The British Sundial Society

BULLETIN

VOLUME 18(i) MARCH 2006

GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the Bulletin on the subject of sundials and gnomonics; and by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.
2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis@btinternet.com*. Material can also be sent on CD or as typescript, single- or double-spaced, A4 paper.
3. Figures: For photographs, colour or black-and-white prints as large as possible (up to A4). Slides and transparencies are also acceptable. Pictures can be sent electronically as jpg (do not over-compress) or tif files. For email attachments, do not exceed 20 Mbytes. Tables should be treated as figures and numbered as part of the same sequence. Drawings and diagrams should be in clear black lines on a white background. Each figure illustrating an article should carry on the back the author's name, and a number indicating its relative position in the text (Fig.1, Fig.2 etc…). Captions for the Figures should be written on a separate sheet in numerical order. They should be sufficiently informative to allow the reader to understand the figure without reference to the text.
4. The Bulletin does not use footnotes. Where additional information is required, notes should be numbered as a Reference with a superscript number. For very long notes, use an appendix.
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   For books: Author's name; Title of book, in italics; Name of publisher, Place and date of publication.
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   Examples:

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

   If you simply wish to give a short list of books associated with the subject of the article, this may be given at the end of the article under the heading 'Bibliography', using the convention as given for 'Books' above.
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Front cover: Cruciform Dial at Tallreuddyn near Dyffryn Ardudwy on the coast of north west Wales, erected on the tomb of Ann Griffiths in 1863. It shows the time from shadows created by the three upper limbs of the cross on six separate scales. For further details see 'Sundials of the British Isles' pp. 97-98.
Photo: Mike Cowham.

Back cover: St John of Jerusalem, Dinmore Manor, Herefordshire. The site is a Knights Templar foundation with the church adjacent to the Manor House. The central design is most unusual; very few mass dials have such a feature. The gnomon is modern. Photo M Evans

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BULLETIN

OF THE BRITISH SUNDIAL SOCIETY

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CONTENTS

EDITORIAL

Readers will be pleased to see a four pages in this issue in colour, showing some fine dials. I also commend to your notice Mike Cowham's suggestions for solutions to some of the dial-photographers' problems.

Historians among the readership will enjoy the account of Herr Hofbauer's lecture: and also, John Wall's article on church orientation, a contentious subject; and the potted history of 17th century makers. There are also plenty of "How did they do it?" articles. I always find these humiliating as I become aware that other people's problems on dial-making are even more intractable than my own.

I hope you enjoy the articles and pictures in this issue. I ask you to consider writing something yourself for a future issue of the Bulletin: even a short account of making a visit to a particular dial. (Was it worth the effort? Did it disappoint you?) The Bulletin is for every sundial enthusiast, not only for makers and mathematicians.

Readers may have noticed the Bulletin title and issue number printed on the 'spine' of this and the December issues. This was suggested by John Foad and will be a regular feature for future BSS publications, allowing you to find the right yellow journal from the row on your bookshelves.

THE MARTIN SUGGETT MEMORIAL SUNDIAL WORLD MUSEUM, LIVERPOOL

ALAN SMITH

A new sundial in memory of Martin Suggett (1951-2000), past Curator of Physical Sciences, Liverpool Museum, was unveiled on 15 July 2005. Martin had been a much respected and admired member of the museum staff and the financing of the project was implemented by friends and colleagues, with assistance from the museum itself.

Fig. 1. The dial in its alcove.

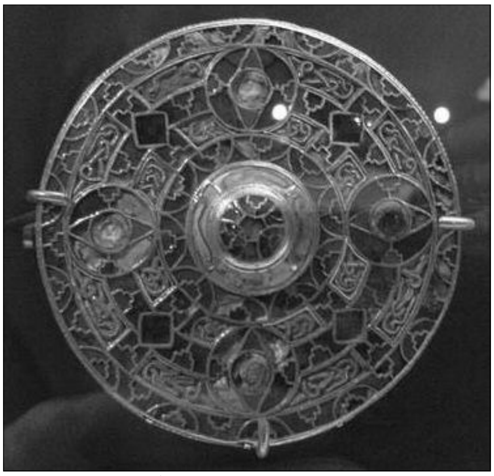

Fig. 3. The 7th century Kingston brooch.

The dial consists of a piece of blue/grey Welsh slate, three feet (915mm) in diameter, mounted in a recess close to the main entrance of the museum in William Brown Street (see Figure 1). Because the arch above the recess would have cast a shadow on the dial if it had been mounted on the inner wall, it was necessary to support it on a stainless steel framework (its shadow is partly visible in Figure 2) to bring it level with the main wall surface. From the front, however it appears to be 'floating' in the space.

Fig. 2. The dial on its supporting stainless steel structure.

The vertical dial declines some 3.5º to the west and has been calculated to show local Liverpool time (2º 59' W = 11m 56s slow of GMT). The advisory committee felt that it was better to do this rather than to calibrate it to GMT, and an explanatory leaflet has been prepared to help visitors to interpret the dial relative to modern timekeeping.

The main hour lines, half and quarter markers, numerals and lettering are carved and gilded as are the two large circles surrounding the dial, while the incised solstice and equinox lines and Lat-Long etc. are coloured in pale grey to distinguish them clearly. The gnomon is of stainless steel with an inset brass bar nodus which makes it possible to read the declination of the sun easily at and close to noon. The relief carved design round the edge is based on the champlevé ornament of the 7th century Kingston Brooch, a superb Anglo-Saxon piece of jewellery excavated in Kent in the 18th century and now one of the most prized possessions of the museum (see Fig. 3). The motto, or perhaps more appropriately the *dedication,* was selected by Martin's widow from a list of about thirty suitable texts.

The dial was designed, calibrated, carved and gilded by the author and the slate was obtained from Aberllefenni Slate Quarries, Machynlleth, Powys. The supporting framework was made by Philip Irvine of Southport who also fitted it in place. Administration of the whole project was supervised by Martin Hemmings, Building Operations Manager at the museum.

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A BIRD’S EYE VIEW

MIKE COWHAM

How often do we wish that we were a bird when we go looking for sundials? Many vertical dials are mounted too high for close inspection and for good photography. I have come across this problem innumerable times and think that I have now solved the problem, at least to my own satisfaction. The digital camera certainly helps with this because we can take many pictures of the same dial until we get the one that we really need.

Fig. 1. ‘Man With a Plank’ dial photographed from the top of a brick pillar.

Fig. 2. The ‘extended tripod’ technique used for the pillar dial at Great Staughton, Cambridgeshire.

For example, we have a nice vertical dial placed high above a church porch and we need its picture. Some years ago at our Conference at West Dean, Robert Sylvester gave us a talk about how to get the best results from photography. His solution is to carry a step ladder in his car. This works fine but it is a heavy thing to carry around and none of us are getting any younger. What if we should fall - it doesn't bear thinking about. Furthermore you will get some strange looks from passers-by and some child is sure to say “Mummy, what is that man doing up there?”. You may even be suspected of attempting to steal the dial or of breaking into the church.

I recently photographed the ‘Man with a Plank’ dial at Market Harborough for ‘Sundials of the British Isles’. To get the shot that I really wanted meant climbing up on some brick pillars close by so that I could look down on the dial. I felt decidedly wobbly and if I had fallen it would have been into the canal or onto the railings or hard concrete. In trying to save myself from injury it would have cost me a new camera. Luckily, the shot worked and the picture is now in the book. So heights are not a good thing for anyone, especially when ‘over 40’.

