

# The British Sundial Society

## BULLETIN

75th edition



# 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.
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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)  
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**Front cover:** *A timeless scene. This horizontal dial by the provincial dial-maker and bell-founder Thomas Eayre (1691-1757) is still leaded onto its original pedestal and could well have stood at this same location in central England since it was made. Photo: John Davis.*

**Back cover:** *The Triangular Lodge at Rushton, Northamptonshire, was built by Sir Thomas Tresham c.1597. Everything about it is in factors of three, including the three vertical sundials, one on each of the faces. The stones would originally have been painted but some traces of the hourlines, preserved by differential weathering, can still be seen. Unfortunately, the dial on the north face (on the right in the picture) has its gnomon upside down—English Heritage have been informed. Photo: John Davis.*

# BULLETIN

## OF THE BRITISH SUNDIAL SOCIETY

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### EDITORIAL

This is our 75<sup>th</sup> edition! To mark this occasion, the cover colour has been changed, for this issue only, to blue. Never fear, the famous BSS sunny yellow will be back next time. Perhaps we will repeat this change for the 150<sup>th</sup> issue, so that your bookshelves will have markers to show our progress.

We also have an extension this time to 52 pages, allowing slightly more to be packed in. When our founding Editor, Charles Aked, started in 1989, he rationed the material to hand in case he used it all up too rapidly. I am pleased to report that, 75 issues later, there is no sign of there being a shortage of things to write about in the dialling world.



### Dial the Sun

I shun the shade  
I thirst the sun  
For I was born e'er time begun  
On a summer's day I rise 'fore the rest  
On a winter's day I take my rest

By humble croft, by loftier keep  
I tell my tale e'en while the restless sleep  
Wrought of iron in the smith's mighty grasp  
Hewn from virgin stone, wrought of burnished brass

Electricity technology all I shun  
For as life itself, I only crave the sun,  
Invention, innovation, I've left them all on the shelf  
For strive as you may, I am simplicity itself

As history itself has passed me by,  
Whilst eternal I tell my story 'neath God's blue sky  
Whilst innovators search, whilst inventors scheme  
Whilst there is light, I still reign supreme.

*Ki Chapman, Lowestoft, 2010*

# A NEW BABYLONIAN AND ITALIAN HOURS SUNDIAL FOR SELWYN COLLEGE, CAMBRIDGE

## Part 1. Design and Construction

FRANK H. KING

*The new Selwyn Dial was inaugurated in March 2010 and a non-technical description<sup>1</sup> published on the Internet generated considerable interest. Several readers commented that incorporating an introduction to Babylonian and Italian hours in a Bulletin article would be appreciated. Others commented that it was interesting to see photographs taken in the workshop. What follows takes these comments into account. There is also some emphasis on the way the design evolved.*

### Genesis

Once in a while, deeply buried in the mire of administrative chores and general spam, an email arrives which turns out to be a golden nugget. On 5 November 2008 a message appeared in my inbox from Professor Richard Bowring, the Master of Selwyn College, Cambridge. It began:

Dear Dr King

Selwyn has received a benefaction which has one string attached to it; we are to have a sundial...

There was an invitation to lunch to discuss possibilities but no mention of a budget or any other constraints. I accepted the invitation and made a covert reconnaissance visit.

Selwyn College first opened to undergraduates in 1882 and its oldest buildings date from that time. In recent decades the College has expanded considerably and there are numerous south-facing walls to regard as candidate sundial sites. There are also many paved areas and lawns. These are potential sites for analemmatic sundials or sundials on pedestals but, in Cambridge, college lawns are treated as hallowed ground. Only Fellows and gardeners are permitted to walk on them; a sundial would be enjoyed by only a select few.

The original court, Old Court, is still the heart of the College and this seemed to be the best place to explore. The court follows a traditional plan with a roughly square lawn surrounded by paving. Three sides are dominated by the gatehouse, chapel and hall. The fourth side, the north side, is largely student accommodation.

I retired to my office and, courtesy of Google Earth, established that the north side of Old Court declines about 4° west.

I had recently returned from a short trip to Italy where I had had breakfast each day in sight of a dial that indicated Italian hours (hours since the most recent sunset). I wondered how such a dial would look on the north range of Old Court. I made an outline sketch and was unable to resist the temptation of adding Babylonian hours (hours

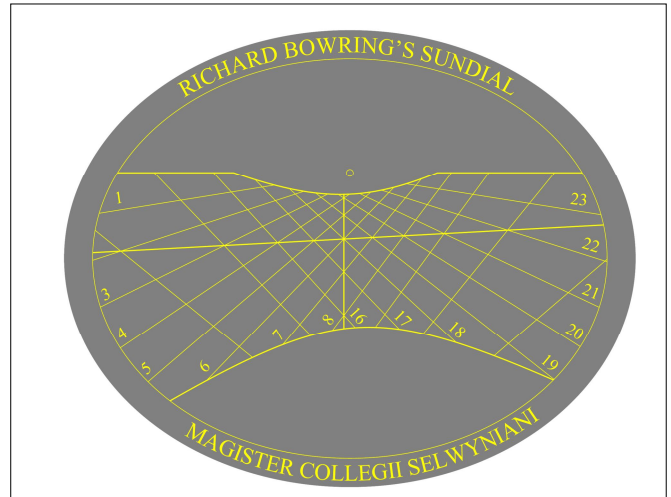


Fig. 1. A first sketch.

since the most recent sunrise). See Fig. 1. I included this sketch in a portfolio of photographs, diagrams and props that I proposed to take with me to lunch.

Over lunch I described a number of sundial types and expressed my own preference for vertical dials over horizontal dials on two pragmatic grounds. First, horizontal dials are harder to read at a distance and, secondly, they suffer from rain and general detritus, not to mention a problem alluded to in one of Hillaire Belloc's less well-known sundial mottoes:

*I am a Sundial. Ordinary words*

*Cannot express my thoughts on Birds.*

I explained my liking for wall dials that dominate public squares in Italy and, more locally, for the wall dial in Queens' College just down the road. After lunch, I suggested a spot on the north range of Old Court that would be ideal. Nevertheless, there was early enthusiasm for an analemmatic sundial which could be incorporated into the Old Court paving.

The most suitable site had many merits but it was near a passage that led to another court. In use, a dial in this position could interfere with the free flow of people walking about. I handed over an outline design for an analemmatic sundial but I also handed over my first sketch.

Most of the dials that I have had a hand in have been executed on slate and the principal purpose of this sketch was to give just a hint of the elegance of gilded slate. Yellow lines and poorly aligned lettering on a dark-grey background are a pale imitation of the real thing but they give the right idea.

I chose an elliptical shape because it suited my favoured site, a blank area of brickwork between the corners of four windows.

A secondary purpose of the sketch was to show that sundials can readily incorporate inscriptions. Selwyn has a strong tradition in the classical languages so a mixture of English and Latin was used for the sample wording. At this stage the name of the benefactor had not been made public so I referred instead to my host, the Master of Selwyn College.

The hour-lines on my sketch were originally intended as sample gnomonic features but, by now, my own enthusiasm for a real dial that indicated Babylonian and Italian hours had grown. Somehow I had to convey this enthusiasm to the College. I stressed that a sundial based on my first sketch could be both elegant and educational, very appropriate for a Cambridge college.

### Changing Perceptions

It is unfortunate that so many people, chancing upon a sundial, compare the indicated time with the time on their watches. The result generally reinforces the Belloc view that sundials make a botch of what is done far better by a watch. I suggested that a prospective sundial owner should consider choosing a design that accurately indicates a time which is so different from ordinary clock time that there is no danger of being confused with it. As Chris Lusby Taylor<sup>2</sup> almost said at the BSS Exeter Conference:

*I am a Sundial. I'm prepared to bet  
Your watch can't tell when the sun will set.*

I also outlined some history, noting that the introduction of mechanical clocks had forced a change from using unequal hours to equal hours. These clocks ran from 0h to 24h but midnight was not necessarily the best moment to start and end the day. It is rather difficult to estimate the moment of midnight unless you are a trained astronomical observer.

Running a 24-hour day from noon to noon was a possibility. Greenwich Mean Time itself used this scheme until 1926. Until then, the dates in navigators' logs changed at noon and not at midnight.

The traditional day had begun at sunrise and ended at sunset and these were two other obvious possible reference moments. One advantage of using sunrise or sunset is that these moments can be estimated, albeit only approximately, even when the sky is overcast.

The new clocks with their new ways of indicating time spurred the development of new designs of sundial, for sundials were the most convenient way of setting mechanical clocks.

### The Cardozo Kindersley Workshop

Although a decision on the choice of sundial type took a few days, the choice of workshop to make the dial was made very quickly. Professor Bowring himself proposed the Cardozo Kindersley Workshop<sup>3</sup> in Cambridge.

It was in 1980 that David Kindersley first asked my advice about a sundial (a double wall-dial for a private client in Hungerford) and I have served as the Workshop Diallist for numerous dials since. Following David's death in 1995, the Workshop has been run by his wife and business partner Lida Cardozo Kindersley.

Commemorative plaques made by the Cardozo Kindersley Workshop abound in Cambridge and it turned out that Selwyn was the only College that did not have anything made in the Workshop. This sundial would fill a lacuna.

### The Slate and the Nodus

Once it had been decided that there would be a slate sundial showing Babylonian and Italian hours, a number of dimensions had to be specified or determined:

1. The size (and shape) of the slate
2. The size (and shape) of the nodus and the nodus height
3. The latitude and declination of the wall.

For much of the year, the range of solar azimuth during the course of a day greatly exceeds 180°. In simple terms, the shadow of any object cast onto a wall races in from infinity in the west in the early morning, then crawls along during the middle of the day, before racing out to infinity in the east in the evening.

For any real dial, there will be periods when the shadow is off the dial to the west in the morning and off the dial to the east in the evening. This suggests that the dial should be as wide as convenient: to be landscape rather than portrait.

A rectangle would be fine but the proximity of the corners of two first-floor windows, either side of the intended site for the dial, limits the width unless the upper corners of the rectangle are rounded off. Further rounding-off suggested an ellipse, one of the few decisions which didn't change from the first sketch.

As delivered by Ivett & Reed, a local supplier of stone, the ellipse had major and minor axes of 1067 mm × 864 mm. This is about as large a slate as can be readily handled. It was 35 mm thick and weighed around 76 kg. It is standard workshop practice, whenever such a slate is turned over or lifted from a table to an easel, to wear safety boots.

On the celestial sphere, Babylonian hour-lines and Italian hour-lines are great circles and these project into separate families of straight lines on a plane dial. The lines in each family do not meet at a point so a gnomon whose shadow indicates a line on the dial cannot be used. Instead a nodus whose shadow indicates a point on the dial is required.

Here there are two design considerations that do not apply to a sundial which has a conventional polar-oriented gnomon. You have to design a nodus and an appropriate support, and you have to choose the nodus height, the perpendicular distance of the nodus from the dial. The sub-nodus point is shown as a yellow circle in Fig. 1.

The nodus is a simple disc, 27 mm in diameter and 2 mm thick, almost exactly the size of a £2 coin. It is supported by

Fig. 2. The nodus and nodus support.



a 9 mm diameter rod set in a hemi-spherical base. The nodus height is 175 mm. All this was fabricated in brass by Mackay Engineering of Cambridge and the newly-delivered nodus is shown in Fig. 2 casting a trial shadow onto my slate-coloured document case.

The nodus height governs the scale of the gnomonic features on the dial. If the height is reduced, the diamonds of the criss-cross pattern close up. The design looks more cramped and it becomes more difficult to read the times but the shadow of the nodus is off the dial to the west or east for a smaller proportion of the day.

The chosen nodus height, 175 mm, is a compromise. In summer, the shadow is on the wall but off the dial for about an hour in the morning and another hour in the afternoon. Around the summer solstice, there are further prolonged early morning and late afternoon periods when the sun is on the north side of the wall.

No point on the dial is more than around 600 mm from the base of the nodus support and this figure and the nodus height of 175 mm were used to determine the diameter of the disc nodus. If the nodus is too small its shadow, at extreme points on the dial, degenerates into pure penumbra and does not show up very well.

One needs to imagine a bug, equipped with heavy-duty sunglasses, at the 600 mm point staring at the nodus. The nodus is 625 mm away because, by chance, (175, 600, 625) is a Pythagorean triplet. To the bug, the disc appears as an ellipse whose major axis matches the diameter of the disc but whose minor axis is reduced by a factor of 175/625 (the sine of the angle subtended by the nodus support).

If the minor axis subtends an angle less than the angular diameter of the sun, the bug will be able to see the limb of the sun on either side of the minor axis when the sun aligns with the nodus. The bug will not be in full shadow. The chosen diameter for the disc is 27 mm. When seen by the bug as an ellipse, the minor axis is 7.56 mm. At a distance of 625 mm this subtends an angle of about  $0.7^\circ$ , comfortably greater than the angular diameter of the sun,

about half a degree. Note that the shadow of a circular nodus mounted parallel to a plane dial will always be a circle, albeit modified by the surrounding penumbra.

There are numerous ways of determining the latitude and orientation of a wall. Preliminary values had already been determined via Google Earth to produce the first sketch. For more refined values, it was decided to use a local company, Hurst Surveys of Toft, who had previously undertaken topographic surveys for the College. By a delightful coincidence, one line of the postal address of Hurst Surveys is Meridian Court. Their premises are very close to the Greenwich Meridian.

Hurst Surveys use highly specialised surveying kit which exploits the Global Positioning System (GPS). In the photograph in Fig. 3, a GPS receiver can be seen mounted on a tripod. A second tripod (off the picture to the right) provides a reference direction.



Fig. 3. Surveying the wall using GPS.

In general terms, the equipment notes the ephemeris data of each satellite in sight but, via a mobile telephone, uses information provided by a fixed base station some miles away to correct the data. The position of the base station on the National Grid is known to high precision.

Two pieces of surveyors' reflecting tape were stuck to the wall about 1 m apart and at the same horizontal level. Each piece of tape was marked with a cross and the two crosses were surveyed using a total station. The survey data was processed back in the office and a full report was delivered. This included the Grid Coordinates of the two points each specified to 1 mm precision relative to the National Grid reference origin off the Isles of Scilly. These days the National Grid<sup>4</sup> is *by definition* a transformation of the European Terrestrial Reference System 1989 (ETRS89) which, in turn, relates to the main European tectonic plate.

The report gave the orientation of the wall relative both to grid north and to true north. Defining true north is now almost as challenging as defining time but the indicated precision, about 3 arc-minutes, was sufficient for my purposes. A precise estimate of latitude was bundled in at

no extra charge. The values assumed in all subsequent calculations were:

Latitude =  $52^{\circ} 12' 3''$  and Azimuth =  $184^{\circ} 26'$

The azimuth here is the azimuth of the outward normal to the dial measured clockwise round from true north.

### Refining the Design

With the dimensions of the slate and the nodus height now known and the wall parameters determined too, I refined the first sketch. The revised design is shown in Fig. 4.

By this stage, I had discussed the design with Lida Cardozo Kindersley who suggested two immediate improvements. First, she suggested dispensing with the inscription band. There was plenty of room for inscriptions above the horizon line and below the summer solstice curve. An important additional benefit from this change was that there was more real estate on the west and east margins of the slate that could be used for the hour-lines.

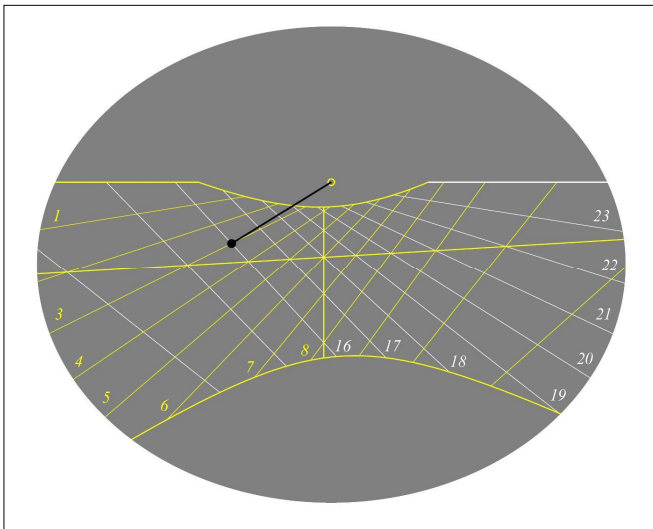


Fig. 4. 3h Babylonian hours, 16h Italian hours and 09:30 French hours.

Secondly, she suggested colour-coding the two families of hour-lines. We decided the Babylonian hour-lines should be gilded and the Italian hour-lines should be painted off-white.

These suggestions are incorporated in Fig. 4. Notice that the eastern end of the horizon line equates to Italian hour 24 and is therefore white. The labels on the Italian hour-lines were also changed to white.

There was considerable discussion about whether the Babylonian hour-lines should run across the Italian hour-lines or *vice versa* or whether the all lines should break at the crossing-points. It was eventually decided that Babylonian hour-lines should go on top. It was also decided that the three constant-declination lines and the noon line should be gilded as in the first sketch.

Fig. 4 incorporates a synthetic shadow. Compare this with the shadow in Fig. 2. The shadow of the nodus falls on the Babylonian hour-line labelled 3 and it also falls on the Italian hour-line labelled 16. It is therefore three hours after

sunrise and 16 hours after sunset. Given that there are 24 hours in a day, there are  $24 - 16 = 8$  hours *until* sunset. Hours that count downwards to sunset are sometimes called co-Italian hours.

As will be explained in Part 2, the average of the two times, Babylonian hours and Italian hours, gives what will be referred to here as French hours, often called modern or common hours. This is the time that would be indicated on a normal sundial with a polar-oriented gnomon.

In Fig. 4, the average is  $9\frac{1}{2}$ , the average of 3 and 16, which corresponds to 09:30, two and a half hours before noon.

### Further Refinements

By now, Lida Cardozo Kindersley had assigned one of her apprentices, Russell Purdham, to undertake the setting out and cutting. Several further refinements to the design were made. First, Lida had more information about the proposed inscriptions and said that the design should be shifted upwards on the slate to make more space below the summer solstice curve to accommodate the inscription that was to go there.

Secondly, I noticed that, in my first sketch, the sub-nodus point was on the vertical centre-line of the slate, the minor axis. The design was shifted slightly to the right to ensure that the noon line falls on the minor axis of the ellipse instead.

Thirdly, Lida and Russell pointed out that the natural viewpoint would be several metres from the dial and the lines should be heavier. It was decided that all the gnomonic lines should be 5 mm wide.

Fourthly, Lida proposed that the top region of the dial should have a fiery sun. There would be space for a short inscription in the centre of the sun.

Finally, Russell solved a problem which is evident on the first sketch: one of the Babylonian hour-line labels is missing. To reduce clutter, it was decided early on to restrict the labelling of the Babylonian hours to the morning side of the noon line and the labelling of the Italian hours to

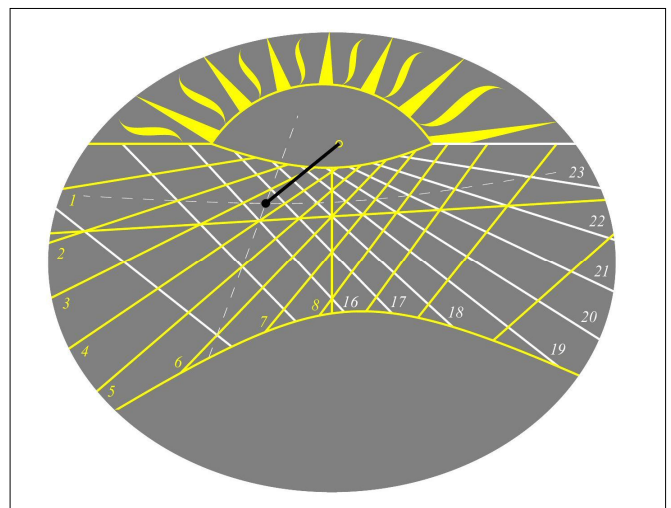


Fig. 5. 3.5h Babylonian hours, 16.5h Italian hours and 10:00 French hours.

the afternoon side. It was also thought that Babylonian hours are most useful in the mornings and Italian hours are most useful in the afternoons.

A more difficult decision was how to accommodate the label for Babylonian hour 2. This label is missing in Figs. 1 and 4 because, in its natural position above the associated hour-line, it would fall across the left-hand end of the equinoctial line. Russell's solution was to have labels 1 to 5 below their respective hour-lines. This meant having 5 and 6 in the same cell but that doesn't spoil the appearance.

Fig. 5 shows my rendering of the design at this stage. The shadow of the nodus is shown half an hour later than it is in Fig. 4. The Babylonian and Italian hours are now 3.5h and 16.5h respectively. The average is 10 indicating that normal sundial time is 10:00.

The shadow of the nodus approximately follows a constant-declination curve during the course of a day and the relevant curve in the present case is shown as a broken line. This runs through a sequence of crossing-points in the criss-cross pattern. It will be shown in Part 2 that for a constant-declination curve to run through the crossing-points in this way, the number of hours from sunrise to sunset must be an integer.

In Cambridge, the number of hours of daylight varies from fewer than 8 hours to more than 16 hours so there are nine declinations for which the constant-declination curve runs through crossing-points. In the example shown, the number of hours of daylight is 11 and the declination is  $-5.78^\circ$ .

A second broken line joins the crossing-points which correspond to 10h French hours. This is a straight line and would be the regular 10h hour-line on an ordinary sundial. As such, its upward extension intersects the upward extension of the noon line at what would be the root of the polar-oriented gnomon if this sundial had a gnomon.

### Setting out

When a slate is being worked on, it is generally either flat on a table or almost vertical on an easel. Often, the slate is on a table for marking out and on an easel for cutting.

The traditional approach is to begin by establishing the major and minor axes of the ellipse. Ruler and compass constructions are not very helpful here and the usual method is to make a rubbing of the entire slate outline on tracing paper and fold the result in half both ways to establish the axes. The ends of these axes are transferred to the slate as light tick marks.

The next step was to mark the sub-nodus point whose coordinates (in millimetres) relative to the centre of the ellipse are (13.6, 223). The horizontal offset of 13.6 mm ensures that the noon line falls on the minor axis given a nodus height of 175 mm. Russell and I then set out a grid of 100 mm squares, effectively making a large piece of graph paper with the sub-nodus point as the origin.



Fig. 6. Russell Purdham setting out the summer solstice curve.

The hour-lines were set out first and, as they are straight lines, each can theoretically be specified by just two points. Nevertheless, I prepared a spreadsheet showing the coordinates of five points on most hour-lines. We drew best-fit straight lines through the points.

For the winter and summer solstice curves we used the end points of all appropriate hour-lines and several intermediate points as well. Using a flexible strip of wood and G-cramps we set out the winter and summer solstice curves as illustrated in Fig. 6.

A single line is not a suitable guide for a stone-cutter because the line disappears at the first cut with a chisel. The standard practice is to draw parallel lines on either side of the centre-line. Although it is difficult to see in Fig. 6, each of the hour-lines is actually a triplet of lines with the outer lines 2.5 mm either side of the centre-lines. It is the outer lines which are used as guides for cutting.



Fig. 7. Most hour-lines now cut.

### Cutting

When all the gnomonic features had been set out, the slate was transferred to an easel and Russell embarked on the cutting. Fig. 7 shows the appearance of the slate after the equinoctial line, the summer solstice curve and most of the hour-lines had been cut.



The nodus has been included in the photograph to show where it was intended to go. It is held in place by three M6 bolts which are screwed in through a baseplate on the back of the slate. For most of the cutting stage the nodus was kept safely in a box.

### Inscriptions

There is no sign of the sun or the inscriptions in Fig. 7 and the winter solstice curve is absent too. About this stage, it was decided that the central part of the sun should be a stippled gilded region whose lower margin should form the winter solstice curve. The upper inscription would be incorporated in this region too.



Fig. 8. Russell Purdham cutting the Latin inscription.

Fig. 8 shows the glorious sunburst complete and the upper inscription is complete too. Russell is working on the longer inscription below the summer solstice curve. The upper inscription consists of the two Greek words, ΚΑΙΡΟΝ ΓΝΩΦΙ, attributed to Pittacus, one of the Wise Men of Greece. These words translate as ‘know the time’ or ‘recognise an opportunity’. This inscription also appears on a sundial on the south side of Ely Cathedral.

In the space below the summer solstice curve there is a Latin inscription, *Collegio suo lactarius Eboracensis me dono dedit*, which is a reference to the benefactor: ‘To his college the Yorkshire dairyman gave me as a gift’. By now the identity of the benefactor had been made public. He is Jim Dickinson, a Selwyn College alumnus, and the Latin refers to just one of his professional interests.

Later, two further inscriptions were cut into the rim of the dial in the thickness of the slate itself. These are explanations: BABYLONIAN HOURS SINCE SUNRISE and ITALIAN HOURS SINCE SUNSET. The inscriptions were almost the last items to be cut. The labels on the hour-lines are the major outstanding items in Fig. 8.

### Finishing

After concluding the cutting, the slate was washed and gold leaf was applied to almost all the dial furniture except for those elements that relate to the Babylonian

hours: the hour-lines, the labels and the instruction in the rim. The nodus and its support were gilded too.

The slate was now almost ready for fixing to the wall. The traditional way of fixing slate plaques and sundials is to drill three holes a short distance into the back of the slate and glue in three pins which are used as studding. The holes are 15 mm in diameter and were drilled 20 mm into the thickness of the slate. The fixing pins are 120 mm long so 100 mm protrudes.



Fig. 9. Lifting the finished dial into position.

The slate was taken to Selwyn College where the scaffolding that had been used by the surveyors had been erected again. A template was used to position the three holes in the wall. The holes were drilled and the slate was lifted into position using a good deal of muscle power. See Fig. 9.

