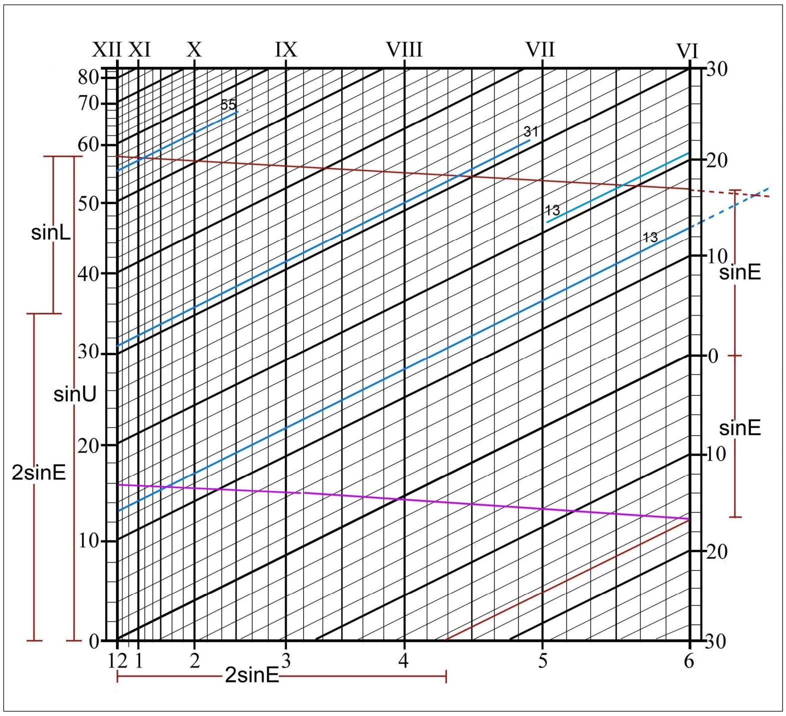

Fig. 5. Example of use for latitude 53º, declination +21º and three solar altitudes.

them, join the value of sin$E$ as first found by the sloping line on the right scale to that of sin$L$ on the left scale, as shown by the purple line on Fig. 5, and read the times at the intersection with the 0-0 horizon line. This could be done by laying a straight edge across the dial face to avoid disturbing the cos$h$:sin$a$ line. These methods work because cos$h$ is symmetrical about 6 hours, apart from the change of sign.

Latitude	+53		
Declination	+21		
U	58		
L	-16		
E	16.7		
Calc. *E*	**16.6**		
Calc. sunrise	**3:58**		
Calc. sunset	**8:02**		
Meas'd sunrise	3:56		
Meas'd. sunset	8:04		
Altitude	55	31	13
Calc. time am	**10:46**	**7:36**	**5:35**
Calc. time pm	**1:14**	**4:24**	**6:25**
Meas'd time am	10:50	7:36	5:33
Meas'd time pm	1:10	4:24	6:27

Fig. 6. Comparison of times read from Fig. 5 and calculated values.

The details of this example are shown in Fig. 6, which compares the time readings from the dial with calculated values shown in boldface type. Generally, the results from the dial are within a few minutes of the calculated values.

Another example is shown in Fig. 7 with latitude 33° and declination -19°. The comparison of the results and calculated values is given in Fig. 8. In this case for a negative declination all the dial indications fall within the 6am–6pm range and agree with the calculated values to a minute.

The two sin$U$:sin$E$ lines shown on the nomogram of Fig. 4 are drawn for these two examples and confirm the values found for sin$E$.

Accuracy of the Dial

The apparent accuracy shown in these examples is in many respects unrealistic. It is one thing to make a drawing for illustration purposes using integer values for the latitude, declination and altitude but quite another to use real values with their fractions of degrees, and manipulating dividers to locate the various settings. Working in cos$h$, the time scale is very compressed and non-linear within an hour or so of noon and is correspondingly difficult to read accurately even if the thread setting is correct. Small errors in the settings will lead to inaccurate time determinations. It is considered that a quarter of a degree in the setting of the cos$h$:sin$a$ thread and of the altitude reading is the best accuracy which could reliably be achieved.

The equation of the cos$h$:sin$a$ line is:

$$\sin a = \sin U \cos h - \sin E \cos h + \sin E$$

This can be differentiated to find the error in h (Δh) consequent upon an error in one of the other values (Δa, ΔU, ΔE).

$$\Delta h = \cos a \Delta a / \sin h (\sin E - \sin U) \quad (1)$$

$$\Delta h = \cos U \cos h \Delta U / \sin h (\sin E - \sin U) \quad (2)$$

$$\Delta h = \cos E \Delta E (1 - \cos h) / \sin h (\sin E - \sin U) \quad (3)$$

For constant values of U and E:

In 1, the denominator includes sin$h$ which approaches zero towards the meridian and Δa will increase rapidly with decreasing values of h.

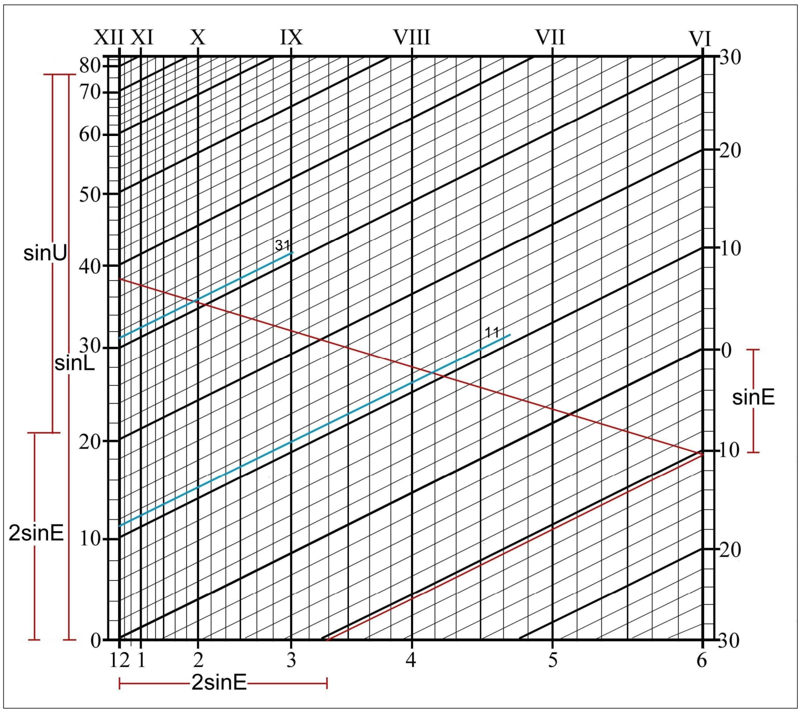

Fig. 7. Example of use for latitude 33°, declination -19° and two solar altitudes.

Latitude	+33	
Declination	-19	
U	38	
L	-76	
E	-10.4	
Calc. *E*	**-10.2**	
Calc. sunrise	**6:52**	
Calc. sunset	**5:08**	
Meas'd sunrise	6:53	
Meas'd. sunset	5:07	
Altitude	31	11
Calc. time am	**10:03**	7:51
Calc. time pm	**1:57**	4:09
Meas'd time am	10:03	7:52
Meas'd time pm	1:57	4:08

Fig. 8. Comparison of times read from Fig. 7 and calculated values.

In 2, $\cos h$ is divided by $\sin h$ which is equal to $\cot h$ and Δh will again increase rapidly with decreasing values of h.

In 3, the division of $(1\text{-}\cos h)$ by $\sin h$ is zero at the meridian and unity at h=90º. Δh will increase slowly from the meridian with increasing h.

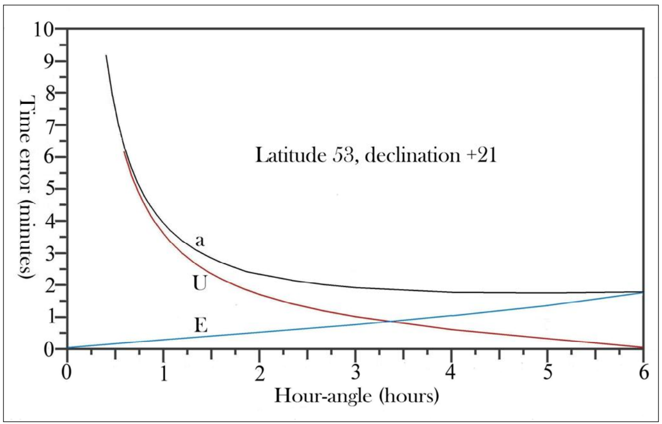

Fig. 9. Time errors resulting from small setting errors in a, U and E.

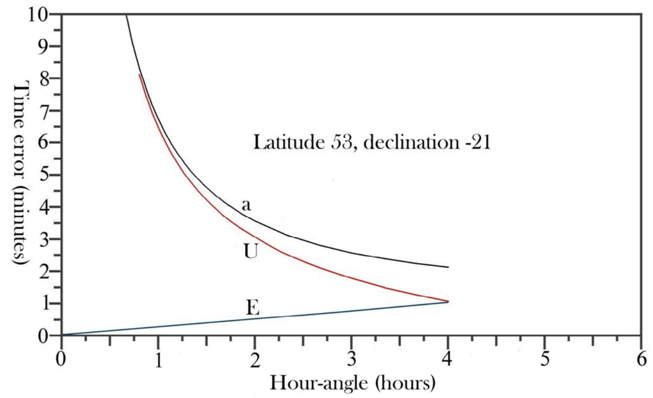

Fig. 10. Time errors from small setting errors in a, U and E.

Values of Δh derived from these expressions are multiplied by 4 to convert from degrees to minutes of time (Δt). These are plotted in Fig. 9 for latitude 53º and declination +21º as used in Fig. 5, and in Fig. 10 for the same latitude but -21º declination. Errors Δa, ΔU, ΔE are taken to be a quarter of a degree. The curve of Δt for Δa is shown in black, that for ΔU in red and that for ΔE in blue. They confirm the conclusions noted above and comparison of the two figures will show that the errors are larger at lower declinations.

In practical use there are likely to be errors in the position of more than one of the lines and the effects will combine in the incorrect time readings. The signs of the errors may be positive or negative and the line errors could add together or partially cancel out. For example, if a and U were approximately equal and of opposite sign, the accuracy of the time readings near the meridian would be enhanced.

The time errors also depend on the latitude and are larger at higher latitudes. This arises because, as can be seen by comparing Fig. 5 with Fig. 7, at the higher latitude the $\cos h : \sin a$ line makes a more acute angle with the altitude lines and a small error in one or the other will have a proportionately larger effect on the time reading. A lower declination has a similar effect on the $\cos h : \sin a$ line.

Use at Low and High Latitudes

Although the instrument is nominally usable at all latitudes, there will be complications. Within the tropics, the calculation for U can give a result greater than 90º: this implies that U and L are both on the same side of the zenith and is corrected by subtracting U from 180º. Within the Arctic Circle (use within the Antarctic Circle is perhaps unlikely!) the sun may be above the horizon for 24 hours and L will be positive. In this case subtract 90º from the calculated value for L and add the result to the value for U on the left-hand scale instead of subtracting. However, the derived times at very high latitudes will become most unreliable if small errors are present. In addition, the altitude becomes more nearly constant throughout the day and at the pole (to take the extreme case) does not change at all.

Discussion and Conclusions

This appears to be the only known example of this type of instrument, although it may be thought that having made one Marke would perhaps have made others. Most altitude dials are made for fixed latitudes and this universal device would have been useful for travellers in an age of rapid development of commerce and exploration.

The dial can be regarded as a nomogram for solving the spherical triangle for the special case with the hour angle equal to 0° and 90°. It is thus a simplified version of the more general 'geometrical square' described by the London-based mathematician Samuel Foster in 1659.[7] Foster's works were well-known to Henry Sutton and probably Marke too. At present, the inventor of the Marke form is open to speculation. Other uses of nomograms in gnomonics have been discussed by Sawyer.[8]

The lack of a sun's declination scale on the instrument remains a puzzle. This data can be read off directly from a double horizontal dial, or even a print of such a dial. Thus the existence of such a print, also signed by Marke and associated with Robert Boyle,[5] raises an intriguing possibility that the two instruments were in some way linked, perhaps even being commissioned as a pair. However, the sizes of the instruments (that is, the scale length of the altitude dial and the radius of the horizon circle of the double horizontal dial) are not the same and so some possible combined operations, using dividers to transfer values from one instrument to the other, are precluded, thus lessening the likelihood of their being commissioned together. Nevertheless, the connection between Marke and Boyle remains an interesting area for further investigation.

ACKNOWLEDGEMENTS

It is a pleasure to thank: Adrian Whicher & Jane Wess (London Science Museum) for access to the dial and permission to photograph it; Daru Rooke & Dale Keeton (Bolling Hall) for details of the Abraham Sharp quadrant;

Fred Sawyer for information on nomograms; and Michael Hunter for discussions on the works of Robert Boyle.

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Visit to Bramshill House, June 6th 2009

Mike Isaacs

On a wet 6th June 2009, a party of about 20 brave BSS members plus two from a local U3A architectural group, paid a visit to Bramshill House, a magnificent Jacobean mansion in Hampshire. The house was the former National Police Staff College, and is now the home of the National Policing Improvement Agency (NPIA). The objects of the visit were to examine the noon mark described by Doug Bateman in BSS *Bulletin*, 20(iii) September 2008, and have a conducted tour of the house.

We were met by the Curator, Ms Lindsey Kerr, in the entrance hall, which was full of heraldic shields and a table apparently made from a single piece of wood, 20 ft long by 4 ft wide and 4 inches thick! After giving us a brief history of the various owners of the house since its construction in the early 1600s, Ms Kerr showed us many large and small rooms, some with magnificent tapestries. As the house had been the Police Staff College before becoming the NPIA, the country's largest collection of truncheons and tip-staffs was displayed in cases and wall mounts, as also many silver items presented by visiting forces, both in the UK and overseas.

The Stately rooms now have many different functions, being used primarily as offices and lecture rooms. For example, the magnificent long gallery, over 100 ft long, is now used as the main library.

After touring the ground floor, the visitors went outside into the customary wind and rain to see the noon mark. This is partially exposed to the open, being in a loggia with one side opening onto a terrace. The aperture is in a blanked-off window at one end and the noon line is faintly visible carved into the stone floor. Ancient wooden benches line the inner wall of the loggia, with interesting carvings on the dividers between the seats. Close by, on a stone parapet, is a small brass horizontal dial.

At the other end of the terrace, in a similar loggia, is the Trocco stone. This is a large stone polyhedron, properly described as a rhombicosidodecahedron, with pentagonal faces and hemispherical depressions. No-one seemed interested in volunteering to layout the various dial faces, which the polygons obviously needed.

Records show that another dial had been situated at the end of another parapet about 100 yards from the house, but there are no traces remaining.

We then returned inside to see the larger rooms on the upper floor. As we were visiting the house on the 65th anniversary of D-Day, we enquired about any wartime activities at the House. It was not used by the military during World War II, but was taken over by the Red Cross to administer the 'Penny-a-Week' campaign, which was a donation scheme where every civilian worker was asked to donate one penny a week from their wages to the Red Cross, who sent food parcels to troops overseas and to Prisoners–of War (POWs) . (Googling 'Red Cross penny-a-week WWII' will bring up accounts from local people working at Bramshill for the Red Cross in the 1940s). We saw some photos from that time showing the typing pool at work in a tapestry-hung room.

We finished the indoor tour in the Common room, where we were refreshed with tea, coffee and biscuits, before ending the visit by examining the remains of a vertical dial set diagonally across a corner of a wing of the building. As it was still raining, and the dial being about 15 ft above the ground, it was difficult to make out any detail in the carving, but the figures 16 could be faintly seen from the ground.

The visit was originally scheduled to last one hour but the curator good-naturedly led us around the fascinating house for nearly two hours, answering many queries from the party. Thanks were expressed to Ms Kerr for her excellent tour and also to Doug Bateman for organising our visit.

We left Bramshill in different directions, some of us repairing to a nearby pub for lunch, before returning to our homes after a satisfying trip.

MODERN MASS DIALS AND AN EXPERIMENT WITH TIME

TONY WOOD

The title should more accurately be ‘modern scratch dials’ since attending mass is not the *raison d’être* of those dials scratched for various reasons since the official end of the medieval period (1629, in Upton, Oxfordshire). Some have already been described but further ones have appeared and a sufficiently large corpus exists to warrant attention from a registration point of view.

The one at Southwell Workhouse (NT) was a remarkable effort but finished up in the square sundial tradition and made use of a (just) sloping window-sill as a gnomon.[1]

The first truly modern one to come my way was from a French lady, Nicole Marquet, a member of the French ‘Sundial Commission’ who encouraged me with a motto: ‘le Soleil brille toujours au-dessus des nuages’ and featured an ‘angel’.[2] It is a decorative and linguistic fancy and, so far, the only mass dial with a name: ‘(H)OVR LADY’. The dial was tracked down to Ian Hamilton-Finlay’s ‘Little Sparta’ Gardens at Biggar, just south of Edinburgh. It is quite intriguing and following it up resulted in the discovery that the Gardens (highly praised by Sir Roy Strong) featured no less than *ten* dials, all proper and not scratch, and that Ian’s dials had spread, not only to Edinburgh but to Canterbury in Kent and beyond, even to foreign parts across the Channel. The Little Sparta dials are still unrecorded and unregistered – somebody in Scotland please *do* something about it!

Most recently, Roger Bowling, in Macclesfield, has carved a memorial to his faithful hound – ‘Ishtar’ – incorporating a collar *and* a fine motto in Latin.[3] This dial is in active use and I quote:

“… and the dial works too. After a leisurely breakfast, say at 9am, I go to consult the dial and find the morning is already over halfway through, and at about 4:30pm I think it is about time to put the tools away then discover that the afternoon is not yet half spent. I am looking forward to the winter seasonal hours when I hope not to be expected to work so long.”

A true ‘experiment with time’, no doubt suiting Roger in his recent retirement.

Back to Scotland and out on the remote western island of Canna is a little church – an architect’s fancy this time, built in 1912 with local stone and thick walls. The three south-facing windows each have on their sills a ‘dial scratching’ (Fig. 1), presumably part of the architect’s decoration. There seem to be no gnomons but the church is in an area where horizontal mass dials are known – did they influence these three? They are recorded in the Mass Dial Register[4] so that any future discoverer can be reassured that their provenance is known to the Society.

A recent visit by my daughter to Leeds Castle in Kent turned up the ‘Toucan Dial’ in the Lady Baillie Garden. It is actually recorded in the Sundial Register as SRN 4792 but a look at the picture (Fig. 2) shows a horizontal gnomon and noon way over on the left side. The dial, featuring a beautiful toucan, is carved in limestone by Karl Vizi, and is a memorial to Lady Baillie, the last owner of the Castle. It was unveiled by Princess Alexandra in 1999. Facing south-west, the dial must have been marked out from the gnomon shadow on a sunny summer’s day.

In Chipping Campden there are a couple of dials scratched on south facing house window-sills. It is hoped that an article on these will appear when more historical research has been carried out.

We may record Ishtar, the toucan and the angel as diversions in an old tradition and say:

“Oh yes, they are still being made, you know.”

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Acknowledgements to Nick Fulcher, curator at Leeds Castle.

Fig. 1 (far left). Windowsill dial at Canna church. Photo: Ms J. Crockford.

Fig. 2 (left). The ‘Toucan dial’ at Leeds Castle. Photo: John Foad.

PRESTORIC SUNDIALS IN IRELAND

MICHAEL J. HARLEY

Fig. 1. Aerial view of Brú na Bóinne. Courtesy of GoogleEarth©

Brú na Bóinne (Fig. 1), Gaelic for Palace of the Boyne, is the ancient name for an area in County Meath which sits in a horseshoe bend of the river Boyne near the east coast of Ireland. It is 50 kms north of Dublin and 6 kms inland from Drogheda. Surrounded on three sides by water, this prehistoric cemetery contains the three great megalithic passage graves of Newgrange (Fig. 2), Dowth (Fig. 3) and Knowth (Fig. 4) and 35 smaller mounds. The tombs were built during the Neolithic Stone Age over 5000 years ago, making them older than Stonehenge in England and the Pyramids of Giza in Egypt. Brú na Bóinne is one of the largest and most important prehistoric megalithic sites in Europe and was designated a World Heritage Site by UNESCO in 1999.