My solution to the problem is quite simple and straightforward. Elevate the camera and not the photographer! To do this I use my tripod, usually set to its maximum height with the camera perched on top and the tripod legs held together in a hand above my head. Now this way I can get the camera up to about 12 feet, high enough for most dials over porches or on pillars - and what a lovely shot it can produce! However, there are further technical problems to solve, but this is where a digital camera comes in. Firstly we must have a remote shutter release. For me this involved making a 2 metre extension cable because they never make these release cables long enough. The alternative is to use the delay timer function. When the shutter is pressed the camera usually sets exposure level and focus, so aim it first at a lower part of the supporting structure. If the dial is over a church porch do not press the shutter with the camera pointing into the porch or the results will be over exposed and out of focus. Simply take two steps to one side where there is a wall, then quickly move back into position, lifting the camera to its correct height waiting for the final ‘click’. The next problem may be that you have missed the dial, but you can easily check this on your LCD screen and try and try again. Aim for a fairly wide shot with some surrounding brickwork then crop this off later. You can see yourself if

Fig. 3. 'Bird's eye view' of the west facing dial at Great Staughton.

the camera is correctly centred on the dial but height is difficult to judge. Either start by holding the camera close to the dial and adjusting its height or, if you have a helper with you, get them to stand to one side and some distance away to tell you if your camera is actually pointing at the dial. After a few shots you should start to get reasonable pictures, but if the wind is blowing, holding the camera steady can be a problem. The technique is simple to master and I have used the technique for some time and have got some excellent shots this way.

The same technique can also be used for horizontal dials. These are notoriously difficult to get a real overhead view. We usually end up with the camera held up high above our heads just hoping that we can get a good shot. Even with the minimum of zoom we still manage to get only some of the dial in the picture. Also the camera strap drops down

Fig. 4. Familiar problems with photographing a garden dial.

Fig. 5. 'Extended tripod' technique used for getting a good overhead shot a garden dial.

just at the wrong moment and gets across the picture. Then when we get the picture home we discover that our feet can be seen either side of the pedestal - we really should have cleaned our shoes first! We may also find our shirt, pushed out by 'middle age spread' just obscuring that essential part of the dial and a shadow of our elbow on one side. The photographer really *has to get out of the picture.*

Therefore, with the camera on our tripod (now strictly a monopod) we can hang the camera over the dial and get that shot that we are looking for. Don't leave your camera case or a bag too close to the dial or that will also find its way into your shot and make sure that the camera strap is secured to the tripod.

This technique can be used for many applications, *even for snooping over a wall,* but it does really need the digital camera with instant preview to make it work properly. Although I have not tried it yet, it should also be possible to lean over a church parapet and photograph the dial from above - but don't drop your camera and tripod!

One refinement that I would like is to have a camera with a remote LCD monitor so that the perfect shot can be taken every time. The same technique may also be used with a film camera, but the cost of film would soon mount up and you wouldn't know the results for days.

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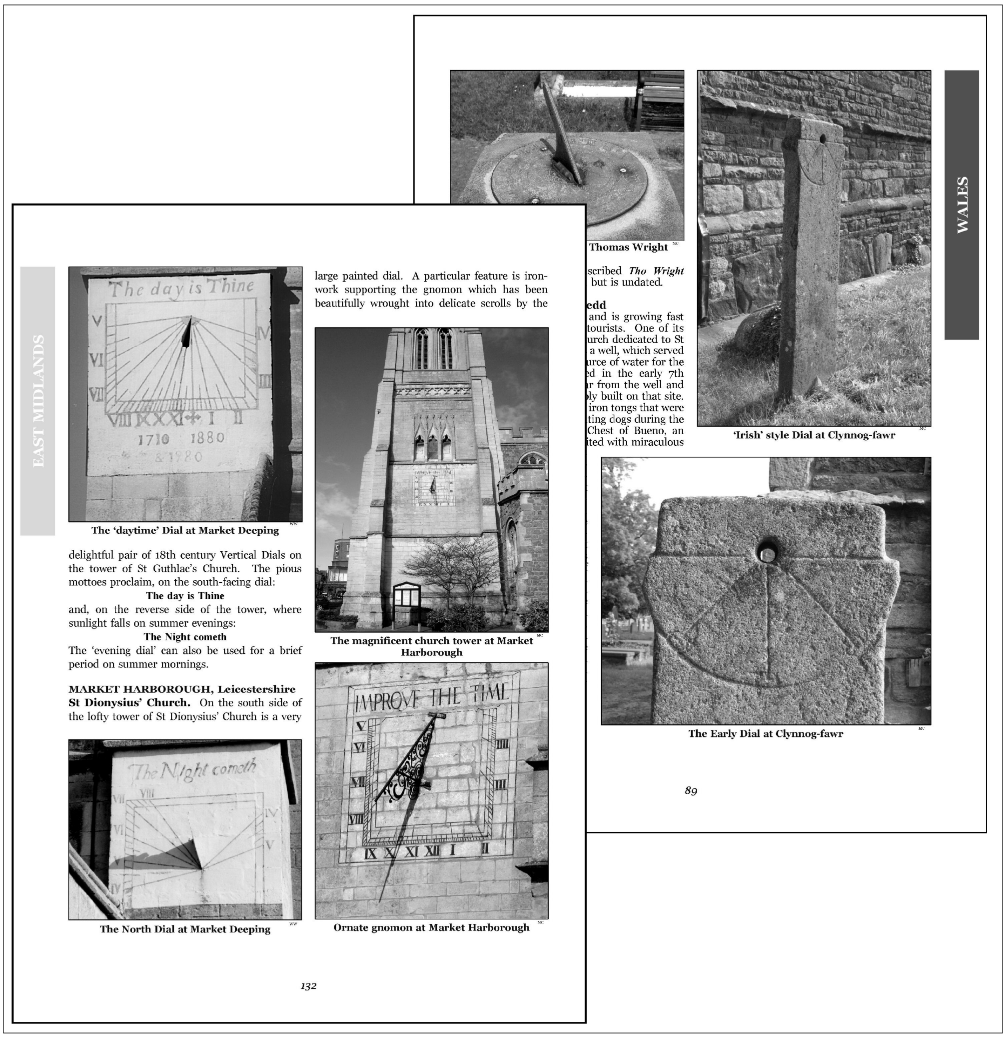
BOOK REVIEW

Sundials of the British Isles, edited and published by Mike Cowham. *Hardback, 300mm × 225mm, 272 pp with over 500 photographs, full colour throughout. Cover price £48.50 (but see advert in the December Bulletin for concessionary prices).*



Yesterday I received a remarkable book: "Sundial of the British Isles" with more than 500 colour photos of sundials of the British Isles in very good quality by 51 photographers. There are 12 regional chapters (South West including the Channel Isles, South and South East, London, East of England, Wales, West Midlands, East Midlands, North West, Yorkshire, North East, Scotland and Ireland), written by 30 authors who either live in those regions or have a detailed and deep knowledge of the dials there. Each of them has done a tremendous job getting the various items of information together. And this is the charm of this fascinating book. The authors have their own personal views of the most beautiful and interesting sundials in their area and describe their positions, main features and specific individuality. All dials chosen in regional chapters may be visited.

We find a lot of examples of regional styles of sundials: polyhedral in Scotland, Saxon in Northeast and slate dials in Wales and Cornwall. In addition to these area by area examples of sundials, the books includes a specialist article (4p) on Early Dials of Britain, starting with Saxon and Scratch Dials. Another chapter describes the most beautiful vertical stained-glass sundials of historic buildings, with 14 excellent photos of these rare and valuable dials. If your curiosity is aroused have a look at *http://advanceassociates.com/Sundials/Stained_Glass/.*

The editor himself has written a chapter of 6 pages, giving a brief look at some portable sundials, made in Britain. Sixteen brilliant photos will tempt you to buy his first book "A Dial in Your Poke".

This in not a technical book. Don't expect mathematical formulas. The appendix gives a glossary of terms on two pages, which is sufficient to understand all the information, without being a sundial-enthusiast. The price is equivalent to 49 €. You pay less than 10 cents of each of the 500 photos and get a lot of useful information. You can use this book as a travel guide for your personal 'sundial safari' in the British Islands.

If I had a wish free: provide a slipcase, which protect the book in the car, when travelling in search for sundials. From my personal point of view: the book is a 'must' for the enthusiastic sundial designer, collector and maker and highly recommended to those who have an interest in the subject. And if I were rich man…I would buy two of the books as an instant gift for my two friends and another 99 for my acquaintances and customers, knowing that Christmas will come soon.