The slate was kept in a transparent protective covering during this stage and the nodus was still in its box. Assuming the survey data were correct and all the calculations and setting out was properly carried out, there



Fig. 10. The finished dial.

should be no need to do anything more than to ensure that the horizon line is horizontal and the face of the slate is vertical.

Some walls have such undulating surfaces that a large slate can be rocked to and fro. In such circumstances, if the sun is shining, I can cant the dial slightly so that it faces in the intended direction. The 19<sup>th</sup> century brickwork at Selwyn College was remarkably true and no such adjustments were necessary. The sun was indeed shining and I could satisfy myself that there was nothing horribly wrong. This is a nervous moment for the diallist!

The dial was lifted off the wall ready for the permanent fixing. The protective cover was taken off the slate and the nodus was bolted into place. Russell wore white gloves for this task. Plastic Padding™ was squeezed into the holes in

the wall, the slate was offered up again and I had a few brief minutes to make final checks. The Plastic Padding goes off very quickly.

The scaffolding was taken down and the sun continued to shine for just a few minutes. The finished dial was at last in its intended position. See Fig. 10.

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*To be concluded in Part 2*

## NEW DIALS

### Derbyshire Dial

This dial was made by David Brown and commissioned by a client in Derbyshire. The client wanted the dial to have a strong resemblance to the Hampton Court sundial by Thomas Tompion, particularly the design of the gnomon and the ogee shape of the perimeter. This dial, though, is slate whereas the Tompion is brass. It is 50 cm diameter and 44 mm thick. The gnomon is made of cast bronze 12 mm thick, and is gilt. There is an added nodus to indicate a wedding anniversary date curve and the vertical (north) edge of the gnomon acts as a shadow-caster to indicate solar azimuth. The chapter ring is graduated in 10-minute intervals and the client's coat of arms is engraved at the south of the dial. All the incisions in the slate surface are gilt.



*David Brown*

### Flowton, Suffolk

The BSS Editorial Office has a new sundial! Commissioned to replace a badly peeling painted wooden one, the new dial is in Carrera marble and was made by Harriet James (Sunnydials), whose monogram can just be seen in the lower right corner. The dial serves a dual purpose as it is also the house sign, being mounted on the SE side of the house so that it faces visitors arriving from Ipswich. It declines 49° from S so the origin is moved to the right of centre to make the most of the available space. It is 1250 mm tall and has a gold-plated brass gnomon which it is hoped won't leave copper stains on the dial surface. Installation was on the summer solstice, a particularly auspicious date.

*John Davis*



## BOOK REVIEW

**Time Reckoning in the Medieval World – A study of Anglo-Saxon and Early Norman Sundials** by D. Scott & M. Cowham. BSS Monograph No. 8. 140 + vi pp., A4, soft covers, colour illustrations throughout. Price £19.50 + p&p from BSS Sales. ISBN 978-0-9558872-4-6

This is an important and timely monograph with wide appeal. Important because its subject is our oldest surviving sundials. Timely because it is now approaching a century since such dials were last systematically reviewed. Wide appeal because it has much to offer both the general diallist and the specialist interested in Saxon and early mass dials.

It is perhaps English dialling's starkest irony that Saxon dials – despite being used for several hundred years and despite churches being well surveyed – should have been so little studied or appreciated. This monograph is a most welcome contribution to their rehabilitation. It considers and examines the first half (to c.1200) of the 'mass dial era'. In sharp contrast to the later abundance of 'scratch' dials, Saxon dials are rare. The authors identify just 100 candidate dials, concluding that about 50 are genuine Anglo-Saxon/Early Norman (i.e. pre-1100) dials with a further 25 judged to be later Norman.

The bulk (105 pages) of the monograph is a detailed cataloguing of these 75 dials. Each dial is imaged via colour photography and line drawings showing hour line angles (corrected for photographic foreshortening), sized via diameter measurement, located via description and photography, fully referenced to earlier literature and discussed in detail. The discussion includes (when helpful) previous images of the dial. In the light of all the evidence, each dial is dated according to a four-period categorisation – Early Anglo-Saxon (650-800), Intermediate (800-900), Late (900-1100) and Norman (post 1100). This catalogue is to a very high standard and represents a most valuable resource to specialist students and researchers.

The remainder of the monograph is devoted to developing a context and framework within which these dials can be collectively appraised. It breaks new ground on two fronts; in scope it is the most comprehensive, and analytically it is the most nuanced, yet developed. Ambition in scope and humility in conclusion is the hallmark of the authors' scholarship. Indeed they regard their monograph as an interim work intended to encourage others to contribute.

This is perhaps most dramatically demonstrated by the placing of English dials within a wider European context.

There are brief introductions to Continental and Irish dials. International stylistic parallels and similarities are noted, and suggested dates and directions of influence transmission proposed – many linked to the spread of Christian missions and monasticism. Interestingly, these are both into and out of England. Although much fine brushwork remains to be painted in, the validity of the bigger European picture has without doubt been convincingly made. It is to be hoped this marks a decisive break and a less insular approach to the appreciation of our mass dial heritage.

The authors nuanced approach results in a more plausible interpretation of surviving dials. On dating it is concluded that Saxon/Saxon-type dials continued into Norman times.

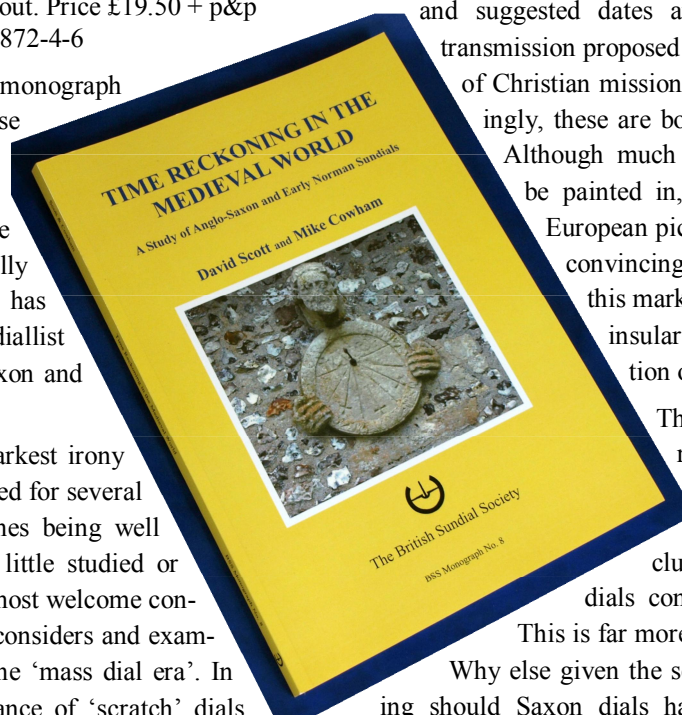
This is far more credible than a clear break.

Why else given the scale of the Norman rebuilding should Saxon dials have survived? The varying number of hour lines on dials has been interpreted by earlier students as differing time keeping systems – tidal, decimal and duodecimal. In aggregate such conclusions suggest an incoherent pattern of time keeping practices. The monograph reminds us there is no other corroborating evidence, and that the number of hour lines might reflect varying conventions on the inclusion of non-Canonical hours and the changing time of services. Differences in time keeping systems may well be more apparent than real.

Another fascinating insight derives from examining contemporary written sources. These reveal (in diagrammatic form) horizontal dials with vertical rod gnomons indicating the varying length of daylight and the consequential 'repositioning' of the twelve seasonal hours. In the light of this it is suggested that several dials (similarly delineated) were originally horizontal rather than vertical. Whilst all dials are now vertically positioned most have been moved – perhaps more than once and from other sites.

If the mark of a good book is to be left wanting more, this is an excellent one! It should grace the library of all serious diallists. There can be no better guide to our earliest sundials, many over 1000 years old. For the mass dial specialist it is an inspirational call to arms – there is still so much to research.

*Chris H K Williams*



# THE HORIZONTAL QUADRANT

## Part 2 - Use, and the Inverted Quadrant

MICHAEL LOWNE and JOHN DAVIS

*This article is a continuation from the previous issue.*

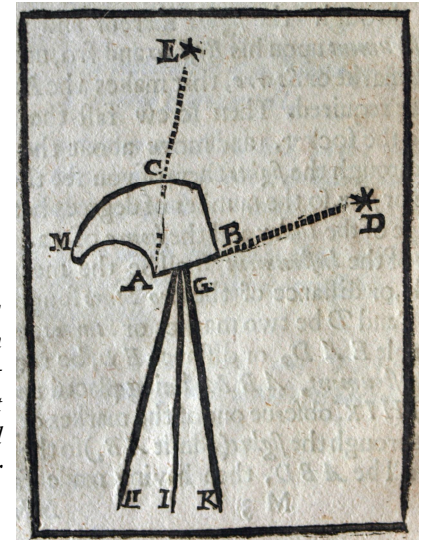
### Using a Horizontal Quadrant

The principal function of a horizontal quadrant was to determine the time of day and the azimuth of the sun from its declination, the measured altitude and the latitude for which the instrument is made. Some examples include trigonometric scales for other purposes, including surveying: for this purpose the angular height of an object could be measured by sighting it through the apertures.

The stereographic projection represents both halves of the sky superimposed. In this way the declination arcs are identical, and the ecliptic arcs are labelled with the zodiacal sigils for signs equally spaced on either side of the solstices. The hour lines represent times at the same intervals either side of 12 noon and are so labelled, for example 9 (am) and 3 (pm). Generally, the morning hours are given in Roman and the afternoon hours in Arabic numerals. On some dials a date scale at the ends of the declination arcs is calibrated for both series of days between the equinoxes, others use the declination lines corresponding to the zodiacal signs. Either a plumb-bob or a pivoted rule (a plummet) is suspended from a point at the corner at the top of the 12 noon line and is allowed to hang freely when the sun is sighted through two small apertures by allowing the light passed by one to fall upon the other. The altitude is indicated on a degree scale around the convex limb. The measured altitude is either set by the bead on the plumb-bob cord by means of an auxiliary scale or read directly on the rule by a calibrated scale, and then transferred to the projection at the declination appropriate for the date. The time is then read at the intersection point where the bead or altitude reading meets the declination line. On some instruments the azimuth of the sun could be read from the scale on the limb when the setting for time has been made.

With care, an accuracy of about two minutes in the derived time can be attained, except near the meridian where the solar altitude changes only slowly with time. There is ambiguity between times before and after noon, which can be resolved by taking another reading shortly afterwards: the value which gives a later time is the correct one.

In his book, Delamain describes<sup>10</sup> numerous other uses for his quadrant, rather in the style of a modern patent application attempting to corner the market for all conceivable applications! These include measuring the angular separation between two stars, using the two sets of sights and with the quadrant mounted on a tripod. Fig. 11 shows the rather



*Fig. 11. Delamain's woodcut illustration from Ref. 10 showing his quadrant mounted on a tripod and measuring star positions.*

crude illustration for this. No known horizontal quadrant has any facilities for being so-mounted and the method is so impractical that one doubts whether Delamain even tried it.

### Star Positions on Quadrants

Some of the quadrants described here carry the names of stars and one or both of their celestial coordinates, in Right Ascension (RA) and declination (dec). The primary purpose of these appears to be for time-finding at night but they may have had other uses, for example in surveying or navigation. Three HQs have star names, with variable numbers of stars listed, ranging from ten on HQ-1 to 46 on HQ-7, and for comparison the stars shown on two Sutton's inverted projection quadrants (HQ-2 and the drawing given by Collins<sup>19</sup>) may also be considered. The stars are identified either by their proper names or by their positions in the mythological constellation figures, in Latin (sometimes abbreviated) or English.

Some of the stars included are beyond the range of declinations between the tropics and so cannot be used with the stereoscopic grid. Others are too faint to be reliably seen by sighting through the apertures: the naked-eye limit of star visibility is the sixth magnitude and then only in a dark sky in the absence of moonlight. When fully dark-adapted the pupil of the eye is generally open five or six millimeters but the sighting apertures appear to be only one or two millimeters at most. On sighting a star through them, the apparent brightness could be reduced by 2 to 3 magnitudes ( $5 \log \{ \text{diam}_{\text{pupil}} / \text{diam}_{\text{aperture}} \}$ ), so that there is little chance of using any star fainter than third magnitude.

Table 2 lists the five instruments and the twelve stars which are most commonly used, occurring on three more instru-

Desig.	Mag.	Proper name	HQ-1 J Allen 1633	HQ-7 J Browne	HQ-9 J Linden 1596	HQ-2 H Sutton 1658	Collins-Sutton 1658*
$\alpha$ Ari 1:48	2.2	Hamal	Pri $\Upsilon$	Rammes head		Cap Arietis	Cap Arie
$\alpha$ Tau 4:16	0.8	Aldebaran		Bulles Eye	Oculus $\Upsilon$	Oc Taurus	Oc Tauri
$\beta$ Ori 4:58	0.1	Rigel		Onions left foot	Sinister pes Ori		Pes Orion
$\alpha$ Cma 6:30	-1.5	Sirius	Can mai	Great dogge	Canis maior	Canis Major	Canis maj
$\alpha$ CMi 7:21	0.4	Procyon	Can min	Lesser dogge	Canis minor	Canicula	Canicula
$\alpha$ Hya 9:11	2.0	Alphard	Cor hid	Hydra brightest	Lucida Hydrae	Cor Hydr	Cor Hydr
$\alpha$ Leo 9:50	1.4	Regulus	Cor $\delta$	Lions heart	Cor Leonis	Cor Leonis	Cor Leoni
$\beta$ Leo 11:31	2.1	Denebola	Cau $\delta$	Lions taile	Cauda Leonis	Cau Leonis	
$\alpha$ Vir 13:07	1.0	Spica	Spica $\mathfrak{M}$	Virgins Spike	Spica Virginis	Spica Virgin	Spic Vir
$\alpha$ Boo 14:00	0.0	Arcturus	Arct	Bootes thighs	Arcturus	Arcturus	Arcturus
$\alpha$ Aql 19:34	0.8	Altair	Aquila	Eagles heart	Aquila	Cor Vultur	Cor Vult
$\gamma$ Peg 23:55	2.8	Algenib	Ala Peg		Ala Pegasi	Ala Pegasi	Ala Pega
No. other stars not listed:			0	35	4	11	10

Table. 2. Stars shown on horizontal quadrants (\* and one Sutton's quadrant in the Oxford Museum of the History of Science).

ments, but omitting those stars which are outside the tropics and third magnitude or fainter. The first column is the modern designation of each star and the right ascension, the second the magnitude, and the third the proper name. The modern star designation comprises a Greek character and a three-letter abbreviation for the constellation name. The Greek letters were assigned by Johannes Bayer (1572-1627) in 1603 and generally but not always follow the alphabet sequence in order of decreasing brightness. The first three instruments are identified by the maker's name and the serial number in the monograph catalogue.<sup>4</sup> The first of the two Sutton quadrants HQ-2 (based on a variant of the astrolabe projection on the plane of the equator) is in the Oxford Museum for the History of Science<sup>17</sup> and the second is from Collins' book<sup>18</sup>. The star names or identities are transcribed from the instruments. Of the star identifications, 'Pri' implies the brightest star, 'Oc(ulus) is the eye, 'Cau(da) is the tail and 'Ala Peg(asi)' is the wing of Pegasus, the flying horse. The last row of Table 2 shows the number of stars which have been omitted, either because there are only one or two entries or by reason of their faintness or position outside the tropics.

There are large gaps in RA between the three last stars, but as half of the area between the tropics is above the horizon at any one time several stars will always be available. The minimum number is three on HQ-1.

There is a noticeable improvement in the accuracy of the declinations on the later instruments over those of the 1596 Linden quadrant, where there can be errors of up to a degree or more. The improvement can be attributed to the publication of Tycho Brahe's star catalogue in 1602 which soon became of widespread use for accurate star positions.

### Time Determination from the Stars

The primary purpose of the stars on the horizontal quadrants appears to have been for finding the time at night.

One method of achieving this is given by Delamain<sup>10</sup> which in modern terms is

$$\text{Local solar time} = (\text{RA}_{\text{star}}) \text{ minus } (\text{RA}_{\text{sun}} \pm 12^{\text{h}}) \text{ plus } (\text{hour-angle}_{\text{star}}).$$

At midnight, the sun is at lower meridian transit (below the horizon due north) and adding 12<sup>h</sup> to its RA gives the sidereal time at midnight. Subtracting this from the star's RA (the sidereal time when the star will be at upper transit) gives the time interval between midnight and star transit which (disregarding the 4<sup>m</sup>/day acceleration of sidereal time over solar time) is the solar time of star transit. If (RA<sub>star</sub>) is less than (RA<sub>sun</sub> ± 12<sup>h</sup>) add 24<sup>h</sup> to (RA<sub>star</sub>). In the final step, if the star is east of the meridian it has not reached transit and the hour-angle is subtracted. If west, the meridian has been passed and the hour-angle is added to derive the local solar time.

All the required quantities can be derived from the instrument. RA<sub>sun</sub> is read from the hour lines at the position on the ecliptic corresponding to the current day on the date scales. To find (hour-angle<sub>star</sub>) it is necessary to know the star's dec. as well as the RA which is either engraved or plotted on the grid (except in the case of the Linden quadrant on which they are neither engraved nor plotted). The hour-angle (measured in time units east or west of the meridian) is found from the observed altitude of the star in conjunction with its coordinates.

As the quadrant effectively folds the whole sky into four, prior knowledge of the approximate RA of sun and stars is needed to determine this coordinate correctly. The convention for numbering the hours appears to be that morning hours were labelled with Roman numerals and afternoon hours with Arabic. The rules to give RAs in the 24-hour system are:

RA 0<sup>h</sup>-6<sup>h</sup> (Mar11-Jun 11 for RA<sub>sun</sub>): read the positions at the intersection of the ecliptic line with the declination line

for date, right-to-left on the Roman numerals and subtract 6<sup>h</sup>.

RA 6<sup>h</sup>-12<sup>h</sup> (Jun 21-Sep 13): read the positions left-to-right on the Arabic numerals and add 6<sup>h</sup>.

RA 12<sup>h</sup>-18<sup>h</sup> (Sep 13-Dec 11): read the Roman numerals and add 6<sup>h</sup>.

RA 18<sup>h</sup>-24<sup>h</sup> (Dec 11- Mar 11): read the Arabic numerals and add 18<sup>h</sup>.

In the case of the sun, confirmation can be obtained from the zodiacal sigils which are generally engraved along the ecliptic. Near the solstices it would be difficult to obtain the accurate RA of the sun because the daily change of declination is small. It could be estimated by taking the RA to be 6<sup>h</sup> on June 11 and 18<sup>h</sup> on December 11 and subtracting four minutes for every day before or adding four minute for every day after these dates.

The time-finding procedure is:

1. Measure the altitude by sighting the star through the apertures in the sights, allowing the plummet to hang freely.
2. Transfer the altitude reading to the grid using the plummet, matching the altitude scale to the declination of the star, either as it is plotted or found from the given places. Read the time scale at the intersection point, using the Arabic numerals. This is (hour-angle<sub>star</sub>).
3. Find RA<sub>star</sub> from the position given or plotted on the grid.
4. Find RA<sub>sun</sub> by locating the required date on the calendar scale and following the declination on which this falls to meet the ecliptic. Add or subtract 12<sup>h</sup> as necessary to keep the midnight sidereal time within 0-24<sup>h</sup>.
5. Subtract the result of step 4 from RA<sub>star</sub> and add or subtract to the result (hour-angle<sub>star</sub>) from step 2. The sum (diminished by multiples of 24 hours if it exceeds this) is the local solar time in the 24-hour system. For time in the 2×12<sup>h</sup> am-pm system, subtract multiples of 12<sup>h</sup>.

Although the finding of the star's altitude can be done in darkness, the remaining operations would need to be done

in artificial light. It would also be advisable to write down the three derived values to facilitate the arithmetic!

The practicality of time-finding from the stars and the quadrants is perhaps doubtful. The method involves measuring the altitude of a star by sighting it through the two apertures, holding the instrument almost upright so that the plummet or plumb-bob can swing freely but not too far from the dial-plate, restraining it to obtain the reading, and then transferring the dial to another location where there is enough light to read the derived altitude and carry out the other operations. Additionally, locating even a bright star may not be easy: the aperture furthest from the eye will subtend an angle of only about half a degree (the diameter of the full moon) and the sight may not be visible against the dark sky background.

### The Accuracy of Horizontal Quadrants

In common with all dials which use the altitude of a body as one of the input parameters, horizontal quadrants suffer from limitations which affect the accuracy of the time determination. At the latitude of London (51½°) for which the majority of the dials considered here were made, a change in altitude is always less than the corresponding change of hour angle, implying that an error in the altitude will introduce a greater error into the hour angle and hence the derived time. The hour angle is the time which will elapse before or has elapsed since meridian passage.

In Fig. 12 the sun's altitude is plotted against hour angle at the declinations of the equinoxes (0°) and solstices (±23·5°). The horizontal and vertical scales are the same, enabling a direct comparison of the relative changes to be made. It is seen that at hour angles furthest from the meridian the relation is approximately linear but as the meridian is approached the curve flattens out until near noon there is virtually no change of altitude with hour angle, implying that a small inaccuracy in altitude will introduce a large error in the time. The curves of Fig. 12 may be recognised as the inversion of the declination lines on a shepherd's (cylinder) dial which also operates from the sun's altitude.

The type of dial with a plummet to measure the altitude, carrying a scale to set on the projection, should have small intrinsic errors but for dials with a bead (perhaps three or four mm in diameter) on a plumb-bob cord estimating the bead centre might not be so accurate. From consideration of the physical sizes of the quadrants, it does not seem likely that the altitude or declination could be measured or set reliably with greater precision than about a quarter of a degree, even on the dials equipped with a plummet.

Differentiating the equation linking latitude ( $\phi$ ), declination ( $\delta$ ), hour angle ( $h$ ) and altitude ( $a$ ) with respect to  $h$  and  $a$ , for errors in altitude  $\Delta a$  and the resulting time error  $\Delta t$ :

$$\Delta t \text{ (minutes)} = -4\Delta a \cdot \cos a / \cos \phi \cdot \cos \delta \cdot \sin h \quad (3)$$

Putting  $\Delta a = 0.25^\circ$  in Eq. 3 gives the values for the declinations of the solstices plotted in Fig. 13, from which it is

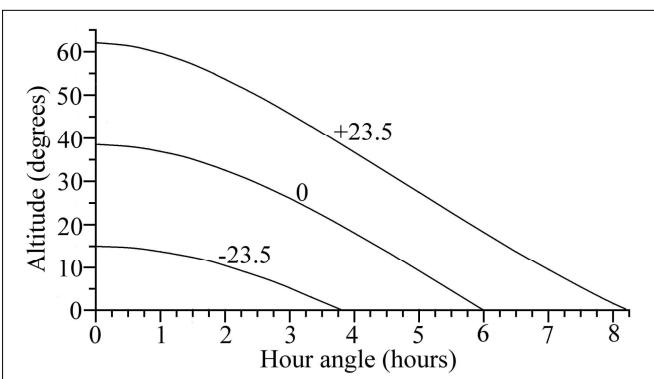


Fig. 12. The hour angle of the sun and its altitude, at the declinations of the solstices and equinoxes.

seen that the time errors are larger at negative declinations than positive and increase rapidly at small hour angles until near to the meridian it is virtually impossible to obtain a reliable time. The sense of the derived time errors is that a positive (negative) error in altitude will cause a morning time to be too late (early) and an afternoon time too early (late).

The solar declinations obtained from the plan of the sky on the dial are values averaged over the leap-year cycle and in any one year may be up to 9 arc-minutes wrong, particularly at the equinoxes when the daily change of declination is most rapid. Here too any errors introduced will be largest near the meridian. Adopting an error  $\Delta\delta$  of  $0.25^\circ$  the differentiation is:

$$\Delta t \text{ (minutes)} = 4\Delta\delta(\tan\phi/\sin h - \tan\delta/\tan h) \quad (4)$$

Values from this are similar to those shown for altitude errors in Fig. 13 at small hour angles but are slightly larger further from the meridian. A positive (negative) error in declination will give a morning time too early (late) and an afternoon time too late (early).

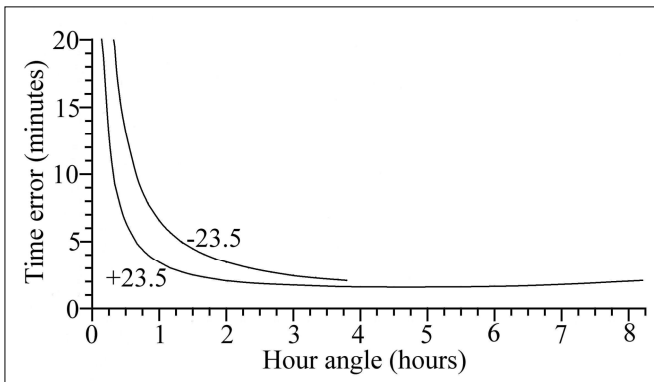


Fig. 13. The time errors for errors of  $0.25^\circ$  in altitude or declination, at the solstice declinations.

From the curves of Fig. 13 it is apparent that the limit of accuracy with errors of  $0.25^\circ$  in altitude or declination is about two minutes. If errors are present in both they may add or partially cancel.