Fig. 2. Newgrange. Photo: Ken Williams©

Fig. 3. Dowth. Photo: Michael Fox©

Fig. 4. Knowth. Courtesy of GoogleEarth©

The best-known monument within the complex is the impressive passage grave of Newgrange, famous for its winter solstice alignment.[1] In 1962, excavation and restoration work on the tomb began under the supervision of Professor Michael J. O'Kelly[2] and continued until 1975 when it was opened to the public. Newgrange is also famous for its many examples of megalithic rock art, none more elaborate than the beautifully carved entrance stone (Fig. 5). There are many symbols recognisable as the sun at Newgrange and Reijs[3] lists seven in the 'radials' section of his website. The solstice sun enters the tomb through an opening over the entrance known as the roofbox and, on the inside stone corbel that supports the lintel over the roofbox, there is a carving that resembles a sundial (Fig. 6)

Fig. 5. Newgrange entrance stone. Photo: Ken Williams©

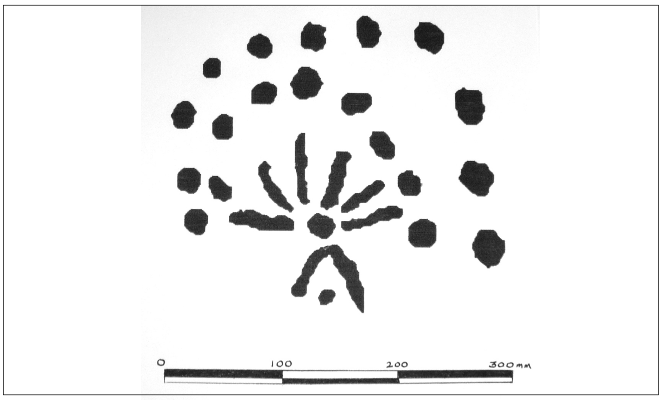

Fig. 6. Scale drawing of a sundial at Newgrange. After Claire O'Kelly in ref. 2.

In the 19th century, large amounts of cairn material were removed from Dowth for road building and an 'excavation' by the Royal Irish Academy in 1849 left the mound considerably disfigured with a massive crater in the top. There are two passages on the western site of the mound, referred to as Dowth North and Dowth South. Dowth North is 14 metres long. Dowth South is 3.5 metres long and is aligned to the setting sun at the winter solstice. On the east side of the mound one of the exposed kerbstones has been aptly named as the 'Stone of the Seven Suns' (Fig. 7).

While Dowth has never been scientifically excavated, Knowth has. It measures 80 metres (east-west) by 95

Fig. 7. 'Stone of the Seven Suns' at Dowth. Photo: Ken Williams©

Fig. 8. Pillar stone at Knowth West Entrance. Photo: Ken Williams©

Fig. 9. Central groove on the West Entrance stone. Photo: Ken Williams©

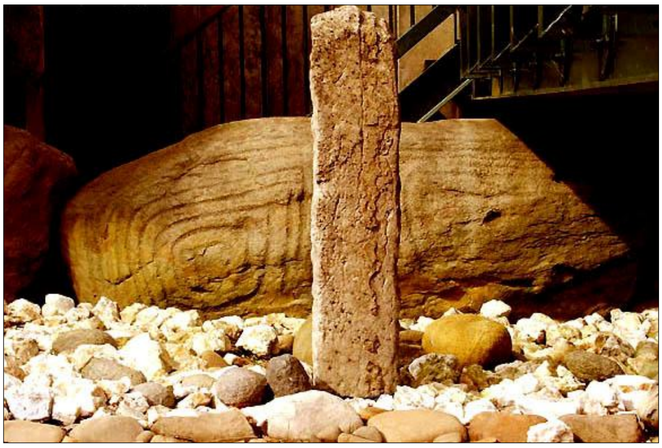

Fig. 10. Pillar Stone at Knowth East Entrance. Photo: Megalthic.com©

metres (north-south) and the clay, stones and shale flat topped mound is 10 metres high. It is larger than Newgrange and is surrounded by 18 smaller mounds. It has two back-to-back passages, running east/west, with entrances on opposite sides of the mound. Outside the mound and in line with the entrances are two re-erected pillar stones which cast their shadows on the vertical lines engraved on the entrance stones to the internal passages (Figs. 8-10). In recent years, the theory that the passages were aligned towards sunrise and sunset on the Spring and Autumn Equinoxes has been questioned and Reijs[4] has determined the azimuth of the easterly passage as 85° east of north and the westerly passage as 259° east of north. A lunar alignment for the passages has now been proposed by Murphy.[5] Nearby farm buildings and trees now block the rising Equinox sun from illuminating the east passage entrance stone.

Professor George Eogan[6] and his team of archaeologists began excavating Knowth in 1962 and uncovered the two passages and a collection of carved stones that comprise 25% of Western European Neolithic art, much more than at Newgrange. The debate continues as to whether the stone carvings are abstract decorative art, had a religious significance or contain astronomical depictions. There are 124 massive kerbstones, varying from slightly under 1 metre to over 3 metres in length and each weighing several tonnes, surrounding the mound. The site was excavated, and then reconstructed, over a period of 40 years and has been open to the public since 2002 on a guided tour basis only.[7] As part of the reconstruction, a projecting concrete ledge (Fig. 11) was put in place over the kerbstones to stabilise the mound from slippage and help protect the rock art.

Fig. 11. Projecting concrete ledge over Kerbstone K7.

Evidence of late Neolithic and Early Bronze Age activity was found during excavation and then it appears that the site was abandoned for the remainder of the Bronze Age, a period of some two thousand years. Slowly, over time, the high mound slipped and the entrances to both passages were buried and became overgrown. People returned in the late Iron Age, the early centuries of the first millennium AD, and Knowth became an inhabited hill fort with two encircling ditches, one at the base of the mound, inside the kerbstones, the other around the top. The area around the mound was occupied during the 9th to 11th centuries AD and the remains of a settlement consisting of 13 houses, nine souterrains, a bronze-working area and three iron-smelting areas were found. The eastern chamber had been opened and occupied at this time. In the 9th and 10th centuries, Knowth was an important political centre and the Royal Residence of the Kings of Northern Breaga. In 1142 AD the first Irish Cistercian Abbey was founded at nearby Mellifont and the lands of Knowth became part of its possessions and stone buildings surrounded by stone walls were built on top of the mound. The Normans invaded Ireland in 1169 AD and eventually occupied Knowth bringing the centuries-old native settlement to an end. Mellifont however flourished until the Reformation in the mid 16th century, when the Abbey was suppressed and its lands, including Knowth, were confiscated. Thereafter the green hillock that the mound had become was used for agricultural purposes until it was purchased by the Irish State in 1939.

Mrs Gatty[8] did not comment on Newgrange or Knowth; they would have been grass covered mounds at the time she wrote her famous book. She did however observe that

> "The Journal of the Society of Antiquaries of Ireland gives drawings of stones at Dowth and Lough Crew[9] with drawings of small circles on them, either crossed or rayed, and with central holes. A stone on Patrickstown Hill, Lough Crew shows a small rayed circle with a central hole, and below the circle a double semicircular arrangement of rays terminating in round holes, very much like some of those which we still find on churches." (Fig. 12.)

At Knowth, in addition to the entrance stones, there are two other Kerbstones that are of special interest to sundial enthusiasts. Professor Eogan used a simple numbering

Fig. 12. Patrickstown Hill stone at Loughcrew Site X1. Photo: Ken Williams©

Fig. 13. Knowth Kerbstone K7.

Fig. 14. Knowth Kerbstone K15. Photo: Ken Williams©

system to identify the individual kerbstones, starting with K1 in the north east and incrementing in a clockwise direction to K127. K11 is the lavishly decorated east passage entrance stone and the two stones of interest are symmetrical about this; K7, (Fig. 13), four stones north of the entrance and K15, the so-called 'sundial stone' (Fig. 14) four stones south of the entrance. Professor Eogan says of K15:

> "...An interesting motif is the rayed design. The most elegant example is on K15. This dominates the central part of the stone, and has a pocked oval area delimited for part (perhaps originally all) of the circumference by means of two channels. In the centre near the bottom, there are two holes, one beneath the other. From this, twenty lines fan out over a semicircular area. The inner part of each line is oar-shaped, and beyond it is a narrow notch, then a large picked area. Beyond this again, for part of the perimeter is a small circle. Similar but less elaborate motifs are found on kerbs 7, 46, and 68… and in the interior of the large basin in the eastern tomb. A close parallel for this motif is known on a stone in Site X1 at Sliabh na Cailllighe."

This is the stone mentioned by Mrs. Gatty at Loughcrew. N.L.Thomas[10] has put forward an argument for K15 to be a calendar stone. He suggests that the hole in the centre of the stone represents the sun. Above, in the picked area of the stone inside the concentric arced lines is a hole representing the moon, and the stars are the picked marks. The twin arced lines indicate a solid shell over the earth to represent the firmament. The radial lines are seen as the sun's rays reaching out to the semi-circle of 16 squares which represent the 16 months of the Neolithic year. The 16-month theory suggests that the year is divided into four by the solstices and the equinox. The half-time points between these intervals are called the cross-quarter days which mark the turning of the seasons. One eighth of a year is a period of approximately 45 days so a further subdivision gives us smaller one sixteenth periods or megalithic months if you prefer that term. This 16 month theory was first proposed by Thom[11] from his observation of standing stones in England. While derided at first, the theory now has a growing number of supporters. Arnaldi[12] visited Brú na Bóinne while researching his book but was unable to examine the kerbstones at Knowth because of the on-going excavations. His observations were therefore based on the photographs and drawings of others. He did say of K15 that "...the stone on which the decoration is found is facing east and it makes it difficult to think of a true sundial…" and again "...There is a theory, which I agree with, which sees in this design the central idea of a calendar..". Brennan[13], however, was convinced that this was a sundial and says "...The sun casts its shadow [from the upper gnomon] on the spiral indicating the beginning and end of a solar year at winter solstice…".

Kerbstone K15 faces in an easterly direction so the shadow cast by a horizontal pin set in either of the two possible gnomon holes would not sweep the semi circular carving: indeed, at the equinoxes it would trace out a straight line

Fig. 15. Knowth Kerbstone K15 with Equinox and Solstice lines superimposed.

pointing towards the bottom right corner of the stone and even then it would only cast a shadow in the morning as this east facing stone would be in the shade in the afternoon. (Fig. 15.)

The reader can make up their own mind as to whether the markings on K15 depict a sundial, a calendar, or neither. However, on the flat top of Kerbstone K7 is a carving of

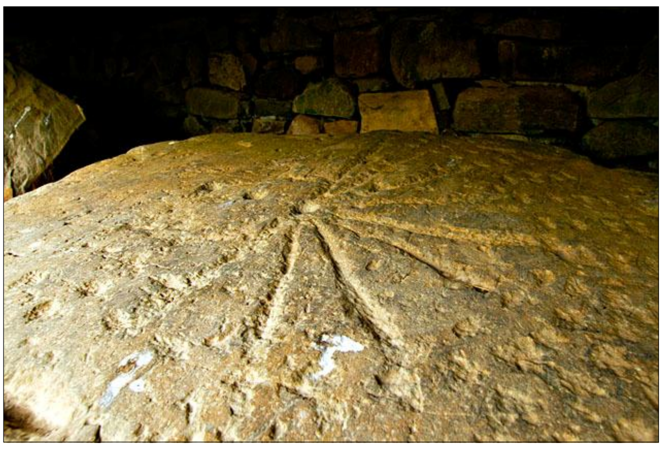

Fig. 16. Sundial on top of Knowth Kerbstone K7. Photo: Ken Williams©

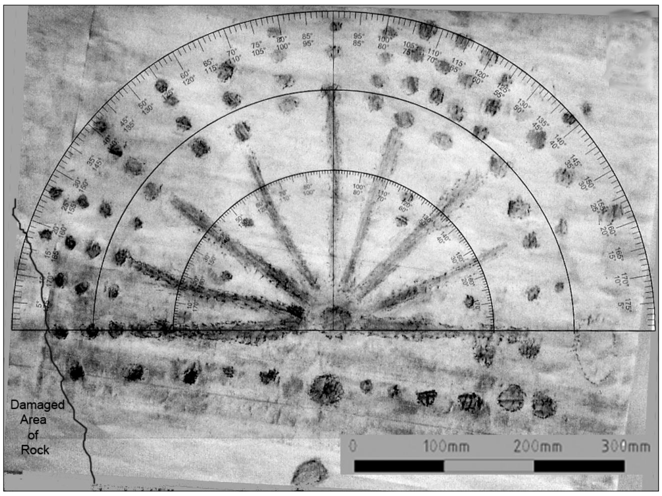

Fig. 17. Tracing of the sundial on Knowth Kerbstone K7.

what definitely appears to be a horizontal sundial (Fig. 16). Brennan says of the K7 sundial:

> "The dial measures what are known as the unequal or 'planetary' hours, which are shorter in winter and longer in summer. At the equinoxes it divides the day into 8 equal parts, which are further subdivided into 16 parts. This corresponds to the solar division of the year into 8 parts. The importance of the dial is immense as it is the earliest sundial known, preceding other known dials by thousands of years."

and again he says

> "The dial has been shown to a number of professional astronomers who confirm that it is a dial with real and intentional fiducial markings. The dial is precisely oriented. In style and technique it is megalithic as is supported by the fact that the engravings are weathered to the same colour as the surface of the stone".

In his book Professor Eogan[6] says of this sundial:

> "….Some of the rayed motifs resemble sundials, but it is unknown whether they served such a purpose. However, on the motif on the top of K7 during the summer it takes the sun's shadow about an hour and a half to pass from one ray to the next. It may of course be that those motifs have a symbolic meaning such as representing the sun."

The overhanging protective concrete ledge has put this dial in permanent shade but a magnetic compass indicated that the dial was pointing 2° east of magnetic north. This is no more than an indication because of the influence on the compass of the iron reinforcing bars in the concrete ledge above. The top of the stone slopes towards the front but the concrete ledge above it makes detailed examination and photography almost impossible but a finger-rubbed tracing (Fig. 17) of the stone enables closer inspection of the layout. As can be seen in Fig. 17, the dial can be enclosed in a 700 mm diameter semi-circle. Using the central 10 mm diameter by 5 mm deep recess as a possible gnomon hole, we can observe that the dial is divided into eight sectors each delineated by a continuous grove terminating in three or four 5 mm diameter by 5 mm deep dots. Each sector is sub-divided by one row of three or four dots except for sector six which is divided into four parts by three rows of dots. Table 1 shows the angular separation of the sectors.

Fig. 18 (above). Cup-and-ring carving on Knowth Kerbstone K7 flat top.

The sundial does not occupy all the top surface of K7 and there is another megalithic rock art carving (Fig. 18) of a common type described by archaeologists as a 'cup and ring' motif. Like K15, K7 is on the east side of this 10 metre high mound, definitely not the preferred location for a functional horizontal dial.

Of the 124 kerbstones at Knowth, 90 are engraved. The remaining 34 are smaller than average and made from softer stone. Because of weathering and spalling it is impossible to tell if they ever bore any art. Only six of the stones have what could be described as a flat top. Of these the tops of two are covered in scratch marks, possibly caused by ploughing

Groove No. (E to W)	Ray format Groove (G) + dots (d)	Sector angle (degrees)	Accum. Angle (degrees)	Sector sub-divisions Rows (r) of dots (d)
1	200 mm G + 4d	-	-	1r 3d
2	200 mm G + 4d	19	19	1r 4d
3	210 mm G + 4d	20	39	1r 4d
4	180 mm G + 3d	25	64	1r 4d
5	220 mm G + 3d	26	90	1r 4d
6	200 mm G + 4d	18	108	1r 4d
7	220 mm G + 4d	26	134	1r 3d then 1r 4d & 1r 3d
8	190 mm G + 3d	21	155	1r 2d
9	200 mm G + 0d	25	180	1r3d

Table 1. Angular separation of sectors on Knowth Kerbstone K7.

activities when the stones were buried underground, but only K7 has a flat top suitable for engraving. The similarity of the ray design to that on the Newgrange corbel stone shown in Fig. 6 and the fact that it shares the top with another undoubted megalithic carving implies that the K7 sundial is Neolithic and not a later carving.

We may never know the actual meanings of these particular designs but it is safe to say that the Neolithic people who built Knowth were capable engineers and astronomers, and the engravings, the meaning of which has been lost, were important enough for them to expend much time and energy in their carving.

Professor Eogan says in his book "It may, of course be, that these motifs have a symbolic meaning such as representing the sun". Eogan has promised us eight major volumes on the archaeology of Knowth. Four have already been published[14] and the fifth, on the megalithic art, is in preparation. We must wait to see what the authors have to say about the K7 sundial and the K15 sundial/calendar at Brú na Bóinne.

ACKNOWLEDGEMENTS

Thanks to Ken Williams and Michael Fox (Knowth.com) for permission to use their photographs, the Office of Public Works at Brú na Bóinne for allowing me to inspect, photograph and 'rub' the kerbstones at Knowth and Google Earth for permission to reproduce their aerial photos. Thanks also to Eve O'Kelly, daughter of Claire O'Kelly who made the original tracing of the sundial on the Newgrange Corbel stone.

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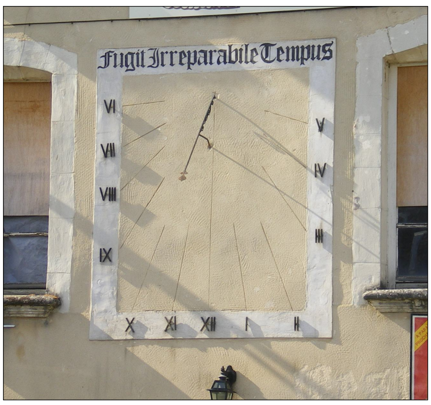
Postcard Potpourri 13 – Rémalard, France

Peter Ransom

This year (2009) in May we spent a week in the Perche area of France exploring the magnificent selection of old and new dials in that area of Normandy between Alençon and Chartres in the Orne departement. This was because a few years ago I purchased a small guidebook from the tourist information office in Alençon called *Cadrans Solaires du Perche* that contains itineraries in the Perche area taking in a vast range of dials and earlier this year John Lester sent me an article from the March 2009 edition of *The Oldie* that featured the sundials of this area. We stayed in a gîte close to Rémalard, so saw the pictured dial quite often!

I think the postcard dates for the early 20th century, but not being posted there is no external evidence of dating when the picture may have been taken. There is a similar postcard in *L'ombre demestiquée* by Apel and Pytel (1990), which dates the card to the 1920s and it was that card which allowed the restorers to produce a similar dial in the original position. The gnomon is in the form of an arrow 1.18 metres long. The dial itself measures 2.20 m by 2.60 m and the motto is *Fugit Irreparabile Tempus* in gothic letters.



Dials in this area of France kept us occupied all week and exploring some of the small villages was entrancing – a possible sundial safari in the future for the BSS?

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SEARCHING FOR LOST TIME

Finding Sundials in Rutland

BRYAN WAITES

[A version of this article first appeared in *Leicestershire & Rutland Life* (January 2009, pp.29-32*)*. Although written for the general public and not for committed diallists, it is of interest to our readers. The author is a local historian and freelance journalist. Ed.]

Once upon a time, there was no time – *accurate* time, that is. The farmer had a sense of time without needing an accurate watch. He had a good idea of the working day from dawn to dusk. There was no need for the desperate accuracy we demand to-day.

In fact, it was the coming of the railway in the mid-19th century which introduced 'railway time', that is standard time, eventually known as Greenwich Mean Time in 1880. However, earlier in 1869, the electric telegraph brought time to Oakham Post Office and in the 1870s it reached Empingham, North and South Luffenham and Ketton. By 1925 over 50% of Rutland parishes had telegraph offices. Then the telephone, the Speaking Clock, the wireless with the pips and 'Big Ben' arrived.

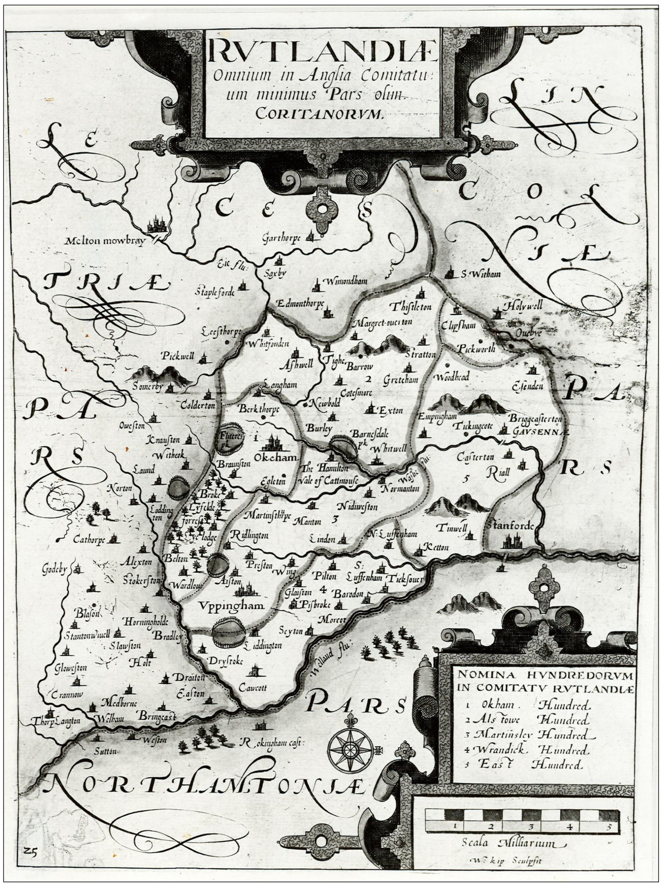


Fig.1. Map of Rutland from William Campden's 'Britannia', 1607.

Thousands of years ago attempts were made to determine the time of day using a shadow stick, an hourglass, a graduated candle and a floating dish with a tiny hole letting water in so that the dish sank in about one hour. Such an artefact was discovered at Market Overton in Rutland in 1908 during the excavation of a Saxon cemetery.