A hint for those of you living outside the British Isles: join together for a common order, as the post and packing charge for one book to Europe is 13 €.

Peter Kunath
Germany

"THE MOON HAS SET AND THE PLEIADES" - SAPPHO;
TIME MEASUREMENT IN CULTURAL HISTORY

K G HOFBAUER

This paper is a version of the Andrew Somerville Memorial Lecture presented by the author at the 2005 BSS Conference, Holloway College.

INTRODUCTION

The measurement of time has a long history which is closely linked to that of the sciences and arts. Moreover the instruments used to measure time have always reflected the changing needs for time-keeping in our civilization. Before the invention of mechanical clocks a basic knowledge of astronomical principles was a prerequisite for telling time during the day or the night and for understanding the course of the seasons. From about 1300 AD onwards mechanical clocks made it possible to read time by way of simple numbers. In our days the meaning of time is changing again. A second is no longer defined as a fraction of a mean solar day but as a multiple of atomic oscillations. Unfortunately much of our understanding of the movements of sun, moon and stars became lost because astronomical knowledge is no longer needed to read and interpret time.

In the present article a poem by Sappho is taken as the starting point to discuss some aspects of the history of time-keeping in Europe. The meaning of the term *hour* will be followed through the centuries and the use of celestial phenomena to tell time at day or night will be addressed. Some aspects of ancient time measurement in central Europe, with specific examples from the area around Basel, Switzerland, will be used to illustrate these historical developments.

Δέδυκε μὲν ἀ σελάννα
καὶ Πληίαδες· μέσαι δὲ
νύκτες, πάρα δ᾽ ἔρχετ᾽ ὤρα·
ἔγω δὲ μόνα κατεύδω,

Fig. 1. The text of Sappho's poem in its original writing.

SAPPHO'S POEM

Sappho lived on the island of Lesbos around 600 BC. Not much is known about her life. She was probably married and had a daughter named Kleis. She was famous at her time which is evident from a poem by Alkaios, one of her contemporaries and colleagues. Unfortunately, most of Sappho's poems have only reached us in the form of fragments.

One of Sappho's short poems – whose ascription is actually uncertain, it may be piece of popular poetry – is shown in Ancient Greek in Figure 1. An almost literal translation into English reads as follows:

> The moon has set,
> and the Pleiades, it's
> midnight, the hours
> march on: I lie alone.

These lines are usually interpreted as one of the first examples of poetry that describes the feelings and emotions of an individual rather than the adventures of heroes or gods in war and peace. However, if one looks at this poem from another angle, it is also remarkable for another reason: it contains several pieces of precise astronomical information. It talks of midnight and of passing hours. The moon has set and a constellation, the Pleaides, have just disappeared below the western horizon.

From these astronomical terms several questions arise. Is this information in Sappho's poem meaningful? Do we understand the message behind these terms? What are the associations a contemporary audience might have had when listening to Sappho reciting this poem? Did they understand more than we do? Did they understand different things when they heard the same words as we do? What was known about astronomy in Sappho's days?

Sappho lived approximately two centuries after the poets Homer and Hesiod (both around 800 BC). In their works various astronomical terms, including the names of stars, solstices and equinoxes, and the cycle of the moon can be found. At Sappho's time two famous philosophers, Thales and Anaximander, lived and worked in Milet, an important Greek town on the east coast of the Agaean Sea. Thales is said to have predicted a solar eclipse probably based on Babylonian traditions and wrote on solstices and equinoxes probably based on Egyptian traditions. Anaximander is said to have set up a sundial in Sparta on which he marked solstices and equinoxes, time and seasons. These examples show that Ancient Greece was exposed to influences from other cultural centres. In particular Egyptian and Babylonian science had a strong impact on the development of the culture in this area of the old world.

My hypothesis concerning the interpretation of Sappho's poem is that terms which seem clear to us – i.e. *hour* and *midnight* - were less clear to Sappho's audience. Con-

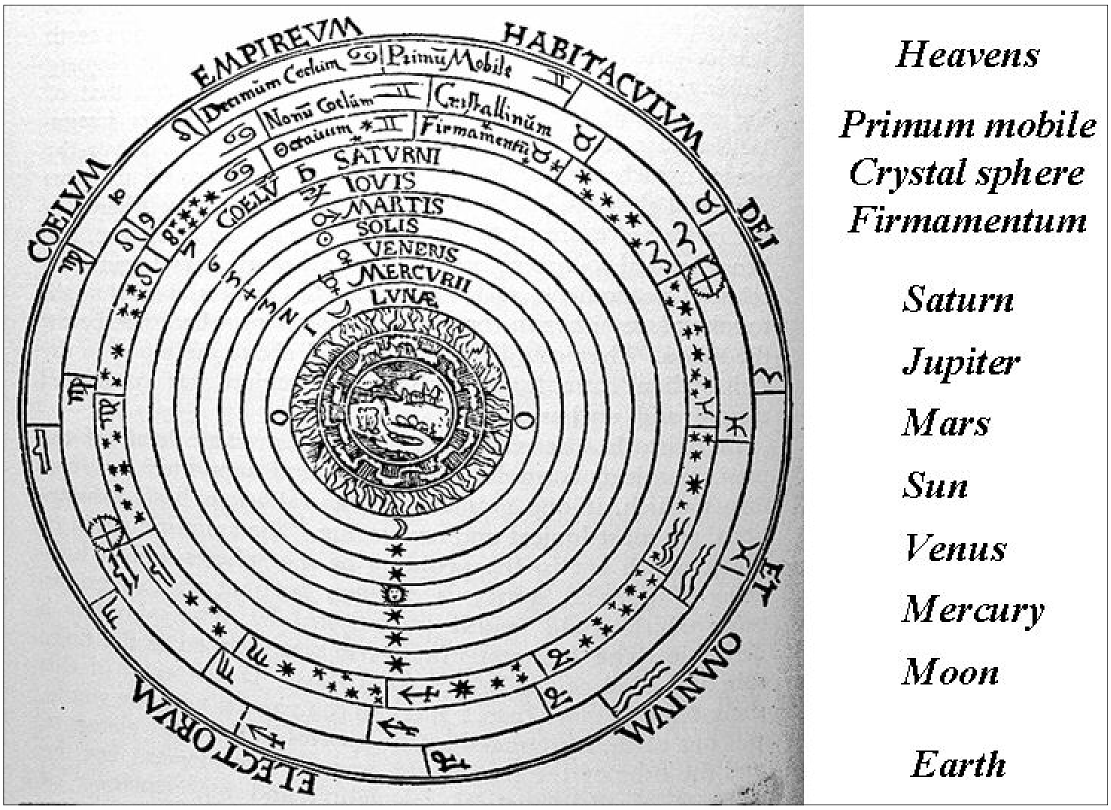


Fig. 2. The Ptolemaic universe. The earth is in the centre, surrounded by air and fire. The next seven spheres belong to the planets, the moon's sphere being the innermost followed by that of Mercury and Venus. The next one belongs to the sun, followed by that of Mars, Jupiter and Saturn. These planets' spheres are surrounded by the firmament, the crystal sphere and the primum mobile, the machine responsible for turning all spheres. The outermost sphere is that of the heavens also designated as the house of God. From Petrus Apianus, Cosmographia, 16th century AD.

versely, the *setting* of the *moon* and the *Pleiades* no longer raises an association today while their interpretation was familiar to members of Sappho's audience and helped them to fully appreciate the content of the poem.

THE CLASSIC UNIVERSE

In Ancient Greece the earth was considered to be the centre of the universe – solid, immobile and stable (Fig. 2). The universe consisted of several spheres rotating around the earth and ranging from the nearest, the moon, to the farthest, the house of God. Sun and moon were two of a total of seven planets, "wandering stars", which showed individual movement against the background of the fixed stars. The movement of the sun was the most important of these phenomena in daily life, with sunrise in the east and sunset in the west determining the length of the day. These points in time were easy to define. It was more difficult to assess the middle of the day by observing the highest position of the sun in the south. When it was recognized that the course of the shadow was much easier to follow than that of the sun itself, the art of sundialling was born.