Using the quadrant at latitudes other than that for which it has been made would be another source of inaccuracy. For

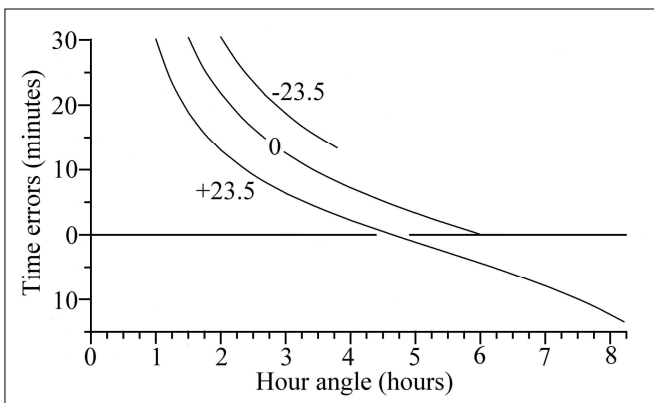


Fig. 14. The time errors if used at York instead of London, at the solstice and equinoctial declinations.

example, suppose an instrument made for London is used in York at a latitude of  $54^\circ$ , a difference  $\Delta\phi$  of  $+2.5^\circ$ . The differentiation is:

$$\Delta t \text{ (minutes)} = 4\Delta\phi(\tan\delta/\sin h - \tan\phi/\tan h) \quad (5)$$

Values of the time error for the equinoxes and solstices are plotted in Fig. 14 and show considerable inaccuracies for a relatively minor change in latitude. Notice that the error for the summer months passes through zero and changes sign near  $5^h$  hour angle: the explanation for this is left as an exercise for the reader. If used at the wrong latitude north (south) of the design latitude the morning time will generally be too early (late) and the afternoon time too late (early). But, as shown by Fig. 14, in the summer months the sense of the errors in the early morning or the evening will be reversed.

The amount of all the time errors near the meridian will depend on the sign of the error causing them. In these conditions the differential equations used here give approximately average values.

### The "Horizontal Projection Inverted"

A rare variant of the horizontal quadrant is one which uses the "horizontal projection inverted". This was described by John Collins in a small booklet on a *General Quadrant with the Horizontal Projection on it Inverted*, Fig. 15.<sup>19</sup> The booklet was unillustrated and was published in 1658, a year before his much more famous book *The Sector on a Quadrant...*<sup>18</sup> describing the quadrant devised by Harvey and with a number of excellent plates engraved by Henry Sutton. The two books are often found bound together but, whereas 'Sutton's quadrant' became well-known, the 'inverted quadrant', with its obscure description, virtually disappeared.

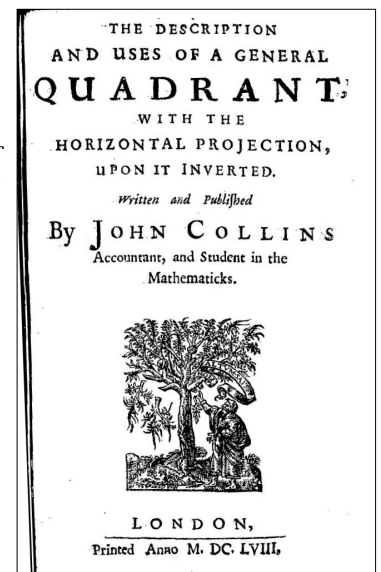


Fig. 15. Frontispiece of John Collins' 1658 book on the inverted quadrant.

A much shorter and more comprehensible description of the inverted quadrant was printed, c.1701, in a broadsheet by John Prujean. This was entitled *A Short Description of a Quadrant of the particular Astrolabe inverted*: it is printed together with the tract on *Oughtreds quadrant*.<sup>16</sup> These de-



Fig. 16. Henry Sutton's paper-on-wood example of a horizontal quadrant inverted, HQ-2. Photo by the author, courtesy of the Oxford Museum of the History of Science. The scale running approximately horizontally across the grid is "Mr Dary's curve" – see text.

scriptions are clearly intended to act both as advertisements and as instruction manuals to be used alongside a real instrument. Despite this, no example from Prujean – presumably a paper-on-wood device – is known. We do, though, have one example from Henry Sutton (Fig. 16, HQ-2 in Table A1) dated 1658, significantly before Prujean and the same year as Collins' published description.

The derivation of the inverted horizontal quadrant is shown in Fig. 17. The usual stereographic projection is a view of the sky as seen from the nadir projected on to the plane of the horizon but in this case the sky is projected from the zenith. In this way the projection is turned 'inside out' so to speak, the declination arcs are interchanged, those for the winter months appearing the nearer to the centre of the instrument, and the solar altitudes increase towards the limb. The hour circles are convex to the meridian, not concave. This instrument is confined to a quadrant of a circle, which would leave unrepresented that part of the projection for the summer months which falls beyond the prime vertical. It is included by continuing the projection into that area which is unused by the winter declinations: this is known as the 'reverted tail'.

The operation of this design is similar to that of the usual form of quadrant, with sights and a plumb-bob to read the altitude on a scale of degrees around the curved limb. The sun's declination is obtained from date scales on the reverse of the quadrant correlated with a scale of declinations. A bead on the plumb-bob cord is set to the measured altitude on a scale: this is called 'rectifying the bead'.

Fig. 17 (below). The 'inverted quadrant'. (a) The device described by Collins with the 'reverted tail' in red; (b) a meridional section showing how the inverted (black) and normal projections (red) are formed; (c) the relationship between the inverted (black) and normal (red) projections. The three figures are drawn for a latitude of  $51.5^\circ$  N and for the same horizon circle radius.

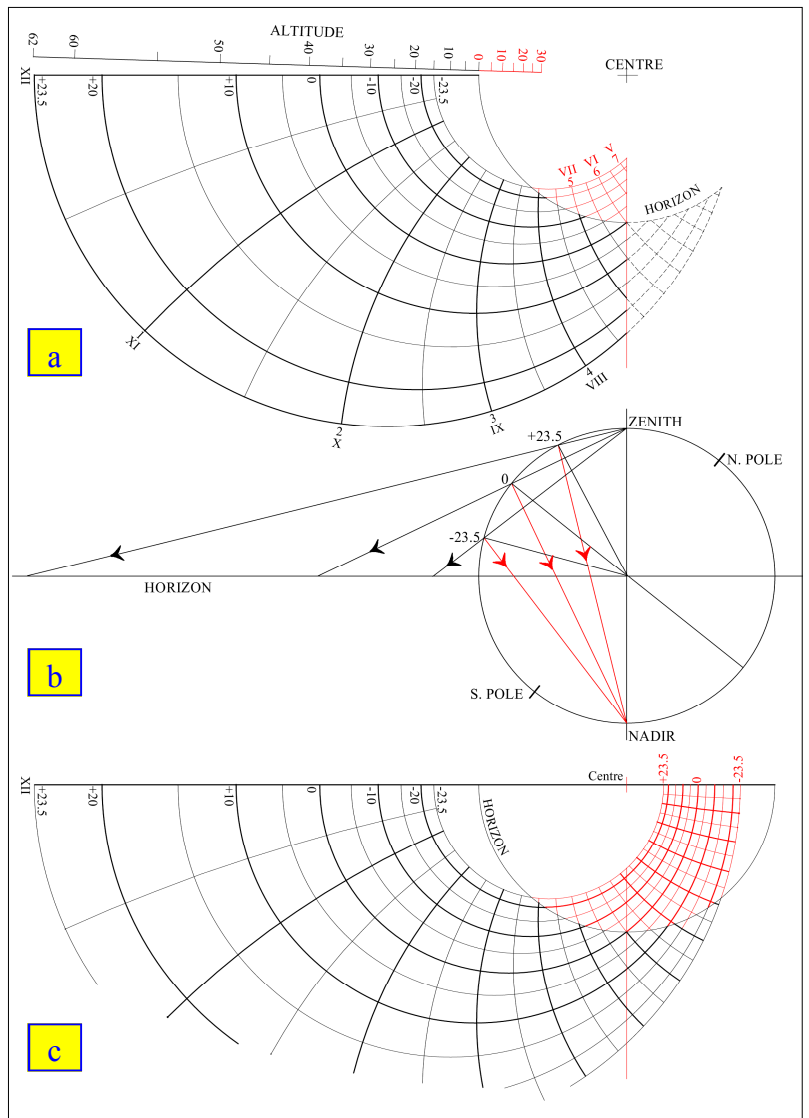




Fig. 17(a) gives a simplified drawing with that part which falls beyond the prime vertical shown in dashed lines and the reverted tail in red. This is used if the bead when set to the altitude cannot be matched to the appropriate declination on the main projection, implying that the sun is too low for the time to be in the range 6 am to 6 pm. The bead is rectified to the altitude on a subsidiary scale (shown in red) and set to the declination (with reversed sign) on the reverted tail where the time can then be read. Fig. 17(b) is a meridional section showing the inverted projection of the declinations of the tropics and the equator on to the horizontal plane (black lines) and the normal projection in red. Fig. 17(c) is a comparison of the inverted projection in black and the normal projection in red. This shows that the reverted tail is effectively part of the normal projection and is used in the same way. The reduced scale would have an adverse effect on the precision of reading the time.

It is difficult to see much advantage in this construction over the normal quadrant. One is that the scale of the divisions is greater for the summer months, which could add precision in the period in which the quadrant is most likely to be used.

The inverted HQ by Sutton (Fig. 16) follows the above method. The strong curved line on this instrument is “Mr Dary’s curve”.<sup>20</sup> The method of drawing this line is described (rather obscurely!) in Collins’ book.<sup>19</sup> Together with two straight parallel scales on either side of the quadrant projection it forms a latitude-specific nomogram which relates the time, the altitude and declination of the sun to find any one from the other two by stretching a thread across. The nomogram can also be used to relate the azimuth, altitude and declination and derive other quantities such as sunrise and sunset, and twilight.

Collins also describes the use of other scales which can be used for time-finding in latitudes other than that for which the instrument is made. It is not clear whether these scales are included on the Sutton quadrant among all the other scales which are present.

### Conclusions

The horizontal quadrant was capable of being a good time-finding instrument and it was also useful as a calculator diagram, converting one set of celestial coordinates to another. It was also a compact way of carrying solar information, such as the times and azimuths of sunrise and sunset in a compact form for the pocket. The more outlandish of Delamain’s claims for it may have been impractical, particularly for surveying and astronomy, but the basic design was sound. It may have suffered in popularity as a result of the priority dispute between Oughtred and Delamain. The association of the instrument with Delamain may have convinced Oughtred not to get his favourite instrument maker Elias Allen to produce examples, preferring instead to promote the horizontal instrument and the double horizontal dial, the latter becoming quite famous. Delamain, on the other hand, did not have the necessary mathematical reputa-

tion or contacts (despite his royal appointment to teach mathematics) to get his design more widely known, or to solve some minor shortcomings in its design. Certainly, the muddled prose in his various publications cannot have helped his cause.<sup>22</sup>

The horizontal quadrant was eclipsed by Sutton’s quadrant and, particularly, by Gunter’s quadrant. The former of these remained popular whilst Henry Sutton, with his unparalleled engraving skills, was still alive and his printing plates were available for paper instruments. Gunter’s quadrant, which remained a favourite with many instrument makers for well over a century, may have been simpler to engrave but it does not have the immediate visual appeal of the stereographic instruments. Perhaps this article will redress the balance slightly.

### ACKNOWLEDGEMENTS

We are grateful to several organisations for allowing us to photograph their instruments or for providing photographs, particularly the Oxford MHS, London Science Museum, British Museum, Germanisches Nationalmuseum Nuremberg, Lord Daventry, Christ Church Oxford, Musees Royaux d’Art et d’Histoire, Brussels. Numerous individuals have also helped in our study including: Jim Morrison, Stephen Johnston, Tony Simcock, Adrian Whicher and Silke Ackemann.

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17. The Sutton quadrant is Oxford MHS inventory No. 32551.
18. John Collins: *The Sector on a Quadrant – or a treatise containing the description and use of four several quadrants, two small ones and two great ones, each rendered many wayes, both general and particular. Each of them accommodated for dialling: for the resolving of all proportions instrumentally: and for the ready finding of the hour and azimuth universally in the equal limbe. Of great use to seamen and practitioners in the mathematics*, Printed for George Hurlock, London, (1659).
19. John Collins: *The Description and Uses of a General Quadrant, with the Horizontal Projection, upon it inverted*; together with John Lyon: *An Appendix touching Reflective Dialling*, J. Maycock, London, 1<sup>st</sup> edition (1658).
20. “Mr Dary” is Michael Dary (1613-79), a friend of John Collins and another self-taught mathematician. By profession, he was a tobacco-cutter as well as a teacher. His earliest publication is *Dary’s Diarie or the Description and Use of a Quadrant* (1650) which included engraved prints of a quadrant which could be cut out. Philip Lea’s advertisement of 1699<sup>21</sup> included ‘Dary’s quadrant’ amongst the prints of instruments available. See Ref. 12.
21. Philip Lea: *Advertisement of Globes, Books, Maps &c Sold by Philip lea, Globe Maker at the Atlas and Hercules in Cheap-side, near the corner of Friday-street; and at his shop in Westminster Hall, near the Court of Common Pleas*. London. Broadsheet (1689-95).
22. D.J. Bryden: ‘A Patchery and Confusion of Disjointed Stuffe: Richard Delamain’s Grammelogia of 1631/33’, *Trans Cambridge Bibliographical Soc*, 6, pp.158-166, (1974).

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# SHADOWY SECRETS

## Part 5 – Shadows in the mind

JOHN MOIR

To a diallist, the significant part of a shadow is generally its edge. To this end we make dial plates whose surface, colour, texture and reflectivity register the sharpest possible shadow edges. In large sundials we may even resort to shadow sharpeners for increased accuracy. Beyond this our interest in shadows and how our minds perceive them is possibly limited. It turns out that the subject is far more intriguing than we may at first suppose.

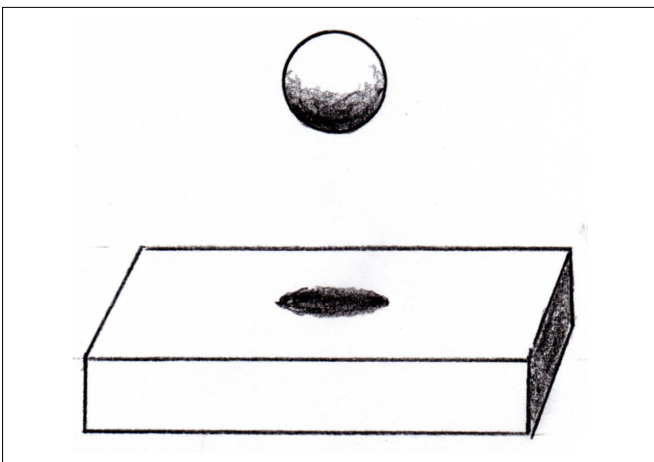


Fig. 1. Ball with shadow experiment.

A few years ago, scientists conducted an experiment to test a six month old baby's perception of shadows. They set up a sphere that cast a shadow on to a moveable box below (Fig. 1). First they moved the box sideways, with the shadow remaining immobile beneath the sphere. The baby's eyes registered surprise at this. They then glued a 'shadow spot' in place of the natural shadow, which then moved with the box, causing no surprise at all! In its short life, the baby must have learnt that marks on objects always move with the object, and had yet to learn that a shadow is a different kind of mark, overlaying but not 'tied' to a surface.

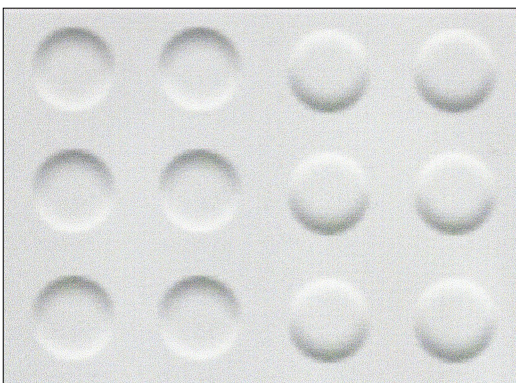


Fig. 2. Dimples-and-pimples pattern.

As we grow up, we begin to recognise shadows for what they are, but our minds often make assumptions about them, in particular their light source. Because the sun and most artificial lighting shine light from above we take this as our 'default' light source. Although we have only the disposition of the surface shadows to go by in Fig. 2, most of us will see dimples on the left and pimples on the right (consistent with a high light source). Simply by *imagining* the light is coming from *below* it is sometimes possible to change dimples into pimples and vice versa. If this fails, just turn the page upside down and they change shape as if by magic.



Fig. 3. What shape object can cast these shadows?

We can often guess the shape of an object purely from its cast shadow. We are cheated though when that rabbit's shadow on the wall turns out to be the product of an illusionist's hands! Artists too seek to intrigue us by contriving objects that can cast totally different shadows, depending on their orientation with respect to the light source. For example, any single one of the **H** or the **o** shadows appearing in Fig. 3 can be produced by the same object by adjusting its orientation. Try to imagine what that object might look like! (Answer on page 39.)

Fig. 4 shows an unbelievable shadow illusion by Edward Adelson. Although (or perhaps because) we know that a shadow darkens a surface, our minds tend to 'read' the underlying lighter tone as if no shadow existed. Because

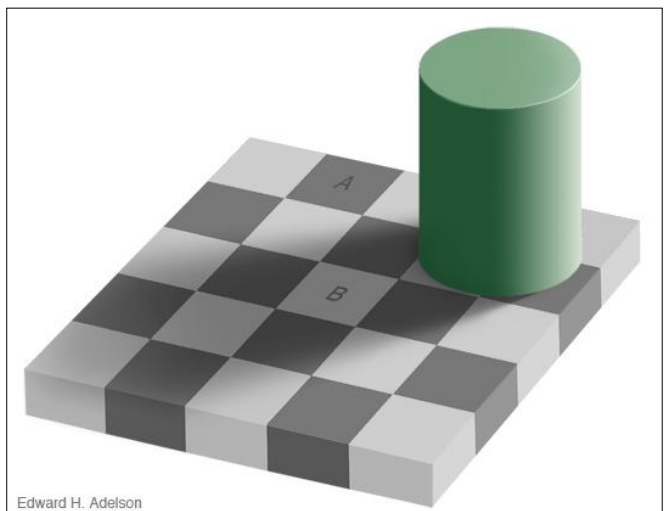


Fig. 4. Shadow illusion.

square B is in shadow we therefore see it as lighter than it actually is. In reality, squares A and B are exactly the same tone! (Disbelievers – see page 39 and/or visit [www.youtube.com/checkershadow](http://www.youtube.com/checkershadow).)

Anyone trying out their analemmatic dial early or late in the day will cast a very weird shadow as in Fig. 5 (left). It is tempting to attribute its strange shape solely to the low sun, but that only elongates the shadow. The distortion (small head, long legs) is a perspective effect caused by one's oblique viewing angle. We may also assume that our shadow must look the same to anyone else. However, someone standing at the head of our shadow would see it very differently – the same elongation but a reversed perspective, Fig. 5 (right).

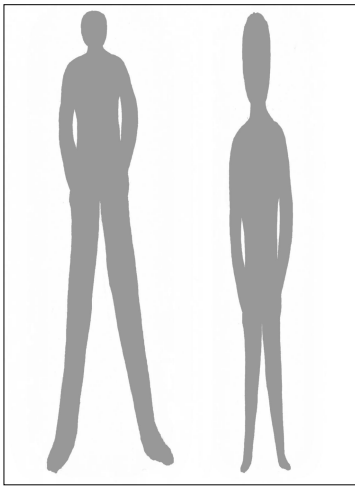


Fig. 5. Elongated and distorted shadows from a low light source.

Now for a perspective effect on a rather larger scale. A while ago I noticed that the shadow line on the moon, close to its first quarter, suggested that the sun ought to have been much higher in the sky than it actually was (Fig. 6). I have since been told that the trick is to stretch a piece of string between the sun and moon images. Viewed this way, in the plane of the ecliptic, the shadow line on the moon, or terminator, now appears square-on to the sun, but this has to be tried to be believed.

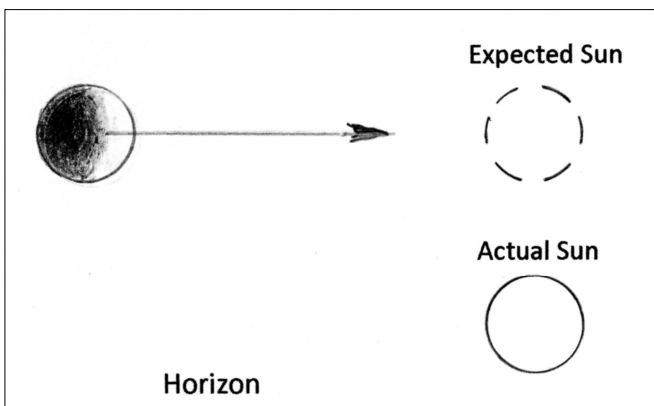


Fig. 6. The shadow terminator on the moon.

Finally we come down to Earth, for a story of a builder from Stroud who, on learning that giant garden sundials were the rage in his area, decided to construct one using a redundant house ladder, sideways on, for the gnomon, as in

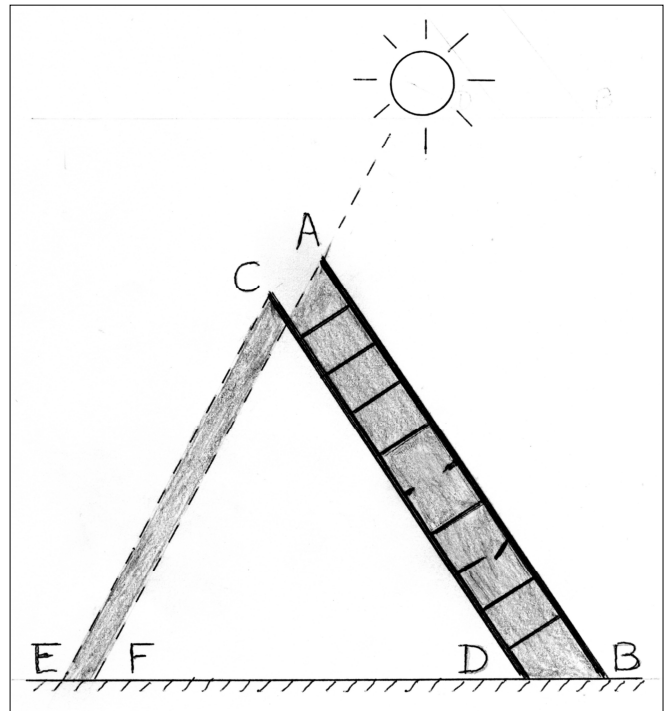


Fig. 7. A ladder not up to the job?

Fig. 7. Sadly, his parsimonious wife resisted the idea, complaining that it was a waste of a useful ladder and in any event the proposed dial had a fundamental design fault. She went on to argue that since shadows can definitely not pass through opaque objects, the noonday shadow of AB in the summer would be completely blocked by the lower edge of the ladder, CD.

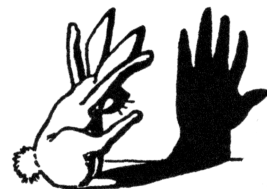
Furthermore, apart from a small section (at most a few inches long) at its tip, CD itself would not receive the light that is necessary to cast a shadow so only a very short noon shadow, EF, would be cast onto the ground in the summer. Similarly, in winter only a small section at the tip of AB would cast a ground shadow at noon. Knowing that it was usually best to agree with his wife our builder abandoned the project, but was he right to do so? After all, he knew that the 'man with a plank' sundial in Market Harborough casts a full noonday shadow, and a plank is only a ladder with the gaps filled in!

[The mention of the Stroud area is a reference to the dial which Michael Maltin described at the last Newbury meeting and which was shown in Tony Wood's article in *Bulletin* 22(ii) p.41 (June 2010). Ed.]

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# A BENJAMIN SCOTT HORIZONTAL DIAL

JOHN DAVIS

This dial (Fig. 1) by Benjamin Scott may be small (8¾" or 222 mm in diameter) but it carries many features normally only found on much larger dials. Surprisingly, it is one of two dials once at Lochnaw Castle.



Fig. 1. Overall view of the Benjamin Scott dial.

## The Dial

The dial is believed to have been made for Lochnaw Castle in Wigtownshire, Scotland, the ancestral home of the Agnew clan.<sup>1</sup> It carries the crest of the arms of the clan, *an eagle issuant and regardant proper* and their motto of 'Consilio non impetu' or 'By wisdom not by force' (Fig. 2). It is also inscribed "Lat 54 – 51" which compares well with the accepted latitude of 54° 55' N for the castle.

The most surprising feature of the dial is the set of *transversals* (sometimes called diagonal scales) around the out-



Fig. 2. The full Agnew arms and the version of the crest and motto (rather worn) on the dial.

side of the dial (Fig. 3).<sup>2</sup> This is the smallest dial which I know of to carry these scales – usually, they are found on dials of around 18" diameter. The scales allow the time to be read to 1-minute resolution with comparative ease. They are thought to have been introduced on English horizontal dials by Scott's master John Rowley<sup>3</sup> at the beginning of the 18<sup>th</sup> century and are most commonly seen on the dials of Scott's brother-apprentice, Thomas Wright.<sup>4</sup> The form seen here, a series of nearly-parallel lines running across a set of five concentric circles, is unusual as the more common form is a single sawtooth line, so that they are sometimes described as 'zig-zag' scales. The version on this small dial is perhaps easier to read than the more conventional form.

The ends of the transversal scale, at the south side of the dial, are neatly terminated by a 'bobbin' decoration (Fig. 4).<sup>5</sup> This is another feature seen on Thomas Wright's dials so clearly there was a shared pattern book in Rowley's workshop.