Although the Egyptians are thought to have developed sundials to tell the time, in this country the earliest known sundials are of Anglo-Saxon date, the finest being on the wall of St. Gregory's Minster, Kirkdale, Yorkshire (c.l064) – the earliest is on the Bewcastle Cross, Cumbria, thought to be seventh century. No Saxon sundial has yet been found in Rutland though a doubtful find at the Ram Jam Inn in 1929 might be one and, nearby at Barnack, Lincolnshire, there is a suspected Saxon sundial on the tower.

One kind of primitive timepiece which can be found on the walls of many Rutland churches is the scratch dial. This consists of a central hole into which a stick or gnomon would be placed, with radial lines scratched into the stone either all round or just on the lower side. Usually, these dials were located on the south wall of the church where the footpath reached the south porch.

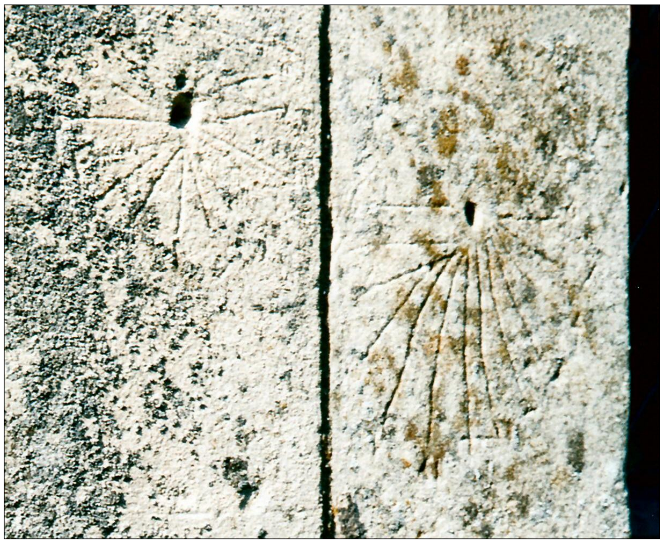


Fig. 2. Two of the 12 mass dials on Egleton church.

They were variously called mass clocks, scratch dials or mass dials and in a simple way indicated the time of the main services. At the right time the priest would ring the bell to call people to mass. A national survey of scratch dials was undertaken by the British Sundial Society, founded in 1989. In Rutland, Robert Ovens and Sheila Sleath conducted a similar survey for the Rutland Local History & Record Society to mark the Millennium. They

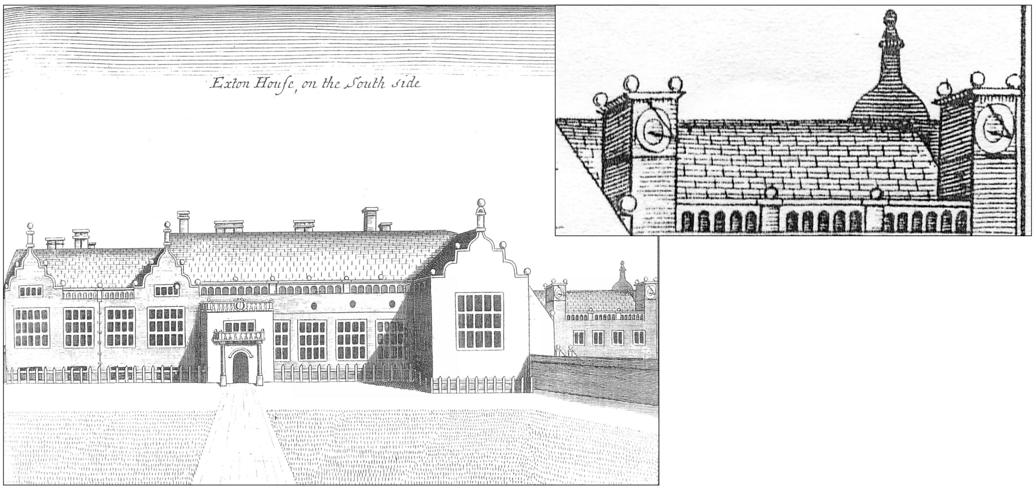
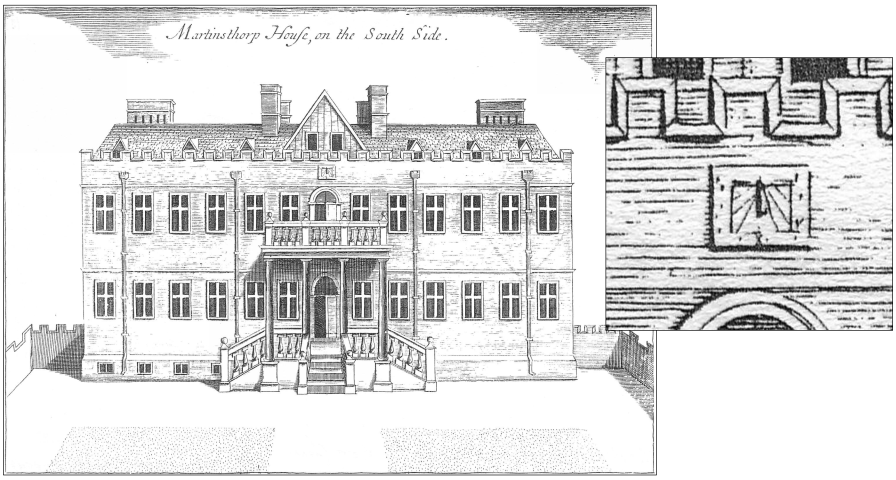
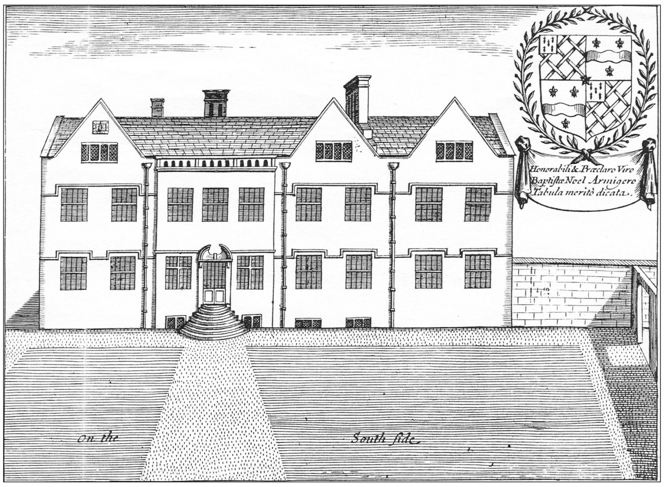


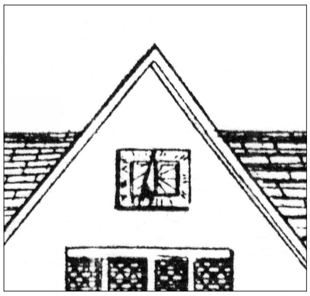
Fig. 3. Engravings from James Wright, 1684.

a. Exton Old Hall, destroyed by fire in 1810, from an engraving of 1684. Note the two sundials on the right hand side.



b. Martinsthorpe House, demolished in 1755. The sundial is below the central gable windows.





c. Luffenham House, North Luffenham, demolished in 1806.

went much further, investigating and recording all types of sundial, clocks, bells and every aspect of time. The study was published in 2002 as *Time in Rutland* providing an authoritative review of permanent value.

Five hundred years ago most Rutland churches would have scratch dials, often several, but many have been lost perhaps in renovations and restorations. Some have been relocated as at Burley, Ayston, Clipsham, Egleton, Greetham, Lyddington and Teigh. So far only one example on a secular building has been found, which is in St. Mary's Road, Manton.

You can still find good examples of scratch dials on the church walls at Egleton where there are 12 (Fig. 2), Caldecott 5, North Luffenham 4 and Whitwell 4, dated as 14th or 15th century. Of course, these are only effective when the sun shines.

More scientific is the vertical or wall sundial which seems to have arrived in this country about the 16th century, reaching Rutland later. In these sundials the gnomon was parallel to the earth's axis and the face could be divided into equal hours. In fact, this kind of sundial led to a specialised mathematical study involving longitude and latitude. Again, these sundials were found on church walls, usually over the south porch. It became a fashion to have a sundial on mansions as an architectural feature. Old engravings show wall sundials at Exton Hall, Martinsthorpe House and North Luffenham Hall (Figs. 3(a,b,c)). In towns, sundials were often located above inns (e.g. the Unicorn and the Crown, Uppingham, Figs. 4 and 5, respectively) or on the gables of houses, some houses actually being called Sundial House.

Fig. 4 (left). The dial on the former Unicorn Inn, High Street East, Uppingham. Dated 1765, it had the motto 'Improve the Time'.

Fig. 5. The dial on the Crown Hotel, High St East, Uppingham. Dated to the early 19th century, it is now badly overshadowed and has a broken gnomon. Its motto 'Non Rego Nisi Regar' translates to 'I do not guide unless I am guided'.

This name can be found in Edith Weston, Morcott, North Luffenham, Pickworth, Uppingham and Wing.

Over ninety pre-1900 horizontal and vertical sundials were recorded in Rutland but about one-third no longer exist. The former type were very few in number, one of the earliest being 1614 in Ridlington, and there is also a late 18th century one at Normanton Hall. Thirty-four of these 'pedestal' sundials were recorded in the survey, mostly in the gardens of houses. This kind of sundial is making a comeback as a feature of modern gardens.

The wall sundial was more accurate than the scratch dial and it continued to be used alongside early clocks until the 1800s. Apart from identifying sundials in the field, other sources are old large scale OS maps, sketches of Rutland churches in the 1790s and the 1830s, old photographs and postcards as well as engravings, particularly in *History and Antiquities of the County of Rutland* (1684) by James Wright.

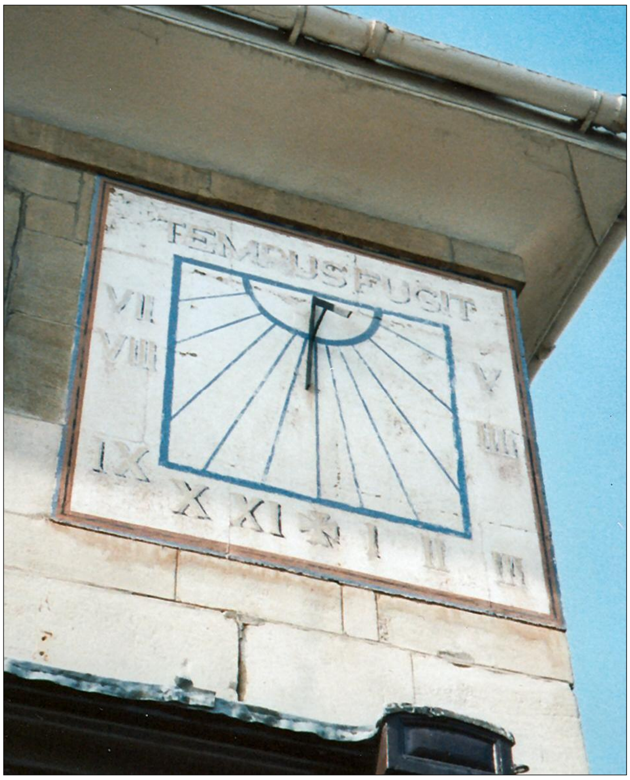


Fig. 6. A 19th century dial in the High St, Oakham, declining very slightly from due south.

An interesting aspect of sundials is that they often impart advice via a motto. In Oakham High Street a fine example (Fig. 6) quotes *Tempus Fugit.* At Belton, *A shadow round about my face. The sunny hours of day will grace.* At Caldecott, *Your sunny hours alone I tell.* In Uppingham School, *Make time, save time, while time lasts. All time is no time when time is past.* Wardley church is the most ominous of all – *memento mori* – remember death.

Looking for sundials can be another good excuse for an

Fig. 7. A restored dial on the porch of Preston church.

Fig. 8 . The sundial on the Old Manor House, Preston.

outing around Rutland on a fine sunny day. You can work out a route to include some of the best, starting, perhaps, at Belton-in-Rutland, then to nearby Wardley church, on to High Street East, Uppingham, then to Ayston church.

Fig. 11. The cuboid sundial on the Butter Cross, Oakham, now devoid of gnomons.

Preston is only a mile to the north and here you will find four wall sundials, two of the best at the church and in Cross Lane (Figs. 7 and 8). Over the road to Wing where there is a 17th century engraved sundial on a dormer window of Sundial House, restored in 1995 with a motto translated as *As birds fly so does time* (Fig. 9).

Fig. 12. A 17th century limestone dial on the chapel of St John & St Anne, Oakham.

From Wing follow the country lane to Manton where you can see two scratch dials on the south porch of the church and another on a house in nearby St. Mary's Road. Then on to Egleton church where you can search for the 12 scratch dials and the sundial over the porch, probably installed when the porch was rebuilt in 1872 (Fig. 10).

Just down the lane and uphill to Hambleton brings you to Hambleton Hall Hotel where there is an *art nouveau* sundial on the front inscribed *It's drinking time now - time passes, friendship remains,* in French. This was placed there in 1882.

Fig. 10 (left and above). The dial over the south porch of Egleton church.

Fig. 9 (far left). The 17th century dial set into the dormer gable of Sundial House, Wing.

Now carry on into Oakham to see the fine sundial on the corner of 13 High Street and the unusual cuboid sundial (Fig. 11) on top of the Buttercross, not easily recognisable as such. Once it had painted lines and numbers with gnomons. The chapel of St John and St Anne, Westgate, has a rather crude sundial dating from the 17th century on the south-west corner (Fig. 12). Both chapel and sundial were restored in 1983. Another day you might like to continue visiting more sundials in Rutland. If so, there is a comprehensive list in *Time in Rutland* which will help you to devise your route.

There has been a revival of interest in sundials recently since they have been recognised as an important part of our heritage worthy of restoration and conservation. More people are installing sundials as a focal point in garden design and there are many manufacturers in Britain listed by the British Sundial Society, www.sundialsoc.org.uk.

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NEW DIAL

Vertical Dial, Midlands

This declining vertical dial is in a style which is designed to match the dials on the Gate of Honour, Gonville & Caius College, Cambridge, as closely as possible (see the June 2009 *Bulletin*, p.2). This is where the client, who is building a new house in the arts-and-crafts style on a green-field site, once studied. The dial measures 1090 mm by 990 mm and sits on a raised brick panel between two first-floor windows, as specified by the architects, the Dyer Group. It was designed and made by Flowton Dials and is based on a vitreous-enamelled steel panel on a composite core (manufactured by Vitramet Europe Ltd). The hour numerals and inner frame were hand-cut from 3 mm brass sheet and gold-plated by Modern Metal Finishes Ltd before being attached to the surface. The gnomon and the outer frame are from patinated brass: the whole dial weighs 50 kg. The coat of arms in the bottom right corner, with the motto "Prepared" are for Aston Villa Football Club—the client is a long-term fan!

JD

READER'S LETTER

Chiming sundial

If John Davis had an example of Kircher's *Organum Heliocausticum* (March *Bulletin*, 21(ii), p.48) I think he would be very disappointed. As the instrument is drawn it cannot possibly work: the distance from the spherical lens to its focus is shown far too long in comparison with the diameter of the sphere. The focal point of a glass sphere for incident parallel light is only about one-fifth of the sphere's diameter beyond the surface, not four times as shown in the drawing.

The focussing property of a glass sphere is used in the Campbell-Stokes sunshine recorder, in which the image of the sun burns a trace in a prepared card strip enabling the duration of sunshine throughout the day to be measured. Pictures of this instrument confirm the proportion of sphere diameter to focal distance.

Michael Lowne, Hailsham.

The 20th Annual BSS Conference, Cumbria Grand Hotel, Grange-over-Sands, 15-17 May 2009

Chris Lusby Taylor

This will be the last conference organised by our outgoing Secretary Doug Bateman. So it was very pleasing that it was most successful. The programme followed the established pattern from our arrival on Friday afternoon to the end at Sunday lunchtime.

Although we didn't take over the hotel literally, there were few guests apart from ourselves, so it felt like a club. On arrival we were greeted by Doug who gave out a conference pack with a new issue of *The Recorder*, a card Sun Calendar and the weekend's programme. It was pouring with rain, as is now traditional. Tea was very welcome after a long drive. Looking around, one saw pretty much all the usual suspects, a number of new faces and one or two returning after an absence.

After dinner Chris Daniel welcomed us, particularly mentioning his pleasure at seeing so many foreign visitors – mostly old friends who come every year – and new members. He thanked Doug for organising the conference and laying on good food and wine, although he could have tried harder to organise better weather. He welcomed Elspeth Hill of Rogers Turner who has recently taken on the selling of all the Society's publications.

Then it was straight into the programme of talks on sundials. Tony Belk first entertained us with a most amusing account of life in south Wales under King Hywel Dda, which means Hywel the Good. A modern dial in Whitland celebrates his life and the legal system he created that lasted for 600 years. Unusually, even in Wales, it has a Welsh inscription and cloisonné plaques of Hywel's deeds. An article in *The Recorder* tells of the other known dials in Welsh. Hywel was evidently A Good Thing.

Tony, as Chairman of the Sundial Design Competition's committee, reminded us that we have until December 1st to get our entries in. Dials constructed in the last five years are eligible.

Johan Anton Wikander revisited us to show and tell of a newly discovered dial, believed to be the earliest yet found in Norway, found at the southern tip of the country on an old trade route to Russia. It looks like a compass rose with 16 equal sectors but has no cardinal marks. It has a single rune that looks like 'K' and, Johan explained, could represent the sixth year in the 19 year lunar cycle, at which time the sixth hour ends at noon. So, although it has no hole for a gnomon, it is thought to be a sundial showing time in the old

tide system. Its diameter seems to relate to the Swedish unit of length so it may have been carved by a Swede. Some in the audience were not totally convinced that such objects were used to tell the time, but keep an open mind.

Next morning, Chris Williams continued his analysis, started with his talk at last year's conference, on the prevalence of scratch dials. Using complex statistics and analysis of the various mechanisms whereby dials get lost, he has been able to show that every Saxon church in England probably had a dial. (Actually, he doesn't use words like 'probably' but said the statistics are "...consistent with every church having had a dial".) He thinks some surviving dials have been misattributed and

were actually Saxon. Soon, he hopes to be able to show what types of dial were made in different periods.

We were in Cumbria and planning to visit Hawkshead so it was excellent to have Frank Evans explain the puzzling features of the famous dial on the

grammar school.[1] The inscription: PI Long 35° 43' 40" was hotly debated on the Sundial Mailing List a while ago, with Frank King the first to spot that Plains Longitude refers to the angle on the dial between the substyle and the vertical noon line. Another problem, though, is that the dial is canted into the wall by around 10°. The building is older than the dial. When we visited it, we could see no valid reason for deliberately canting the dial into the wall. Had the dial perhaps been made originally for a different building?

After a coffee break, our Patron, Sir Mark Lennox-Boyd showed us how the Greeks estimated the size of the earth and thus the distance to the moon, using gnomonic methods for both. They were helped by the coincidence that the moon and the sun appear to be the same size, but the achievement was a considerable intellectual feat nonetheless. By timing a lunar eclipse they found that the earth's umbral shadow was around 2.5 times the moon's diameter. Knowing the earth's diameter this gave the size of, and distance to, the moon.

The next talk was a double act, with Chris Daniel and John Davis telling the story of John Seller, a seventeenth century instrument maker and cartographer who, as they proved, was a plagiarist who stole others' designs, erased their signatures and added his own.[2] Quite how he got away with publishing as his own work charts which still had Dutch inscriptions on them seems a mystery. In the display area John even had a genuine Elias Allen dial of the type Seller had doctored. As he concluded "Seller was a crook".

Lunchtime and coffee break provided opportunities to see the bookstall, the exhibits and the photographic competition entries. Many of the exhibits were familiar from previous years, but it was

good to get another chance to see them and, in the case of some, to buy portable dials or high quality card models and replicas of historic instruments including a working orrery. Mike Cowham had brought dozens of portable dials that he made to illustrate his new monograph[3] which was selling well. The most unusual dial was perhaps one by Fiona Vincent in cross stitch which I know inspired one member's wife to attempt to make a sundial cake for his forthcoming birthday.

A montage of pictures from the display room clockwise from top: Fiona Vincent's cross stitch dial; David Young and Mike Isaacs discuss Tony Moss's work in stainless steel; Anton Schmitz's marble cross dial; a cluster of members around the BSS Publications table; Alastair Hunter's commercial noon mark.

Last year several members of the Society helped restore a local sundial from an auction to its original location by identifying where it must have been from its geometry and inscription. Its new owner, Brian Campbell brought it in to show us. Although clearly made for the grounds of the very house he lives in, it has levelling feet and two spirit levels, the N-S one graduated. But it has no compass so seems to be neither a fixed nor a typical portable sundial.

Other dials on show included a (heavy!) stone cross dial from Anton Schmitz and a new noon-mark analemma from Alastair Hunter.

Chairman Chris Daniel presents the Photographic Award prize to Mike Cowham (top) and a thank-you to outgoing Secretary and conference organiser Doug Bateman (lower).