TEMPORAL, BABYLONIC & ITALIAN HOURS

The shadow of the sun cast by a gnomon such as a vertical stick in the ground provides information on the direction and altitude of the sun. This simple dial can be used as a clock and as a calendar. The main disadvantage of that arrangement is the fact that it shows unequal (or temporal) hours.

The shadow of the sun cast by a gnomon located in the centre of a hollow sphere provides a direct image of the sun's movement across the sky (Fig. 3, left panel). Such elegant dials called skaphe are said to have been invented by Berossos in Persia and were first introduced to Greece by Aristarch of Samos around 300 BC. They also show unequal, temporal hours.

A logical way to count the hours is to start at sunrise, i.e. at the beginning of the present day. However, it also makes sense to start counting at sunset, i.e. at the end of the previous day. Hours since sunrise are called Babylonic hours while those since sunset are called Italic or Italian. The advantage of counting hours like that may not be obvious to us but it was practical for people who wanted to know the duration of daylight rather than having a precise but less meaningful information about the time of the day.

When Goethe travelled to Italy in 1786 he was confronted with Italian hours. Far from being upset by the problem of adjusting to a foreign way of time measurement he actually saw good reasons why the local population had adapted this system and should keep it: "…In a land where people enjoy the day, but especially delight in the evening, nightfall is most significant…. their clock is most intimately connected with their nature…". Goethe was eager to learn how this system worked and depicted in his book "Italian Journey" a scheme he designed to translate the Italian into conventional hours (Fig. 4).

CANONICAL HOURS

A different way to look at time was adopted by monks in the early centuries of Christianity. For them the most important purpose of measuring time was to establish a regular schedule for prayers during the day. The first prayer (prime) was due in the morning and was followed by further ones three, six and nine hours later (terce, sixt and none). The last prayer (complet) concluded the day. The hours for these prayers were usually read from vertical dials with horizontal gnomons. Although the hours indicated by these dials were of different lengths over the year they served perfectly the purpose they had been designed for. However, their strictly numerical logic was not maintained over the centuries but gave way to basic human needs. In the original schedule the nones signified three o' clock pm which was defined as the time for the main and, during Lent, the only meal of the day. Most probably driven by the monks' desire to eat earlier the nones were shifted forward and eventually replaced the sixt. Now it was possible to eat already at six instead of nine hours after sunrise. This shift of the nones towards the middle of the day provided the root of the term "noon" and its present meaning.

When the first mechanical clocks appeared around 1300 AD their precision was so deficient that they needed to be regularly adjusted at noon by readings taken from a sundial. However, a problem for the conventional sundials arose from these competitive time-measuring devices because by their very nature the mechanical clocks showed and struck equal hours. This deviation between sundials and mechanical clocks throughout the day became irritating enough to stimulate other solutions.

EQUAL HOURS

The measurement of equal hours on a sundial can be achieved be a simple modification of its construction, i.e. the replacement of a horizontal gnomon by a polos which is oriented parallel to the earth's axis. This seemingly minor detail in the construction of a sundial represents a great conceptual difference. A polos sundial is no longer a simple shadow casting device but a model of the earth in the solar system. By precisely indicating the position of the earth's axis at a specific latitude it allows one to extrapolate to the terrestrial and celestial poles and equators. All sundials showing equal hours contain either a visible polos or a less obvious part of it. This may be an edge, a thread, an ornament, or even only a single point, which resembles the centre of the earth.

SYMBIOSIS

Once both sundials and mechanical clocks showed equal hours, they could exist together in harmony. On some churches one can still find a gnomon sundial and its polos dial successor next to each other and not far from the dial of the mechanical clock. One such example can be seen at the cathedral in Regensburg, Germany (Fig. 3, right panel). The only difference that persisted between their indications was firstly the sense of direction in which the hands of a mechanical clock and the shadow of a vertical dial turned and secondly the fact that a sundial had (at least theoretically) a 24 hour scale while that of the conventional mechanical clocks had only a 12 hour scale. There were isolated efforts to eliminate these last remaining inconsistencies and since the indications of the sundial can't be changed, mechanical clocks were constructed which had a 24 hour dial and whose hands moved counter-clockwise like the shadow. One example of such a construction is the dial of the clock at the dome in Florence which carries paintings by Paolo Uccello.

LOCAL PECULIARITIES

The symbiosis of a sundial and a mechanical clock on the facade of a church is such a common view that one would hardly expect different indications in different places. However, when the sundial at Basel cathedral is closely examined it becomes evident that it shows 1 o'clock where other dials show 12 o'clock. Thus the time given by the Basel dial is one hour ahead of that shown by conventional dials (Fig. 5).

Is this an error or does it have a special meaning? Several stories give anecdotal explanations, e.g. that the delegates of the Council of Basel (1431 to 1443) became tired of their never ending disputations and suggested this change in order to have lunch one hour earlier than usual. A more likely explanation is that the people of Basel had to set their mechanical clock when it was first installed in their church. Since there were probably no examples available from other churches in the area they had to decide on their own which number should be assigned to local noon. Was it more logical to define noon as the last hour of the morning (the 12th hour after midnight, *hora completa*) or as the first hour of the afternoon (the 1st hour of the afternoon, *hora incipiens*)? While the former definition became widely used in Europe, the citizens of Basel preferred the latter and this tradition is documented as early as 1422. The fact that they took this decision appears less remarkable than the fact that they adhered to it until 1798, which means for almost 400 years. If one considers that even in the close neighbourhood of Basel people were using the more common way of counting hours, the durability of the Basel system is an outstanding example of independent thinking and perseverance.

PRECISION HOURS

With the invention of the pendulum clock by Christian Huyghens in 1656 and the construction of the first examples by Salomon de Coster in Amsterdam and soon thereafter by Ahasuerus Fromanteel in London, mechanical clocks

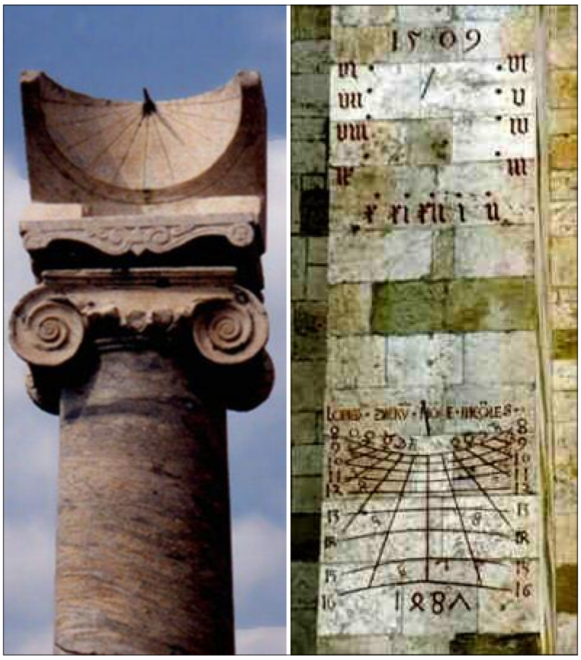


Fig. 3. Left panel: a Roman skaphe in Pompeii. Right panel: Two sundials from the cathedral of Regensburg, Germany. The lower one, dating from 1487, has a horizontal gnomon, the upper one, dating from 1509, a polos.