Inside the main chapter ring is a narrow oakleaf border, a usual feature for any dial made by a mathematical instrument maker who was a Freeman of one of the London guilds. Inside that is an Equation of Time ring of the 'Watch Faster/Slower' type – again, a surprising feature for a small dial (Fig. 5). The scale is a complete circle with 1 Jan / 31 Dec positioned at the S. The engraving is oriented to be read from the outside of the dial, in the form introduced by Rowley between 1700 and 1710. In this case, the months are arranged to run anti-clockwise round the dial so that they can be read naturally from left to right, unlike most of Wright's dials where the clockwise scales make reading error-prone.<sup>4</sup> The scale gives the EoT in numbered 1-minute increments and, additionally, the numbers of extra

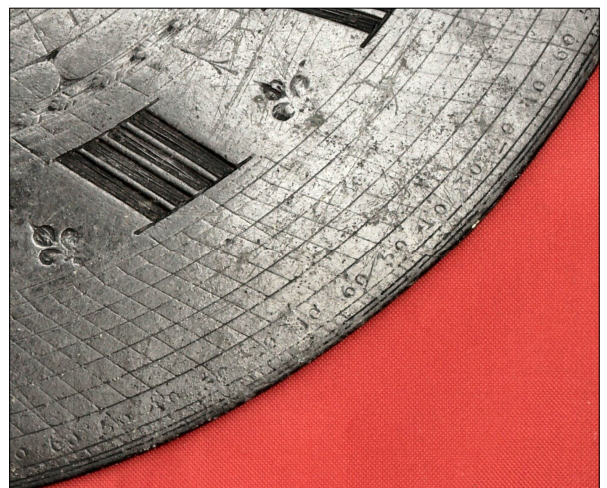


Fig. 3. The transversals.



Fig. 4. The 'bobbin' decoration at the ends of the chapter ring.



Fig. 5. Part of the EoT scale, showing the maximum of 14m 49s on 31 Jan.

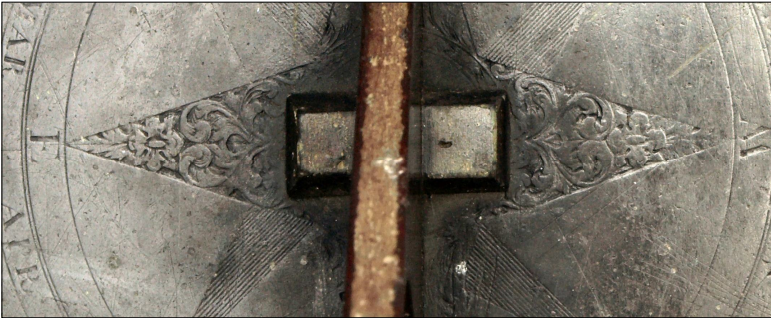


Fig. 6. Compass rose engraving.

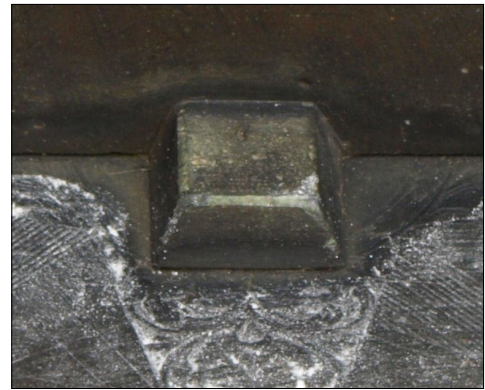


Fig. 7. The 'truncated pyramid' gnomon supporters.

seconds at the maxima and minima are also engraved.<sup>6</sup> These values can be compared with those in a database of published tables<sup>7</sup> to allow the data source to be identified as that printed in 1710 by John Smart, based on John Flamsteed's calculations of 1702.

The 8-pointed compass rose on the dial is fairly standard although it has a nicely-engraved pattern infilling the E and W points (Fig. 6). The pattern for the N and S points has been adapted to allow for the gnomon without unnecessary unseen engraving beneath it.

The dial has a simple but robust unpierced gnomon. Its most interesting feature is that it is supported by a pair of small 'feet' of a truncated pyramid shape (Fig. 7). This shape of supporters was almost a trademark of dials made by John Rowley and his apprentices throughout their careers. The feet are actually cast into the gnomon rather than being separately attached (as in modern replicas), meaning that each gnomon had to be individually designed and cast. The gnomon was originally retained by four screws from

underneath (two of them into the supporters) though these have now lost their heads.

The signature, "B Scott Fecit" is engraved either side of the N end of the gnomon, again in the style of Rowley.

### Benjamin Scott

Benjamin Scott (c.1688-1751) was John Rowley's first apprentice, being turned over to him in 1706 having originally been bound to James Anderton in the Grocers' Company in 1702. As a result, Scott became a Freeman of the Grocers' (despite Rowley being in the Broderers'), in 1712 and was later able to train several important dialmakers in that guild. Amongst these was Thomas Heath who went on to create a very large instrument-making business. Scott's address in London was in the Strand, variously described as at Exeter Exchange or the Mariner & Globe, though these probably refer to the same premises.<sup>8,9</sup> The engraving of a plain scale shown in Fig. 8 (datable to after 1725) gives the full address.<sup>10</sup>

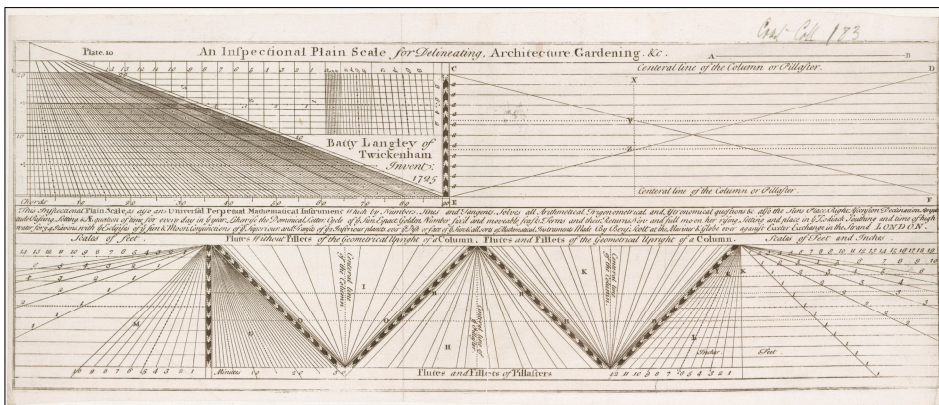


Fig. 8. Extract from an engraving of a plain scale containing an advertisement for "all sorts of Mathematical Instruments Made By Benj. Scott at the Mariner & Globe over against Exeter Exchange in the Strand LONDON". Courtesy Science Museum, London (inventory no.1042273). See Note 10 for a full transcription of the text.

Perhaps the most famous of Scott's sundials is the large double horizontal dial which he made for Paris and which remains there, now in the Musée des Arts et Métiers.<sup>11,12</sup> An instruction book for this dial, handwritten by Scott, is now in the British Library.<sup>13</sup> Only a small number of other horizontal dials are known. One was sold by Sotheby's in 2003.<sup>14</sup> Of the three in the BSS Register, one, at Cliveden, was seen by BSS members during the 2008 BSS Conference.<sup>15</sup> Another (SN 6054) is at Ham House and is of the form sometimes called a Grocers' geographical.<sup>16</sup> A portable inclining dial in silvered brass is also known,<sup>17</sup> as is a ring dial.

Scott was clearly much more than a mere jobbing instrument maker. He published *The Description and Use of an Universal and Perpetual Mathematical Instrument* in 1733, describing an 18" circular sliderule of twenty circles, and earlier he was working with the hydrographer Charles Price in making globes.<sup>18</sup>

Scott emigrated to Russia in 1733, initially working for the Admiralty in St Petersburg, and this sets an end-date for the making of the Lochnaw dial.<sup>19,20</sup> But even before this, it is evident that he had been considering moving away from London. In a letter written on 10 August 1732 by William Adam (1689-1748) the architect (and father of the more famous Robert) to the Professor of Mathematics at Glasgow University, Robert Simson<sup>21</sup> (1687-1768), about his library, there is a revealing paragraph reading:<sup>22</sup>

"Mr Benjamin Scott Mathematical Instrument maker att London and one of the best of the Profefsion having made a Jaint into the North of Scotland about some businefs He had there Stopt here in his return & upon Conversing with him I find He has some inclination to settle in this place and I have said to him that He could not miſs in having a very good businefs here there being none of his Employment in Scotland, As He proposes to make a trip to see Glasgow I have taken the Liberty to desire him to wait on you & I beleive [sic] you will Join with me in thinking it would be a happinefs to the Country As well as a benefit to himself to setle among us, As Mr Stewart is near Glasgow Just now will you be so good as gett them together I persuade myself Mr Stewart will Encourage the design, Profefſor Crawford is to write along with him to Mr Stewart & you."

Evidently the move to Scotland did not proceed though it is possible that it was on this trip that Scott received the commission for the Lochnaw Castle dial. The letter clearly shows why it was necessary for the dial to be commissioned from a London rather than Scottish maker.

Fig. 9. Photograph of Lochnaw Castle across the loch. It is just possible to discern the outline of a sundial in the formal garden on the right. Courtesy Historic Scotland, image A4339.

Scott may have been one of a number of men recruited to work in St Petersburg by the diplomat (and poet) A.D. Kantemir (1708-44) over the period 1733-38.<sup>23</sup> His master Rowley had already made a number of instruments for Russia, including a mural quadrant and a very fine standing mechanical equinoctial ring dial which was presented to Peter the Great<sup>3</sup> and this may have provided an introduction for Scott. By 1747, Scott had signed a four-year contract for a salary of 600 roubles with the St Petersburg Academy of Sciences. His work there included repairing the great globe of Gottorp, which Peter had acquired in 1713, and other instruments (some by Rowley) which had been damaged in a fire.<sup>24</sup> He eventually became the head of the Academy's 'Instrument Workshop' (*Instrumental'naia palata*) teaching Russian apprentices and advising on various astronomical instruments. Scott had clearly moved his family to Russia as his son, also Benjamin, became a well-known engraver of coins and medals at the St Petersburg mint. Scott snr. died in St Petersburg after a long long illness in the Spring of 1751.<sup>25</sup>

### Lochnaw Castle and the Agnews

Lochnaw Castle, Wigtonshire, is the ancestral home of the Agnew clan and stands on the southern shore of the White Loch, 5¾ miles WNW of Stranraer. Its oldest part, a central square battlemented tower, five stories high, bears the date 1426; a modern portion, harmonising with the old, was commenced in 1820. An 18<sup>th</sup>-century extension, together with the Victorian mansion which was built adjacent, have been demolished. The garden and grounds were of great beauty, finely wooded with trees both native and exotic.<sup>25</sup> The Castle was sold by the Agnew family in 1948 and it then passed to Olaf Hambro who pulled down the 1820 wing in 1952. He sold the castle in about 1956 to a Miss Del Agnew from Australia (if there is a family connection it was in the 1620s) and she ran the castle as guest house until it was sold by her in the 1980s.<sup>25</sup>

A document currently being prepared by Historic Scotland<sup>26</sup> has an entry which includes the paragraph:

"In 1892, Sir Andrew Agnew, 8<sup>th</sup> Bt, died and Lochnaw was inherited by his son, Sir Andrew Noel.



Around this time, some of the Flower Garden beds were rationalised (the walled enclosure straddling Mill Isle Burn to the south of the main walled garden), and superfluous beds were turfed over. Storms in 1894 felled two of the firs on the loch point, the trees around the walled garden, and most of Craighhead Wood. A lot of clearing and replanting of the evergreen woodland understorey was carried out in the late 1890s, and the terracotta sundial was replaced by a stone one.”

The final phrase here indicates the presence of a sundial at the end of the 19<sup>th</sup> century but there is no proof that it was the Benjamin Scott one. A photograph of the Castle in the early-20<sup>th</sup> century (Fig. 9) by RCAHMS just shows the presence of a sundial pedestal in the formal garden.

In fact, the 25 inch OS map of the area from 1894,<sup>27</sup> shown in Fig. 10, indicates the presence of two sundials, marked SD! One may have been the Scott dial but another sundial with the Agnew arms on it is known. It is by A. Adie of

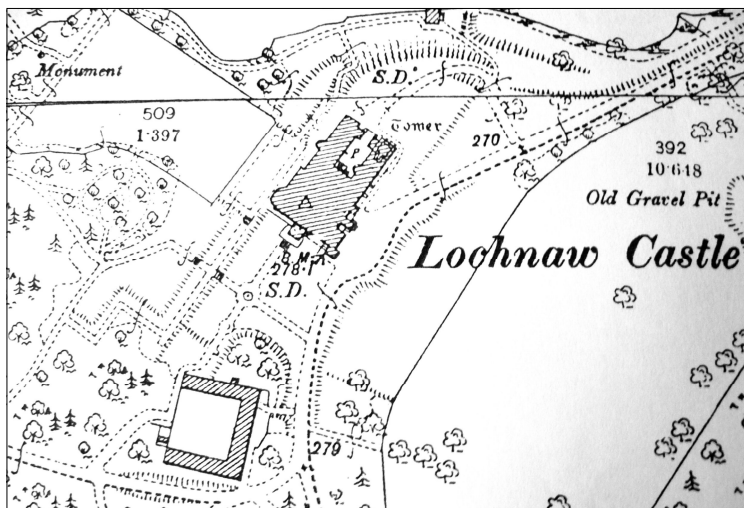


Fig. 10. 25" OS map of Lochnaw Castle, 1894, Sheet 10.16. Two sundials are marked 'SD'.



Fig. 11. The A. Adie dial for the Agnews. Note the full coat of arms. Photo © National Museums of Scotland.

Edinburgh and was once in the Arthur Frank Collection: it is now in the National Museums of Scotland.<sup>28</sup> It also features on the cover of *Brass and Glass*<sup>29</sup> and is shown in Fig. 11. It is dated to between 1822 and 1835 and so is about a century later than the Scott one. It was probably commissioned by Sir Andrew Agnew (1793-1849), 7<sup>th</sup> Bt., and is 398 mm in diameter. It also features an EoT scale, though not in such fine detail as the Scott one. This Sir Andrew (7<sup>th</sup> Bt) attended classes at Edinburgh in 1810-11 and it was he who, in subsequent years, improved the castle and estate. He employed the Edinburgh landscape designer John Hay (1758-1836) to design the formal garden in which the Adie (?) sundial stood.<sup>30-33</sup>

Why did the Castle need two sundials? One possible reason is that the EoT scale on the Scott dial is for the Julian calendar and hence was out of date by the 19<sup>th</sup> century so a new dial with a Gregorian calendar was commissioned. But perhaps a more practical reason is that something more imposing was required for the new gardens and so a new, larger dial was commissioned, this time by a Scottish maker and with the full Agnew arms rather than just the crest.

Returning to the Benjamin Scott dial, the most probable person to have commissioned it is Lt Gen Sir Andrew Agnew of Lochnaw, 5<sup>th</sup> Bt (1687-1771). It could possibly have been his father Sir James, 4<sup>th</sup> Bt (d. 1742) but he had made over the estate to his son in 1724 when he retired to Edinburgh so it is possible that his son had the dial made at that time. Sir Andrew was described by Sir Walter Scott as “a soldier of the old military school, severe in discipline, stiff and formal in manners, brave to the last degree, but somewhat of a humorist.” He once addressed his troops in the Scots Fusileers on the eve of a battle with the words “Weel, lads, ye see these loons on the hill there! If ye dinna kill them, they’ll kill you.” He is also credited with coining the phrase ‘Don’t shoot until you see the whites of their eyes’ during the battle of Dettingen (June 14, 1743).<sup>34</sup>

#### ACKNOWLEDGEMENTS

I am very grateful to Alison Morrison-Low (NMS) for information about the Adie dial and pointing out the map of the Castle to me; Sir Crispin Agnew for details of the Agnew and Castle histories; to Mary Plunkett of Wigtonshire for the provenance of the dial; Adrian Whicher and John Herrick at the London Science Museum; and to Mike Cowham for details of Scott’s instruments.

#### REFERENCES and NOTES

1. The dial was purchased privately, having been bought by the previous owner’s late father in the mid-1980s, a time when the Castle was changing hands.
2. Although common on astronomical instruments, transversals are rare on sundials. An example on a 1673 stone equatorial sundial from Germany in the Adler Planetarium (inventory M-272) precedes Rowley, though is probably not directly related. I am grateful to Maciej Lose for pointing this out.

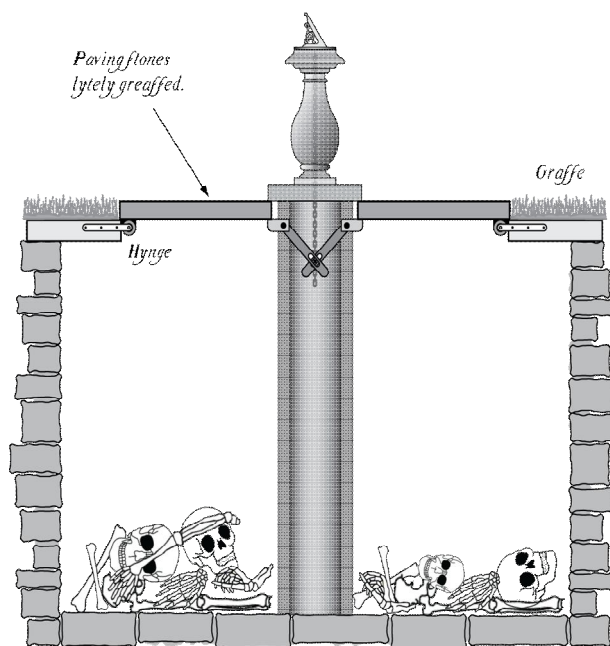
3. J. Davis: *John Rowley: Master of Mechanicks to the King*, presented at the BSS Conference (2008).
4. J. Davis: 'Thomas Wright's horizontal sundials', *BSS Bulletin*, 16(iv), 135-143, (Dec. 2004).
5. See Ref. 4, fig 11.
6. The values are: 31 Jan, 14m 49s (F); 4 May, 4m ?s (S); 16 July, 5m 46s (F); 23 Oct, 16m [1s] (S).
7. J. Davis: 'The Equation of Time as Represented on Sundials', *BSS Bulletin*, 15(iv), 135-144, (2003) and 'More on the Equation of Time on Sundials', *BSS Bulletin*, 17(ii), pp. 66-75, (June 2005).
8. J. Wilson: *Biographical Index of British Sundial Makers from the Seventh Century to 1920*, BSS Publications (2003).
9. G. Clifton: *Directory of British Scientific Instrument Makers 1550 – 1851*, Zwemmer, London, (1995).
10. The text in the centre of the advertisement for Benjamin Scott in the Science Museum, London, (1042273) reads:  
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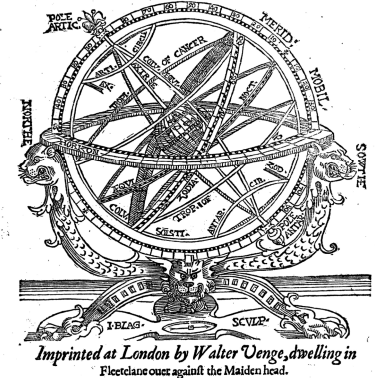
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John Davis

David Harber has been making sundials for 17 years<sup>1</sup> but he has only recently realised that he is descended from the Blagrove family and hence has a direct link to the distinguished 16<sup>th</sup> century mathematician and diallist John Blagrove (c.1558-1611). Not only that, but David's first dialling workshop was only a few miles from Blagrove's birthplace of Sonning and the large memorial to him in the nearby church at Reading. An account of Blagrove's life and some of his work was described by Charles Aked (drawing on a 1920s publication by Robert Gunther<sup>2</sup>) in an earlier *Bulletin*.<sup>3</sup>

David decided that this connection ought to be celebrated in a tangible way. One of John Blagrove's most famous and earliest inventions was his 'Mathematical Jewel'. This was a form of astrolabe which he described in his first book, published in 1585. It proved to be rather difficult to make and to

use and never found much acceptance – there is an unsigned version in the Adler Planetarium. At this early stage in Blagrove's career, he couldn't afford to employ an engraver and so he cut the woodcut illustrations himself. The frontispiece shown above includes an armillary sphere depicting the three-dimensional cosmos which the Mathematical Jewel represented in a two-dimensional instrument.

A representation of this armillary sphere from David Harber Sundials was unveiled in a presentation to an invited audience at a gathering in the Director's Suite at the Science Museum in South Kensington on 28 April. This was a well-attended affair and my first visit to this part of the Science Museum – a rather impressive panelled and book-lined room reminding us that the museum once did proper historical research rather than its current rôle of providing entertainment for children. David described his connection to his illustrious predecessor before introducing us to a reincarnation of the man himself, or at least BSS-member Peter Ransom reprising the impersonation he gave us at a Conference a few years ago. After describing his life, Blagrove and David jointly lifted the cloth to reveal the splendid dial



# THE EVOLUTION OF ENGLISH MASS & SCRATCH DIALS

c.1250 – c.1650

## Part 1 – Dial Categorisation

CHRIS H K WILLIAMS

**A**lthough it has long been recognised that mass dials come in a variety of forms, agreement on their categorisation and evolution has yet to emerge.<sup>1</sup> Categorisation has not been mass dial students' finest hour. It sits most uncomfortably next to the triumph of recording. An inconclusive literature portrays an ironic position – over-interpreting the appearance of surviving dials yet under-utilising the available data. By developing a scientific approach analysing thousands of recorded dials this article (including its subsequent parts) establishes, for the first time, the pattern of scratch dials' evolution.

The father of scratch dial categorisation is Horne.<sup>2</sup> His criteria include structural positioning of the gnomon (in the body of a stone or their jointing), hour lines (above as well as below the sunrise/set horizontal, jointing used in lieu of

scratching), circle (present or absent) and holes (as well as or instead of hour lines). Horne posits 12 dial types but many more are implicit. Green,<sup>3</sup> by elaborating all possible (sub)variants of each categorisation criterion, takes Horne's approach to its logical conclusion. Realising a complete enumeration of the resulting combinations would be a very long list, Green foregoes a formal typing. Tellingly, both Horne and Green confine themselves to quoting individual example dials rather than systematically allocating all their recordings to their categorisation(s). Had they attempted to do so, the methodological flaws inherent in their approach would have been revealed.

Data and category alignment is not a trivial matter. Without it, no categorisation can authoritatively reveal anything. For all their detail and complexity, Horne's and Green's categorisations are not mutually exclu-

sive (many dials appear to conform to more than one type) or exhaustive (some dials appear not to fit any type). No meaningful analysis is possible when the very cornerstones of logic and mathematics have not been met.<sup>4</sup> Whilst each of Horne's and Green's categorisation criteria might appear useful when describing an individual dial, collectively when considering all dials they produce a 'not able to see the wood for the trees' situation!

Subsequent students sought a simpler, smaller categorisation. Cole, the remaining member of the inter-war scratch dial triumvirate, attempted one reflective of differing timekeeping systems.<sup>5</sup> Others, most recently Cook,<sup>6</sup> usually employed some combination of the number of hour lines and the presence or absence of circles and pock marks. The prime motivation has been the perceived need to preface the publication of a county listing

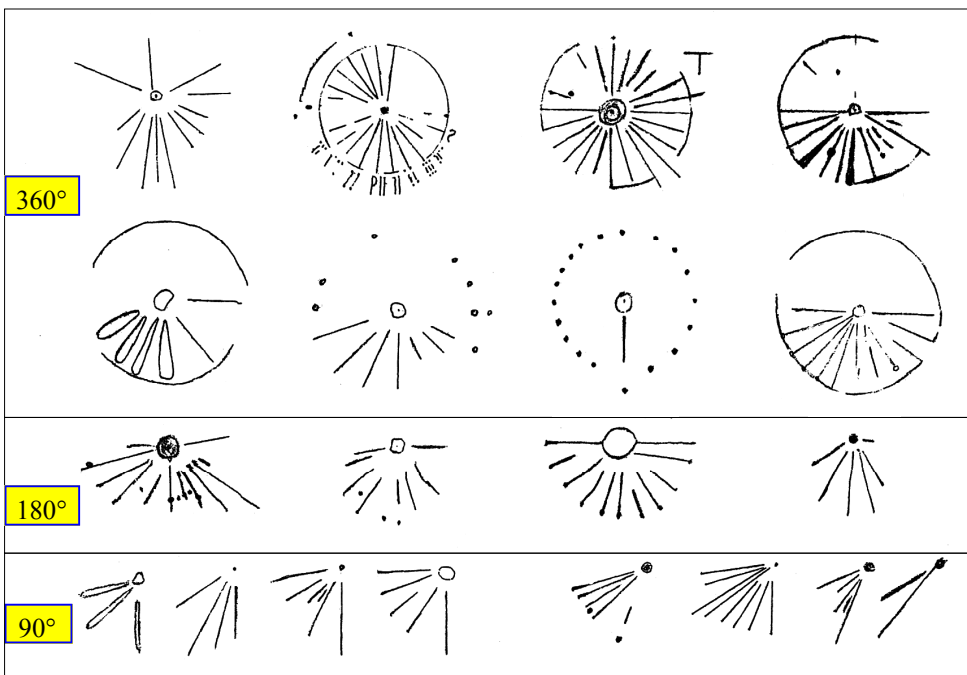


Fig 1. Using surviving scratch dials as a guide to the original appearance of mass dials.