After lunch we split into two coaches for our outing to see notable local dials. First stop was Holker Hall, home of Sir Mark's friends Lord and Lady Cavendish for whom he had designed a stunning slate dial. Lord Cavendish welcomed us and explained that he had commissioned the dial partly to keep going a local slate quarry he owns and for which there was little work at the time. The quarry manager showed how they used their huge circular saw not to cut the slate into slabs but to hollow out the curved dial bowl. It was raining when we arrived but the sun came out, the dial dried up very quickly and we were able to confirm its accuracy. Lady Cavendish's lurchers seemed puzzled that we were paying more attention to a lump of stone than to them.

Next stop was to have been Graythwaite Hall, home of the Sandys family who built Hawkshead Grammar School and where there is a fine pillar dial. But the coaches couldn't turn into the gates from the narrow lane and we had to continue to Hawkshead. The Grammar School dial was duly admired and puzzled over. None of us could see any advantage to canting the dial into the wall except perhaps that this supported its weight.

Back to the hotel, by a very scenic route along Lake Windermere, for dinner. Over dinner the awards were presented to the winners of the Photographic Competition, the best new author in the *Bulletin* in the last year and the best new sundial trail. Chris Daniel thanked Doug for his years of superb service to the Society, including organising the conferences, and presented him with a copy of Hester Higton's *Sundials of Greenwich* as a token of our esteem.

Sunday morning's four talks exemplified the breadth of interest and scholarship of the Society. We warmed up our brains with Fred Sawyer who seems to delight in showing how limited is everyone else's vision of what forms a sundial can take. He turned his attention this time to equant dials which have the property that, from some point on the dial, the hour lines appear equispaced. This allows a simple mechanism to show mean time. Previous equant dials had been of a cardioid-like form until

Yabashi found the ‘Yabashi Point’ which allows the dial to be almost circular or almost accurate. But not 100% accurate, so Fred showed us that there is a point near the meridian line from which a linear dial can be equi-angular. The position of the linear dial relative to the equant point is a function of latitude. Fred showed a dialling scale that allows the dial to be laid out for any latitude. Not content with this, he then went on to describe several variants, all with the property that they can be made to show mean time, or even day-light saving time, if the hour lines are made to rotate about the equant point.

Fred was followed by Tony Moss who, despite being retired, is never retiring. His great experience with the issue of measuring wall declina-tion has led him to design and make a series of precision declinometers. They are all based on the idea of measuring the shadow of a nodus on a board mounted temporarily on the wall. But they have become very sophisticated, with plumb lines protected from the wind, symmetri-cal nodi so that the shadow centre

can be easily seen, graph paper to allow measurements and digital photographs to capture the shadow at a known time. Some members of the audience proposed even more developments but Tony seemed reluctant to commit to them as the world market for declinometers is somewhat limited. [See ref. 4 for more details.]

Kevin Karney has devoted a great deal of time to representations of, and diagrams and mechanisms to model, the Equation of Time. Helio-chronometers that directly show mean time can use shaped or mov-ing hour lines, style or alidade. Kevin showed examples of all these before turning his attention to graphical ways to show the EoT alongside a sundial. He proposed that any graph should be judged on its ease of use, clarity, compactness and style. On these bases he rejected in turn Cartesian graphs (too difficult to use), the conven-tional analemma (difficult to read), the Bromley House graph (inelegant) and various other repre-sentations. Finally he introduced intrinsic equations which make each day’s section of the graph the same length, but, in comparison with the analemma, disregarding the sun's declination. So, whereas the analemma goes in one direction from winter to summer, an intrinsic graph may change direction if desired. This allows novel and beau-tiful designs to be realised. The mathematics was first discovered by William Whewell of Trinity College, Cambridge, and was later employed on a dial in the Abbey Gardens, Bury St Edmunds, for an unusual EoT graph.[5,6] Unlike an analemma, this version was not closed, but by choos-ing different dates to reverse the graph’s direction, Fred Sawyer created the beautiful, closed flame-shaped graph that he showed us at a previous conference.

In his talk Allan Mills noted that the sun makes a good timekeeper but, un-fortunately, there are no hour lines marked in the sky and in any case the sun is too bright to look at. All the other sundials on display at the con-ference used a shadow to trace the sun’s position but this is not the only way to do so. We can use the polariza-tion of light as it is scattered in the atmosphere. Polarization is greatest ninety degrees away from the sun, so the Celestial North Pole makes a convenient direction to observe as the sun is always around ninety degrees from it. Allan pointed out that such a dial can be used after sunset and does not require a totally cloud-free sky. With cellophane in different thick-nesses placed between crossed polar-izers he showed how a very colourful display can be made, since the colour seen is a function of the thickness and the angle of polarization of the light. Blue, orange, green, pink and brown can be seen. On a practical note, Allan told us that parcel tape is a cheap and long-lasting source of cellophane. [See ref. 7 for more details.]

The culmination of our annual con-ferences is always the Andrew Somer-ville Lecture given by an invited speaker. This year we were honoured to be addressed by Father Leo Maidlow Davis, a monk of Downside Abbey and headmaster of Downside School. Father Leo invited members to make appointments to visit the abbey to see Mrs Gatty’s collection in the library.

Benedictine houses such as Down-side follow the instructions in St Bene-

dict's slim book which he called "a little rule for beginners". This lays down rules for monks living in common under an abbot. In his lecture Father Leo touched on a number of aspects of the rules while concentrating on the importance of timekeeping in order to ensure that the various different prayers and services are performed at the right time. St Benedict lived from 480 to 547, rather before mechanical clocks, so we don't know exactly how time was kept but we do know that one or two members of the house were responsible for timekeeping. Each day and each night were divided into 12 equal parts. The first prayers of the day, Vigil, were to be said at the eighth hour of the night, corresponding to the hour of the resurrection. Due to the difficulty of telling time at night, St Benedict recognised that the time would not be exact but he stressed that, even if late, Vigils must be kept. By day, sundials were used. On cloudy days, body clocks could estimate the time.

During the day, St Benedict took literally psalm 118 that tells us to pray seven times a day. He laid down a timetable: Lauds, Prime, Terce, Sext, None, Vespers and Compline to be observed at daybreak and 1, 3, 6, 8½, 11 and 12 hours later. Mealtimes are for silent reading of scripture.

Father Leo thought we might wonder why anyone would want to live such a life. He explained that reading scripture is a personal way to listen to God and that following Christ in self-denial, obedience, charity and love of God leads us to eternal life. Time matters because it reminds us that every moment of life is infinitely precious. St Benedict taught that we must hurry and act now in a way that will bring in blessings in eternal life.

It was fascinating to hear Father Leo explain this philosophy of time and the importance of measuring and being aware of its passing even though one's life is so structured that every day is similar to the next. David Brown commented that he thought the invention of equal hours, which break the connection between the time and the sun, was a bad idea.

This was the end of the conference. It just remained to hold the Society's AGM, have lunch and wend one's way home, minds buzzing with all we had seen and heard.

Photographs from Chris Lusby Taylor, John Davis and Jim Holland.

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MYSTERY INSCRIPTION

This vertical south dial once hung outside the Fleece Inn in Keighley, West Yorks. It is now in the Keighley Museum (previously the Cliffe Castle Museum). The date is clearly given as 1782 but what do the other inscriptions:

C.G · 1 51 33·34·1450

indicate? The museum's curator, Mike North, and Tony Wood would like to know.

A SUNDIAL HAT

This unusual hat was designed for the Ascot meeting in May by Joanna Migdal who is seen here wearing it. It is designed for the latitude of Ascot and is delineated in Race Time, i.e. it gives the start time of the races. It was made by the milliner Jane Corbet of Hungerford and uses feathers as the gnomon. Joanna is accompanied by her husband, Sir George White, who is carrying a pocket compass to ensure that she is walking in the correct direction. The hat was a big hit with the paparazzi and it featured on many websites and tv programmes from Ascot to the Ukraine.

Photo courtesy of Stephen Simpson Photography.

A VERTICAL SUNDIAL INDICATING THE PRESENT ECLIPTIC POSITIONS OF THE CONSTELLATIONS

ORTWIN FEUSTEL

In classical times, the apparent path of the sun was divided into twelve sections each of 30°. Each of these sections was provided with the name of a constellation. The constellations in their natural order are Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces. The set of constellations is called the zodiac. The first sign of the zodiac ♈ begins the natural or astronomical year: it is the March point, i.e. one of the two intersection points between celestial equator and ecliptic. The sun passes through this point along the celestial equator from south to north and enters, for an observer on the earth, into the sign of Aries ♈. About 2500 years ago the positions of constellations had coincided exactly with the named zodiac sections of the same names.

Currently, the sign of Aries (the vernal point) is in the constellation of Pisces, the sign of Taurus is in the constellation of Aries, and so on.[1] The sundial described in this paper and shown in Fig. 1 shows these facts to the observer. The dial face indicates both the ecliptic with the present positions of constellations represented by an angle-preserving cylindrical mapping (the Mercator projection[2]), and seven declination lines marked with the twelve zodiac signs. A distinguishing feature is that the dial also functions as a nomogram: one can read, depending on the season, the constellation in the night sky to the south of the dial face.

Dial Face Markings

CET scale with longitude correction

The correction of local time for the dial numbering

$$CoLT = (15°\ E\ longitude - local\ longitude) \times 4 \qquad (1)$$

takes the time difference between the zone meridian (15° east of Greenwich) and the sundial's location into account. With a local longitude of 8.38° E, the hour lines are moved towards the morning hours, i.e. the difference to zone time is (15° - 8.38°) × 4 min/° = 26.48 min. It can be seen that the time difference between the hour line XII and the triangle, which indicates the true culmination of the sun (noon), amounts to 26.48 mins.

The time scale is marked CET (Central European Time), symbolizing the zone time which is applicable. It does not mean correct time since the equation of time has to be taken

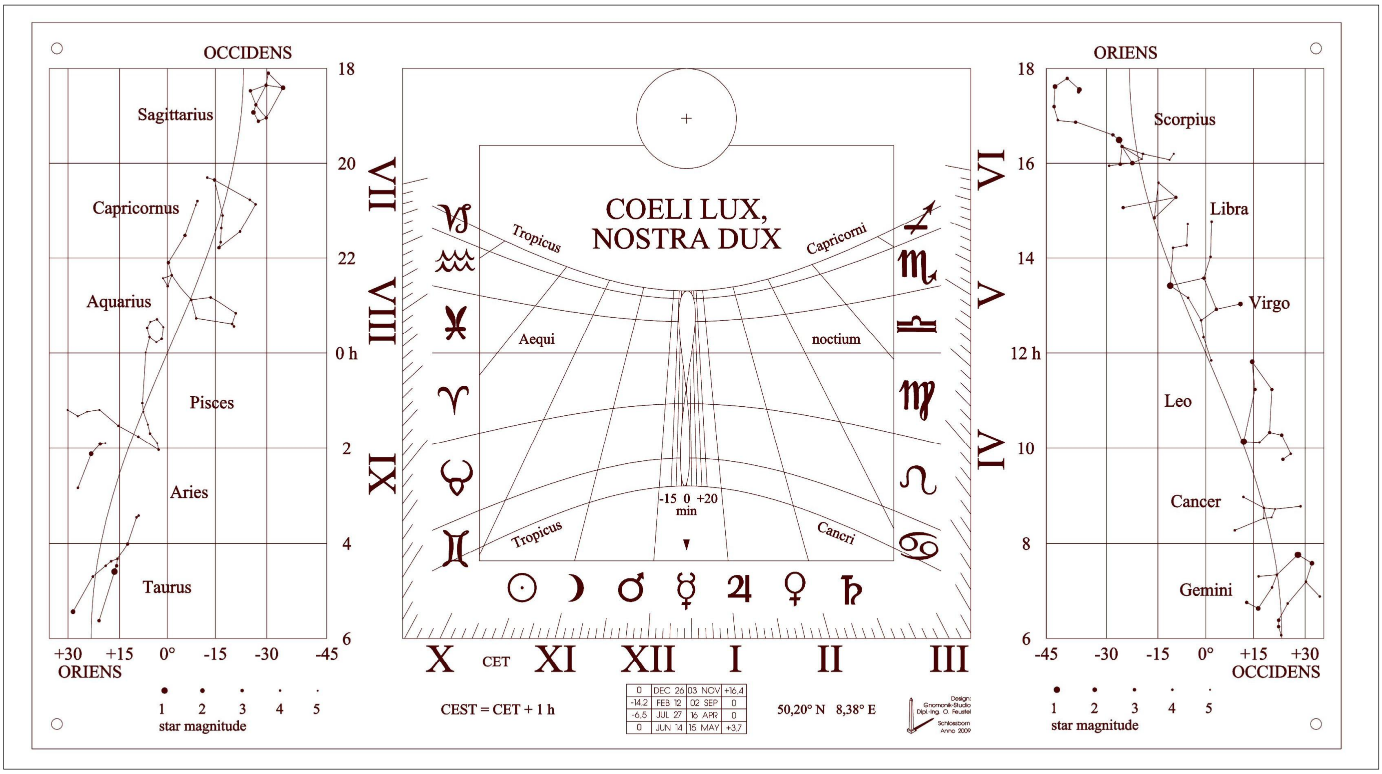

Fig. 1. The face of a vertical sundial with correction of local time, seven declination lines, twelve zodiac signs, seven planetary symbols according to the weekdays names, the equation of time as figure-of-eight curve at meridian, and the current ecliptic positions of the constellations. The dial plate measures 1310 mm × 726 mm. The polar-pointing gnomon would be fixed at the origin of the Cartesian coordinate system (x⇒ horizontal lines, y⇒ vertical lines), which is the small cross at the centre of the circle.

into consideration and, for CEST (Central European Summer Time), a further one hour must be added.

Equation of Time as a figure-of-eight curve

The Equation of Time, i.e. the difference of *LAT* (Local Apparent Time) and *LMT* (Local Mean Time), is valid too according to the notation

$$EoT = (LAT + CoLT) - (LMT + CoLT) \qquad (2)$$

$LMT + CoLT$ is nothing but the zone time *CET,* and $LAT + CoLT$ corresponds to the sundial's Time Scale Reading *TSR*. Supplementing the sundial's indicated time with the actual equation of time value cgives standard time

$$CET = TSR - EoT. \qquad (3)$$

During the year - starting at Christmas - the course of the Equation of Time is like most people's writing of a figure '8'. To provide a quick overview, the zero and extreme values (in minutes) are arranged in a table below the time scale corresponding with positions of values along the curve. The full curve is placed within the family of declination lines along the meridian line. The shadow of a small spherical nodus indicates, amongst other things, the relevant value: negative values mean that the dial is slow; positive values mean that the dial is fast.

Declination lines and signs of the zodiac

Each point along a polar-pointing gnomon – for example a small spherical nodus – produces a characteristic shadow path whose position depends on the daily value of the sun's declination.[3] Seven of these 365 paths (lines of declination) are represented. They are marked with zodiac signs, each line representing two zodiac signs. Table 1 shows assignments of zodiac signs, date, and ecliptical longitudes with the sun's declination. The position of the sphere's shadow indicates therefore (approximately) the actual date.

Zodiac sign	Date[4] ⇓	Ecliptic[5] long.	Sun's dec.	Ecliptic[5] long.	Date[4] ⇑	Zodiac sign
Capricorn	**21 Dec**	**270°**	**-23.439°**			
	19 Jan				20 Dec	
Aquarius	20 Jan	300°	-20.150°	240°	22 Nov	Sagittarius
	18 Feb				21 Nov	
Pisces	19 Feb	330°	-11.475°	210°	23 Oct	Scorpio
	20 Mar				22 Oct	
Aries	**21 Mar**	**360°/0°**	**0°**	**180°**	**23 Sep**	Libra
	20 Apr				22 Sep	
Taurus	21 Apr	30°	+11.475°	150°	23 Aug	Virgo
	20 May				22 Aug	
Gemini	21 May	60°	+20.150°	120°	23 Jul	Leo
	20 Jun				22 Jul	
			+23.439°	**90°**	**21 Jun**	Cancer

Table. 1. The pairs of zodic signs, dates and ecliptic longitudes for each value of the sun's declination.

The Zodiac

On the left and right of the time scale, the spherical celestial coordinates near the equator have been mapped onto flat Cartesian coordinate grids using the angle-preserving Mercator projection: right ascension $0 \leq \alpha \leq 24h$ and declination $-45° \leq \delta \leq 35°$correspond to the ordinate and abscissa respectively. The sun's apparent path, represented as a sinusoidal curve, and the constellations along the ecliptic are shown within the grids. The left half of the ecliptic is valid from 21 December to 21 June and the ecliptic's right half extends from 21 June to 21 December.

The Mercator projection has been chosen because shapes around a point are geometrically correct.

Mercator projection

The Mercator projection (see Fig. 2) is characterized by the following features:

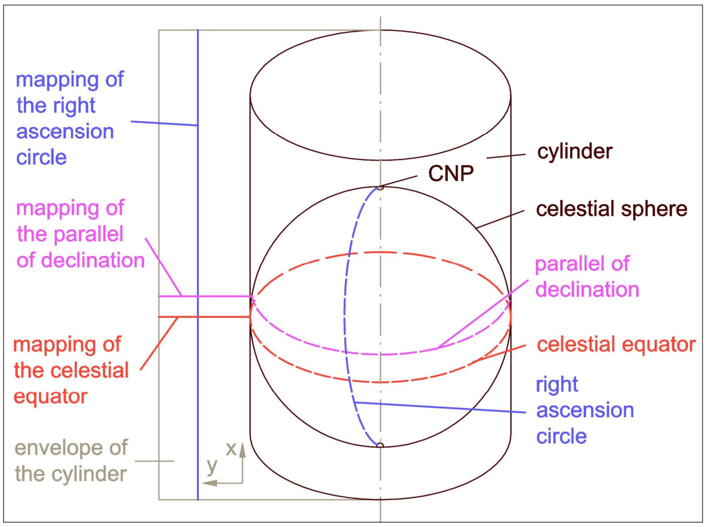

Fig. 2. The Mercator projection maps, for example, parallel circles and great circles of a sphere by means of a mathematical procedure into a grid of straight lines (crossing at right-angles) onto an enveloping cylinder. The sphere and cylinder touch each other. The envelope of the cylinder is then metaphorically speaking cut open and unwound into a plane. Note: x and y correspond to the orientation of the dial plate's Cartesian coordinate system.

- Using an angle-preserving[6] (conformal) mathematical procedure, the sphere is mapped onto the envelope of a cylinder. The sphere and cylinder touch each other along the sphere's equator so that the structures to be mapped (for example constellations) are represented with their shapes preserved.
- The length of the sphere's equator is preserved because the radii of sphere and cylinder are equal in size.
- The longitudinal circles of the sphere map to parallel line segments into the cylindrical envelope unwound into a plane.
- The parallel circles of the sphere are mapped as parallel line segments with the same length as the equator. Their distances are determined by the mapping function.
- The equatorial belt can be represented particularly well.
- The poles cannot be mapped because they move to infinity.

The right ascension α (measured in hours, minutes and seconds) and declination δ (measured in degrees) determine unambiguously the position of a celestial body on the celestial sphere (see Fig. 3). Such pairs of values are tabulated in astronomical yearbooks or star catalogues.

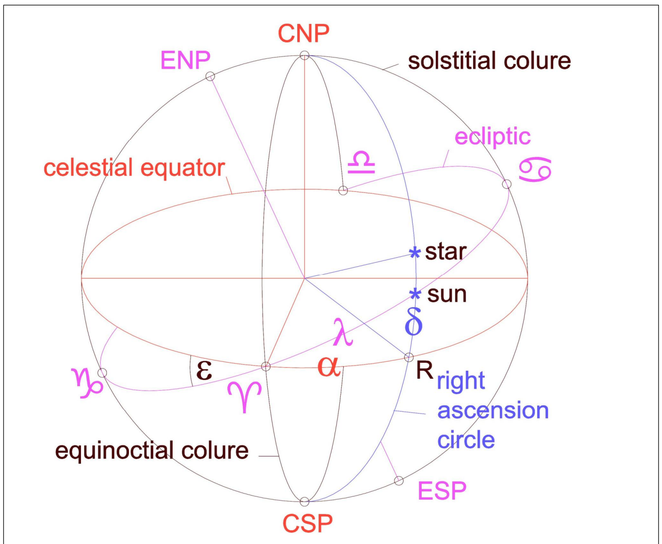

Fig. 3. The declination δ and right ascension α characterize the position of the sun or a star in the equatorial co-ordinate system. α is measured from the vernal point ♈ (intersection point of the sun's path and the celestial equator, i.e. the instant when the sun's apparent longitude is 0°) eastward in the plane of the equator and δ is measured perpendicular to the equator. ε = obliquity of ecliptic, λ = ecliptical longitude, CNP = celestial north pole, ENP = ecliptical north pole, CSP = celestial south pole, ESP = ecliptical south pole.

The relations for mapping both longitudinal circles (right ascension α) and small circles (declination δ) into a Cartesian coordinate system[7,8] with respect to the orientation of the dial plate's coordinate system are

$$x = R \ln \tan(45° + \frac{\delta}{2}) \qquad y = R\frac{\pi}{12}\alpha \qquad (4), (5)$$

R, the radius of the cylinder, results from

$$R = \frac{l}{2\pi} \qquad (6)$$

where l is chosen to fit the celestial equator on the dial face.