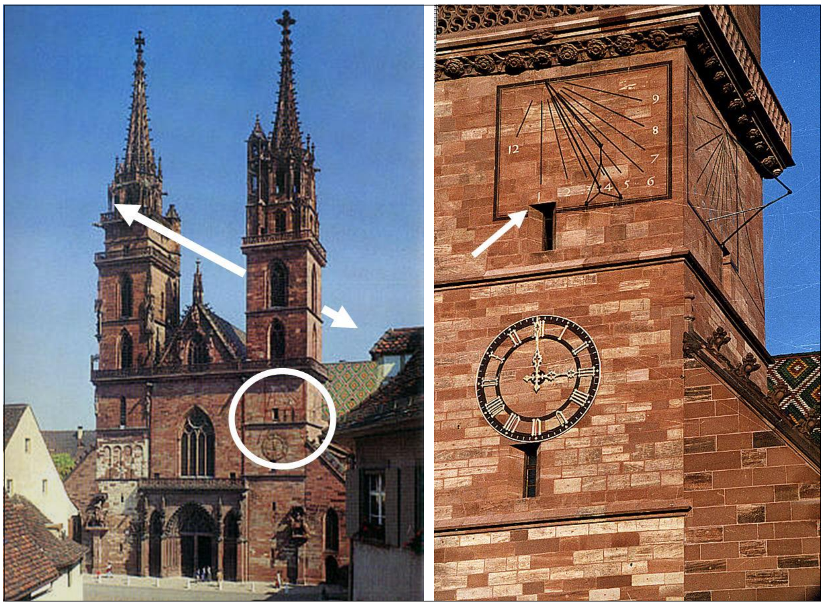


Fig. 5. Left panel. The cathedral of Basel, total view. The arrow indicates the orientation of the length axis towards the point of sunrise at summer solstice. The circle indicates the position of the sundials next to the dial of the mechanical clock. Right panel, enlarged view of the south tower facade. Two sundials indicate local time. At the usual position of 12 o'clock the Basel sundials are labelled 1 o'clock. Originally the mechanical clock would have shown the same local time.

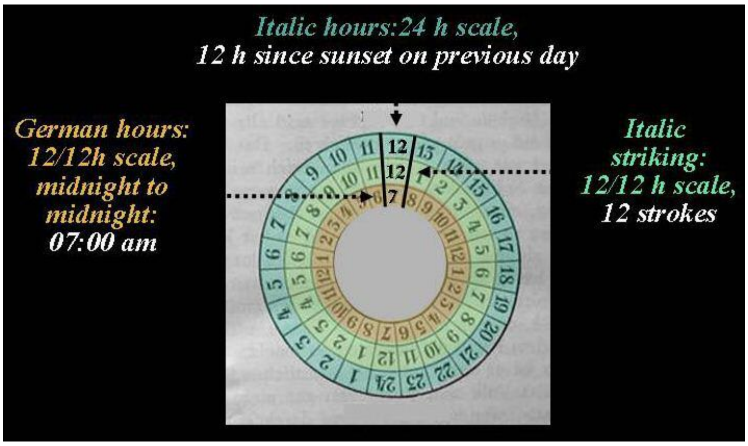


Fig. 4. Scheme designed by Johann Wolfgang von Goethe to convert conventional or German hours into Italian ones. The outer ring shows a scale with 24 hours counted from sunset (Italian hours), the middle circle a scale with 12 plus 12 hour counted from sunset (Italian striking) while the inner circle shows a 12 plus 12 hour scale counted from midnight (German hours). Goethe designed this scheme on 17th September 1786 and it is intended to be used at this time of the year. A correction table is added for other dates. In order to make a correct reading it needs to be considered that the counting of Italian hours started half an hour after sunset. Furthermore the next correction of the scheme by half an hour is foreseen for 1st October.

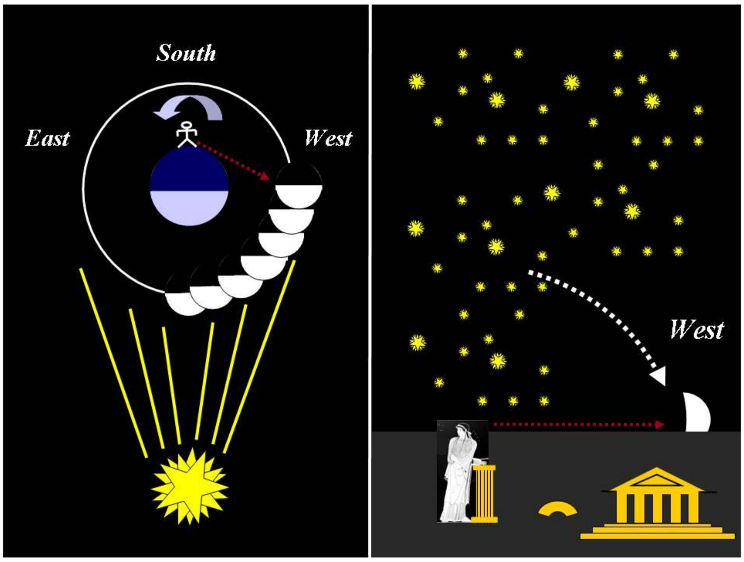


Fig. 6. Left panel: The positions of the moon during the seven days following new moon as seen by an observer on the earth at midnight. The waxing first quarter moon sets on the western horizon at midnight. Right panel: The midnight setting of the first quarter moon as seen by Sappho on Lesbos.

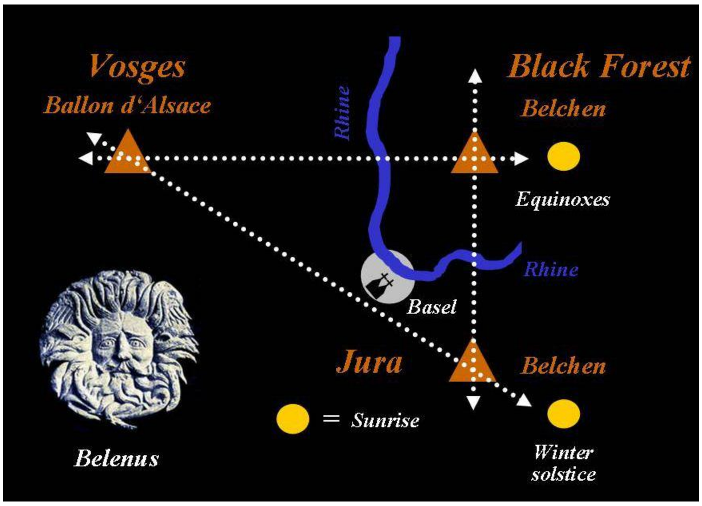
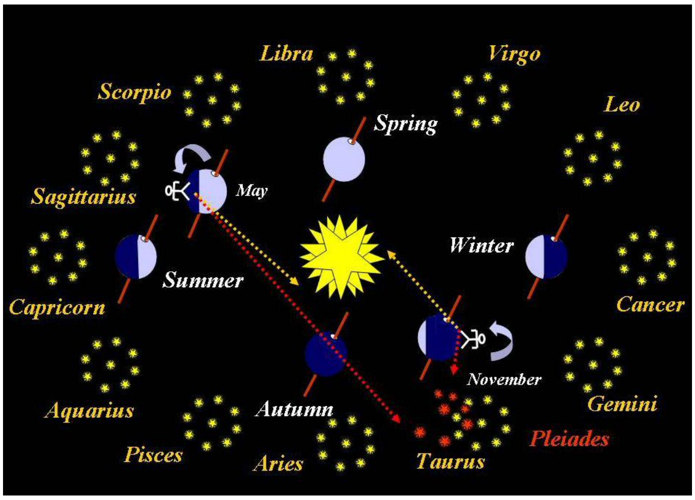


Fig. 7 (left). Schematic drawing of the hypothetical Belchen triangle formed by three mountains in Germany, France and Switzerland. These mountains, the Belchen in the Black Forest, the Ballon d' Alsace in the Vosges and the Belchen in the Jura carry names that are derived from a common source, namely the Celts' god of the sun, Belenus. In their language Bhel meant shining. The church symbol stands for the cathedral in Basel which is located at the knee of the Rhine where this river turns from an east-west to a south-north direction.

Fig. 8 (right). The earth's orbit around the sun and its positions vis-à-vis the fixed stars. The two morning observations which are described in Hesiod's 'Works and Days' are indicated. One occurs in May when the sun rises immediately after the Pleiades above the eastern horizon. The other one happens in November when the Pleiades disappear below the western horizon just before the sun rises above the eastern horizon.