### Notes

1. Based on 3950 scratch dials with recorded images. (Earlier, and Saxon, dials are not included – see main note (1)).
2. Surviving dials are but a shadow of their former selves – see main text. All have completely lost their original painted detail and decoration. Not all painted detail need also have been scratched. Some original scratching will have been lost.
3. Surviving scratching and pock marks are used to determine whether the original mass dial encompassed 360°, 180° or 90° in terms of visual appearance. (Typical examples for each shown).
4. The implied original difference between 360° and 180° dials was one of decorative or symbolic appearance; functionally – below the sunrise/set horizontal – they were equivalent.
5. The 90° dials, in contrast to the 360° and 180° types, are all 'morning' only; the few (apparent) 'afternoon' dials are invariably fragmentary/repositioned.

with an indication of scratch dial variability. No consensus has emerged; they are invariably only illustrative, and if dials are allocated to the categorisation the results are not analysed. Clearly any proposed or implied dial evolution is, in reality, unsubstantiated. The true state of current understanding is laid bare in the mass dial section of the Society's website. It honestly adopts an agnostic stance, emphasising wide dial variety and a problematic chronology. Its discussion is framed around examples and possibilities rather than an established development and evolution of scratch dials.

Virtually the entire attention of the literature is focussed on the surviving appearance of dials.<sup>7</sup> Surely our ultimate focus must be dials' original (painted) appearance and functionality not that of their (partially) surviving skeletal remnant?<sup>8</sup> Realising dials were painted, it becomes obvious that not all hour lines need have been scratched – only enough to guide painting/reinstatement. Similarly, neither encirclement/decorative enhancement, nor hour line annotation, need have been fully, or even partially, scratched. Likewise, original dial size is not necessarily indicated by the scratching. Allowing for the twin possibilities of not all painted detail being scratched and not all scratching surviving, it follows that surviving appearance is at best a partial, and at worst a misleading, guide to a dial's original appearance.

But surviving dial appearance is the only evidence available; there is no alternative to using it. That said, the previous discussion dictates we forego an extensive categorisation based on questionable detailed variations in surviving dials in favour of a smaller one that definitely reflects real differences in their original appearance. Earlier discussion also identified another essential requirement: confronting the categorisation with the data is not an (illustrative or partial) afterthought, but a single combined process – the data must drive determination of the categorisation, and the categorisation must maximise the data used.

Intensive examination of all dials with a recorded image results in the threefold categorisation of Fig. 1.<sup>9</sup> It is predicated on using the only surviving evidence – scratching and pock marks – to provide the most pragmatic and robust guide possible to the original appearance of mass dials. At the risk of repetition, the practical emphasis is on the identification of major and certain, rather than minor or questionable, differences. Most surprisingly, for diallists, the categorisation eschews the number, and detailed positioning, of hour lines. (Not because it is unimportant, but because the evidence is beyond unambiguous interpretation.) How the categorisation applies can be gauged from Fig. 1's sample of example dials that have been allocated to each type. It is contended that in terms of a dial's original (painted and decorated) appearance, the magnitude and certainty of variation within a dial type is but a fraction of that between

them. It is further contended that differences between the three dial types represent the most visually and generically differentiated categorisation possible.

The categorisation meets the dual methodological requirement. Firstly, definite differences in original appearance – although 'when in use' dial appearance is irretrievable, no one can doubt this categorisation is indicative of three very different types of dial. Secondly, the maximum use of data – only dials in a seriously distressed condition are unrecognisable and beyond allocation within Fig. 1. Any imagined benefit from further (sub)categorisation must be weighed against its costs – reduced certainty that only genuine original differences are being identified, together with fewer dials unambiguously allocated to the categorisation.<sup>10</sup> Both render subsequent statistical analysis/discrimination problematic and less certain. More detailed categorisation is not the handmaiden of more or better information!

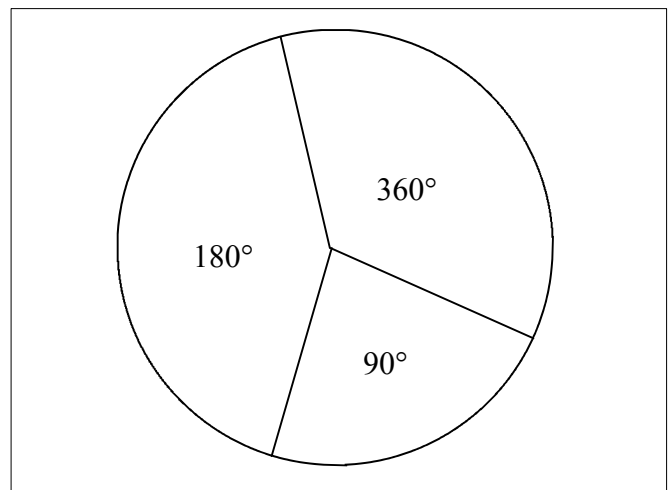


Fig 2. England's surviving dials by type.

Notes

1. Dial types as outlined in Fig 1 and main text.
2. Reconciliation with the English database of 5,500 listed dials (100%) – dials allocated to the categorisation 53%; distressed dials that are uncategorisable 19%; and listed dials without (mainly due to dial loss) a detailed recording 28%.

Pending the results of further investigation, the current purely descriptive nomenclature (360°, 180° and 90° dials) will be retained as a convenient shorthand. Their comparative frequency is shown in Fig. 2. All the underlying data are of course available by county within the database: their detailed statistical analysis to determine the sequencing and age of dial types, as well as any regional variation, will be outlined in subsequent parts of this article.

REFERENCES & NOTES

1. Whilst Saxon dials are beyond the scope of this article it is worth noting that there is an accepted mass dial distinction between Saxon and scratch dials. Although their associated age and quality differences are indisputable, it coincides with an evidential watershed – scratch dials survive by the thousand, Saxon dials by the ten. We need to beware of artificially oversimplifying or dichotomising the pre- and post-Conquest situa-

- tion. For a fuller discussion see Chris H. K. Williams: 'The English Scratch & Mass Dial Era: Origins to c.1250', *Bull BSS*, 22(i), 14-17, (2010).
2. Dom Ethelbert Horne: *Primitive Sun Dials or Scratch Dials*, The Wessex Press, Taunton, (1917). Ch. III.
  3. A. R. Green: *Sundials Incised Dials or Mass-Clocks*, Macmillan, London, (1926). Ch III.
  4. This cannot be circumvented by deeming 'inconvenient' data to be uncategorisable or by the creation of an additional catchall 'miscellaneous' dial category. Each amounts to choosing a biased sample.
  5. Albeit an interesting shift from surviving appearance to original functionality, it has to be admitted that the detailed basis of Cole's categorisation drifted with his interpretation of time-keeping systems, much of which is unsupported by modern scholarship. (Compare T. W. Cole: *Classification of Church Scratch-Dials*, The Hill Bookshop, Wimbledon, (1936) with 'Church Sundials in Medieval England', *Journal of the British Archaeological Association*, (1947)). Furthermore, he never systematically allocated recorded dials to his threefold (including Saxon dials) categorisation.

6. A. Cook: *Mass Dials on Yorkshire Churches*, BSS Monograph No. 3, (2008).
7. More strictly the surviving appearance of dials that have survived (see note 1).
8. The most cursory examination of medieval ecclesiastical art and culture indicates dials would have been painted. Although this was recognised by Horne and Cole, neither considered nor appreciated the consequential implications for interpreting surviving dials. Almost all subsequent students make no mention of painting.
9. To be fair to the earlier literature, Green, *op. cit.*, mentions an equivalent categorisation of wheel, half-wheel, and quarter-wheel dials. But it is merely a single subset of a much larger edifice attracting no particular emphasis or prioritisation.
10. Extending the categorisation results in less dissimilar 'adjacent' dial types: more dials become consistent with more than a single type. Fewer dials can be definitively allocated to the categorisation. Data – information – is being dissipated.

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## GNOMON SUPPORTERS

In his article on 'Gnomon Supporters' (*Bulletin* 21(iv), p.40, December 2009), Mike Cowham asked for other examples. Frans Maes has responded with this horizontal dial on the ground of a park in Kleine Huisjes, a hamlet in the very north

Marten described how the schematic yet lifelike figure was obtained: a man knelt in front of a large sheet of paper, illuminated by a slide projector, whereupon his silhouette was traced.



of the Netherlands. It is a 'Monument for Agriculture' and depicts a farm labourer, picking weeds by hand. He holds a hoe that serves as the pole-style. It was designed and constructed in Cor-Ten steel as a community project in 1995. Gnomonic advice was given by Marten Hugenholtz, member of the Dutch Sundial Society.

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# A LOCAL PECULIARITY

IAN R BUTSON

Although not unknown, the scaphe dial is rarely seen except as a feature on multiple dial structures, where the diallist displays his proficiency in producing sundials of varying types on a number of different surfaces and of varying orientation.

During my travels recording sundials within the county of Buckinghamshire, three scaphe dials have been found in very close proximity to each other.

## 1. Hillesden

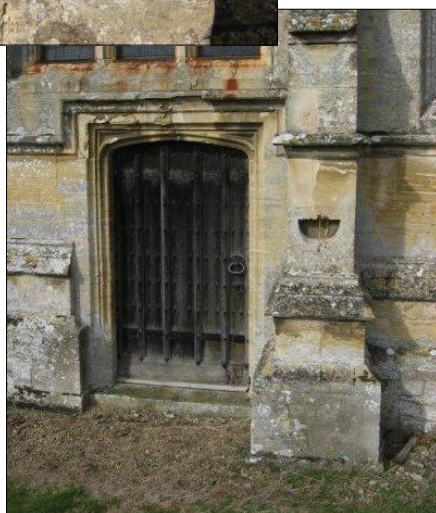
Fig. 1. A half-hemisphere, south facing dial is carved into the stonework on a buttress at All Saints Church, Hillesden. The hour lines are inscribed within and it also has “1601 Georg De Fraisne” inscribed across the upper edge of the dial with the motto “Sic Transit Gloria Mundi” around the lower semi-circle.

The inner surface of the scaphe bowl is marked to show the hours from 6am to 6pm, with half-hour divisions also being indicated. Although no longer extant, it seems likely that the gnomon would have been a short vertical rod set into the upper and lower niches on the front surface of the dial.

The hour lines originate from the lower mounting point of the gnomon. Although not measured precisely, but using a satellite and OS map view of the church, the dial would appear to face almost directly towards the south.



*Fig. 1. The dial on All Saints Church, Hillesden, set to the east of the priest's door.*



*Fig. 2. (Top) The Five Elms pub at Weedon; (centre) the scaphe dial; (bottom) close-up of the gnomon.*

## 2. Weedon

Fig. 2. A vertically mounted scaphe, shaped as a shallow bowl, is set into the front wall of The Five Elms public house at Weedon. The wall appears to face just slightly to the south of east. The bowl of the dial is also very slightly canted-out on the left hand side presumably to ensure that it actually faces due east. The shallow bowl of the dial is marked from 4am to 11am to indicate the morning hours, as would be expected from a dial in this position. The chapter ring shown across the centre of the dial seems much in the style of that at Hillesden, also with half- as well as quarter-hours indicated. With additional painted ornamentation to the dial there is a small black disc in the upper part of the bowl and a painted star below, close to the 4am hour line. Perhaps these indicate the moon and stars during the 'dark hours'. A straight gnomon rod is fixed at the upper and lower points from where the hour lines originate. Above the actual gnomon a curved bow is mounted having five short stubs fitted, each having an irregularly shaped piece at the upper end of the stub. Perhaps these are intended to appear as trees and symbolically indicate the name of the public house?

## 3. Creslow

Fig. 3. A small stone block which is carved with a half-hemisphere and set into a south-west facing support to the porch at The Manor House, Creslow. A sloping diagonal

straight edge forms the gnomon. Again from the OS map and satellite view, the surface on which this dial is situated faces slightly south of south-west (approximately 245 degrees). Although there are now no hour markings visible within the bowl of this dial, and some cement repairs have been made in the past, it does appear that the sloping straight edge (approx. 50° to the horizontal) on the right hand side of the bowl would have formed the style edge to the gnomon. With markings shown within the dial bowl and with this orientation it could have indicated hours from mid-morning to late-afternoon. (10:30am to 4:30pm perhaps?)

Although Creslow is now a tiny hamlet, it was at one time a parish but its history is obscure. At the time of the dissolution of the monasteries the manor belonged to the Knights Hospitallers. The Manor House, built c.1330 and having 16<sup>th</sup>- and 17<sup>th</sup>-century additions, is now a farm-house. Adjoining are relics of an associated chapel with some 12<sup>th</sup>-century features, but now used as a farm building. If the dial here is original, was this perhaps the inspiration for that at Hillesden?

Hillesden, as at Creslow, is now only a small and remote hamlet but having once been a much larger parish. Its church, however, is 'dial rich', with mass dials and the remaining gnomon of a vertical dial on the south transept, as well as this unusual scaphe dial. Situated in one of the most

out-of-the-way places in the county, time must have been rather important to its population in the past!

Weedon and Creslow are about two miles from each other, with Hillesden being only nine miles away.

Can these dials be an example of a 'local peculiarity', perhaps even derived from the influence of one dial-maker?

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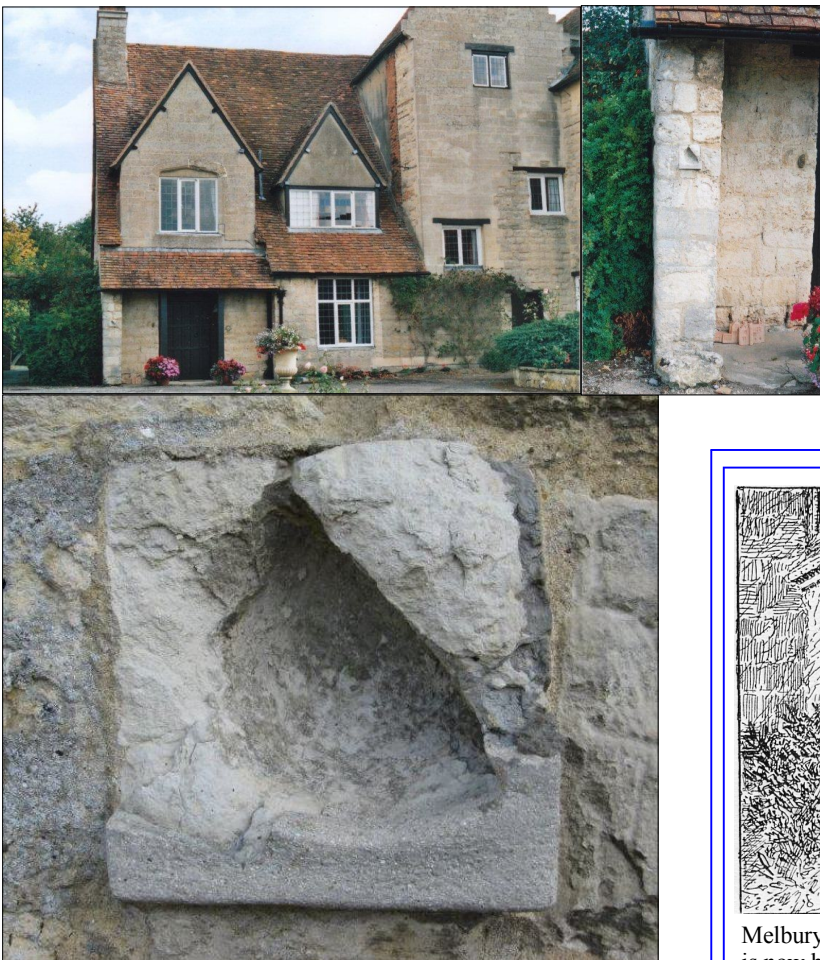
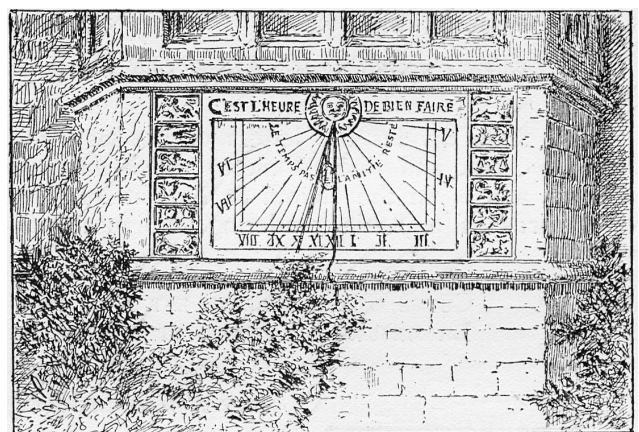


Fig. 3. Three views of the dial at the Manor House, Creslow.



Melbury House, Dorset, SN 2531. Dating from 1890, this dial is now believed to include declination lines as well as the zodiac symbols and French mottoes. After Gatty.

# THE RETURN OF TWO DIALS

MIKE COWHAM

This is the story of two very interesting sundials that, having been lost, have recently been returned to their rightful owners.

## Myddelton House, Enfield

The dial here has a spectacular pedestal that is carved on eight faces showing a number of mainly navigational scientific instruments.

I first heard about this dial when I was in an antique shop in Hertford. I had been asking if they had any dials for sale when a man, Andrew Newman, sensing that I was involved with sundials generally, informed me of a dial that had recently been stolen (March 2005) from the gardens of Myddelton House, a local stately home but now owned by Lee Valley Regional Park Authority. He told me that it had a spectacular pedestal and he let me see some photographs of it.



Fig. 1. The dial pedestal at Myddelton House, carved with instruments.

Almost three years later, in January 2008, a dealer in monumental antiques contacted me, as he was interested in advertising in the *BSS Bulletin* for an old dial to fit a wonderful pedestal that he had just acquired. He was then going to take this to sell at Grosvenor House Antiques Fair. His description rang a few bells with me and I asked him to send me a picture of his pedestal. On seeing the picture I immediately realised that it was the one that had been stolen from Myddelton House. Cautiously and somewhat timidly, I decided to call him with the bad news about his dial. Although disappointed he was grateful that the dial did not go to the antique fair; its 'discovery' there would have been most embarrassing. I then gave him details of its owners and left him to arrange for the pedestal to be returned to them.

Earlier this year, I was contacted by Lee Valley Regional Park Authority to ask me to attend a ceremony to welcome the dial back to the house, it now being placed in the gardens at the front of the house, but with a modern replica dial plate fitted on top. The ceremony followed the AGM of the 'E. A. Bowles of Myddelton House Society' whose chairman is Brigadier Andrew Parker Bowles. Afterwards I was able to photograph the details of this fine pedestal and have since been trying to identify the various instruments illustrated on it. (Fig. 2.)

The earlier history of the dial and pedestal goes back to when Edward Augustus Bowles lived at the house. He apparently bought it and had it installed at his house. He may have acquired it from Gough House, a neighbouring property which had been purchased by Bowles and then demolished around 1900. Harry Gough, born 1681, had purchased the house in 1723. He was an MP and Director of the East India Company. From 1707 to 1715 he had commanded the ship 'Streatham'. There is therefore a strong nautical link through him. The actual date of the pedestal is unknown but the dial plate that was fitted is said to have been signed by Charles Lincoln of Leadenhall Street and was dated 1765. It has still not been recovered. The pedestal is somewhat earlier than that, probably early 1700s. It is believed that E A Bowles fitted this dial to the pedestal.

Interestingly, the pedestal is carved with very similar instruments to those of a tomb in nearby Waltham Abbey and could be the work of the same mason. If it had not been made for Harry Gough, then it may have belonged to the man buried in this tomb; Robert Smith. He was born in 1637 and was later captain of a merchant ship. He had retired to live near to the church and died on his way to a service there in March 1697, although his dates were a little earlier than the date being assigned to the pedestal.



Fig 2. The various instruments carved on the eight faces of the dial pedestal. Face 1: Protractor, Sector and probably a Speaking Trumpet (an early form of Megaphone).

Face 2: Caduceus\*, Knife (a Dirk?) and another Speaking Trumpet.

Face 3: Cross-Staff, Chart and a Ruler.

Face 4: An early Back-Staff, Sand Glass and Three-Legged Dividers.

Face 5: Protractor, Square and Universal Equinoctial Ring Dial.

Face 6: Dividers, Ink Pot, Quill Pen, Ruler and Quadrant (its plummet hanging below).

Face 7: Back-Staff (Jacobstaff), possibly a Sounding Cannon and a Telescope.

Face 8: Quill Pen, Chart, Dividers and a 360° Protractor.

\* The Caduceus was in antiquity Mercury's rod, or sceptre, being entwined with two serpents. Wonderful properties were assigned to it by the poets, such as raising from the dead. It is also a symbol of good conduct, peace and prosperity. Today it is often used by hospitals and physicians. Its true significance on this pedestal is not known.



Fig. 3. The tomb of Robert Smith at Waltham Abbey.

### Tywyn

This early Celtic sundial was described in the June *Bulletin*.<sup>1</sup> It has recently been moved inside the church to stand next to the famous Cadfan Stone.

I received an invitation to join with them in a special service of Evening Prayer to end with the blessing of the dial by the Rt Reverend Andrew Jones, Bishop of Bangor. Over 80 people turned up for this special service including some from the BSS, Val & myself, Bill Linnard and his wife and Tony Wood with a colleague. The press were



Fig. 4. The Bishop of Bangor, Andrew Jones, blessing the sundial, splashing it with water with a sprig of box.

there to record the event as were representatives from other churches and chapels, plus organisations in the town and some town councillors. The half-hour service started with a hymn and some prayers (some in English and some in Welsh), followed by a short address by the vicar, Rev Richard Vroom, concerning time and its enigmatic nature, with a few details of canonical hour time reckoning. He then invited Bill Linnard to say a few words about the dial, which he did, first in Welsh and then in English. After some further prayers we moved to the back of the church where the dial now proudly stands, and to my surprise I was asked to do the unveiling! Having done this, the Bishop blessed the stone, splashing it with water with a sprig of box; a



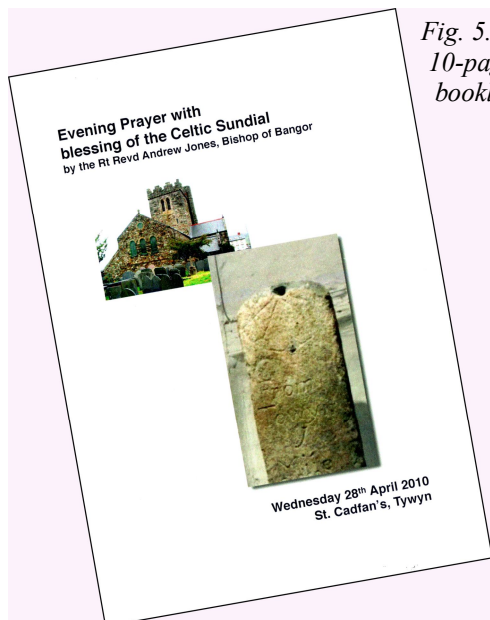


Fig. 5. Front of the 10-page service booklet.

Fig. 6. Prayer for the dial.

#### Blessing of the Sundial

Almighty God,  
after many centuries telling the time to monks,  
christian folk, all and sundry,  
marking the times for praise, prayer and silence,  
this monumental sundial stone has come to rest  
in a place where it will not show the progress of time anymore.  
It is here, in a place where heavenly time is celebrated again  
and again, a place where there is no more direct sun, but  
just the light of your glory.

Bless this stone, and all those who shall see this silent witness of  
time, in the ☩ name of the Father, and the Son, and the Holy Spirit.  
May it be a constant reminder that there is a heavenly time  
beyond our time and space, a time here and now, where the hours  
do not count, the minutes do not pass and the seconds are more  
than moments of eternity. **Amen.**

shrub that easily roots from a cutting, symbolising everlasting life. We sang the final hymn standing round the stone before refreshments were served for all. An article with a photograph of our group with the Bishop was published a few days later in *The Cambrian* newspaper.

It was just coincidence, but the two ceremonies described above took place just four days apart on 24 and 28 April

2010, and that both had top men named Andrew; in fact it was Andrew Newman who originally told me about loss of the Myddelton House dial. I would like to thank him for his notes about the possible origins of the Myddelton House pedestal that he believes may have come from Gough House.

#### REFERENCE

1. M. Cowham: 'Update on the Tywyn Dial', *Bull. BSS* 22(ii) p.24 (2010).

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## Postcard Potpourri 17 – Stainboro Castle, Barnsley, Yorkshire

Peter Ransom

This card is unusual since it features a living sundial together with a date: March 1932. We can see all the roman numerals and lines laid out using either plants or small bushes (box?) together with the initials BW. Any information about who BW was would be most appreciated!

Although the card says Stainboro Castle, the dial was at Wentworth Castle, Stainborough. An internet search narrowed it down to this place and an image on the website at [www.rotherhamweb.co.uk/gallery/wentworth1/index.htm](http://www.rotherhamweb.co.uk/gallery/wentworth1/index.htm) shows a slightly different view of the dial allowing the initials to be seen more clearly.

It appears the stately home was built in the 17<sup>th</sup> century and features 26 listed buildings. It came third in the 2003 BBC series *Restoration* and the Heritage Lottery fund provided £10.3 million for a massive improvement project that was due for completion at the end of 2007. Whether this included the sundial or not, I do not know.

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# TWO METHODS TO FIND THE ECCENTRICITY OF THE EARTH'S ORBIT FROM MEASUREMENTS WITH A SUNDIAL

## Part 1 - Theoretical Considerations

STAN ULENS AND JOS KINT

### 1. Eccentricity

As is well known, the earth turns around the sun in an elliptical orbit. The sun is at a focus of that ellipse. Such an ellipse is characterized by its major and minor semi-axes  $a$  and  $b$  (Fig. 1). The linear eccentricity  $e$  is defined by:

$$e = \varepsilon = \sqrt{\frac{a^2 - b^2}{a^2}} = \sqrt{1 - \left(\frac{b}{a}\right)^2}$$

Two methods are presented here for calculating the earth's orbital eccentricity. The first method uses the ancient geocentric model of Ptolemy. A graphical method is then used to find the eccentricity as the crossing point of two straight lines.