Grid of lines

Inserting $\delta = \delta_{grid}$ with the values $\delta_{grid} \Rightarrow 0°, \pm15°, \pm30°, +35°, -45°$ into relation (4) as well as $\alpha = \alpha_{grid}$ within the range $0 \leq \alpha_{grid} \leq 24h$ (in 2 hour intervals) into relation (5), we get the coordinates for the grid of lines.

Mapping the Ecliptic

Assuming that the right ascension $0 \leq \alpha_{sun} \leq 24h$ (normally expressed in units of time, 360° = 24h) is known the right-angled spherical triangle sun♈R in Fig. 3 (ε is the obliquity of ecliptic) leads for the sun's declination to relation

$$\tan \delta_{sun} = \tan \varepsilon \sin \alpha_{sun} \qquad (7)$$

With the substitutions $\alpha = \alpha_{sun}$ and $\delta = \delta_{sun}$ follow from (4) and (5) the ecliptic coordinates for drawing it.

Mapping of the constellations

For calculating the Cartesian coordinates of every single constellation's star its equatorial coordinates are required, see Fig. 3. Furthermore, the star magnitudes[9,10] are of interest for the graphical representation of the stars within the grids.

The equatorial coordinates[11] used for the twelve constellations refer to equinox and epoch J2000.0,[12] i.e. with the assignments $\alpha = \alpha_{2000}$ and $\delta = \delta_{2000}$ (see, as an example, Table 2 for the constellation Cancer) we obtain from (4) and (5) all the Cartesian coordinates of the constellation's stars.

star name	right ascension α_{2000}	declination δ_{2000}	visual apparent mag.	star mag.
α_{Cnc}	8h 58m 29.2s	+11° 51' 28"	4.25 mag	4
δ_{Cnc}	8h 44m 41.1s	+18° 9' 15"	3.94 mag	4
γ_{Cnc}	8h 43m 17.1s	+21° 28' 7"	4.66 mag	5
ι_{Cnc}	8h 46m 41.8s	+28° 45' 36"	4.02 mag	4
η_{Cnc}	8h 32m 42.5s	+20° 26' 28"	5.33 mag	5
ϑ_{Cnc}	8h 31m 35.7s	+18° 5' 40"	5.35 mag	5
β_{Cnc}	8h 16m 30.9s	+9° 11' 8"	3.52 mag	4

Table. 2. Equatorial coordinates (valid for J2000) and magnitudes for the stars of the constellation Cancer.

The constellations to be drawn comprise stars of first to fifth magnitude class. The brightest stars have the largest diameter. Five of the well-known stars come under the first class: Aldebaran in Taurus, Antares in Scorpio, Spica in Virgo, Regulus in Leo and Pollux in Gemini.

Constellation at midnight

Owing to the arrangement of constellations and zodiac signs on the dial face it is possible to read – dependent on the season – in which constellation the sun stays on a particular date, and which constellation is then visible at

constellation at midnight	sun at constellation	zodiac sign	Sun's declin.	zodiac sign	sun at constellation	constellation at midnight
Gemini	Sagittarius	♑	**-23.439°**			
Cancer	Capricorn	♒	-20.150°	♐	Scorpio	Taurus
Leo	Aquarius	♓	-11.475°	♏	Libra	Aries
Virgo	Pisces	♈	**0°**	♎	Virgo	Pisces
Libra	Aries	♉	+11.475°	♍	Leo	Aquarius
Scorpio	Taurus	♊	+20.150°	♌	Cancer	Capricorn
			+23.439°	♋	Gemini	Sagittarius

Table. 3. The details which are generally readable from the dial face concerning the nocturnal visibility of the 12 constellations. One should not confuse the name of a constellation with the zodiac sign of the same name.

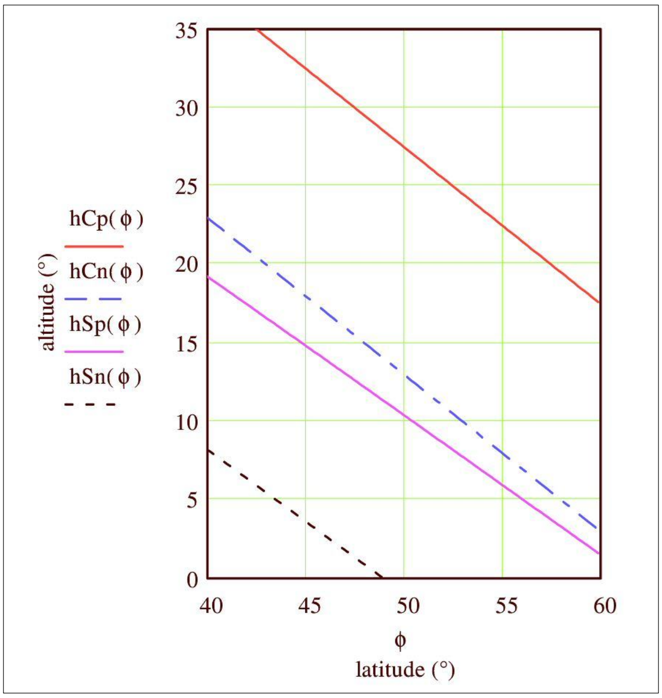

Fig. 4. The possible observation of the constellations Capricorn (C) and Sagittarius (S) at midnight and after midnight respectively (see Fig. 7) depends on hour angle, t, star declinations, δ, and geographic latitude, ϕ. The subscripts p and n denote the most positive or negative declination of each constellation. The altitude curves h(ϕ) shown for the upper and lower parts of the constellations refer to the fixed parameters $t = 0°$, $\delta = -12.5°$ for $hC_p(\phi)$ and $t = 0°$, $\delta = -27°$ for $hC_n(\phi)$ as well as $t = 30°$, $\delta = -25°$ for $hS_p(\phi)$ and $t = 30°$, $\delta = -37°$ for $hS_n(\phi)$.

midnight in the south, see Table 3. The constellations are in pairs situated diagonally across the face. The difference of their right ascension values amounts to 12^h.

The inequality

$$\left|\delta_{star}\right| < 90° - \left|\phi\right| \tag{8}$$

has to be fulfilled so that the constellation can be seen completely or at least partly over the horizon, see also Fig. 4. The ecliptic's markings ORIENS and OCCIDENS are helpful for finding the constellations at night sky. They indicate the direction to the eastern or western horizons, respectively. The natural position of the zodiac belt in the firmament results from joining the two halves at $\alpha = 18^h$, see Fig. 5.

Sidereal time disc

The relative motion of earth and sun as well as constellations, i.e. the interdependence between sidereal time[13] Θ, right ascension α and hour angle *t* (measured in units of time), expressed by the relation

$$\Theta = \alpha + t \tag{9}$$

can be shown clearly with a simple cardboard model drawn in Fig. 6. Looking from the celestial north pole onto the equatorial plane illustrates its principle.

The arrangement consists of three concentric discs which rotate relative to each other. On the biggest one, the celestial equator is drawn with both the zodiac signs and

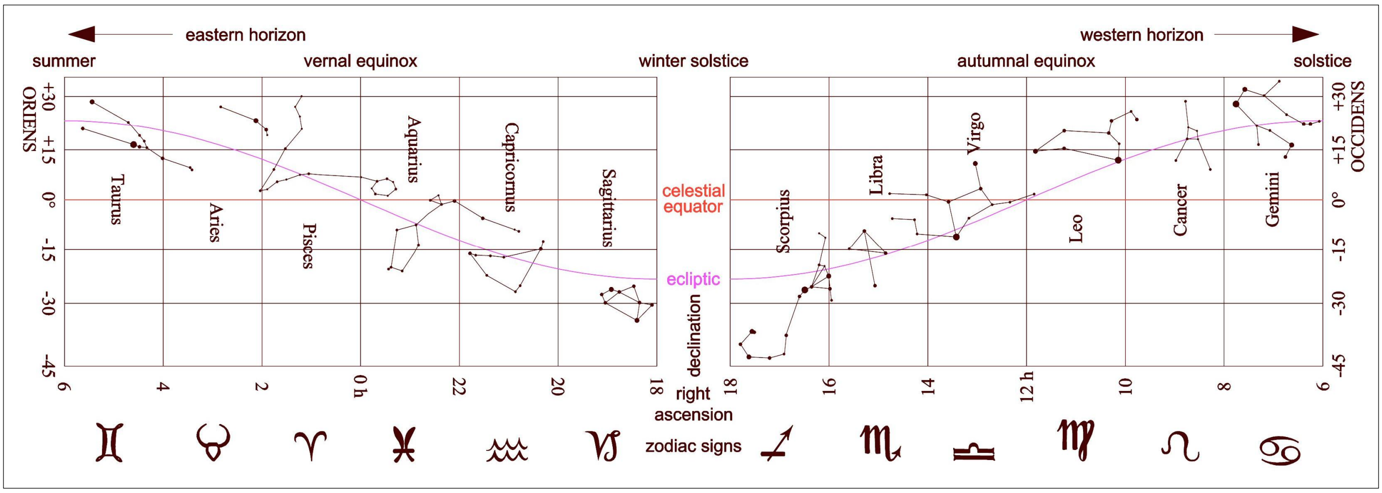

Fig. 5. Folding up the dial's two halves of the ecliptic at α= 18h shows more clearly how they match together and thus the natural appearance of the constellations in the firmament.

right ascension values. Particular attention should be paid to the vernal point ♈. The next smaller disc serves for positioning the sun along the equator or rather the zodiac. The innermost disc embodies the earth's rotation and bears the four points of the compass as well as the hour angle numbers, counting from the south point S westwards.

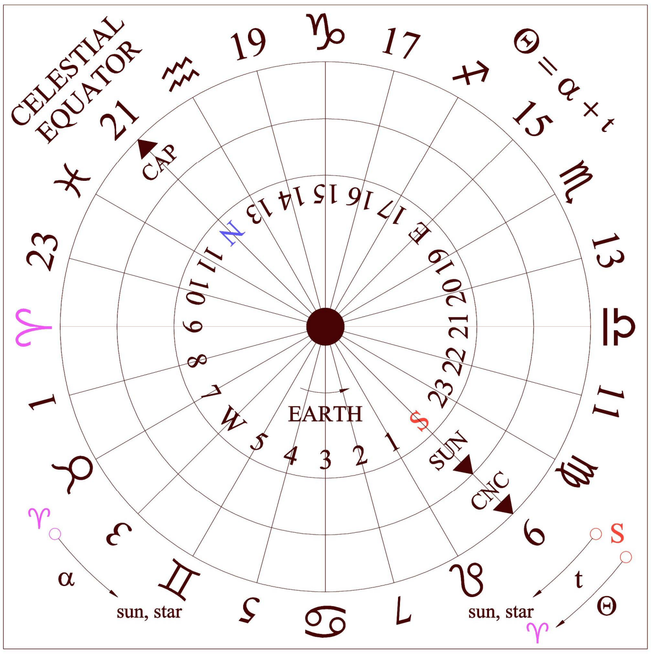

Fig. 6. Sidereal time disc with the following adjustments: (a) the sun is at both its upper culmination point and approximately the middle of the constellation Cancer (CNC); (b) the constellation Capricorn (CAP) is at its lower culmination.

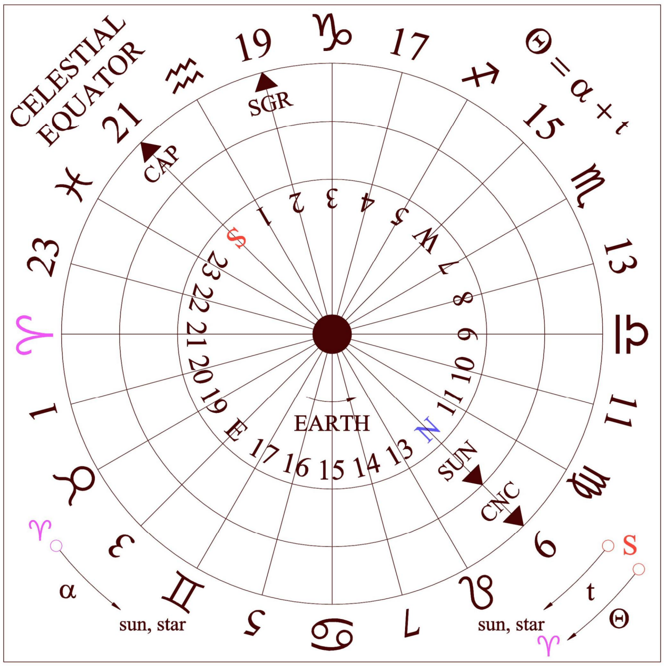

Fig. 7. Sidereal time disc with the following adjustments: (a) the sun is at both its lower culmination point and approx. the middle of the constellation Cancer (CNC); (b) the constellation Capricorn (CAP) is in the meridian in accordance with its upper culmination; (c) The constellation Sagittarius (SGR) has passed its upper culmination (the hour angle is 2 hours after midnight).

Figs. 6 and 7 demonstrate the application of the sidereal time disc concerning the sun (SUN) and the constellations Cancer (CNC) and Capricorn (CAP): it can be seen that the difference of the constellations' right ascension values amounts to 12^h, i.e. the constellations are situated diagonally across the disc's face. Tables 4a & b underline this fact.

celestial body	SUN	CNC	CAP
hour angle t	0^h	0^h	12^h
right ascension α	9^h	9^h	21^h
sidereal time Θ	9^h	9^h	$33^h - 24^h = 9^h$
zodiac sign	♌	♌	♒

Note: If the sum of α and *t* exceeds 24^h it should be reduced by substracting 24^h.

celestial body	SUN	CNC	CAP	SGR
hour angle t	12^h	12^h	0^h	2^h
right ascension α	9^h	9^h	21^h	19^h
sidereal time Θ	21^h	21^h	21^h	21^h
zodiac sign	♌	♌	♒	♑

Tables 4a & b. The application of equation (9). 4a corresponds to Fig. 6 and 4b to Fig. 7.
Note $\alpha_{CAP} - \alpha_{CNC} = |12^h|$.

Planetary Symbols as Furniture

In ancient astrology the moon and sun were counted among the planets. Therefore in a cosmological seqence – i.e. at a geocentric point of view from the outside (furthest from Earth) to the inside (nearest to Earth) – are belonging to the seven classical (visible) planets: Saturn ♄, Jupiter ♃, Mars ♂, Sun ☉, Venus ♀, Mercury ☿ and Moon ☾. The decoration above the horizontal part of the time scale symbolizes the sequence of our weekday names. The sun in the first place represents the week beginning with Sunday. The remaining assignments arise from the consecutive (cyclical) counting to three planet positions at a time.[14]

REFERENCES AND NOTES

1. Owning to the gyroscopic motion of the earth's axis (mainly caused by the sun and the moon) the vernal equinox moves retrograde (i.e. westwards) by about 1° along the ecliptic in 72 years – the 'precession of the equinoxes'.
2. Named after Gerhard Kremer (1512-1594), more commonly known by his Latin name Gerardus Mercator, a mapmaker from the Low Countries.
3. Due to sun's movement along the ecliptic, its equatorial coordinates (right ascension and declination) are continuously changing. In gnomonics it is assumed that the sun's path throughout the day is a small circle parallel to the celestial equator, i.e. sun's declination can be regarded as constant.
4. The sun is approximately from ... to ... within the current zodiac sign, at a geocentric point of view. The arrows indicate the vertical movement of the sphere's shadow on the dial face during the half-years.
5. The ecliptical longitude λ is measured from the vernal equinox along the ecliptic. Referring to Fig. 3: $\sin\delta_{sun} = \sin\varepsilon \sin\lambda_{sun}$.

6. The stereographic projection is likewise angle-preserving but it belongs to the category of perspective projections: it is a central projection with the centre at the touching point's antipole.
7. A. Schödlbauer: *Geodätische Astronomie - Grundlagen und Konzepte*, Walter de Gruyter, Berlin, New York, (2000).
8. G. Hake, D. Grünreich, L. Meng: *Kartographie - Visualisierung raum-zeitlicher Informationen*, Walter de Gruyter, Berlin, New York, (2002).
9. The visual apparent magnitude of the stars perceived at earth is characterized by their star magnitude (abbrevated *mag*): between 0.5 *mag* and 1.49 *mag* first magnitude class, between 1.5 *mag* and 2.49 *mag* second magnitude class, and so forth. Stars of the sixth class are the faintest ones to be just visible to the naked eye.
10. J. B. Kaler: *Sterne und ihre Spektren - Astronomische Signale aus Licht*, Spektrum Verlag Heidelberg, Berlin, Oxford, (1994).
11. A. E. Zavalishin: StarCalc Version 5.7, eng. Varonezt, Russia, (1995-2001).
12. Because of precession, the coordinates of celestial bodies are subject to change. Therefore the catalogued positions of stars are referred to a mean equator and equinox of a so-called standard epoch, i.e. they are valid only for a given instant of time.
13. Sidereal time: hour angle of vernal equinox point ♈.
14. The astrologers assumed that the seven classical planets are the rulers over the unequal (planetary) hours of the day in succession. Using the assignments:

hour	1	2	3	4	5	6	7
planet	☉	♀	☿	☾	♄	♃	♂

for the first seven hours of Sunday and repeating this cycle every seven hours we get the following array for the rulers of the various hours of the days of the (planetary) week:

rulers of the day					rulers of the night						
hour	1	7	8	12	13	14	15	21	22	23	24
Su	☉	♂	☉	♄	♃	♂	☉	♂	☉	♀	☿
Mo	☾	☿	☾	☉	♀	☿	☾	☿	☾	♄	♃
Tu	♂	♃	♂	☾	♄	♃	♂	♃	♂	☉	♀
We	☿	♀	☿	♂	☉	♀	☿	♀	☿	☾	♄
Th	♃	♄	♃	☿	☾	♄	♃	♄	♃	♂	☉
Fr	♀	☉	♀	♃	♂	☉	♀	☉	♀	☿	☾
Sa	♄	☾	♄	♀	☿	☾	♄	☾	♄	♃	♂

It can be seen that the algorithm $24^h = (3 \times 7^h) + 3^h$ yields in the column of the first hour the rulers for naming the appropriate days. It is interesting that we obtain a star-shaped heptagonal figure, if we arrange in a circle the seven planets and connect them together in the sequence as decribed for the rulers of the day's first hour.

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TWO MANCHESTER GLASS DIALS

ROGER BOWLING

There were once two glass dials within a few miles of the centre of Manchester: both have now disappeared. One was at the Old Parsonage, at Didsbury in the south of the city, and the other at Kersal, in the City of Salford. The only thing which can be considered to connect them is that both might have been caused to be erected by once prominent citizens of Manchester and Salford. We know exactly by whom and when the Didsbury dial was constructed and I wish in this article to just suggest by whom the Kersal dial may have been conceived.

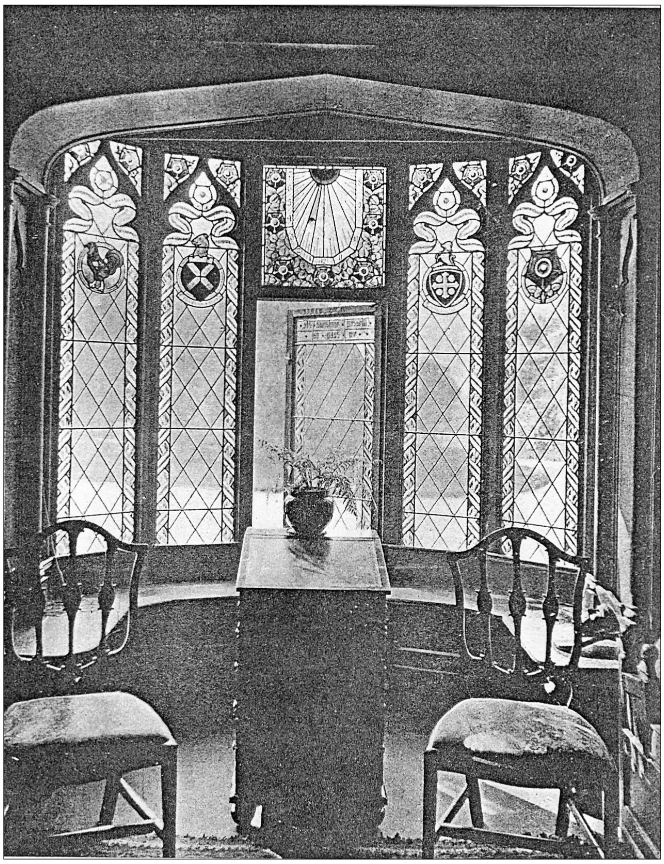

Fig. 1. The 1903 stained glass dial at Didsbury Old Parsonage. From a contemporary photograph in ref. 1, also believed to have been published as a postcard.

The Dial at Didsbury Old Parsonage

Mr Fletcher Moss was a Manchester business man. He moved to the Didsbury Old Parsonage in 1865, buying it 1884 and living there for over 40 years. He was a Manchester worthy, councillor, philanthropist and antiquarian, becoming Alderman of the City, JP for the County Palatine of Lancashire, and President of the Lancashire and Cheshire Antiquarian Society. He left the Parsonage and its gardens to the city.