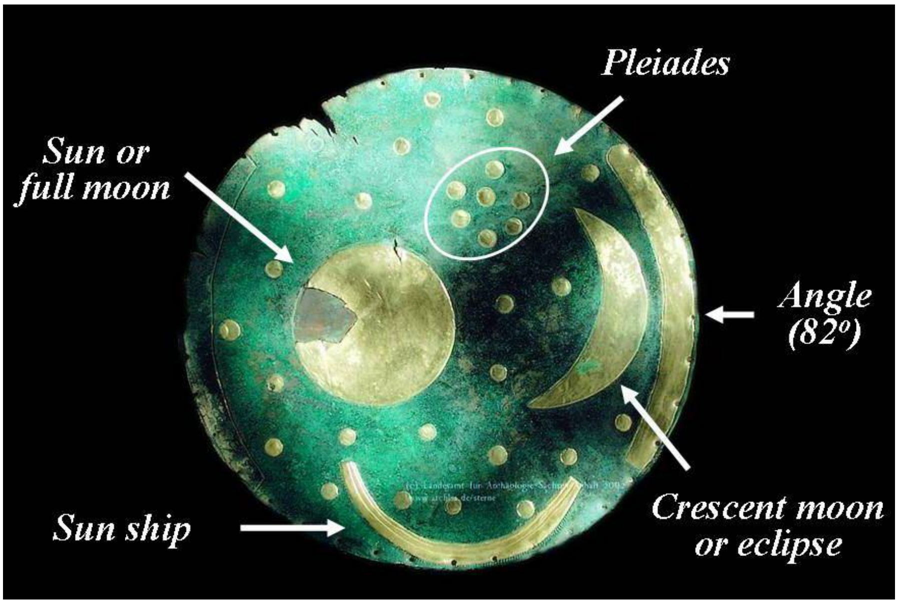


Fig. 9 (left). The disc of Nebra. This bronze object with a diameter of approximately 32 cm has a weight of 2.5 kg. The image is thought to represent the night sky but other interpretations are possible (alternatives in parentheses). The figures show the full moon (or the sun?), the waxing crescent moon (or a lunar or solar eclipse?), the sun ship and two angles of 82° indicating the difference between the points of sunrise and sunset at the summer and winter solstices. While the small golden points representing stars cannot be specifically attributed the only constellation on the disc appears to depict the Pleiades.

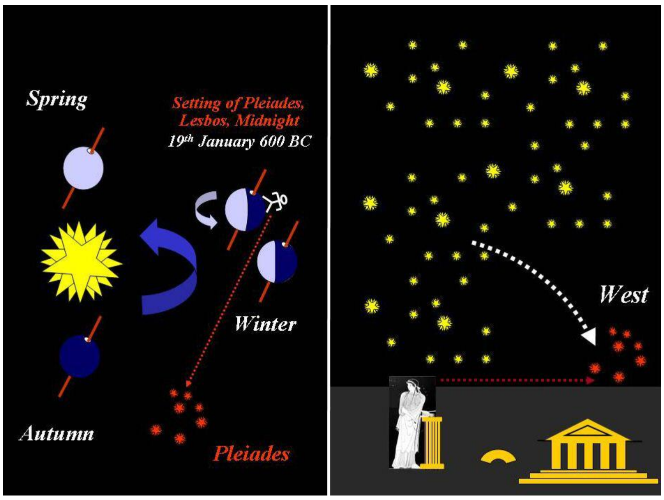


Fig. 10. Left panel: The earth's position vis-à-vis the Pleiades on a special date, the 19th January of the year 600 BC. Right panel: The midnight setting of the Pleiades as seen by Sappho on Lesbos.

gained enormously in precision. As a consequence the irregularities of the time shown by a sundial became apparent. Since it was still necessary to adjust the pendulum clocks from time to time to the sundial, correction tables had to be designed for the so-called equation of time, i.e. the regular deviations of solar time from clock time during the course of the year. Conversely these corrections were graphically displayed on precision sundials by a loop of eight. Generally speaking these adaptations implied that the rotation of the earth was still the dominating principle of time measurement but had to be corrected for its variations during the course of the year.

ULTRAPRECISION HOURS

The development of precise timekeepers did not stop with the invention of pendulum clocks. Instead of using the gravity-driven pendulum as a natural reference for a precise time interval scientists preferred to use atomic oscillations for this purpose. In 1967 the frequency of caesium became the standard for defining a second. Now that such atomic clocks perform with extreme precision the celestial motions strike back. The rotation of the earth is progressively diminishing by a few milliseconds per day mainly due to the gravitational influence of the moon. Consequently our modern time-measuring devices have to be adjusted by adding an additional second every couple of years to stay in line with what is still the main timer of our life, namely the rising and setting of the sun.

From a philosophical perspective it is interesting to follow the ongoing discussion among specialists about whether these adjustments should continue to be made. There are mainly practical reasons for or against such a decision. However, if it was decided to uncouple the duration of the day from the rotation of the earth a conceptual gap would open between a virtual definition of time and the real motion of the earth vis-à-vis the sun. Time would then become a purely human convention and no longer remind us of the fact that we are inhabitants of the solar system.

SAPPHO'S HOURS

When Sappho used the term *hour* in her poem she didn't think of any of the kind of hours discussed above. In her days the word *hour* had the meaning of time in general, period or season. Only several centuries later this term obtained its current meaning, i.e. the 24^{th} part of a day or an hour of 60 minutes duration. When Sappho's audience listened to the line "… the hours go by…" they probably understood that time was passing or that the right moment had been missed.

The notion that the term *hour* had originally a very broad meaning is supported by the etymology of the modern words derived from it such as the English *year* and the German *Uhr*. The Greek *ωρα* survived in the Latin *hora* which in turn gave rise to the Old English *yar* that eventually became *year*. A parallel development was the transition from *yar* to *hour.* The Old German *yar* was permutated into *Jahr* (i.e. similar to yar/year in English) as well as into *Uhr* (i.e. clock). It is interesting to note that the closely related Dutch term *Uren* means hours but not clocks.

MIDNIGHT

If we assume that Sappho was not used to counting the hours of the day, what might have midnight meant to her? The middle of the day, noon, was an important time point early in the development of time measurement and it was well known that when the sun stood in the south at its highest position it cast the longest shadows. The middle of the night is an equally important intersection, not only for the sleepless and the poets. How could Sappho have known that it was midnight when she felt lonely?

KLEPSHSYDRA, MERKHET, NOCTURNAL

In Ancient Greece an instrument was in use which was capable of telling the time independently of sun or stars, namely the water-driven clock or *klepshydra*. In its simplest form it consisted of a vessel with a defined in- or outflow. In its most sophisticated form it was almost a precision instrument with various mechanical devices guaranteeing a constant and reliable flow over longer periods. In Sappho's time most probably only simple vessels were available which were mainly used to measure short periods such as the time allotted to a politician for a speech.

Time can be read at night from the position of the stars. The fixed stars move from east to west slightly faster then the sun and therefore reappear each night 4 minutes earlier. Relatively simple instruments make it possible to determine the southern position of a star i.e. its transit through the local meridian. If the selected star stands exactly at 180° to the sun at the chosen date, its passage indicates midnight. The Egyptians used a plumb line called Merkhet for these measurements and an example dating from Sappho's time can be found in the collections of the British Museum in London. However, its use requires profound astronomical knowledge and it is unlikely that any layperson would have used such an astronomical instrument.

An elegant device for telling time at night is the so called nocturnal or star-dial. This instrument consists of a calendar to adjust the position of the sun to that of the stars during the year, a central hole to align the instrument with the North Star and a movable index to locate either the Great Bear or Cassiopeia. If correctly manipulated this instrument enables the observer to read time at night with the same precision as provided by a sundial during the day. However, first examples of such instruments only date from the period of the Roman empire and therefore most probably were not available at Sappho's time.

How could Sappho know that the first half of the night had passed when she wrote her poem? What image had the people in mind who listened to her talking about midnight? One possible interpretation is related to another astronomical term in the poem, namely the setting of the moon.