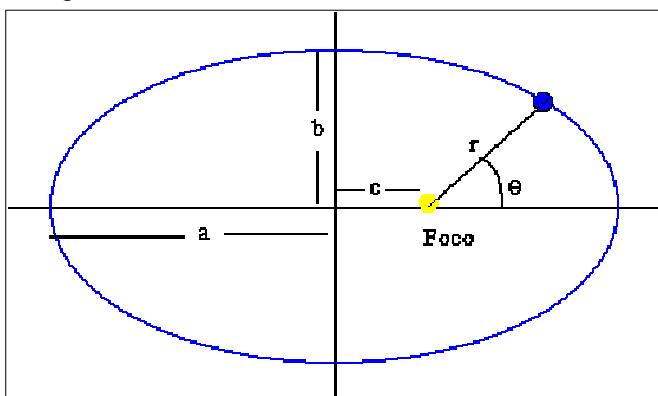


Fig. 1. Ellipse with a semi-major axis  $a$  and a semi-minor axis  $b$ . The sun is at one of the two foci.

The other method is based on the calculated value of the Equation of Time (EoT), which can be found after regular observations on a sundial and some subsequent calculations. From this value of the EoT an algebraic formula can be derived which gives the desired value of the eccentricity.

### 2. Method Based on the Geometric Model of Ptolemy

For simplicity, let's use the Ptolemaic model, which means that the sun is spinning on a circle of radius 1 unit and the earth is  $e$  units from the centre of the circle. For the calculations it makes no difference if the sun is in the centre or the earth. See Fig. 2.

When you have established the lengths of the seasons you need to solve the diagram to find  $e$  and the longitude of perihelion. The lengths of the seasons give you the blue angles. The eccentricity you get should be about 0.033. It can easily be shown that, to a first approximation, this is twice the value of  $e$  used in Kepler's elliptical model.

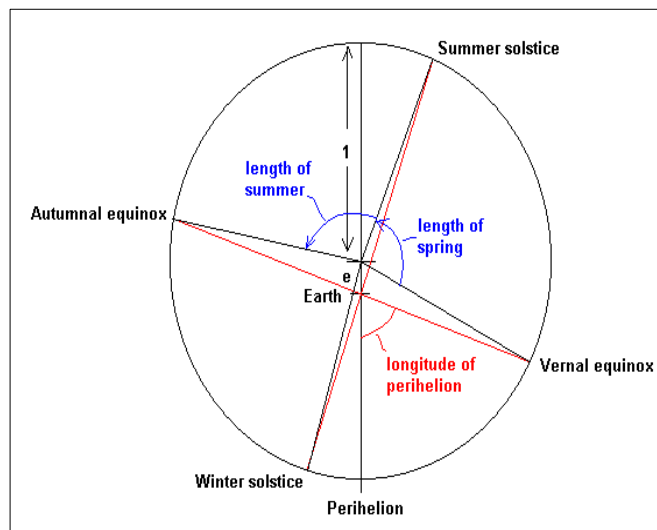


Fig. 2. The Ptolemaic model of the solar system.

Eccentricity and phase were established in classical times by Ptolemy by timing as accurately as possible the solstices and equinoxes. From the solar noon altitude one can calculate the solar declination. Timing the equinoxes is then relatively easy, as the declination at that moment follows an almost straight line. Timing the solstices is somewhat harder as the declination at this extreme value does not change much from day to day. However, by application of a curve fitting program these calculations can be made without much problem.

This can easily be done with a common sundial. First one calculates the moment of the equinoxes and of the solstices. To achieve this one measures the solar noon altitude on as many days as possible. From this solar altitude and the local latitude, it is easy to calculate the sun's daily declination. A graph with this declination as a function of the date is then used to calculate the moments of the equinoxes (where declination is zero) and of the solstices when the declination is a maximum or minimum. Doing so from one vernal equinox to the next, one gets a good estimate of the length of the year. Putting this value equal to  $360^\circ$ , one can then locate the moments of equinoxes and of solstices on the circle. Once one knows the lengths of the four seasons one can obtain graphically the eccentricity and the dates of perihelion and aphelion (see Fig. 2). The Ptolemaic model, with the sun on a uniform circular orbit about a fixed point in space somewhere near the earth, is quite accurate enough for these purposes.

### 3. Algebraic method based on the EoT

#### 3.1 Introduction

The Equation of Time (EoT) gives the difference between the apparent solar time and the mean solar time. The apparent solar time is the time corresponding to the hour angle of the sun and is e.g. given by a sundial.

The mean solar time is the time that would be indicated by a clock going steadily over the year; it can be derived from the local official time by taking in account the longitudinal position of the observation point in the time zone.

Apparent solar time and mean solar time differ for two reasons:

- i) Kepler's laws state that the angular speed of the earth (or of the sun, as observed from the earth), is not constant, but varies with the distance of the earth to the sun. The sun is 'fast' near the perihelion (smallest distance to the earth) and 'slow' near the aphelion (largest distance to the earth)
- ii) But even if the trajectory of the earth were perfectly circular, there would be a difference between apparent solar time and mean solar time. This a consequence of the fact that the earth moves in a plane that makes an angle of 23.5 degrees with respect to the equator, or equivalently, the obliquity of the ecliptic with respect to the celestial equator. The sun moves uniformly along the ecliptic, but due to the obliquity, the projection of the trajectory of the sun on the celestial equator, where solar time is measured, is not uniform. The sun seems to move fast at the solstices and slow at the equinoxes.

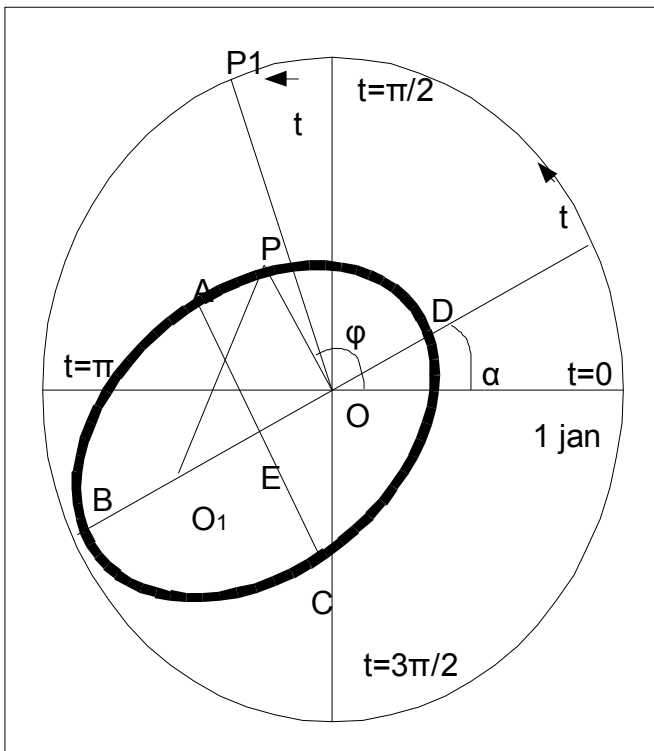


Fig. 3. Earth orbit ( ellipse) and orbit of the fictitious sun (outer circle).

The total value of the Equation of Time can be measured by a sundial. As the purpose of this study is to determine the eccentricity of the orbit of the earth around the sun, the proposed method is to calculate the second part (the part due to the obliquity) of the Equation of Time and to deduct it from the total; from the remaining part it is possible to calculate the eccentricity.

#### 3.2 Equation of Time due to the eccentricity

In Fig. 3, the ellipse represents the elliptical orbit of the earth around the sun, or equivalently, of the sun around the earth as it is seen by an observer on earth (position P). The outer circle represents the orbit of a fictional sun (with position P1) that moves around the earth with the same period as the real sun, but with constant speed. So,  $t$  is a measure for the mean solar time,  $\varphi$  is a measure for the apparent solar time and  $t - \varphi$  is a measure of the part of the EoT due to the elliptical orbit of the earth.

The formula for an elliptical trajectory in polar coordinates with the origin in a focus of the ellipse, is well known:

$$r = \frac{a(1-e^2)}{1+e\cos(\varphi-\alpha)}$$

Where  $r$  represents the radius,  $\alpha$  and  $\varphi$  respectively give the angular position of the sun at the perihelion and at the observation day,  $a$  is the major semi-axis of the ellipse,  $b = a\sqrt{1-e^2}$  the minor semi-axis and  $e = \sqrt{1-b^2/a^2}$ .

Introducing  $l = a(1-e^2)$  we can write:

$$\frac{r}{l} = \frac{1}{1+e\cos(\varphi-\alpha)}$$

From Kepler's second law ('law of equal areas')

$$\frac{1}{2}r^2d\varphi = Cdt$$

Where  $\varphi$  and  $t$  are expressed in radians.

To find the constant  $C$  we calculate the area of the ellipse

$$\int_0^{2\pi} \frac{r^2}{2} d\varphi = \int_0^{2\pi} Cdt = 2\pi C = \pi ab = \pi a^2 \sqrt{1-e^2}$$

So

$$2\pi C = \pi a^2 \sqrt{1-e^2}$$

$$C = \frac{1}{2} a^2 \sqrt{1-e^2}$$

$$\frac{C}{l^2} = \frac{a^2 \sqrt{1-e^2}}{2a^2(1-e^2)^2} = \frac{(1-e^2)^{-3/2}}{2}$$

Or with good approximation (because  $e^2 \ll 1$ )

$$C = \frac{1}{2} l^2$$

So we have

$$d\varphi = \frac{l^2}{r^2} dt$$

And we have, with

$$r^2 = \frac{l^2}{(1 + e \cos(\varphi - \alpha))^2}$$

$$d\varphi = (1 + e \cos(\varphi - \alpha))^2 dt$$

$$= (1 + 2e \cos(\varphi - \alpha) + e^2 \cos^2(\varphi - \alpha)) dt$$

Or with good approximation,

$$d\varphi = (1 + 2e \cos(\varphi - \alpha)) dt$$

From this formula it is clear that the sun 'accelerates' around the perihelion ( $\cos(\varphi - \alpha)$  being positive) and 'decelerates' around the aphelion ( $\cos(\varphi - \alpha)$  being negative).

As the difference  $t - \varphi$  is small compared to  $t$  or  $\varphi$ , with good approximation  $\varphi - \alpha \approx t - \alpha$

$$d\varphi = (1 + 2e \cos(t - \alpha)) dt$$

$$dt - d\varphi = -2e \cos(t - \alpha) dt$$

$$t - \varphi = -2e \sin(t - \alpha) + C$$

We are only interested in the difference  $t - \alpha$  which has to be periodic without bias which requires  $C = 0$ .

So the part of the Equation of Time due to the elliptical orbit of the earth is given by

$$EOT1 = t - \varphi = -2e \sin(t - \alpha)$$

In this simple formula, all arguments are expressed in radians. EOT1 equals zero at the perihelion ( $t = \alpha$ ) and the aphelion ( $t = \alpha + \delta$ ).

Expressing EOT1 in degrees,

$$EOT1^{\text{deg}} = -\frac{360}{\pi} e \sin(t - \alpha)$$

The Earth rotates around the sun in 365.24 days; in one day, on average, it rotates  $360/365.24 = 0.98565$  degrees, so

$$t^{\text{deg}} = 0.98565 N$$

where  $N$  is the number of days after January 1<sup>st</sup>, and

$$(t - \alpha)^{\text{deg}} = 0.98565(N - P)$$

where  $N - P$  is the number of days after the perihelion.

Converting the argument to radians

$$(t - \alpha)^{\text{rad}} = \frac{2\pi}{360} 0.98565(N - P) = 0.0172029(N - P)$$

We want to express EOT1 in minutes of time instead of degrees. As the Earth rotates around the sun in 365.24 days, each day it has to rotate  $360/365.24 = 0.98565$  degrees more than 360 degrees i.e., 360.98565 degrees. It makes this rotation in  $24 \times 60 = 1440$  minutes. So 1 degree corresponds to  $1440/360.98565 = 3.98908$  minutes. Thus we have

$$EOT1^{\text{min}} = -3.98908 \frac{360}{\pi} e \sin(0.0172029(N - P))$$

Or

$$EOT1^{\text{min}} = -457.117 e \sin(0.0172029(N - P))$$

### 3.3 Equation of Time due to the obliquity of the ecliptic

In the spherical triangle formed by the ecliptic (Fig. 4), the celestial equator and a celestial meridian,  $a$  represents the (uniform) time travelled by the sun along the ecliptic, while  $b$ , the projection hereof on the celestial equator, represents the apparent solar time corresponding to it. The difference of both arcs, expressed in minutes of time, yields EOT2, the part of the equation of time due to the obliquity of the ecliptic. It is clear that this difference is zero at the equinoxes and at the solstices, as both  $a$  and  $b$  have the values of  $0, \pi/2, \pi$  and  $3\pi/2$  at these points.

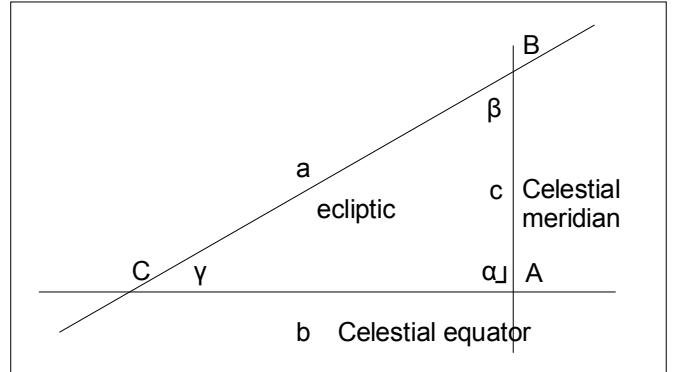


Fig. 4. Spherical triangle of the ecliptic  $CB$ , the celestial equator  $CA$  and the celestial meridian  $AB$ .

In the rectangular ( $\alpha = 90^\circ$ ) spherical triangle  $ABC$ ,

$$\cos \gamma = \sin \beta \cos c \quad (\text{cosine rule})$$

$$\sin \beta = \frac{\sin b}{\sin a} \quad (\text{sine rule})$$

$$\cos a = \cos b \cos c \quad (\text{cosine rule})$$

$$\text{or } \cos c = \frac{\cos a}{\cos b}$$

Introducing  $\sin \beta$  and  $\cos c$  in the first equation we find

$$\tan b = \cos \gamma \tan a$$

with  $\gamma = 23.5^\circ$  (the obliquity of the ecliptic).

So

$$\begin{aligned} \tan(a - b) &= \frac{\tan a - \tan b}{1 + \tan a \tan b} \\ &= \frac{\tan a - \cos \gamma \tan a}{1 + \cos \gamma \tan^2 a} \\ &= \frac{1 - \cos \gamma}{1 + \cos \gamma} \frac{\sin a}{\cos a} \end{aligned}$$

EOT2, the part of EOT due to the obliquity of the ecliptic is thus given by

$$EOT2^{\text{rad}} = a - b = \arctan \left[ \frac{1 - \cos \gamma}{1 + \cos \gamma} \frac{\sin a}{\cos a} \right]$$

Expressing, as above, EOT2 in minutes of time instead of radians

$$EOT2^{\text{min}} = 228.557 \arctan \left[ \frac{1 - \cos \gamma}{1 + \cos \gamma} \frac{\sin a}{\cos a} \right]$$

$a$  in radians is given by

$$a = \frac{2\pi}{365.24}(N - G) = 0.0172029(N - G)$$

where  $N$  is the day of the year of the observation and  $G$  is the spring equinox.

#### 4. The Eccentricity of the Earth's Orbit

From the total value of the EoT, measured by use of a sundial, the calculated 'obliquity part' is subtracted to find EOT1.

The eccentricity  $e$  of the earth orbit can be found by the equation

$$e = -\frac{0.002187624 EOT1^{\min}}{\sin(0.0172029(N - P))}$$

It is obvious that the method fails at the perihelion ( $N \sim 3$ , January 3<sup>rd</sup>,  $N - P = 0$ ) or at the aphelion ( $N \sim 185$ , July 4<sup>th</sup>,  $N - P \sim 182$ ) as the argument of the sine takes the values 0 and  $\pi$  and the formula yields a division of 0 by 0.

#### ACKNOWLEDGEMENT

With many thanks to Chris Lusby Taylor for his suggestion to use the model of Ptolemy.

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**NEXT ISSUE:** Part 2 - Observations and calculation of  $e$ .

## READERS' LETTERS

### Novel Meridian Finder (*Bull* 22(ii) pp.41-45, June 2010)

Michael Maltin deserves our congratulations for developing his 'Novel Meridian Finder', using a precise knowledge of local time. The simplicity and elegance of this double, or triple, mirror-image instrument is analagous to that of a sextant when contrasted with, for example, the complexity and cumbersomeness of a theodolite.

The detailed descriptions of the Meridian Finder, by Michael Maltin and Douglas Bateman, are invaluable and constructive.

Edward John Dent's converse use, in 1842, of a 'dipleidoscope' for precise time measurements apparently had a brief demise, perhaps because of the almost concurrent development of the 'Telegraph'. A somewhat cursory outline of the dipleidoscope is given by Gerard L'E Turner in his 1980 book *Antique Scientific Instruments* (Blandford Press).

Incidentally, theodolites have now almost become redundant. In 2004, for example, having sold two quite early sextants (in London), I then bought for just one hundred pounds (in a country auction) a splendid microptic theodolite with all of the accessories. This theodolite surprisingly was made by Vickers Instruments Ltd.

*Maurice J. Kenn, Brisbane, Australia.*

### Has anyone seen Haidinger's brushes?

Last winter my wife and I attended a series of science talks by lecturers from Manchester University. During a talk on animal senses the lecturer mentioned that humans could 'see' polarised light. The doubt in the room was tangible. He got us to stare at a blue computer screen and asked, what could we see? Fifty people saw nothing except a blue screen – it did nothing to dispel the doubt.

Some time later I read a blog of a student's a trip to California. It tells of gazing into the clear blue sky and he

excitedly describes seeing Haidinger's brush. I think a better description would be Haidinger's 'yellow bow tie', for that is what the sight apparently looks like. He mentioned the belief that the brush aligns with the earth's magnetic field, or maybe the sun, or even the plane of polarisation of the sunlight, very useful as it would provide another human body clock. Throw in alignment with ley lines and we've got them all. In fact, I think the only alignment which the brush could adopt is that related to the orientation of the observer's head, for Haidinger's brush is an image of the fovea, the most sensitive part of the retina, which is sensitive to polarised light. Have I got this right?

My wife and I gaze into the clear blue sky, 90° in front of, or 90° following, the sun, but all we see is a brown/yellow smudge, which is not a floater. What is wrong, or what are we lacking; is it youth, faith, or cannabis? So I'll repeat the question; has anyone seen Haidinger's brush?

*Roger Bowling*

### HOLIDAY SIGHTINGS



Edmund Knight

A Greco-Roman conical dial at Side, Turkey, 36° 45' N. In white marble, it has day curves for the solstices but, unusually for a conical dial, not the equinoxes. (S. Gibbs ref no 3059G.)

# TIMEKEEPERS IN BRITAIN, 43–780 AD

## Origins, the Roman contribution, and Anglo-Saxon continuity

JÉRÔME BONNIN

(translated by Tony Wood)

In November 2008, I presented a lecture on the above subject at the University of Lille 3, France. It followed a visit to the British Museum in London, accompanied by Tony Wood and Jill Wilson of the British Sundial Society. The following paper is just a summary of the questions about ‘timekeepers in Britain in antiquity’ raised during this lecture, with the most important one: were there means for measuring ‘Roman Time’ in Britain after 43 AD? Thereby, the particular questions concerning the sundials stored in the museum are not here expressed, neither the problems related to the term ‘horologia’.

### Timekeepers in Britain – what would they be made for?

Within the immediate Greco-Roman region, the *horologium* is at the same time a time marker and an architectural feature. As time markers, they allow people to meet ‘on time’, begin

Senate sessions, open or close public baths and organise water distribution quotas. They appeared in small or important towns and finally in the private villas in the countryside. As architectural features, they were used most often to ornament places in the city. They were displayed in public baths, near temple surroundings, public squares, gardens and other public and private places. The architect had to know different types as is shown in the chapter devoted to them in Vitruvius’ *De Architectura*.<sup>1</sup> However, before we see why we will be right to study them in places far from Rome, we should look at objects actually held in British museum collections.

At first sight it is not difficult to find old sundials in British museums. There is a good collection, thirteen to be exact. But all are pieces from Europe, mostly Greece and Italy. An example is shown in Fig. 1. This brief survey does not tell us anything new about cultural exchange but has the merit of highlighting the apparent absence of Roman dials actually found in Britain. All the dials above in museums are recorded as coming from other regions of the Roman Empire, in the 18<sup>th</sup> and 19<sup>th</sup> centuries in the majority of cases. (It is not so much a case of cultural exchange in antiquity as an exchange of cultural antiquities!) We again address our principle subject. If, in Britain, the archaeological objects are absent we must look elsewhere for answers.

### Are they definitely present in Britain? An awkward iconographic representation

So, there are no Roman sundials in British museums which were discovered in Britain. Why do we wish to find them? If it is true that one only finds what one looks for, however, aren’t we searching for something that does not exist?

My reply is that ‘Britain’ would in such case be a distinctive region in what we will call ‘the sundial using’ area of the Roman Empire. And if there are no dials and no trace of evidence, it is then necessary to discover why, amongst all the Roman provinces, central and remote, Britain is an exception in the introduction and adoption of the customs and culture of Roman life. If we add the fact that it is isolated archaeologically, it is necessary to doubt and explore to prove that absence of dials before accepting it. There are moreover more reasons to think that there were ‘timetellers’ in Britain.

First, the historic and cultural reasons. The Romans took timekeepers with them everywhere. More than the Greeks, they were the true instigators of a new time order in Rome and the conquered lands of their Empire. Each time they settled some-



Fig. 1. An example of a continental Roman dial from Citta Lavinia, brought to Britain at a later time. Photo by the author, courtesy The British Museum, inventory no. 2547.

where they brought back dials, water clocks, pictures, etc. To be like Rome ‘flooded by sundials’, a dial was a ‘must-have’ for provincial provinces. The *horologium* was an ‘element of civilisation’ often provided by Roman officials as a gift (perhaps disguised) to a newly Romanised city. And, as a matter of fact, educated British accepted or adopted Roman rule and culture. The evidence of Tacitus<sup>2</sup> on the phenomena of British acclimatisation to Roman rule at the end of the first century AD lends weight to this supposition. This theme of the introduction of the lifestyle of the conquerors upon the people considered ‘Barbarians’ is well known. It would be repeated in the sixth century by Cassiodorus<sup>3</sup> in his *Variae* relating to the gift of two horologia to the King of Burgundy. The timekeeper in ancient Rome was an object of exchange, having considerable cultural value, although sometimes to the detriment of previous lifestyles, but that is another subject. In view of the Tacitus text and archaeological evidence showing a strong influence of Roman culture from the end of the second to the fourth century AD in Britain, it seems reasonable to expect the discovery of timekeepers in Britain.



Fig. 2. Depiction of an equatorial dial in a mosaic at a Roman villa at Brading, Isle of Wight. Courtesy English Heritage.

A second reason is archaeological, or rather, pictorial. In 1880 the site of a villa in Brading, Isle of Wight was excavated. Dating from the second century AD, it was destroyed by fire in the fourth century. Of interest to us is a mosaic called the ‘sundial mosaic’ (Fig. 2). It is located within a rectangular pattern, placed between two other similar mosaics. The principal scene shows a bearded man seated, pointing with his right hand to a globe set on the ground. In the foreground, on his left, is a bowl and in the background on his right, a sundial on a column. The sundial is particularly stylised, but recognisable nevertheless. There are only four existing ancient mosaics (including Brading) that actually show a sundial. It is confusing therefore to find such a picture in a province where no such object has ever been found.

However, is this mosaic proof of the presence of dials? We must be careful because the scene is imported, symbolic or historic, hardly realistic. It is certain that the owner recognises the importance of the dial but that doesn’t allow us to imply from the picture that there were Roman dials in Britain. It is probable that the villa had a wealthy owner, perhaps accustomed to the presence of sundials in other cities of the Empire. The mosaic is not only artistic work, it is equally a reflection of a distant Greco-Roman culture but it doesn’t allow us to say that there were in fact sundials in Britain.



Fig. 3. Fragment of a Roman stone, sundial or unknown object from Housesteads Fort, now in Chesters Museum. Photograph courtesy of Frank Evans.

### Military influence and timekeepers

We must turn to the military world and the walls and forts built by the Romans in order to search further. We start by looking at an intriguing object, still subject to debate and not in Gibbs’ catalogue,<sup>4</sup> the object discovered in the 19<sup>th</sup> century at Housesteads Fort (*Vercovicium*) and conserved in the Chesters Museum (Fig. 3). This item was described in an earlier *Bulletin*:<sup>5</sup> we will only add that if it is a dial, it is not very good for ‘telling the hours’ and is connected with no other similar type in all the Roman sundial discoveries. The object is still debated. Nevertheless, other discoveries in similar contexts lead us to think that possibly it was a rudimentary sundial.

The next intriguing object (Fig. 4), at present in the Castle Museum at Dover, was discovered in 1932, again in a fort but a long way from Housesteads. This is Richborough (Roman *Rutupiae*), the probable landing site of the Romans in 43 AD, and in use until the fourth century as a fort. The exact location of the object’s discovery is not known but it was found amongst the excavations of the fort before 1932. It is indubitably Roman, evidenced by the Latin inscription on the reverse.