It was his antiquarian interests which occupied his spare time. On frequent occasions, every month or so, he and his friends, mainly other businessmen, visited historic sites on day trips. They travelled by train, bus or bicycle, sometimes considerable distances, exploring many old houses and other buildings. In those days most of the houses were not open to the public but one of the group probably knew the owner, or they just knocked on the door. Those times are long gone.

The results of the travels were written up by Fletcher Moss in seven large volumes illustrated by good photographs, some taken by himself.[1] He was clearly interested in sundials for several are illustrated – in fact I think he wrote the best description of the Marrington dial, Shropshire (SRN 2234).

In his account[2] of his public work for the city, he describes the window of the library which he designed, with the sundial which he also designed in 1903 (see Fig. 1). Whether he delineated it himself I do not know, but certainly he had friends who could have helped. The dial declines 25º west (Fletcher Moss's own figure) and is on frosted glass. In the opening light beneath the dial is the motto, 'As sunshine passeth–so pass me'. I imagine Fletcher Moss got inspiration for the dial from one he saw in some old house that he and his friends visited on their pleasure outings, but I can find no clue in his books. The windows with the mock heraldry survive, but not the dial or the motto.

The Kersal Cell Dial

This dial (Fig. 2) and the house in which it was situated, have already been described.[3] The dial was situated in a large eight-light bow window. It is a simple design, with the unusual feature that the sun's image at the top centre of the dial appears to be shining through white clouds with scalloped edges. It doesn't match the style of any of the known makers of stained glass dials, but appears to be in typical early-18th century style. The building, Kersal Cell, is on the site of an ancient monastic establishment which suffered at the dissolution. It is a large half-timbered 16th century building, very much altered. Not only has the sundial disappeared, but so also have the large bow windows. In its later years the building was a girls school, a country club and finally a night club; the survival of the sundial despite these episodes is remarkable. It disappeared in the 1990s.

Kersal Cell came into the hands of the Byrom family during the 17th century.[4] They also had properties in Manchester. John Byrom was born in 1691: he was educated at Trinity College, Cambridge, becoming a fellow in 1714, and mar-

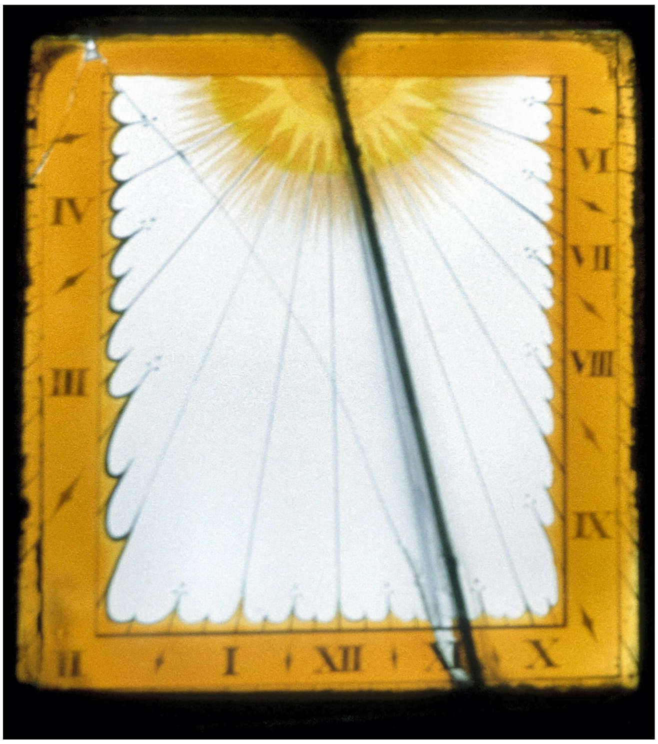

Fig. 2. The Kersal Cell stained glass dial. Photograph by C. Daniel, taken autumn 1982, from ref. 3.

ried his cousin Elizabeth in 1721. He then spent most of his time in London or Cambridge suffering ceaseless complaints from his family that he was never at home. He is best known for three things; inventing a shorthand system and teaching it to the great and good of London in an effort to earn money, writing the words for the Christmas Day hymn, *Christians Awake* (he was a prolific poet), and being a leading Jacobite.

In London, Byrom cultivated the leaders of society, much by teaching shorthand and his membership of the Royal Society, becoming involved with disputes on many topics, and he also filled his head with what may have been fantasies. He was a lover of Princess Caroline, Princess of Wales, later Queen Consort of George II, and convinced himself that he was the father by her of Prince William, Duke of Cumberland. If such was the case then Byrom inadvertently brought about the bloody end to the Jacobite cause. But there are other things that appear more serious; before marriage he went to France to study medicine, but he never practised, so was he in fact plotting in the French hotbed of the Jacobite cause? Was he involved in the death of George I by poison – as has been suggested?

He must have met the Young Pretender, and his daughter certainly did. His support of the Jacobite cause was known in some government quarters and he was friends with some of the leaders of the young Pretender's cause. Two of his near-neighbours in Kersal, a father and son, both Thomas Siddal, lost their heads, one after the 1715 rebellion, and Thomas the son was one of the nine Manchester martyrs in 1746. Around that time Byrom was publicly accused of being the leader of the north-west faction of the Jacobites. He was living a dangerous life and he associated with some very dangerous people. It is surprising that he did not lose his head too – were his old friends protecting him, or was he really a government agent, a double agent? His life was all very mysterious.

In his later years, Byrom retired back home to Manchester and studied philosophy and religion, and, like many educated men at that time, searched for the 'truth' in geometry and proportion. He left a large collection of geometrical and architectural drawings spanning 170 years, which contains a single engraving of a sundial, a John Marke double horizontal dial.[5] This might, along with his young gentleman's Cambridge education, indicate some interest in dialling.

Why would I suggest that John Byrom could have been the instigator of the Kersal Cell sundial? I have no evidence, but I think it reasonable to point a finger in his direction. I might have expected to see some allusion on the dial to the Jacobite cause, a symbol of some sort, but there is none. Unless it can be thought that the sun behind the clouds represents a cause not lost, the clouds will one day part and herald the true king.

One of John Byrom's aliases was John Shadow, so could the sundial very aptly represent his own life of secrecy, scheming, intrigue and fantasies, a life lived in clouds and shadows?

ACKNOWLEDGEMENTS

Christopher Daniel for the photograph of the Kersal Cell dial; John Davis for useful discussions; and Joy Hancox.

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2. F. Moss: *Fifty Years Public Work in Didsbury,* Pub. by the author, (1915).
3. C. Daniel: 'The Kersal Cell', The Sundial Page, *Clocks, 35,* (June 2007).
4. J. Hancox: *The Queen's Chameleon,* Cape, (1994).
5. J. Hancox: *The Byrom Collection,* Cape, (1992).

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After the articles on 'Sundials for the Tropics' in the previous issue, our member Jim Marginson submitted this picture of a rather good multiple dial at Santiago de Cuba, Cuba, located at 20° N, 70° W.

THE PREVALENCE OF ENGLISH SCRATCH (MASS) DIALS c.1650 – Part 2

CHRIS H K WILLIAMS

By using the current incidence of surviving scratch dials and dial losses in the interim, a c.1650 benchmark was established in Part 1.[1] We have also seen regional variability in the incidence of surviving dials.[2] How do the two reconcile?

A definite pattern exists in the geographic distribution of surviving dials (Fig. 1). There is a marked watershed. To the east, in excess of 30% of medieval churches have dials, except for a 'cold' cluster. To the west, survival declines rapidly to a fringing cluster in which most counties have well under 10% of churches with dials – an English fringing cluster extending into Ireland, Scotland and Wales.

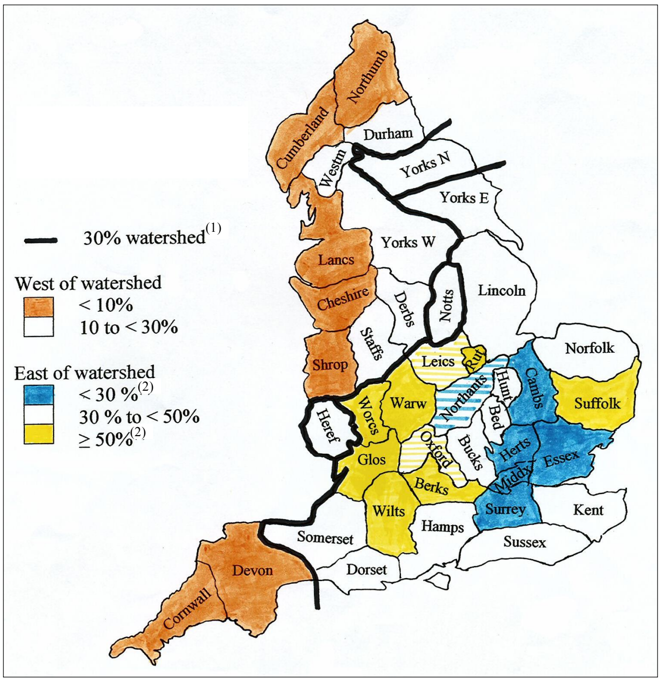

Fig. 1. Geographical distribution of medieval churches with surviving scratch dial(s).
Notes
(1) Estimates for Herefordshire, Nottinghamshire and Yorkshire North Riding straddle the watershed.
(2) Where estimates straddle the relevant figure, the county is shown with striped shading.

The c.1650 benchmark is based on the profile of surviving dials in the median grouping of counties – all east of the watershed, as well as the estimated loss rate extracted from the totality of surviving dials – overwhelmingly east of the watershed. So the benchmark represents the average east of the watershed situation, reflecting the average current surviving incidence and the average rate of dial loss in the interim. In fact half the counties east of the watershed (a quarter of all counties) are within 10% of the benchmark – having lost about two-thirds of their original c.1650 dials. Other counties have more or fewer surviving dials: such variation must reflect variability in dial loss and/or the original c.1650 incidence of dials. Our assessment of this is most easily appreciated against the twin yardsticks of attributing the entire variation to either differential dial loss or differing initial dial endowment (Fig. 2). This merits detailed consideration and cross referencing with Fig. 1 before reading on.

Regional variation in the adoption of equal hour technologies (scientific sundials and clocks) might be expected, via their impact on the timing of scratch dial displacement, to have affected c.1650 dial incidence. As c.1650 incidence reflects dial accumulation over half a millennium and most parishes displaced scratch dials in the seventeenth century,[3] significant inter-county variation in incidence can only have arisen from systematically differing displacements in earlier centuries.[4] There is no evidence suggestive of those counties listed above the benchmark grouping (Fig. 2) adopting equal hours systematically differently from the latter i.e. the benchmark dial incidence should prevail. The 'cold' cluster correlates with examples of early equal hour adoption; it is probable early displacement reduced incidence for some of these counties. For the remaining counties listed below the benchmark grouping (Fig. 2), the evidence suggests most were late adopters i.e. there should be more not fewer dials than the benchmark. The yardstick for varying original dial incidence is utterly implausible! Variability in the incidence of surviving dials is almost entirely due to differing dial loss rates.

The most coherent interpretation of the data is that, to the east of the fringe, benchmark dial incidence approximated the c.1650 reality (apart from some attenuation within the 'cold' cluster and supplementation west of the watershed), with a wide range of subsequent dial loss. Differential dial loss is attributable to many factors including weather, building stone, urban spread and Victorian restoration.[5] We cannot, on the data alone, be as conclusive for the fringe: few surviving dials and a virtually absolute loss is consistent with any original incidence! Given the inherent implausibility of non-universal adoption,[6] (what credible barriers could have quarantined the fringe from both the universal contemporaneous presence of dials to the east and the earlier presence of Saxon dials?), considerations other than complete loss warrant investigation to explain the paucity of surviving scratch dials.

Post c.1650 dial loss		Historic county (2)	c.1650 dial incidence	
Comparative dial loss	% c.1650 dials lost (1)		Average dials/ medieval church (3)	Comparative incidence
Low	35 to <40	Berkshire Gloucestershire	5	High
	40 to <50	Oxfordshire↓ Wiltshire Worcestershire	4	
	50 to <60	Rutland Warwickshire	3.5	
Close to benchmark	60 to <70	Bedfordshire Buckinghamshire Hampshire Huntingdonshire Kent Leicestershire↑ Lincolnshire Norfolk Suffolk Sussex Yorkshire East Rid.	2.5	Close to benchmark
High	70 to <80	Dorset Herefordshire↓ Nottinghamshire↓ Somerset Yorkshire North Rid↓	1.5	Low
		Hertfordshire* Northamptonshire*↑		
	80 to <90	Cambridgeshire* Durham Essex* Staffordshire Surrey* Westmoreland Yorkshire West Rid.↑	1	
	90 to <100	Cheshire Cornwall Cumberland Derbyshire Devon Lancashire London* Middlesex* Northumberland Shropshire	<0.5	

Fig. 2. Variable c.1650 dial incidence vs. differential post c.1650 loss.

Notes

(1) Calculated from surviving and c.1650 benchmark incidences.

(2) Key to symbols

- Some estimates straddle loss ranges. ↑ or ↓ indicate whether a county could be in the category immediately above or below.
- The watershed is marked ==========
- Counties below ===== are west of the watershed apart from the 'cold' cluster identified by an *.

(3) Calculated from surviving dial incidence and benchmark post c.1650 dial loss.

Earlier students, Cole and to a lesser extent Horne, argued scratching was intended to ease dial (re)decoration. Would scratching occur if another method was more practical? Much of the fringe, the geologically oldest parts of Britain, has an uncompromising local building stone. The alternatives are separately hung mass dials, or templates for the (re)painting of 'painted only' dials. There is corroborating evidence for this. Five loose dials (two Irish and single Cornish, Welsh and Scottish examples) have been recorded.[7] Their fragility and negligible intrinsic value must result in a very low survival rate. Their confinement to the British fringe is noteworthy. Whilst not all of these examples are universally accepted as vertical mass dials,[8] collectively they indicate what could have been commonplace for churches with an uncompromising fabric.

In conclusion, we have sufficient data to statistically decode the past in incredible detail. Only a small fraction of dials still survive. What does presents a misleading picture. Today, most churches do not have a dial; formerly they were universal. Moreover our benchmark shows most churches had several. The benchmark is a reasonable approximation for most of England. The geographic variation in surviving incidence reflects a wide range of loss rates, not original incidence. The major exception is the fringe. Here the data is insufficient to infer the past, and there are grounds for supposing (universal) mass dials were not typically scratched into the churches' fabric. In future articles our focus will turn to developments within the mass dial era itself.

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2. C.H.K. Williams: 'The Geographic Distribution of Surviving English Scratch (Mass) Dials', *Bull BSS,* 20 (ii), 75-6, (2008).
3. C.H.K. Williams: 'The Life Cycle of English Scratch (Mass) Dials', *Bull BSS,* 20(iv), 164-5, (2008). Furthermore (discussed in subsequent articles), the estimated c.1650 frequency distribution does of itself indicate a predominantly seventeenth century displacement.
4. The horological literature on the timing and extent of equal hour adoption is surprisingly muted. It is confined to documenting examples. These have been thoroughly examined for any indication of systematic regional differences.
5. It is easy to hypothesise how such factors might plausibly explain dial loss variation. Circumstantial evidence abounds in the literature. Their importance is often indicated by large intra county variations in survival. Each factor is capable of measurement; indeed there may be relevant data in related fields of endeavour. More directly derived loss estimates with explanatory causation are possible.
6. Williams: *Op. cit.*
7. A.O. Wood & F. O'Carroll: 'A Celtic Quartet', *Bull BSS,* 20(ii), 84-7, (2008).
8. L.P. Burge: 'The Crowan Dial, First Impressions', *Bull BSS,* 14 (iv), 168-170, (2002). A.O. Wood & P. Powers: Letters, *Bull BSS,* 15(i), 15-6, (2003).

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THE RECENTLY DISCOVERED IRISH-STYLE DIAL AT TYWYN

MIKE COWHAM & BILL LINNARD

Tywyn in Gwynedd is located on Cardigan Bay on the west coast of Wales at the mouth of the Dysynni river. Its name comes from 'tywyn', a beach, seashore or sand dune. It should not be confused with another Tywyn near Llandudno in North Wales. Its name was formerly spelt Towyn when the county was known as Merioneth but its more recent Welsh name Tywyn is still pronounced like Towyn. The town is a seaside resort lying on sand dunes and is enclosed on the landward side by mountains.

Fig 1. St Cadfan's Church, Tywyn. Its nave and south aisle are of 12th century Norman construction. (Photo: Meryl Gover.)

In the town is an ancient church (Fig. 1), dating back to at least c.800 AD, dedicated to St Cadfan. St Cadfan was a Breton nobleman, c.530-590, who founded a monastery at Tywyn, later moving to Bardsey Island further north up the coast. It is thought that this dial was from the monastery but it is not known if it was brought from Ireland or was just made locally in the Irish style. Inside St Cadfan's Church is another stone with the oldest-known inscription in the Welsh language, dating from the 8th or 9th century (Fig. 2). The original wooden church was sacked by the Vikings in 963 but was rebuilt in stone in Norman times. Its central tower fell down in 1692 but was rebuilt in 1882 as well as other parts, so the only Norman parts remaining are the nave and south aisle.

Fig 2. St Cadfan's Stone in the church showing the earliest known Welsh inscriptions.

The dial (Figs. 3 & 4) is presently set into a lawn, just off the High Street, Tywyn, close to the Public Swimming Pool and the Tourist Office, a position leaving it rather vulnerable to damage. It was placed there by the Town Council some time ago, facing in a southwesterly direction.

The dial is of the type found in several places in Ireland and can be dated to between 700 and 1000 AD but probably closer to the 700. It was discovered and rescued in 1986 by Tom Lloyd who found it placed on top of some rubble from the demolished Ynysymaengwyn Mansion, a house that was located about one mile from Tywyn. This late-medieval house had been demolished but was formerly the most powerful estate in the area. Tom Lloyd reported his discovery to The Royal Commission on Ancient and Historical Monuments in Wales and it was soon realised that the stone was a re-used Early Christian monument of a much older date. Unfortunately, when the stone had been re-used, probably in the outhouses of the mansion, the top was damaged, but luckily for us all was not lost. In its time the stone had also been used as a mile post and is clearly inscribed below the dial, "From Towyn 1 Mile". As the mansion was one mile from Tywyn, it is likely to have been carved there and it is believed that the 'milestone' was located at the gates of the house.

The dial first came to my (BL) attention from a paper written by W Gwyn Thomas[1] giving details of the dial when it was first discovered. The paper includes a detailed sketch of the dial and some of its history. It was later described by me in an article on Welsh scratch dials.[2] I informed Tony Wood who then put both of us (BL & MC) in touch with each other. Contact was then made with Mike Edwards, Churchwarden at St Cadfan's Church, and we managed to obtain details of the dial's present location and he provided some photographs. Little detail could be seen. From the information that we had, we were certain that this was an Irish-style dial and that it was very important, being only the second one found in Wales, the other being further north at Clynnog-fawr.[3] Both dials lie directly on the coast and would have been at landing points of Irish missionaries.

Fig. 3 (left). The dial as we first saw it, illuminated from behind and its details virtually lost.

Fig. 4 (right). The dial illuminated from one side by a mirror, revealing its details.

I (MC) decided that the dial had to be preserved. Where it currently stands it is too vulnerable to vandalism, graffiti and weather erosion. It seemed to have deteriorated in the few years since it was discovered so I wrote to Mike Edwards stressing its historical importance and the fact that it should ideally be preserved *inside* the church. As a member of the PCC he took my suggestions forward and now the dial is to be moved into St Cadfan's Church next to the famous St Cadfan's Stone.

According to W Gywn Thomas, the dial stone is 260 cm tall, 34 cm wide at the top and 23 cm thick. At present, with the lower section buried in the ground, its height above ground is just 120 cm.

It was not until March 2009, when the better weather had come, that I (MC) was able to visit Tywyn to see the dial for myself. I arrived as dark was falling and found the dial illuminated by a nearby street lamp. Although indistinct, even in this light it was possible to see the carving of the 'milepost' and even the circle of the dial.

Next morning, the Sun was shining brightly and, armed with a camera and tripod, I went with Mike Edwards to photograph the dial. As it faces south west, the sunlight was from behind the dial and the markings were virtually invisible (Fig. 3). Several photographs that were previously taken of the dial show almost nothing due to its relatively shallow carving. Expecting these problems I was prepared to try a new technique that I had been working on of re-directing sunlight via a mirror. I had taken a tall bedroom mirror for this purpose and with this the sunlight was reflected across the dial face at a shallow angle revealing the detail of its carving to me (Fig. 4). The mirror was not quite long enough to illuminate the whole face of the stone but enough could be seen to show what I needed. Yes, the dial has lost some detail since its discovery but sufficient still remains to make it worth preserving. The results with the mirror exceeded expectations and we were not arrested for doing strange things in the town centre although I suspect that some passing motorists may have been slightly dazzled at times.

Fig 5. Close-up of the dial.

Fig 6. View of the dial stone viewed from above, showing its cross-section.