SAPPHO'S MOON

The moon was a goddess in Ancient Greece, Selanna or Selene, the equivalent of the Roman Luna. Like the sun the moon goddess was carried across the sky in a chariot drawn by horses. In poetry the picture of the moon might have served a poetical function. The image of the sickle moon was related to fertility and love. The moment when the fading light of the moon had finally disappeared from the sky may have strengthened Sappho's feeling of loss and loneliness. However, she might have used the picture of the setting of the moon to convey to her audience the message that it was midnight.

The phase transitions of the moon were probably among the earliest phenomena recognized by ancient astronomers. When the moon stands exactly opposite the sun in the night sky we see a full moon. The angle from which the moon receives light from the sun is continuously changing because every day the moon lags 12° or 48 minutes behind the sun. About seven days after full moon this delay amounts to approximately 90° or 6 hours. The moon then rises at midnight at the eastern horizon as third quarter waning moon.

The new moon stands in the same direction as the sun. Hence it is at a northern position at midnight and therefore not visible. During the following days the distance of the moon from the sun is again increasing and the waxing sickle moon stays longer and longer visible above the western horizon after sunset (Fig. 6). The waxing first quarter moon sets in the middle of the night. This was known to people in ancient cultures and served as a simple means to determine midnight. Sappho's audience had most probably understood this information and saw in their minds the waxing moon disappear below the western horizon when they heard Sappho reciting about the setting of the moon at midnight (Fig. 6).

SUN, MOON & SEASONS

The sun and the moon were not only used to tell the time of the day and the night but also to determine the seasons of the year. This can for instance be done by reading the sun's direction or altitude. There are many examples of natural objects that were used for this purpose, e.g. rocks or summits of mountains that indicated the position of the sun at either the solstices or the equinoxes. Such information was also used to build sanctuaries in a way to indicate certain times of the year. In and around Basel examples of both traditions can be found.

One example is the cathedral of Basel. This church was erected on pagan fundaments and the axis of the new building was kept in the direction of the old sanctuary (Fig. 5). That had been oriented towards the point of sunrise at summer solstice. Thus on that date the sun shines through the eastern window of the crypt exactly onto the centre of its western wall. There are still people in Basel who rise early in the morning at that time of the year to watch this phenomenon.

Another example is a possible orographical calendar in the region of Basel. Although its existence was suggested several decades ago it is still hypothetical because no vestiges have been found that provide solid evidence for its existence. The hypothesis is based solely on the fact that in the Basel area some mountains carry names which are most probably derived from the same root. They are located in the Black Forest in Germany, the Vosges in France and the Jura in Switzerland. One of the highest mountains in the Black Forest is called 'Belchen' as is a summit in the Jura close to Basel. In the Vosges several mountains are called 'Ballon' which is closely related to the German Belchen. It is likely that these names are derived from 'Belenus', the name of the Celts' god of the sun. In their language the syllable *Bhel* meant *shining*, which is an appropriate attribute to mountain peaks regularly covered by snow in wintertime.

The 'Ballon d' Alsace' is in an interesting geographical position vis-à-vis the German and the Swiss Belchen. For an observer standing on the Ballon d' Alsace the German Belchen is exactly in the east, which means that at the equinoxes the sun will rise from behind this mountain. Furthermore, the Swiss Belchen is located towards the southeast exactly in the direction of the sunrise at winter solstice. Finally the German and Swiss Belchen are located on the same meridian. This makes up a triangle of mountains suitable for astronomical observations which were perhaps also used for ritual ceremonies (Fig. 7).

This hypothesis has been expanded by including another orographical peculiarity. There are three other mountains in the Basel area which carry the common name 'Blauen'. This name has probably the same roots as Belchen or Ballon. These Blauen mountains are in such a position that, as seen from a point in the Rhine valley, they indicate the horizon cycle of the moon. The plane of the sun's and the moon's orbits differ maximally by approximately 5°, an angle that continuously changes over a period of about 18 years (Saros cycle). Only when the sun and the moon are in the same plane can solar or lunar eclipses occur. The precise knowledge of the relative positions of the sun and the moon makes it therefore possible to predict such events, a skill from which astronomers and priests derived much of their prestige and power. It may be no coincidence that the point in the Rhine valley from which these observations can be made is called 'Hell's Ground'. There are other examples of places that had been traditionally used for pagan ceremonies and were later given names intended to reduce their popularity and attractiveness.

THE PLEIADES

The Pleiades are a constellation which has been recognized in many different cultures all over the world for thousands of years. Depending on local traditions this cluster consists of 5 to 8 different stars. The Japanese for instance count 6 stars and call them Subaru, a name that also serves as the logo of an automobile company. In Ancient Greece the Pleiades were considered to contain 7 stars. All of them carried female names because they were believed to be the 7 daughters of Atlas and Pleione, two shining stars situated just next to them. The constellation is close to Taurus and not far from the ecliptic.

With their bright bluish glimmer the Pleiades are a beautiful view in the night sky and were used in Ancient Greece as in other Mediterranean cultures as indicators of the seasons. The observation of their morning rising or setting has provided an estimate of important dates of the year. In Hesiod's famous poem 'Works and Days' the following rules are given:

> When the Pleiades, daughters of Atlas,
> are rising, begin your harvest,
> and your ploughing when they are
> going to set.

The first two lines refer to the morning rising of the Pleiades, i.e. their appearance above the eastern horizon just before the rising of the sun (heliacal rising). This happens in May, the time to harvest the winter wheat (Fig. 8). The last two lines refer to their morning setting, i.e. their disappearance below the Western horizon just before the rising of the sun (acronitic setting). This happens in November, the time to plough and sow the winter wheat. Both readings are taken at dawn, the time a farmer would leave the house and decide on the work to be done that day. This also implies that the observation of the Pleiades and the interpretation of these phenomena was not privileged information but was used in every day life by people whose work depended on the seasons.

The notion that the observation of the Pleiades was common in ancient Europe is supported by the recent discovery of a spectacular archeo-astronomical object in Germany, the so-called disc of Nebra (Fig. 9).

THE DISC OF NEBRA

In 1999 tomb raiders were active in the vicinity of a Bronze age settlement near Nebra in Saxony-Anhalt, Germany. Among other bronze objects, they uncovered a circular disc with unusual ornaments. They soon realized that it must be something very special and might be worth a lot of money. When the disc started its journey on the black market rumours soon spread that an exceptional object was seeking a buyer. This secret information was also passed on to the authorities and eventually the Swiss police intervened at a mock trade meeting which was organized in the bar of the Basel Hilton hotel. After the disc had been recovered for the public a careful analysis was carried out. It is now believed that this treasure dates from around 1600 BC which makes it the oldest known archeo-astronomic object found in central Europe to date.

While the physical and chemical analysis made good progress, the interpretation of the images on the disc proved to be more difficult. The current interpretation by the specialists in charge of the scientific evaluation is that the disc shows the night sky. The golden parts are thus believed to show the full moon, the crescent moon, the Pleiades and several not identifiable other stars. The bow at the lower margin shows the sun ship which carries the sun on its journey through the night. The two angles which are placed opposite to each other at the margins of the disc (one is missing with its vestiges clearly visible) show the position of sunrise and sunset at the solstices. The angles measure 82° which is exactly the difference between these positions to be expected at the latitude of Nebra.

The conjunction of the crescent or the full moon with the Pleiades might indicate the seasons, representing the situation in the night sky in March and October, respectively. This interpretation would be closely related to the use of the Pleiades as seasonal markers in ancient Greece but has been challenged by others. However, regardless of the final interpretation the disc of Nebra clearly demonstrates that as early as 1000 years before Sappho the Pleiades were a constellation of stars worth being depicted in gold on a shield of high ceremonial or cultural value. While at that time the knowledge about their celestial movements may still have been privileged information of priests or astronomers it is not surprising that this information was in common use a millennium later.