The object itself is small, measuring 90 mm × 100 mm. It is a piece of limestone, roughly square, about 25 mm thick, showing on both faces a pattern of carved radial lines. Each dial has only 10 hour lines (perhaps omitting the first and last hours from a 12-hour day). There is also a scratched boundary curve. The lines meet at a circular hole where the gnomon could be fitted vertically. As such it is more a parody of a true sundial



Fig. 4. The 'sundial' from Richborough, now in Dover Castle Museum. Photograph by Rowena Willard-Wright (Senior Curator at Dover Castle).

than a real one. It is impossible to read within an hour, the lines being very crudely drawn. It is the work of someone ignorant of sundial design and way of working, and inevitably we must question the use of such an object. Was it a homemade dial to learn about astronomy? A carved stone by a soldier to pass the time? Or just a simple drawing of a dial without an intention to use it? There is no simple solution but, nevertheless, it is the only object like a dial which has been excavated.

We now go on to our third example, used once again in a military context, the so-called 'water clock' discovered in 2008 at Vindolanda. To summarize what has been written previously,<sup>6</sup> it consists of a fragment of a bronze disc about 80 mm long, initially interpreted as a *parapegma*, a type of calendar (Fig. 5). However, a recent study by M. Lewis showed similarities with objects found at Grand, Salzburg and at Mayence and identified as the dials from water clocks. Like those, the Vindolanda fragment shows the month (September), the abbreviations for Kalends, Nones and Ides, and a mark for the equinox. However, the dial is less accurately made than for the other dials. The inscriptions are punched, not engraved, the signs of the zodiac are not shown and the disc was not complete but certainly part of a circle nailed to a wooden support. Lastly, the dial size in its original state was not larger than 350 mm diameter. If, following Lewis, it is indeed part of a water clock then numerous questions arise. First, for whom and for what was it made? Vegetius and Caesar tell us of the



Fig. 5. Fragment of the dial of a water clock found at Vindolanda. From ref. 6.

necessity for knowing the time, in order to regulate keeping watch and for military operations; Caesar's observations on the subject were made before the second landing in Britain in 54 BC.<sup>7</sup>

"We realised, however, by our water devices [ex aqua mensuris] that the nights were shorter than on the continent."

Was it therefore a luxury object taken by an officer wishing to own something he had seen elsewhere in the Empire? Or was it a simple *parapegma* as mentioned before or even an object in current military use, which seems extraordinary to us because of the biased view archaeology gives us of everyday events? The latter hypothesis is interesting and not absurd because there is too much evidence for it. Firstly, the preceding statement by Caesar, where it is clear that the Roman army had the means to measure time, by water clocks (clepsydra) and took them to the boundaries of the Empire. Furthermore, Vitruvius, who wrote about sundials and water clocks, was a member of the *decuria scribae armamentarii*. He was therefore used to all those devices. Finally, an inscription found at Remagen, an auxiliary fort on the Rhine, describes the repair of "*horologium*" in 218 AD.<sup>8</sup> It is not certain that it is referring to a water clock but the repair and the indication that the "hours were no longer good" suggest such rather than a sundial, which, if broken, wouldn't work at all.

Even if it is too soon to draw conclusions we can suggest that such devices were not as rare as has been thought and the military environment needed them.

The Roman contribution in Britain seems to be limited just to the military world. Soldiers in contact with the local population seem to have introduced 'the time-teller' to the Island and to have used it often – perhaps in a rudimentary way as can be generalised from other Roman provinces in the fourth century AD. Now, let us leave the Romans for a while and proceed further with our investigation.

### The Problem of Saxon Dials

By the sixth century AD the Romans had left and a new invasion and culture had arrived. A new type of sundial appeared called the 'Saxon dial' of which a considerable number remain in Britain.<sup>9</sup> Possessing a number of characteristics, they present a considerable enigma to dial historians as their origin is obscure. Were they as a result of cultural and religious exchanges with Ireland, which had had dials somewhat earlier? Certain stylistic characteristics strongly suggest some influence but there are too many differences for Ireland to be their place of origin. According to Cowham and Scott<sup>9</sup> they could be the result of a mixture of technologies from across Europe and the Middle East followed by a specialised development in England. Christianity and the arrival of Byzantine monks earlier could explain the mixture of design styles. Some authors, e.g. Wall<sup>5</sup>, do not rule out the influence of Roman dials, adopted by the church in the sixth and seventh centuries following the introduction of the Rule of



St Benedict in England and the associated canonical hours. The hypothesis of exchange between different Christian communities in Europe and the Middle East is very attractive, because the characteristics of Saxon dials allow us to propose a religious function that Roman dials definitely did not have. No answer is currently possible, and we wish only to open our presentation to this large question and show the necessity of dialogue between disciplines and historic periods for whoever can address all aspects of the problem. Here we leave 'horologia en Britannie'.

### Conclusions

What do we conclude? Firstly that there are many uncertainties. Each piece of evidence and each artefact is subject to debate and provisos. But there are some key points. To start with, in spite of few archaeological discoveries we can be sure of the presence of *horologia* found *in situ*. However, the form and design typology of these discoveries are in no way comparable to those found elsewhere in the Roman Empire. We discount one feature (the absence of dials) in favour of another: concentration at military sites, abnormal typology. That there has been subsequent exchange of dials between Britain and the Continent seems certain, but mainly one-way. The Romans brought their culture and knowledge through artisans or at least pictorially, as in the mosaic at Brading. This influence seems to have been limited and short-lived. Limited because, at that time, it was within the military world. The soldiers carried out the exchange, which we explain for two reasons. Firstly, they often travelled, saw other countries and cultures and brought with them what they knew and had learned, bringing their knowledge to the local inhabitants (British) even though they were soldiers of an occupying army. Above all they needed instruments or devices to measure time. Vitruvius, Caesar and Vegetius are authors who confirm this, directly or indirectly. Furthermore, if we accept the hypothesis of the appearance without Roman influence for Saxon dials, this raises then the preceding point, for if only the military introduced the 'time-

keeper' it could not become a necessity of everyday life. Following the return to Rome of soldiers, these timekeepers would disappear at the same time. Only the hypothesis of continuity through religious establishments within the Roman Empire would alter the suggestion that they disappeared. But, further, too few items exist for us to be able to accept one hypothesis in preference to another. The discovery of new items is a pre-requisite for further research and a better understanding of cultural exchange over time.

### ACKNOWLEDGEMENTS

Many thanks to T. Wood for all his great help, especially with my French text, to J. Wilson for her advice and help, to M. Cowham, who introduced me to the problems of Saxon dials, and to J. Arce, my professor, who supports all my work and provides me with much valuable advice.

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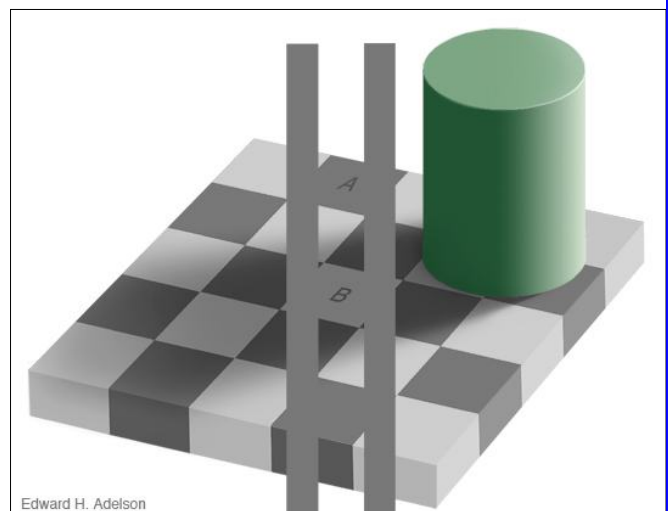
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## SHADOWY SECRETS – Answers from page 16



The object forming the shadows of Fig. 3.



Explanation for Fig. 4.

# AN UNRECORDED SILESIAN SUNDIAL

## BY JOHN ROWLEY

MACIEK LOSE

### John Rowley

John Rowley (ca. 1668–1728) was one of the most prominent English mathematical instrument makers at the beginning of the 18<sup>th</sup> century. In the year 1715 his merits were acknowledged by King George I who awarded him the title of ‘Master of Mechanicks to the King’. Rowley made variety of scientific, measuring and artillery instruments during his career, including: rulers, protractors, quadrants, sextants, length and weight scales, globes, different types of sundials, Copernican spheres and above all, the most famous – complex, mechanical models of the solar system, being predecessors of today’s planetariums, named ‘orreries’ after Rowley’s patron Charles Boyle, 4<sup>th</sup> Earl of Orrery.

Some of John Rowley’s instruments were commissioned by the Royal Court or trade companies and were gifts for the crowned heads of the time - including Tsar Peter the Great, Charles VI Habsburg and the Emperor of China. From amongst the works made for British nobility and the Royal Court, the best known is a set of four beautiful sundials for Blenheim Palace, and of the continental works – a sundial for the king’s residence garden in Hannover.

John Rowley was also a possible maker of the Cranbury Park sundial,<sup>1</sup> commonly attributed to Isaac Newton. Rowley is believed to have had a trade connection with Thomas Tompion, the most well-known master of that time focused on manufacturing of mechanical clocks, for whom he is thought to have made sundials.<sup>1</sup>

Rowley’s work had a large impact on his contemporaries: he brought craftsmanship to new levels of precision, and introduced aesthetic and scientific standards for the next generations of instrument makers.

The Silesian sundial of John Rowley is a typical garden dial, and the greatest puzzle is the very unusual—for a London instrument maker—place for which it was made.

### Silesia and its Capital: Wrocław

Silesia (Pol: Śląsk, Ger: Schlesien, Lat: Silesia) is a geographical region located today mostly in south-western Poland, with its capital in the city of Wrocław [ˈvrɔʦfswaf] (Ger.: Breslau, Czech: Vratislav, Lat.: Wratislavia). During more than a millennium of written history the region—located in the middle of the Central Europe—was influenced by Polish, German and Czech cultures, and changed its national affiliation numerous times. British historian Norman Davies extensively explores Wrocław in his epic book<sup>2</sup> *Microcosm* – a title which perhaps most fully encompasses its cultural diversity and complicated past.

In first decades of the 18<sup>th</sup> century—the period of flourishing baroque that we are interested in—Silesia and the city of Wrocław were for almost two centuries under the rule of the Habsburg monarchy. During the Habsburg reign Silesia, one of the most economically developed lands of the monarchy, attracted many noble families of Austrian origin to settle there, among them the family of Neidhardt von Spattenbrunn whose coat of arms is visible on Rowley’s sundial (Figs. 1 & 2).



Fig. 1(a & b). Oblique and frontal views of John Rowley’s Silesian sundial.



Fig. 2. Detail of the Neidhardt's von Spattenbrunn coat of arms and inscription with the sundial's geographical location: "Breslaw Latt. 51° 02' " in the upper part of the dial.



Fig. 3. Cardinal Eberhard Neidhardt (1607-1681), the most well-known member of the Neidhardt family. Painting by Alonso del Arco, Prado Museum in Madrid.

### Neidhardt's Residence

The Neidhardt von Spattenbrunn family is known in Europe mainly because of cardinal Eberhard Neidhardt (1607-1681), the preceptor of young emperor Leopold and princess Mariana, and later on (1666-69) Grand Inquisitor and *de facto* prime minister of Spain. (Fig. 3.)

The most likely commissioners of the sundial were either the cardinal's nephew, Johann Baptist Snr (1645-1722), or one of his sons, Johann Baptist Jnr (1675-1744). Both men were high ranking officers in the Silesian government. Johann Baptist Snr studied philosophical sciences in Siena and law in Prague, and in the year 1703 he was appointed as president of the Silesian Chamber Council. His son served as vice-president of the Council, and in 1731 he became administrator of the Wołów (Ger.: Wohlau) County, and in 1733 of Legnica (Ger.: Liegnitz), second city in Silesia in terms of population.

Around 1689, Johann Baptist Snr bought the estate of Krzyków (Ger.: Krichen, Kriechen), located some 4 km to the east of Wrocław, at latitude 51° 06'. Adjacent to the residence built at Krzyków, a baroque garden was founded, said by contemporaries to be one of the most beautiful private gardens in Silesia. The garden is mentioned in several monographs of the period, including Hennenfeld's *Silesiographia renovata*<sup>3</sup> printed in 1704, and in the book by Sinapius<sup>4</sup> from 1720.

The horizontal garden sundial by John Rowley can be linked with this complex. Due to the spatial transformations of the Krzyków estate over following centuries, no significant remnants of Neidhardt's former residence and garden survives to our times. The only probable remainders are stonework masonry foundations of several ruined outbuildings and the general contour of the complex, visible from a bird's eye view and bordered by characteristic elements of topography.

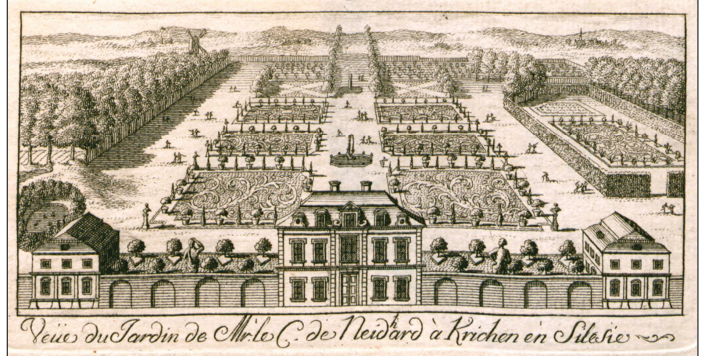
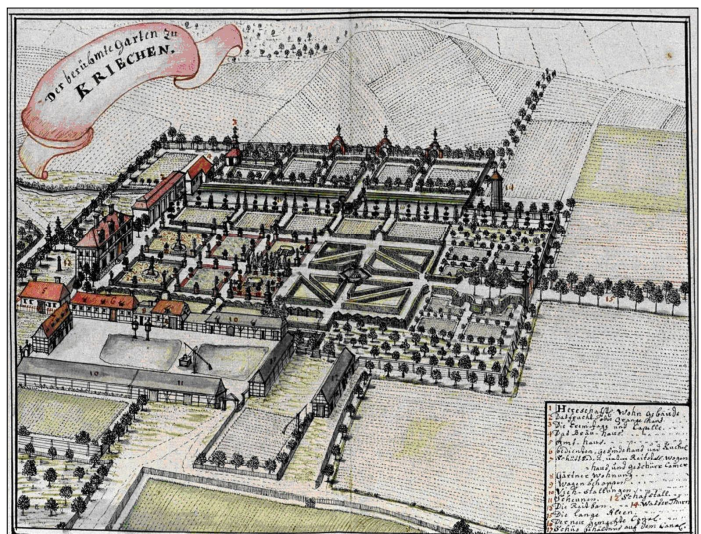


Fig. 4. Contemporary views of the Neidhardt's residence in Krzyków (Ger: Krichen/ Kriechen), with the formal garden thought to be the location for which the sundial was designed. (a) View by Friedrich Werner from the mid-18<sup>th</sup> century, (b) from Johann Haunold's book of friendship. Unfortunately, neither of the views include sundial.

Fortunately, two graphical representations of the garden complex still exist. The author of the first, from the mid-18<sup>th</sup> century, was the renowned engraver Friedrich Werner<sup>5</sup> (Fig. 4a); the other—earlier and highly idealized—comes from Johann Haunold's *Stammbuch* (book of friendship)<sup>6</sup> (Fig. 4b) which was reprinted in a publication of Pierre Le Lorrain de Vallemont<sup>7</sup> from 1708.

The drawings from 1708 had been engraved probably several years before the sundial was made. Werner had a chance to record the sundial but it also does not appear on his drawing. The sundial must have been placed in a prominent, exposed and unshaded place within the garden, mounted on a pedestal standing on a plinth, possibly located at the crossing of footpaths or within one of the main quarters. Werner is known to have made his final graphics based on the working plans which were redrawn many times and corrected in details, to annoyance of later researchers. Based on that, it can be assumed that Werner didn't know the place in detail, and could have omitted the sundial which was a relatively small garden feature or the sundial was lost in one of the subsequent versions of the drawing.

Apart from the missing sundial, two intriguing pedestals appear on Werner's depiction within garden quarters. If they are not figments of the engraver's imagination, they could have been used by the garden's owner to perform astronomical observations. Similar structures—also located within the garden—are known to have been used by Nicolaus Copernicus in Frombork to perform his observations some 150 years earlier.



Fig. 5. Lower part of the dial with the detail of John Rowley's florid script signature. Note engraving of the city Dantzick (today's Gdańsk) with the flipped letter 'z' and capital letter 'K'. The two letters are engraved in different style, suggesting that they were cut by a different person.

### The Dial

John Rowley's Silesian sundial is a type of classic, brass garden horizontal dial, fitted with gnomon pointing to the north celestial pole. The dial is of octagonal shape, 346 mm (13.62") across the flats, and 4 mm (0.16") in thickness.

There are eight mounting holes in the corners of the dial showing scratches – evidence that the dial was mounted to the pedestal at some point (Figs. 1, 2 & 5). The dial is divided into a number of concentric, engraved rings. Counting from the outside:

- \* the precise time ring, engraved to one minute intervals and labelled every 10 minutes,
- \* the main hour ring, inscribed with roman numerals from IIII through XII to VIII, read from the outside,
- \* the general time ring, divided into larger intervals of 1/8, 1/4 & 1/2 hours, and marked with decorative *fleur de lys*,
- \* two geographical rings,
- \* 8-point compass rose in the centre of the dial.

The time and hour rings terminate at the S of the dial in a decorative scroll, whereas the geographic rings are finished with undulating ribbons, ending with knots and tassels.



Fig. 6. An early Rowley garden horizontal sundial, dated ca. 1700, with the hour numerals engraved to be read from the outside of the dial, and geographic place names along the hour lines. Courtesy of Oxford Museum of the History of Science.

The method of inscribing hour numerals to be read from the outside of the dial indicates that the sundial was made probably around the year 1710 the period when Rowley popularised the method, being more convenient in use than previous formula of reading numerals from the inside while making the four large Blenheim Palace sundials.

The change in the direction of engraving the hour numerals must have taken place in the first decade of the 18<sup>th</sup> century as, on Rowley's early double horizontal dial dated c.1700, they are still read from the inside, whereas on a similarly-dated garden dial in the Oxford MHS collection (Fig. 6) the numerals are read from the outside. Beginning with

Rowley, this new method became standard in sundial making for London makers over the next decades.

The mature aesthetic composition of the sundial, balanced in terms of amount of decoration and information, as well as perfect engraving, further implies dating of the dial to the second half of Rowley's career.

In the upper part of the dial, a heraldic cartouche of the Nidhard von Spattenbrun family is engraved, below which sundial's intended location reads: "Breslaw Latt. 51° 02' ". The latitude given on the dial differs by 4 arc minutes from the actual location of Neidhardt's garden in Krzyków, the supposed original location of the sundial. The difference is small given the fact that Wrocław/Breslaw was far from the main sea routes and the largest European metropolises of the time, for which geographical coordinates were known most accurately. It can be noted here that in the same period as the manufacture of Rowley's dial, a far more substantial error of 12 arc-minutes in latitude occurred on several important sundials made by John Bradlee for St Petersburg<sup>8</sup> (which at that time was an incomparably more prominent city than Breslaw).

Inside the inner time ring there are two geographical rings with engraved place names and their respective moments of local noon, marked with a roman 'XII'. This method of marking the time of noon at various places follows the method used by Rowley on the 'geographic' sundial for Blenheim Palace dated 1710, which has three similar rings (Fig. 7). The method is quite different from an earlier garden dial, currently in the Oxford MHS collection, in which the place names are engraved along time lines originating from the origin of the gnomon (Fig. 6). The names of the places engraved on the dial are listed in Table 1.

Outer geographic ring	Inner geographic ring
XII Mexico	Strag:Magelan XII
Bermudus XII	Surinam XII
Tenieriff XII	Pernambuco XII
London XII	Dublin XII
Rome XII	XII Paris
Constantinop XII	XII Dantsick
Bagdat XII	XII Ierusalem
Suratt XII	XII Ispahan
Bantam XII	XII Agra
Nangesaque XII	Pekin XII

Table 1. The geographical place names in the dial.

It is worth noticing the inscription manner of the name of today's city of Gdańsk as *Dantsick*, with a mirrored letter 'z' and uppercase letter 'K' (Fig. 5). Capitalization of the letter 'K' within a word appears commonly on the instruments and in the writings of the 18<sup>th</sup> century – see, for example, Pierre le Maire's Butterfield type sundial, described by Mike Cowham in the March 2010 issue of *Bulletin*.<sup>9</sup> However, it is to be noted that on another city that includes letter 'k' – *Pekin* – a lowercase character was used. The different engraving styles of the above-

mentioned letters may imply that they were cut by a different person.

The central part of the dial is occupied by a richly decorated, 8-point compass rose, which to the North is culminated with decorative lily flower – *fleur de lys* – split into two parts by the gnomon.

The directions are described with symbols: *NE, E, SE, S, SW, W, NW*, engraved in the classic manner – to be read from the inside of the dial. It seems that Rowley practiced this method of describing directions until the end of his career, as it also appears on the royal sundial in Hanover, dated 1719. A similar co-existence of new and old engraving style (which is helpful in dating dials by Rowley's contemporaries) can be found on the garden sundial by Samuel Saunders, who worked for Rowley between 1702-1715.<sup>9</sup>

The cardinal directions are engraved with larger typeface, the North is indicated with letter 'N' located within the noon gap.

The maker's signature is placed on both sides of the noon gap, written in a sweeping, florid script font that reads: *John Rowley Londini Fecit* (Fig. 5). Comparison with Rowley's other signatures reveals that it is similar to those that can be found on earlier instruments and on his indenture. On later instruments, Rowley used a signature of a more modern typeface – though it is possible that both styles coexisted and were used depending on the aesthetic concept chosen for each instrument.<sup>10</sup>

It should be noted that the dial doesn't include the Equation of Time, either as table or as a ribbon, both forms used by Rowley.

### Inscription

The back of the dial reveals three hammered tenons for the gnomon's mounting and nearby, the engraving of an intriguing acronym "RHPH" (Fig. 8). The method of gnomon mounting is typical for garden dials from the begin-



Fig. 7. A section of the Rowley 'geographic' dial at Blenheim Palace, dated 1710, with three rings marked with place names and their local noon times. The Silesian sundial strictly follows this pattern. Note the outward facing hour numerals and inward facing descriptions of the compass rose directions, again like the Silesian sundial.



Fig. 8. View of the central area of the dial's back with one of three hammered tenons of the gnomon mounting and engraved with a contemporary inscription "RHPH", which may be intuitively expanded as: 'Royal Highness Prince(ess) of Hanover'.

ning of 18<sup>th</sup> century and proved to be very effective as the gnomon is still firmly mounted. The letters "RHPH" could be deciphered as the workshop code of one of the Rowley's workers, though none of his known apprentices had these initials. A more convincing hypothesis is that the inscription is related in some way with the dial's commissioner. The most obvious interpretation of "RHPH" is: 'Royal Highness Prince(ess) of Hanover', the title of the future King George II and his wife Caroline von Brandenburg-Ansbach (Fig. 9). It is possible that the sundial was a royal gift for the Neidhardt family, or—less likely—it was commissioned with help of the Prince's court.

Princess Caroline was raised in Berlin (which is close to Wrocław) and was a well-educated woman who maintained intellectual contact with the most notable intellectuals of the time – Leibniz, Newton, Voltaire and others. She had an important role as the patroness of British gardens and commissioned remodelling or founded new complexes, including Richmond Lodge, Kensington Gardens and Hampton Court Palace, this last where a garden sundial signed by Tompion and possibly made by Rowley<sup>1</sup> is still located. There are strong indications pointing to her as a link with the Neidhardts who were well-educated garden art enthusiasts with wide European contacts.

Another suggestion supporting the theory that the sundial was a gift for the Neidhardts is the maker himself and the place of manufacture. One could argue that if the Neidhardts were to commission the dial themselves, the natural choice would be to visit one of the known Central European workshops such as Prague, Vienna or perhaps one of the South-German cities, rather than London.

It is to be stressed that this author could not find strong proof to support these intuitive speculations of personal connections and hopes that readers will help in their positive verification or redirect investigation onto another track!

Fig. 9. Queen Caroline of Brandenburg-Ansbach (1683–1737), possible commissioner of the sundial or an agent between the Neidhardt's and Rowley. Painting by Sir Godfrey Kneller, National Portrait Gallery, London.



### Gnomon

The gnomon of the dial has dimensions of  $156 \times 177.5 \times 8$  mm, its angle measures about  $51^\circ$ , which corresponds well to the latitude given on the dial. The gnomon is pierced with floral scrollwork (Fig. 10).

Comparison with other sundials of the period reveals that the gnomon of Rowley's sundial is very similar to the one on the garden horizontal sundial signed by Thomas Tompion and dated around 1705. That sundial is better known to the public because of its discovery in an attic and later record sale at a Sotheby's auction in 2002.

The Tompion and Rowley sundials have quite similar dimensions and were made for similar latitudes. The dimensions of the Tompion dial is  $30.5 \times 30.5$  cm, which is smaller than Rowley's by 4 cm; and the latitude on Tompion's is  $50^\circ 54'$ , which is only  $8'$  different from the Wrocław/Breslaw sundial.

Closer investigation reveals a number of minor differences between the two gnomons suggesting that they rather did not come from the same mould but certainly they were made based on a pattern from the sketchbook and possibly in the same workshop.