The radius of the dial is about 20 cm below its enlarged gnomon hole (Fig. 5). The missing top section has effectively removed the horizontal line across the top but the other five lines are still clearly shown. At the noon point on the circle is a later hole filled with lead which was probably something to do with its re-use, possibly as a gatepost. The dial is divided into six almost equal sectors and traces of forked ends where the lines meet the outer circle may still be seen on at least two of the lines. These terminations are typical of Irish dials of this period. Below the dial are two circles about 7.5 cm diameter. It is not known what the function of these was. They may have contained crosses or even paintings of some saints. The cross-section of the stone is unusual, being relatively thick and of an irregular shape (Fig. 6).

Another stone, which appears to be of a similar size and shape as the dial stone, has been built high up into the south side of the reconstructed church tower, lying horizontally. It is clearly carved with a cross. No other details of this stone are known.

Hopefully, the dial will soon be moved into St Cadfan's Church and will be set up alongside St Cadfan's Stone. Illumination is to be from a spotlight to one side, so this should clearly reveal the stone's carving.

ACKNOWLEDGEMENTS

We would like to express our sincere thanks to Mike Edwards from St Cadfan's Church for showing us the dial, his Church and for his important work in getting it preserved for the future *inside* the church. Thanks also go to Meryl Gover from St Cadfan's for supplying photographs of the church.

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2. W. Linnard 'Welsh Scratch Dials' *Arch. Camb.* **156** 141-147 (2007).
3. M. Cowham (Ed): *Sundials of the British Isles*. Cambridge (2006).

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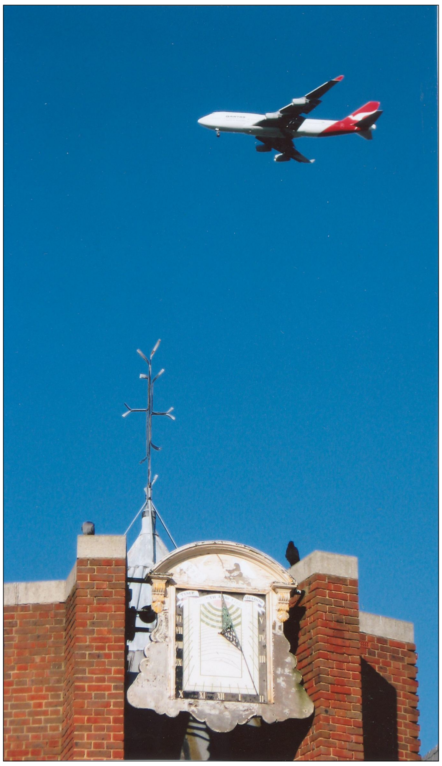
Redacted

Spire - John Foad
Second equal, People's Vote



How Time Flies!
Ian Butson

Top Ten

Moondial by Infra Red - John Davis
Second equal, People's Vote

Some Dial—David Harber obelisk - Tony Wood
Editor's choice

"The Bloody Sun at Noon" - M Taylor
Top Ten

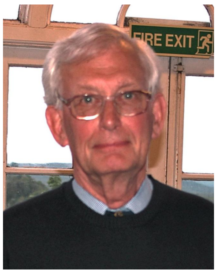
Double Horizontal - John Davis
Fourth place, People's Vote

MINUTES OF THE 20TH ANNUAL GENERAL MEETING

Cumbria Grand Hotel, Grange-over-Sands,

17 May 2009

1. About 60 voting members were present for the meeting, which was opened by the Chairman, Christopher St J H Daniel, at 12:50 pm. He started by thanking Douglas Bateman and Robert Sylvester for organising a most successful and enjoyable Conference, and then thanked the staff at the Hotel for the way they had looked after us. He expressed again his appreciation for all who had attended, most particularly those who had given the talks, and those who had come from overseas.



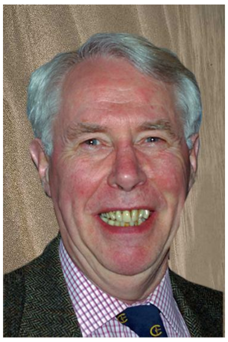
2. No apologies for absence had been received.

3. The minutes of the 19th Annual General Meeting, held at the Latimer Conference Centre, Buckinghamshire, had been published in the Bulletin of June 2008, were taken as read, and were approved by a show of hands. There were no matters arising and the minutes were adopted.

4. Council Member's Reports

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

Secretary: Doug Bateman. *Liaison.* Since the last AGM I have dealt with 7 enquiries by letter, a few more by e-mail, and half a dozen by telephone. Many have sought advice about dials in their possession. A number have been about restoration, and these were referred to Graham Aldred. Whilst we are helping to 'educate the public' as part of our charitable status, few of the enquiries have led to membership. Two queries came from the National Trust. A potential line of research has arisen about a dial from Ballyin, Ireland, now in Georgia, USA: it is a slate dial and Michael Harley is assisting.



Editor: John Davis. The major event this year has been the move to new printers for the *Bulletin*. This has allowed us to enhance to a full colour production, including the covers. At the same time, a 'poly-bag' delivery system has meant that there is no overall increase in cost. I am grateful to John Lester for all his work on proof reading and, of course, to all the authors for their contributions. The New Author Award has been made for a third year, this time to Robin Catchpole for his article on the *Solar Pyramid*.

Two new monographs have been published; *Mass Dials on Yorkshire Churches* by Alan Cook, and *A Study of Altitude Dials* by Mike Cowham. These have been produced by a print-on-demand system which is both economical and convenient for our small print-runs. The latter title included colour illustrations and an enclosed CD-Rom. More titles are in the pipeline.

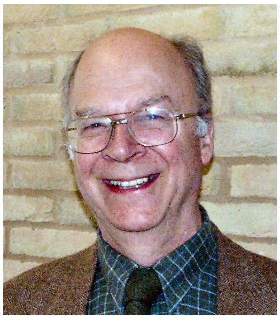
Some projects have been regrettably delayed, particularly the scanning of all the early issues of the *Bulletin* to produce an electronic and fully searchable archive. This remains on the 'back-burner' unless another member would like to help out.

Membership: Jackie Jones. I took over the role of Membership Secretary from John Foad last May and I must express my great thanks to him for his patience and help with my lack of computer skills over the year. Our membership now stands at 471 of which 332 are from the UK and 72 from Europe. 67 are from the rest of the world which includes members in Brazil, Russia, Mexico, Pakistan and Japan as well as many from the USA, Canada and Australia. Over the last year we have welcomed 20 new members to the Society; unfortunately we have also said goodbye to some others, mainly due to old age or health reasons.

Restoration: Graham Aldred. Several sundial restorations are in progress although other restoration work tends to occur without being reported. The independent fund generously donated by David Young last year and aimed at church dials in the South East has been used up and four restorations have been funded. Restoration advice enquiries continue to be received, three are currently in the early stages. The process is slow often due to the requirement to satisfy various interested bodies like English Heritage or the Church Authorities. Funding has always been an issue particularly for local enthusiasts who have no clear route to any money. However at last the BSS can now help with a limited number of annual grants for up to half the cost. The details of the Grant Scheme are on the web site or available from me by e-mail or post. As requested last year members are urged to report any recent sundial restorations and report sundials that deserve some careful attention.

Reference Library at Nottingham: Graham Aldred. There is very little to report: ten books or pamphlets have been received. We have been given more shelf space and so the arrangement has become more satisfactory; discussions regarding the storage of the more valuable books are still ongoing. The Library is not used very much by Members, this is probably because there are so many alternative internet sources of exactly the same information which remove the incentive to visit the Library. The location in Nottingham may also be a difficulty and Council are considering possible relocation in London if the costs are acceptable. The current charges are £130 pa which still represents a very modest cost compared with commercial storage costs, especially given all the additional attributes of Bromley House.

Fixed Dial Register: John Foad. Thanks to the dedication and enthusiasm of our members, well over 900 new reports have been entered in the last 12 months, with news of over 500 previously unrecorded dials. I am grateful to those who have sent in a report for just a single dial, but Tony Wood and Ian Butson must be particularly celebrated for having, over the years, now submitted no fewer than 1,000 reports each!

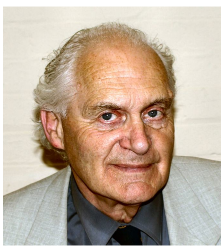


Dials sadly continue to be stolen, but pleasingly three have been recovered in the last year. Members who feel they may have spotted a suspect dial in an antique shop or elsewhere, can now refer to the list of stolen dials which is to be found on the Society's web site.

Noel Ta'Bois left a remarkable legacy of 35 mm transparencies, the result of intensive dial-hunting in the 1970s and '80s. Tony Wood has those with mass dials, and I have inherited some 1,500 slides of scientific dials. These have now been catalogued and will shortly be transferred to CD. They provide pictures for a large number of Register entries that are currently unillustrated, as well as recording many dials that never previously found their way to the Register at all. The CDs together with the catalogue will provide a valuable Society resource, and members will of course have access to them on request to me.

With the Society's copy of *MS Access*, which is used for the main Register, I have started to build a database of place names to be found on 'Geographical' dials, i.e. those which show the time of noon in a multitude of places around the world. Mainly horizontals and mostly dating from the 18th and 19th centuries, they provide an interesting insight into the key world locations of their time.

Mass Dial Group: Tony Wood. The agreement to archive the mass dial records at the Borthwick Institute, York, was confirmed during the year and this is now in hand. It is possible that some collaboration with the Department of Archaeology at York University can be arranged with possible assistance being made available for research.



The Mass Dial Register is now being entered and several counties have been compiled and are available as printed booklets. After reports for a county have been entered, they are deposited at York for archiving.

The counties so far compiled are: Rutland, Lancashire, Devon, Greater London, Scotland, Isle of Wight, Cornwall, Wales, Durham and Northumberland; with Annexes to Lincolnshire, S. Yorkshire and W. Yorkshire. (Lincolnshire and Yorkshire have been printed as separate sections of the Register; the Annexes comprise those records made by members other than the authors of those sections.)

Continental dials continue to appear and a complete French listing (no pictures) is now available. Certain aspects of delineation and distribution are the subject of research. All Continental dials received are filed but not further processed.

Roman Dials. A recent side issue has arisen with an enquiry about Roman dials in Britain. I have dealt with this but some Specialist assuming responsibility might be considered a better arrangement.

Current work. Chris Williams is publishing his statistical analysis of dials discovered and concludes that most have been found now. However, our recorders are still finding dials and it is important that new photographs are taken of existing reported dials. Chris Williams, Bill Linnard and myself gave a joint presentation about mass dials to the Wales and Marches Horological Society.

Special mention to Irene Brightmer, Ian Butson and John Lester with Margaret McKenzie in Wiltshire recently joining our efforts by taking decent pictures of her local dials and finding new ones in the process. Also to Alan Cook for his monograph on Yorkshire mass dials, currently part of the Register. Again, thanks to NADFAS for continuing to inform us of dials on churches that they are recording. The collection of over a thousand colour slides of mass dials taken by Noel Ta'Bois has been transferred to CD but has still to be classified and indexed. I hope that we can acquire further similar collections.

In conclusion, work is progressing on the Register and our understanding of these dials is slowly improving. My thanks to all Members who have contributed in some way over the past year.

Saxon Dials: Tony Wood. Mike Cowham is continuing his study of Saxon dials using the Mass Dial Register and report files. It has been decided that they will be called 'Saxon/Celtic' as the Irish and Welsh 'column dials' are contemporaneous. A Welsh example has been rediscovered at Towyn and the Society is hoping to arrange its removal to a more secure site.

Museums Survey: Tony Wood and Ian Butson. Following the request from Council that the results of the Museums Survey be published, this is being carried out by Ian Butson, who has prepared the text from the Survey Reply forms returned to me over the period 2003-2007. Additionally, Ian has prepared appendices covering makers and dial types. Jill Wilson is assisting Ian by proof checking (following her experience gained with the Biographical Index and other publications) and editing the layout. The completed text is now on CD and Ian's and Jill's computers and I have a full printout. We three are currently proof checking with the aim of handing over to John Davis for publication as BSS Monograph No. 7 within a couple of months. Further museums information is now being consigned to a 'second edition' file.

Website: Richard Mallett. The existing website (*www.sundialsoc.org.uk*) is working well on the new host (AFMU) and is being kept updated, while the new website is currently being developed on one of the two 'spare' domains (*www.sundialsociety.org.uk*) which is currently password protected to hide it from the search engines while the new site is being developed. The usage statistics (monthly averages) for the current website are as follows:- unique visitors 2621; visits 3431; pages 13859; hits 51354; bandwidth 601 MB.

5. Treasurer's Report: Graham Stapleton.

The Treasurer had no points to raise that were not already covered in his written report (Accounts elsewhere with this issue), and there were no questions from the floor.

6. Election of Officers.

The Chairman thanked the retiring Secretary, Douglas Bateman, for his valuable service to the Society over the last ten years. Graham Aldred had volunteered to fill the position.

The Chairman then proposed that Richard Mallett, our webmaster, be appointed a Trustee, to fill the vacancy left by the retirement of the Secretary. Nominations for all posts, including that of Graham Aldred as Secretary, had been proposed and seconded. There being no other nominations from the floor, the following were approved by a show of hands, and the Chairman declared them duly elected.

Chairman, Secretary and Treasurer. Chris Daniel, Graham Aldred and Graham Stapleton respectively.

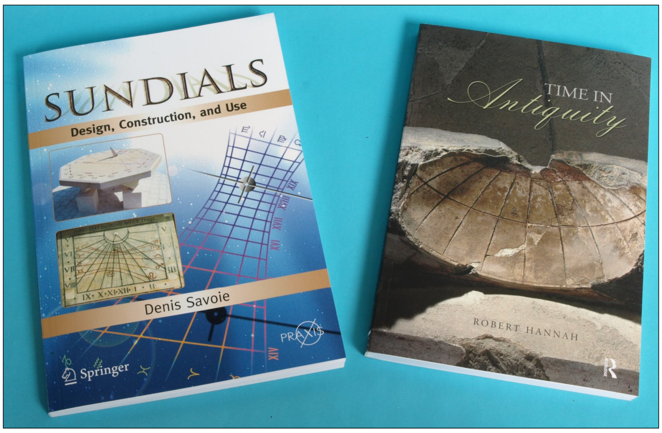
Members of Council. Jackie Jones, John Davis, John Foad, Richard Mallett and Patrick Powers.

Audit. Geoff Parsons audited the accounts for 2008, and had kindly agreed to do so again for this year. His appointment was approved at the meeting by a show of hands.

7. Any Other Business

No points of 'Other Business' were raised, and the Chairman closed the meeting at 1:00 pm.

BOOK REVIEWS



Time in Antiquity by Robert Hannah.
206 pp. Routledge, 2009, soft covers., £21.99.
ISBN: 0-415-33156-0

This book joins a publication series devoted to the presentation of science in antiquity. It considers mainly Greek and Roman timekeeping with a lesser consideration of earlier periods in Babylon and Egypt. Hannah attempts to show a progression in time measurement from the sixth century BC in archaic Greece to the third century AD in the Roman Empire. He believes that sundials carry an extraordinary evolutionary responsibility and his book depicts this. Moreover, his professorship of classics at the University of Otago, New Zealand, gives him the advantage of a command of classical literature with which to interpret the various references to timekeeping by playwrights, satirists and philosophers. He knows, for example, what Aineias said about water clocks, what Anaximander thought about the gnomon and what Aristophanes in his 'Clouds' had to say about missed festival days in an imperfect calendar.

Although describing dials, oil lamps and water clocks of varying degrees of sophistication, he is at pains throughout the book to attribute a true understanding of the movement of the heavens solely to the philosophers, and rather concentrates on the common users of timekeepers as their interests drift from the seasonal needs of the rustic towards the later precise times of day demanded by the city lawyer and doctor. In a curious aside Hannah reveals that the zodiacal divisions used in Greek and Roman astrology survive in people's minds today and were recently made use of in car licensing renewals in New Zealand. His first chapter, entitled 'Cosmic Time', lucidly describes the variations in rising and setting times and azimuths of the sun, moon and stars; he discusses their use in finding time and season and sets forth the well-known difficulties of reconciling solar and lunar years and annual day count.

Early clepsydra or water clocks, dating from 1400 BC in Egypt, are discussed in some detail. It seems they first consisted of a vessel with a hole in the bottom through which water drained. They are not really clocks at all but merely timers. Nevertheless they became quite sophisticated over the years, becoming conical in shape to allow for reducing pressure as water level sank. When fully attended they did serve as clocks and indeed as calendars, with a day peg moveable in a ring of pierced holes in a connected wheel. Hannah is sufficiently up-to-date to note the recent discovery of a portion of such a refined instrument at Vindolanda on Hadrian's Wall. But his description of a water clock would have been much enhanced by a diagram, perhaps showing the header, regulator and receiver tanks together with the float, counterweight and display disc.

Oil lamps also lent themselves to time measurement. The ordinary, ubiquitous clay oil lamps would burn for a length of time fixed by their size, the amount and quality of the oil, the flame size and the material of the wick. It seems that their restriction to measuring small pockets of time favoured their use in sacred performances, invocations, magic rituals and the like.

Much of the book is devoted to sundials. Typically, classical dials are scaphe dials, either quarter spheres ('hemicyclium') or half cones carved in stone blocks, although a few planar dials have survived. In scaphe dials the gnomon, a metal rod extended, at first vertically, to the centre of the sphere, while in later dials it stretched horizontally from the north edge of the dial to the same central point. The shadow of the tip of the rod indicated the time. The equatorial line was cut in the stone along a great circle plane forming an angle with the gnomon the complement of the required latitude. The Roman engineer Vitruvius, in the first century BC, gave brief descriptions of sundials but his account lacks illustrations and interpretations vary. Hannah attempts an illustrated procedure for making a scaphe dial but it is fair to say that his account lacks the clarity of that of Alan Mills (*BSS Bulletin*, 12.1 and 12.2) where we learn that in classical fashion the equatorial and solsticial curves may be divided into hourly or fifteen degree segments and joined with a flexible straight-edge. This method, although incorrect in theory, is sufficiently accurate for latitudes up to about fifty degrees and was doubtless the method used in classical dial construction. The conical dial was simpler to make, requiring only a straight-edged guide but the principle was the same. Inaccurate constructions were common and hour lines meeting incorrectly at the root of the gnomon are plentiful.

Two remarkable timepieces are prominently described. The first is an early equatorial dial from Oropos studied by Karlheinz Schaldach (who guided the first BSS tour in Germany). Hannah's drawing, taken from Schaldach, has omitted the dial face in the original and is thus confusing. It is the only equatorial dial mentioned in the book and the only one showing equal hours, intervals well understood by classical astronomers. The second is the Antikythera Mechanism, an extraordinary but eroded construction of over thirty gears, recovered off the tiny island of Antikythera, half way between Greece and Crete, in 1901. It has been dated to the first century BC. Recent X-ray examination suggests that eclipses of the sun and moon could be predicted with its aid. Such sophistication is no more than illustrative of the achievements of the classical timekeepers.

There is, of course, much more to this excellent book than I have indicated and it is thoroughly recommended.

Frank Evans

Sundials: Design, Construction, and Use by Denis Savoie. pp.181, soft cover, colour & b&w illustrations thoughout, Springer-Praxis (2009), £18.99, ISBN 978-0-387-09801-2.

Denis Savoie is quite well-known to the sundialling world as the President of the French sundial society, the *Commission des Cadrans Solaires*. He has published several dialling books previously but most of these have been advanced texts with significant amounts of mathematics and written in French. But now his 2003 book on simple dialling has been translated into English and published as part of a series on popular astronomy.

In many respects the book can be regarded as a modern version of the classic text by Waugh, beloved by all diallists. It contains the minimum amount of mathematics required to delineate all the standard forms of dial and what equations there are make use of current terminology—none of Waugh's logarithms to confuse the readers! But now there are good colour photographs throughout and clear diagrams—also in colour and with an 'artistic' look designed to encourage the general reader as well as the more academic.

As befits a book by an astronomer, the opening chapters deal with the astronomical basis of sundials and something on their history as well as an dealing with the equation of time. Then the chapters on actual sundials begin logically-with the equatorial dial before moving on through the horizontal, vertical, polar, analemmatic and so on, There is even a chapter on sundials for the tropics, discussed in the last *Bulletin*. Each chapter explains the principles of the type before showing examples and giving practical description of how they can be constructed, using trigonometry or simple construction. These appear to be targeted particularly at teachers. Inset panels carry asides on topics ranging from the faults of mass-produced dials to Babylonic hours. Finally, a set of appendices contain the more hardcore information, data and mathematics that true enthusiasts will want.

The French origins of the book are apparent by the large number of French dials used as illustration but it is none the worse for showing unfamiliar examples. The quality of the translated English is very good. Recommended to both beginners and more advanced diallists.

John Davis

A ROLLER IN A COTTAGE GARDEN?

ROB ALTON

In the BSS June *Newsletter* (no. 52), John Davis challenged members "to write some short notes of your local dials" and suggested possible reasons why they may have been erected. This report is about a dial in my front garden, on public view but privately owned. I hasten to write that I am not "the local squire" and the dial is not where it is now "as a result of a road-widening scheme". However, its position in the garden was determined, in some measure, by me extending the garden into the driveway because I had given up driving.

I would also like to make it clear that the dial is not on "the site of a hideous crime" but it nearly was, as will be hinted at shortly. Neither is it "just an ancient feature of the town" – but the owner will be with a touch more patina.

The garden is my attempt to create that special Cottage Garden feeling – picket gates and fences, vegetables, hollyhocks and fruit trees, "the charm of which" William Lawson (the Izaak Walton of gardening) writes, "is its informality". Quite a challenge in today's urban environment.

Unlike doves, sundials do not feature in the paintings I've seen of cottage gardens. In fact, I've only seen one, painted by John Horner. Richard Jefferies frequently mentions sundials in his writings which would suggest that there was a dial in his home garden at Coate Farm. In the 'Dewy Morn' for example, Jefferies writes:[1]

> "Upon the green and tarnished face of the ancient sundial there was written in worn letters 'Nihil nisi umbra' – Nothing without shadow; no, not even love."

Having decided that a sundial would be an interesting feature and also enhance the composition of the garden, I ordered a 10" armillary sphere from Alan Thompson which suited my purpose admirably. A far more difficult decision was a suitable pedestal. Then I saw advertised for sale a farm granite roller, lately utilised to train heavy horses. It measured about 84" × 13" diameter. What a find – a link with the past.

The installed dial, with its motto

I wasn't around when they loaded the roller into the van and I was in the way when the two stalwarts off-loaded it. After much pulling and pushing (where *is* that heavy horse?) levering and sweating, the roller was manoeuvred into the prepared hole, spragged vertically and left to settle for a few days.

I had a small assortment of DIY tools but I quickly learned that removing the protruding 1" diameter axle from a 13" diameter roller with a 12" hacksaw is a raw-knuckle, non-chuckling job. New, high-cost blades had to be bought and eventually the axle was removed. This left an irritating stub which also had to be removed. My files were unsuitable and not up to it. I was advised to get an angle-grinder and bought the cheapest. The shower of golden sparks shooting upwards and outwards were very pretty until I noticed some blue sparks and an acrid smell of burning. A long cooling-off period seemed to be indicated. The dial base-plate still rocked so more grinding was necessary: the neighbours' curtains twitched ominously.

The base-plate bolt-holes were eventually marked on the top of the roller and drilling commenced. A trip into town for a higher specification masonary bit and a new hammer-drill soon became a necessity. My Old Dutch began to talk fiscal policy. Three hours later, the base-plate literally dropped into place – courtesy of three over-sized holes – but still rocked. Play-dough does help to keep the fingers flexible.

Fixing the motto plate "O tempora! O mores!" (*Alas! what times and manners!* Cicero) was merely a matter of drilling


K. Alton

Installing the roller

Gillian Erskine-Hill

The dial in its setting

Gillian Erskine-Hill

BSS logos in mild steel forming part of the archway

two holes. Because I have a problem drilling horizontal holes, my wife graciously said she would do it. I have to say that the holes were certainly horizontal but they did not align with the plate holes. I referred earlier to the possibility of a hideous crime. Two hours more and two holes later, the plate was fixed.

A local blacksmith made me a metal arch which I so placed that the eye is drawn through it, effectively 'framing' the dial and pedestal so that they become a feature of the garden as opposed to an ornament. Incorporating two 12" × 10¼" copies of the Society's logo into the framework of the arch provided a visual and attractive motif and an extra talking-point, connecting the dial with the objects of the BSS. Shall I be sent to prison?

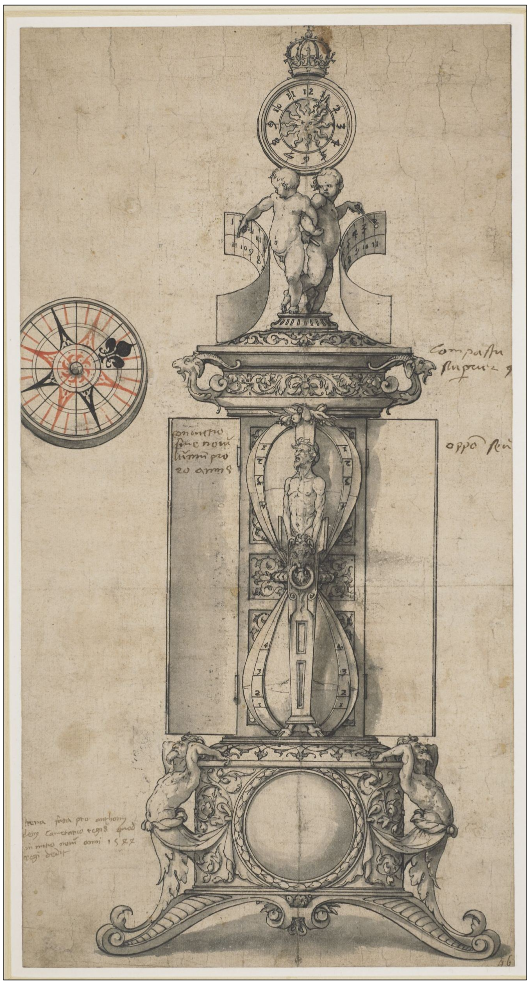
My measure of a successful project is whether I would do it again. In this case, the answer is "yes, I would".

REFERENCE

1. Richard Jefferies: *The Dewy Morn* (1884). Republished by Wildwood House (1982). I am indebted to Jean Saunders, Hon Secretary of the Richard Jefferies Society, for her unstinting patience in providing me with this information.

The author lives in Devon

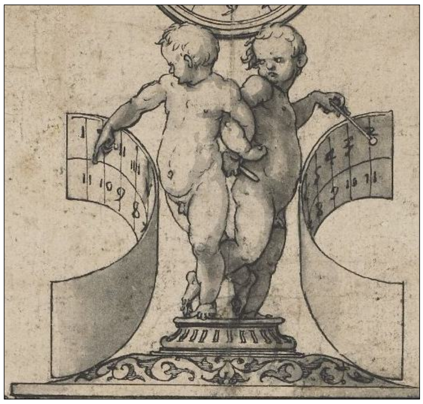
HANS HOLBEIN'S DESIGN FOR A CLOCKSALT



Hans Holbein the Younger (1497-1543) was the court painter to Henry VIII. As well as painting many great images, he also produced designs for silversmiths, such as this one, now in the British Museum, for a clocksalt which the inscription says was made for Sir Anthony Denny to give as a New Year's gift to the king in 1544/5.

The centre of the clocksalt is an hourglass (enclosed behind hinged doors) while on top two putti hold curved east- and west-facing sundials. A clock with a blazing sun at its centre rests on their heads, surmounted by a crown. A compass, drawn separately, would have been placed in the section above the hour glass.

The drawing, in pen and black ink with grey and red washes, was made at the end of Holbein's life. It is 410 mm high so is probably life-sized. The two marginal notes are in the handwriting of Nikolaus Kratzer, a friend and compatriot of Holbein's. As 'Keeper of the King's Horologies' and a famous sundial designer, Kratzer was almost certainly responsible for the designs of the instruments in the drawing. Holbein's very famous painting *The Ambassadors* also features several of Kratzer's sundials and his portrait of Kratzer hangs in the Louvre.



The delineation of the dials is curious. Each dial is divided into what appear to be 15° segments each with two rows of numbers. The upper row of numerals for the east (left) dial run 1am to noon (hidden) for the normal equal hours and the lower numbers on the west (right) from noon (unseen) through to 11 pm. But the other rows (lower on the east and upper on the west) run in the opposite directions and so seem to count hours from midnight. Can anyone explain this?

The clocksalt, alas, has not been seen for several centuries. It would have been a spectacular and expensive piece.

JD

Courtesy of the Trustees of the British Museum

THE HOUSEWIFE'S TRICK

CHRIS LUSBY TAYLOR

Summary

A.P. Herbert suggested that housewives probably just turned their garden sundials a bit to agree with their watches. He called this "The Housewife's Trick" and claimed that experiments showed it to work quite well. Analysis by subsequent authors has rejected the trick as being theoretically unsound and wildly inaccurate. This paper will present a method of implementing it which makes a dial in the UK tell mean time accurate to within a minute except for a few days in July, when it may be up to 90 seconds adrift.

Introduction

A properly constructed sundial can be read to a minute or two, but its reading will not be the same as one's watch. Most people would reasonably expect the dial to agree with their watches. So, a dial that shows, or can be set to show, mean timezone time would match their expectations and help to restore their faith in sundials. The alternative – a table or graph of the Equation of Time (EoT) – is accurate but difficult to apply.

Turning the dial about a polar axis is the theoretically correct way to adjust a dial. Poncet platforms achieve this. They are used by amateur astronomers to rotate a telescope or camera on a polar axis over a small range, typically 15°, to allow a one hour exposure. These platforms are much more compact than a full-blown equatorial mount, but still rather expensive and complex for standing a sundial on. Equatorial sundials have a polar axis built in, so are relatively easy to adjust to show mean time, and even summer time, but what about horizontal dials?

In his charming book *Sundials Old and New*,[1] A.P. Herbert pondered how housewives solve the problem with a horizontal garden sundial. He imagined they would surely just turn the dial to agree with the watch.

I know of nobody who has taken this seriously and not ended up abandoning it. Fred Sawyer[2] analysed it and concluded that it doesn't work well enough to be useful. But that analysis was largely based on 40° North – a typical latitude in the USA. Perhaps it works better in the UK?

Indeed it does: the nearer you are to the North Pole, the better it works. The problem with turning the dial is that the effect on the time shown is different at different times of day. The extremes are noon and sunrise/sunset. In midsummer, the rotation needed at noon can be twice that needed at sunset. But the EoT at midsummer is only 2 minutes. In the winter, when EoT can be much greater, the different rota-

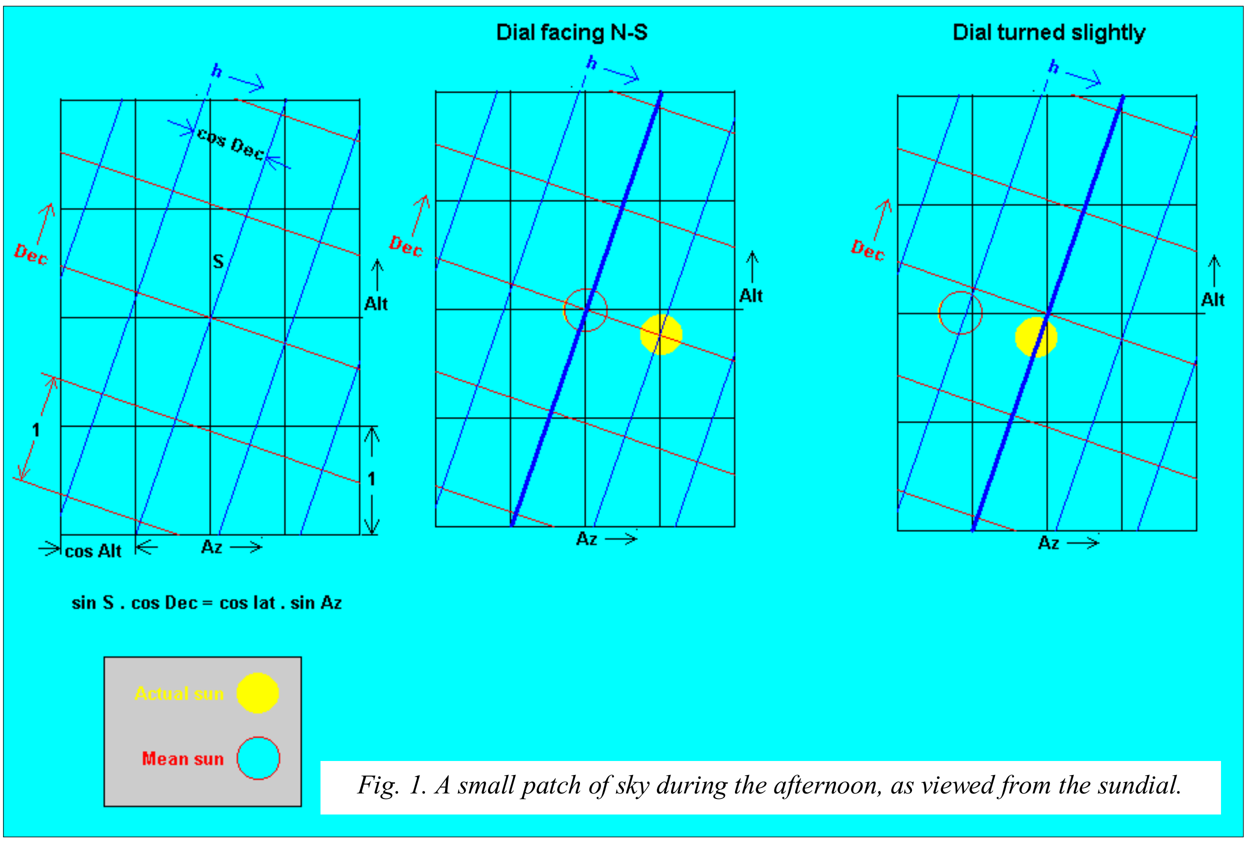


Fig. 1. A small patch of sky during the afternoon, as viewed from the sundial.

tions needed at noon and sunset are much closer. By choosing a suitable rotation angle, the maximum error can be kept to less than 1 minute of time for UK latitudes (51° North and up), except for a short period in July, when the error may get up to 90 seconds.

Analysis

Figure 1 shows a small area of the sky at some time in the afternoon, as seen from the sundial, overlaid with grids to show the lines of altitude and azimuth in black, declination in red and time in blue. At some time when the mean sun (red circle) would be in the centre of the grid on the thick blue hour line, the actual sun (yellow disk) is some distance away, due to the EoT. So, with the dial oriented north-south, it will be showing the wrong time. By turning the dial, and the gnomon with it, we can turn the grid and bring the actual sun onto that hour line.

The time h (expressed as an angle) shown on a sundial at latitude φ when the sun's apparent azimuth is Az and its altitude a is given by:

$$\tan h = \frac{\sin Az}{\cos Az \sin\varphi + \tan a \cos\varphi}$$

The hour angle h can be converted to time by noting that the earth spins 15° per hour or 1° every 4 minutes.

Using this equation, the rotation of the dial needed to change the displayed time by a small amount (one minute, for instance,) can be found for any time or date. Figure 2 shows a graph of this sensitivity for seven different solar declinations at latitude 56° (southern Scotland) from noon to sunrise/sunset. A graph for anywhere in the UK would be very similar.

It is apparent that, on any date, the extremes are at noon and at sunrise/sunset. At the equinoxes and at 6 o'clock throughout the year, the sensitivity is a constant. In the summer the daily variation is huge, in winter much less. In summer, at noon you need to turn the dial a lot more to change the displayed time by 1 minute than you do at sunset. In winter, the effect is reversed and a lot smaller. Luckily for our purposes, the EoT is small when the declination is greatest and relatively small in the northern summer.

So, turning the dial by some angle depending on the date is a compromise. But it is better than not turning it. To allow the dial to be turned by the optimal angle for any date, a date scale may be inscribed around the dial and on the base, assuming the dial is circular. The marks for any date are offset from one another by the calculated angle. The dial rotates about its centre, allowing the corresponding date marks to be aligned on that date.

What is the optimal rotation angle for any date? There are probably different views on this, but the photographed dial uses the angle that minimises the maximum error. This means that the error will be maximum at sunrise, sunset and noon, going through zero some time every morning and afternoon. In practice, most dials don't get sunlit until well after sunrise due to surrounding objects. So it would be justifiable to choose an angle that reduced the error at noon while having a greater error at sunrise/set. But for the following calculations it is assumed that this is not done.

The following is a simplified analysis that assumes the EoT is small. When it is large, very slightly better performance can be obtained with a more accurate approach.

At noon, changing Az doesn't affect the sun's apparent declination, d, so we can use the following simplification:

$$h = \frac{Az \cos a}{\cos d}$$

so the effect on the displayed time of a small rotation of the dial is

$$\frac{dh}{dAz} = \frac{\cos a}{\cos d} = \frac{\sin(\varphi - d)}{\cos d}$$

At sunrise/sunset $a = 0$ so the equation becomes

$$\tan h = \frac{\tan Az}{\sin\varphi}$$

and the effect on the displayed time of a small azimuthal rotation is given by

$$\frac{dh}{dAz} = \frac{\sin\varphi}{\cos^2 d}$$

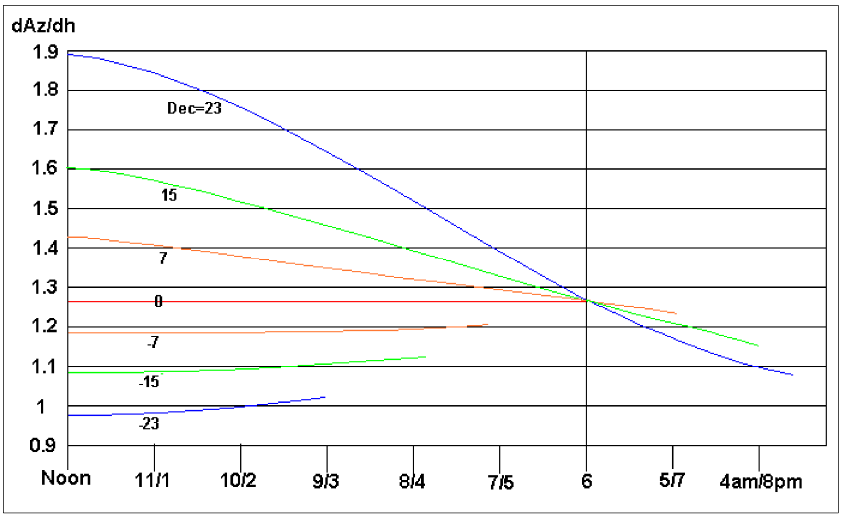


Fig. 2. Graph showing how dAx/dh varies throughout the day for different seasons for a sundial at 56° N. Note that when EoT is maximum, the graph is almost flat. Where the graph is steepest, EoT is small so the error is reduced.

The mean of these two *dh/dAz* values gives the number by which to divide the EoT to give the required *dAz* rotation for any date.

For instance, on 1 November, EoT is +16m 22s and declination -14° 25', so, at latitude 56°N:

At noon *dh/dAz* = sin(70°25')/cos(14°25') = 0.973
At sunrise/set *dh/dAz* = sin(56°)/cos2(14°25') = 0.884

The mean of these is 0.928. The EoT is +16m 22s, which, in angular terms, is +4° 5.5'

So, we should turn the dial by 4° 5.5' / 0.928 = 4° 25' clockwise. This will make the dial

0.973 × 4° 25' = 4° 17' = 17m 9s slower at noon and
0.884 × 4° 25' = 3° 54' = 15m 35s slower at sunrise/set.

But the sundial would be 16m 22s fast if it had not been turned, so it is now just 47 seconds slow at noon and 47 seconds fast at sunrise and sunset. At some time during the morning, and again in the afternoon, the error is zero. This is surely a worthwhile result – merely by turning the horizontal dial while keeping it horizontal, we can reduce the error from over sixteen minutes to less than one.

The worst case turns out to be during July when *dAz/dh* varies greatly from noon to sunrise/set but, luckily, the EoT is only five or six minutes. For a couple of weeks, the maximum error exceeds one minute and can reach 90 seconds.

Another issue in the summer is that we use BST in the UK. To make the dial read BST it would have to be rotated through a much greater angle. It loses so much accuracy in doing so that I do not propose this. Better to have the dial's hour marks show both zones, or to expect the user to make the mental adjustment.

If even more accuracy value is desired, you should take into account that the EoT affects the sunrise/sunset *dh/dAz* values. But this only affects readings in the first or last quarter of an hour of the day. For many sundials the horizon is obscured, so they never get to see the sun when it's that low. Indeed, this factor could affect how you choose the optimal *dh/dAz* for a given site. One more accurate at noon and less so at sunrise/set might be more appropriate and could allow the Housewife's Trick to be used at lower latitudes.

Fig. 3. Dial for 56° North.

Practical Implementation

The dial in Fig. 3, constructed of brass on a Cumbrian slate base, has been made by the author and installed in Scotland. The slate base is fixed. The brass dial can be rotated on it. The dial is shown oriented for a date in early February. It should be evident that in October it would need to be turned considerably clockwise. The photograph does not show the knob that was added later to allow turning without touching the brass. The closeup in Fig. 4 shows the dial set up for 5 March. By the end of the month it will have to be turned about 2° clockwise.

Fig. 4. The dial aligned for 5 March.

For aesthetic reasons, half the adjustment (such as the 4° 5.5' on 1st November) was applied to the fixed marks on the slate base, the other half to the brass. The 366 daily marks were first calculated to be equally spaced, then, for instance, the 1 November mark on the slate base was moved 2° 2.75' clockwise before being engraved, whereas the mark on the brass dial was moved 2° 2.75' anticlockwise. So, when the marks are aligned on that date, the brass dial will be 4° 5.5' clockwise from its average orientation. All marks were calculated by computer and engraved by computer controlled engraving machine.

Since the dial can, in principle, read GMT to within one minute, it has other sophistications – longitude adjustment, a noon gap and adjustment of all time marks to compensate for the error in perceiving a shadow's edge.

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Equation
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WATCH SLOWER
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