Of the differences between the two, most characteristic are (a) a different profile of gnomon tip and (b) thinner cross-sections of the Rowley's gnomon scrollwork. Contrary to what can be seen on Tompion's gnomon, the curvature of the scrollwork's inner side doesn't continue – this is a very unnatural break, shown with an arrow on the photograph (Fig. 10) and seems to be a modification of a standard sketchbook design. It may suggest that Rowley – aware of overall heaviness of the gnomon's design seen on Tompion's signed dial – searched for a way to upgrade scrollwork by reducing thickness of bars and which to some extent affected the purity of the composition in this section of the gnomon.



Fig. 10. Comparison of (top) Tho Tompion's signed sundial, dated ca. 1705, and the side view of the gnomon of the Rowley sundial below. The gnomons are very similar but with very minor differences including: shape of the ending profile of the gnomon bars, width of the scrollwork bars with the Rowley's being slightly more lightweight and a shape of the scrollwork in the place marked with an arrow, where the curved lines of Rowley's gnomon are lacking the continuity present in the Tompion example. Tompion sundial image courtesy of Sotheby's.

The close resemblance of gnomons supports John Davis's hypothesis put forward few years ago, according to which Rowley crafted some of sundials signed by Tompion.<sup>1</sup>

Apart from the gnomons discussed here, a number of other features of Tompion's sundials that are characteristic of Rowley's craftsmanship suggest that Tompion, a generation older than Rowley and focused on mechanical clocks, decided to subcontract rare sundial commissions to his talented junior colleague.

### Fortunes of the Dial

Originally made by an English master craftsman for the Silesian region, at that time under Austrian rule, the sundial changed its national affiliation several times during the next three centuries of its history, never being far from Wrocław. It survived in unexpectedly good condition (actually one of the best of Rowley's known garden dials) many wars and

turmoil which passed through this part of Europe over the centuries.

It was found in 1970s, in the village of Pogwizdów (latitude 50° 57'), located a distance of 65 km to the west of Wrocław, the direction opposite to that of the Krzyków estate for which it was most probably made. According to all the revealed historical data, Pogwizdów village was never owned or connected with Neidhardt von Spattenbrunn family. The only interesting connection is the fact that in the year 1797—some 85 years after the sundial was made—August Neidhardt von Gneisenau, the later Prussian general who, together with Wellington co-defeated Napoleon at Waterloo, and who originates from different branch of Neidhardt family tree, took his marriage vows nowhere else but in a small village church in Pogwizdów!

Today, the sundial is in Wrocław again, close to the place for which it was originally made, and its description together with still not fully discovered history can be presented to the readers of *BSS Bulletin* thanks to the cooperation of Polish and British sundial enthusiasts.

In the search for a phrase to conclude the description of the history of the Wrocław sundial by John Rowley, I recall the title of the BBC popular-science TV series by James Burke – 'Connections'.

### ACKNOWLEDGEMENTS

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# HENRY SEPHTON (1686-1756)

## Architect, Mason and Diallist

IRENE BRIGHTMER

Henry Sephton is described as the “leading mason and architect in Liverpool during the second quarter of the eighteenth century”. A newspaper obituary of his widow, Esther, who died three years after him, stated that her husband was an “an eminent architect and mason”.<sup>1</sup> But little is known of the details of his personal or professional life and he is described as “one of the shadowy figures of provincial Georgian architecture”.<sup>2</sup> He died in 1756 and was buried in St Mary’s churchyard, Walton, where his memorial was probably lost during Second World War bombing.<sup>1</sup>

He is certainly known to have designed, built and altered churches, chapels, large country houses and public buildings, some of which have since been demolished,<sup>3</sup> and there are numerous others which can fairly safely be attributed to him. He also submitted proposals for churches, the plans for which remain in the archives, but which were never executed.<sup>2</sup> And inside one of Lancashire’s most important mediaeval churches there is a signed and dated memorial tablet by H. Sephton to a member of one of the prominent families in the county who died in 1737.<sup>4</sup>

Henry and Esther had a son, Daniel, who died in 1759 and was commemorated on the same tablet as his father in Walton Church, where he is described as “eminent in carving.”<sup>1</sup> He, too, worked in Lancashire and Cheshire; he carved memorial tablets in churches but also chimney pieces.

There has been no major study of Henry or Daniel Sephton, although Findlay<sup>2</sup> has written of Henry’s work on churches. But the literature is silent about him as a diallist. However, in 2009 I discovered a signed and dated double horizontal dial by him which has led to further research and has revealed the existence of other dials, and several which may be attributed to him with more or less confidence. These can all be attributed on the basis of style or are confirmed by documentary sources. There is also a signed architectural drawing by him for a church which incorporated a vertical dial in the plans.<sup>5</sup>

This article is really an account of ‘work in progress’, examining dials which have already been seen by the writer, or are known about, which have close connections with Henry Sephton or clear evidence of his hand.



Fig. 2. The signature on the Croxteth Hall dial.

### Two Double Horizontal Dials

The first Henry Sephton dial seen is in the store at Croxteth Hall near Liverpool (Fig. 1). Croxteth has been the home of the Earls of Sefton (the Molyneux family) since the 16<sup>th</sup> century and the Hall has been in the care of Liverpool City Council since 1972, when the line of succession ended with the death of the Seventh Earl. During the early years of the 20<sup>th</sup> century, his father, the Sixth Earl was building a new front wing at Croxteth and was re-designing the gardens. It was for the latter that the dial was purchased in 1903 from Woolton Hall,<sup>6</sup> which had been a Molyneux seat until 1772.

The dial is signed and dated “HENRY SEPHTON FECIT 1722” (Fig. 2) and the gnomon is inscribed “RICH LORD MOLYNEUX” (Fig. 3). Sir Richard Molyneux (1679-1738) was the Fifth Viscount (in the peerage of Ireland) and lived at Woolton Hall, also near Liverpool. The reverse of the



Fig. 1. The double horizontal dial at Croxteth Hall.





Fig. 3. The gnomon.



Fig. 4. The signature on the reverse of the Croxteth Hall dial.



Fig. 5. Molyneux arms on the Croxteth Hall dial.

plate is signed in a more amateur hand by “Henry Sephton, W. Derby” (Fig. 4). The Croxteth Hall estate is in the ancient parish of West Derby.

Full details of the dial, which is 18 inches in diameter, are recorded in Ref 7. The date makes it the latest brass double horizontal dial until the modern revival. Despite this, the main Roman numerals are inward-facing, a style that was then going out of fashion for London-made dials. The stereographic projection is neatly drawn but it lacks the date scale and ecliptic arcs which are needed for the full range of its usefulness. It does not have a scale for the sun’s altitude but it does have a full Equation of Time (“Watch slower/faster”). The coat of arms (Fig. 5) at the south is for the Molyneux family (*azure, a cross moline*) quartered with those of Mary Brudenell, the Fifth Viscount’s wife, and with the motto “Vivere sat vincere” (to live it is enough to conquer).

A notable feature is the transversals, allowing time readings to 1 minute, which are also seen on other horizontal and double horizontal dials which we can attribute to Sephton and which are generally found on English dials by John Rowley and his associates.

The dial and its pedestal were taken indoors some time ago by the Liverpool City Council after another dial in the grounds, subsequently lost, had been damaged by visitors.<sup>8</sup> The original Sephton dial is in good condition and was restored by R.D. Oliver of Soho in 1903 after its purchase

for Croxteth, as correspondence in the Croxteth archives shows. There are early photographs showing the dial *in situ* in the garden at Croxteth (Fig. 6) but I know of none showing it in its original Woolton home.

The pedestal is crated and stored indoors and also remains in good condition (Fig. 7). It can safely be assumed that it was also the work of Sephton, this time wearing his mason’s hat. The stone is a fine sandstone and flecks of paint remain on the surface; Fig. 6 shows it was formerly painted. The pedestal is large and elaborate and the editor has noted its resemblance to a drawing of a pedestal for the 1710 Rowley dials at Blenheim Palace, the drawing signed by Hawksmoor (Fig. 8). Interestingly, the editor has noted that the three horizontal dials at Blenheim also have transversals and deep rings on the rims.<sup>9</sup>

An excellent replica of the Croxteth dial has been made and has been exhibited at the Hall but is now kept in the store. It is visibly indistinguishable from the original.

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Henry Sephton, although absent from the diallist literature, was soon discovered to have been an architect, builder and mason in the Liverpool area.<sup>1</sup> He was responsible for the main range of Knowsley Hall, only a few miles from Croxteth Hall, also near Liverpool. (Both of these major country houses were on my home patch when I was a child but we never dared to venture through their gates or up their long drives!) Knowsley Hall happened to be open to the public the week after I discovered its connection with Sephton and I arranged to visit, hoping to see another Sephton dial at a house associated with him. And there it was in the garden, visible from one of the state rooms! (Figs. 9 & 10).



Fig. 6. A 20<sup>th</sup> century picture of the dial at Croxteth Hall.



Fig. 7. The crated Croxteth pedestal.

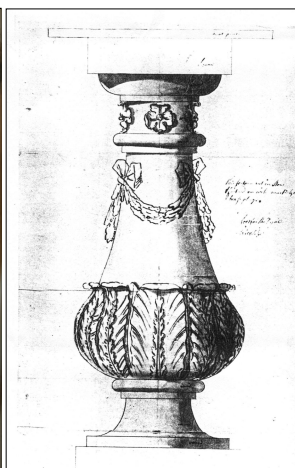


Fig. 8. Hawksmoor’s Blenheim pedestal.

Knowsley is the seat of the Stanleys, the Earls of Derby, who have been here since 1385. Stanley received his earldom in 1485 from the new King Henry VII for his intervention at the Battle of Bosworth. The present earl is the nineteenth. Henry Sephton worked for the Tenth Earl (1664-1736) between 1720 and 1737.<sup>10</sup> The Knowsley pedestal closely resembles the Croxteth one and Figure 9 shows that it is freshly painted. The dialplate is larger (nearly 26 inches in diameter) than the Croxteth dial but in this case the



*Figs. 9, 10 & 11. The Knowsley Hall dial showing the pedestal, dial with deep rim and inappropriate gnomon, and details of the engraving.*

dialplate is also fitted onto a cast rim, 33 mm high. This is a feature only seen elsewhere in high-class dials, e.g. by John Rowley and Thomas Tompion.

There is a replacement non-double horizontal gnomon, which partly conceals some of the dial furniture (Fig. 11). The original gnomon must have been damaged long ago because the replacement gnomon is well-patinated and at first glance was not recognised as a replacement. The heavy patination makes the engraving difficult to decipher, but we can read “FLAMSTEED” and “Watch Faster” etc, names of some of the months and the stereographic grid. The reference to Flamsteed is puzzling: he was mainly responsible for the calculations of the EoT found on English dials but his name is not known on other dials.

The details of the stereographic projection are unclear but they appear again to be lacking the ecliptic arcs and date scale. The transversals which we saw on the Croxteth dial are also here. A search of the Derby archives, still held by the family at Knowsley, is planned in order to look for confirmation of Sephton as the maker and hopefully also a date.



*Fig. 12. The replica Ince Blundell dialplate on its pedestal.*

### **One Horizontal Dial**

Another important country house in south Lancashire by Henry Sephton is Ince Blundell Hall, built between 1720 and 1750 for one of the branches of the ancient Blundell family who had lived here since at least the 13<sup>th</sup> century. A drawing of the elevation, signed by Henry Sephton, has only recently been identified, confirming him as the architect.<sup>1</sup> The Hall is in the same style as Buckingham House, which later became Buckingham Palace. A visit to Ince Blundell Hall, a residential home owned and run since 1960 by Sisters of the Augustinian Order, was arranged in the hope of seeing yet another Sephton dial. Near the main front on a plain baluster is a horizontal dial (Fig. 12) dated 1745, with Sephton’s now characteristic transversals. The dialplate, however, is a replica in poor condition, but the original is in store indoors. It has been cleaned of its patina and varnished(?), revealing a rather worn but attractive surface.

The dial is 12¾ inches in diameter and has a distinctive unpierced gnomon engraved on the sides with “1745 S”



*Fig. 13. The original Ince Blundell dial.*



Fig. 14. Detail of the Ince Blundell dialplate showing the transversals and an "HS" monogram in the noon gap.

FRANCIS ANDERTON B<sup>7</sup>" on the east and a stork (Fig. 13) on the west, and with a chamfered northern edge. The stork is the crest for the Anderton arms which also features three stirrups, which appear towards the south of the dialplate. The dial is delineated from 3:15am to 8:45pm as befits a dial for the latitude of Lancashire, divided once again to minutes by means of transversals. It includes an Equation of Time scale but is otherwise quite simple, though neatly executed. Evidence that it was made by Sephton is the simple monogram of an overlapping HS in the noon gap, which has an unusual hatching (Fig. 14).

Sir Francis Anderton of Lostock (1681-1760) was the sixth and last Baronet and had no issue, leaving his estates to Robert Blundell of Ince, greatly increasing the wealth of the Blundells. It is most likely that the sundial was made for Lostock Hall, and came early to Ince Blundell. A late-18<sup>th</sup>-century print of the latter shows the pedestal near the Hall.

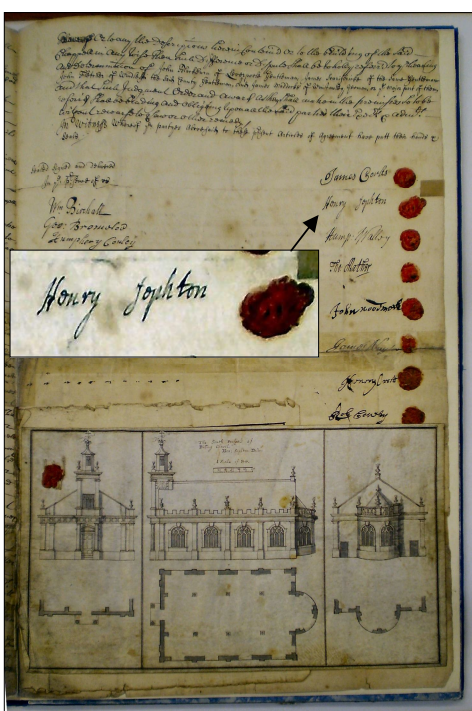
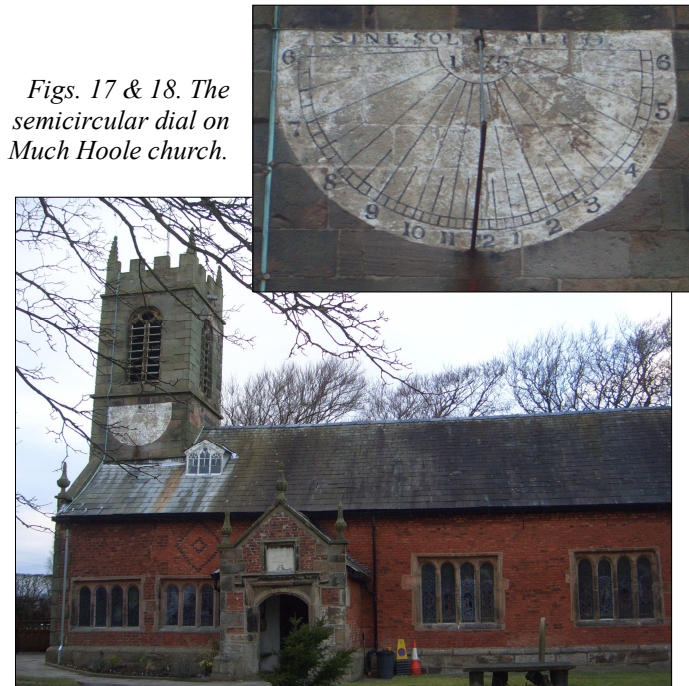


Fig. 16 (above). Billingie church—no room for the dial.

Fig. 15 (left). Articles of Agreement for Billingie church, including Sephton's signature (inset). Compare with Fig. 4.



Figs. 17 & 18. The semicircular dial on Much Hoole church.

### Vertical Dials on Churches

In 1716, early in his career, Henry Sephton and others signed Articles of Agreement to pull down the old church and rebuild St Aidan's Church, Billingie (Fig. 15).<sup>11</sup> The Articles include detailed descriptions of the architecture and the materials to be used, and attached to them are two sheets of vellum with drawings and plans by Sephton. The drawings show that a sundial was designed for the south wall of the tower above the nave roof. In the event it was omitted due to an increase in the pitch of the roof leaving no space for the dial (Fig. 16). The contract and the drawings are in Wigan archives and the church was rebuilt 1717-18.

There are several other Lancashire churches of a similar date which have features which suggest a connection with Sephton.<sup>2</sup> One is St Michael's, Much Hoole, which has a vertical sundial on the tower (SRN 3275, Fig. 17). In 1722 the church was extended by one new bay to the west and a tower (Fig. 18). The large vertical sundial has the date 1875, when it probably received a major restoration. It is tempting to conjecture that Sephton was responsible for the 1722 church extension and original sundial. (Incidentally, readers may be interested to know that Jeremiah Horrocks, who discovered the transit of Venus, observed it in a house at Hoole in 1639, and there is a window in the church to celebrate this.)

The vertical sundial on the surviving eighteenth century portion of the mediaeval church of St Peter and St Paul in Ormskirk



(SRN 1660) could also be from the hand of Sephton (Figs. 19 & 20). In 1724 there was a report on the poor state of the church fabric leading to a major rebuilding in 1729-30 of the nave and aisles, the delay caused by the need to raise the required funds nationally.<sup>12</sup> Little remains of the 18<sup>th</sup>-century work and the builder has never been identified because the rebuilding accounts were kept separate from the churchwardens accounts and appear to have been lost. However, an engraving from the 1830s shows large, round-headed Georgian windows with clear glass in the south wall.<sup>12</sup> Above the windows was a cornice with a central plate projecting above it with a sundial, and this survives in spite of numerous subsequent rebuilding phases.

This vertical sundial is a standard design and has no special features which might link it to Henry Sephton. However, he had several significant connections with this church. He is mentioned in churchwardens' accounts in 1719, and again



*Figs. 19 & 20. The globe pedestal at Ormskirk church with a plain vertical dial behind it.*

in 1721 when he was paid £2 10s in March for putting up the copper weather vane which was made by James Barnes and gilded by Mr Caldwell of Liverpool.<sup>12</sup> He also carved and signed ("H. Sephton") a memorial cartouche to Robert Scarisbrick who died in 1737, which remains on the west wall of the Scarisbrick chapel. Moreover, the patron of the church throughout this time was the Tenth Earl of Derby for whom Sephton was working on the main range at Knowsley Hall from 1720. It is therefore only a guess, but the dates, the knowledge of Sephton's interest in dialling and the fact that he had already incorporated a vertical dial in his plans for Billinge Church, all make it tempting to think that the Ormskirk vertical dial could be his.

### Globe Dials

We may be on safer ground in suggesting Henry Sephton as the creator of another dial at Ormskirk church. It is located outside the churchyard wall near the new Church House where it was moved in 1994 from outside the south porch (Fig. 19). An initial glance may suggest that it is a horizontal dial, albeit on an elaborate pedestal. This perception may be confirmed by the modern cast dialplate on the top, although it looks very out of place. A closer look at the globe part of the structure reveals engraved longitude lines and tropics and the equator (Fig. 21). Visible also is a broad band for the zodiac, which may once have been painted with their signs. The whole object must once have been painted as some flakes of paint remain and may now disguise some of the engraving, especially near the poles. There are no signs of numerals; perhaps they were

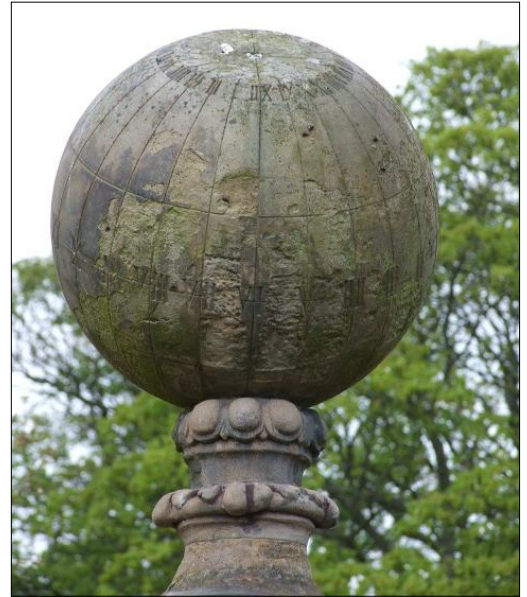


*Fig. 21. Two views of the central part of the globe pedestal at Ormskirk.*

Fig. 22. The globe, clock and multiple dial at Knowsley, now in a private garden.

Fig. 23 (far right). Close-ups of the globe and clock face.

Fig. 24 (below). Early picture from the Stewart Bale Collection at the Mersey Maritime Museum.



originally painted on. The globe may have been merely decorative or it may have operated as a second dial, using the terminator of the shadow to indicate the time. Although these are not uncommon, this is the only known example to be built into a pedestal.

The style of the stone work and the use of paint are reminiscent of the pedestals of the Knowsley and Croxteth double horizontal dials. The pedestal for the former is painted to this day (Fig. 9), and the early photo of Croxteth shows that it was also formerly painted (Fig. 6), and the pedestal in the store still retains patches of paint (Fig. 7) making the present surface finish look very like this Ormskirk globe dial.

Could this dial be the one in the churchwardens' accounts mentioned above, which record that in February 1719 Henry Sephton was paid £3 3s for "a new diall stone"? The existence of this record, the similarity of the style of carved work on the pedestal of the signed Croxteth double horizontal dial, and the numerous links of Henry Sephton to Ormskirk Church all point to him as the possible maker of this globe dial in 1719, early in his career. (By 1693 Ormskirk already had a striking clock on the south face of the steeple, according to records for its maintenance in the churchwardens' accounts. Was the new dial to be used to regulate this clock?)

There is another dial in the area incorporating a globe, which may also be attributable to Sephton. It has been re-sited to a private garden where it is shown here (Fig. 22). It has not been seen by the present writer, but photos of it exist from earlier in the 20<sup>th</sup> century in the gardens at Knowsley Hall (Fig. 24). The dial is also depicted in an 18<sup>th</sup>

century panoramic painting, probably dating to the 1720s, by Peter Tillemans (c.1684-1734), where, it is said, that Tillemans "shows himself at his very best".<sup>13</sup>

This globe dial is part of a multiple dial; beneath the globe is a cube dial, formerly with gnomon(s) and also a working clock on the north face. The hands and mechanism are no longer there, but the hands can be seen in the early photo in Fig. 24.

The globe has 24 arcs of longitude and these are labelled with Roman numerals both around the equator and near the 'arctic circle'. In the former position, the XIIs are located at the north and south of the dial, as would be expected for a dial with a swinging gnomon, aligned to the sun to give the minimum shadow. But the globe is positioned far too high for an observer to have operated a gnomon so the numerals must have been intended to show the timezones around the world (more than a century before their introduction!). The second set of numerals are displaced by six hours so that the XIIs appear to the east and west, as appropriate for reading the time by the shadow terminator. There is some indication that the flattened north pole of the globe was once fitted with a cap of some kind.

Details of the vertical dials are currently unclear but it is likely that there were E, W and S faces.

The elaborate stonework of the pedestal is reminiscent of the Croxteth and Knowsley pedestals, as well as the Ormskirk globe dial, suggesting that we may be looking at another work of Henry Sephton as a diallist, perhaps his most ambitious. It would be very gratifying to find dated accounts in the archives which provide us with the name of the maker of this very special dial.

### Conclusion

There is enough evidence to identify Henry Sephton as a significant 18<sup>th</sup> century provincial diallist from early in his career, although he was principally an architect and mason. At the age of thirty in 1716 he displayed an interest in dialling in his inclusion of a vertical dial in his plans for the church at Billinge. And it is likely that two years later the 1719 payment to him at Ormskirk Church was for the globe dial which still stands near the church today. Not long after, in 1722, he made the signed and dated double horizontal dial for Robert Molyneux at Woolton Hall. In the same year was the extension of the church at Much Hoole, which has several features of his known churches elsewhere, and has a vertical sundial restored in 1875 which may have originally been his work.

Henry Sephton then continued to work for over thirty years on churches, country houses and other buildings such as Wigan Grammar School and a courthouse at Halton in Cheshire for the Duchy of Lancaster.<sup>14</sup> One of his last works was in 1753-5 at the Priory Church of St Mary the Virgin, Lancaster, to design a new tower to replace the old one which had become unsafe, and to oversee its completion.<sup>15</sup> It is intriguing to contemplate the source of Sephton's early interest and expertise in dialling. No connections with local clockmakers or other diallists have yet been identified, so where did he learn his diallist's art and from whom?

There are many gaps in knowledge about the architects of early 18<sup>th</sup> century Liverpool. For instance, the architect is unknown of the famous Bluecoat building in the centre of Liverpool, which has UNESCO world heritage status and is Grade One listed, although Henry Sephton has been suggested as one of the two most likely. It was built between 1716 and 1725. Also unknown is the creator of the main façade of Croxteth Hall, started in 1702, earlier than the Bluecoat building. It has some similarities to the latter and some features are acknowledged to be characteristic of Sephton, but he would surely have been too young to have been responsible, certainly from the beginning.

There are also many 18<sup>th</sup> century Lancashire churches whose architects are, as yet, unknown. Donald Findlay<sup>2</sup> has identified at least 156 Anglican churches and chapels built in Lancashire between 1700 and 1820, many more than in any other county, at least 108 of which have been demolished. One wonders how many of these may have

been by Henry Sephton, and may have been designed with vertical dials. Some may yet come to light from further searches in the archives.

Meanwhile, such searches and fieldwork continue, mainly in Lancashire, to identify church and garden sundials which may yet be unrecorded, and which may throw further light on the work of Henry Sephton, the 'shadowy figure' of Georgian architecture in the region.

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