SAPPHO'S PLEIADES

Unlike the farmers who were observing the sky in the early hours of dawn, Sappho was looking at the Pleiades in the middle of the night – not unusual for lonely poets. At midnight she saw the Pleiades disappear below the western horizon. When the geographical localization of the observer is known and corrections are made for the precession of the earth's axis the setting of the Pleiades at midnight can be precisely related to a specific date. I am grateful to Professor James Evans, University of Puget Sound, Washington, USA, for performing such a calculation. According to his results the Pleiades were setting in Lesbos in the year 600 BC at midnight on the 19th January (Fig. 10). While for the interpretation of the poem the precise date is not important the information about the season is. To spend a lonely night during winter is different from the same experience during summer. It is likely that Sappho's audience was able to interpret the midnight setting of the Pleiades as a metaphor for a winter night which considerably strengthened the emotional message of the poem.

SAPPHO'S POEM REVISITED

After having gone through various aspects of the history of time measurement let us look again at the astronomical content of Sappho's poem. The term *hour* which appeared to be at the first glance so easily understandable turns out to be quite misleading. At Sappho's time the passing of the hours meant nothing more than the passing of time or the seasons, may be also having missed the right moment. This is different for the other precise term, i.e. *midnight*. Although it cannot be excluded that midnight in this poem just means the middle of the night as a period rather than a precise point in time, the term may be more precise when related to the moon. The audience at Sappho's time must have understood the allusion to the midnight lunar setting and related it to the image of a first quarter moon. Finally, and probably most importantly, the midnight setting of the Pleiades transmitted the impression of a winter night which even on a Mediterranean island such as Lesbos can be miserable and cold.

Taken together the astronomical terms in this poem add considerably to its literary message. At Sappho's time people knew much better than a reader today how to interpret this information and to translate celestial phenomena into everyday life. Such an interpretation would still hold true if these four lines had not been written by Sappho but were rather a poem of local tradition. In this case the use of astronomical terms to strengthen a poem's message would even more strongly suggest that in Ancient Greece heaven and earth were more closely related than in our times.

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A MOON DIAL

NORMAN DARWOOD

ASSEMBLY

Photocopy the drawing onto stiff card or other suitable material. Make a pedestal in the form of an equatorially inclined plane, i.e. a wedge with an angle to the horizontal equal to your co-latitude, pointed to face north. Mount the moondial on the equatorial plane pivoted about its centre, so that it can be rotated. Note that the dial is designed for the northern hemisphere only.

MOON'S PHASE

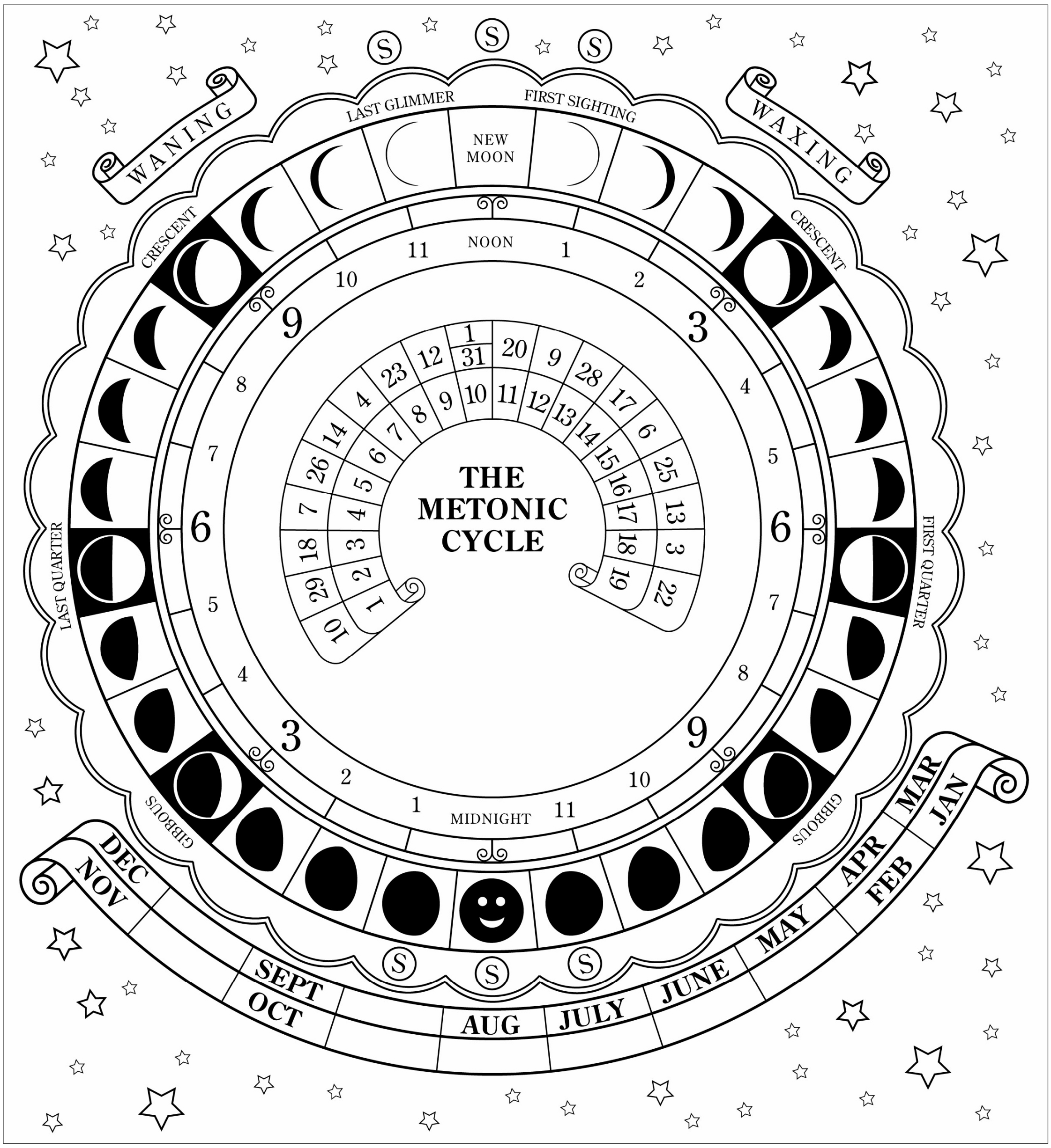
To use the dial, it is necessary to know the phase of the moon. A simple (if not totally accurate) method for this is to use the *Golden Number*. The Golden Numbers are so-called because in ancient Greece they were etched in gold on public buildings and monuments. See Ref. 1 for a fuller definition. The Golden Number (GN) is defined as one more than the remainder resulting from dividing the year by 19. It is an integer number between 1 and 19. For example:

Year		GN
2005	2005/19 = 105, remainder 10	11
1983	1983/19 = 104, remainder 7	8
2013	2013/19 = 105, remainder 18	19

The Golden Numbers are shown in the central arc in the middle of the moon dial. Next to them are numbers which we can define here as the 'Golden Date'. These numbers follow the *Metonic Cycle* and will remain correct until AD 2200.[1] For example, a GN of 1 has a 'Golden Date' of the 10th and a GN of 2 has a date of the 29th. A GN of 10 has a date of either the 1st or the 31st.

Finally, to find the phase of the moon on any date:

1. Start at the moon phase opposite the month name
2. Begin counting with the Golden Date
3. Count up (clockwise) or down (anticlockwise) to reach the day of interest. The symbol shows the moon's phase on that day.



Example 1: 2006, June 5th. The GN is 12. The Golden Date is the 9th. Starting at June (two days before full moon) on the 9th, count down (anticlockwise) to the 5th to arrive at one day after the first quarter.

Example 2: 2023, December 25th. The GN is 10. The Golden Date is the 1st or 31st. Starting at the gibbous moon on the 31st, count down (anticlockwise) to the 25th and arrive at two days before the full moon. Alternatively, count up (clockwise) from the 1st to arrive at the same answer.

The relationship used here between the GN and the 'Golden Date' will change over the centuries.[2]

TO FIND THE TIME BY THE MOON

Rotate the dial so that today's moon phase is pointed to the south, i.e. the highest point. Then the moon's direction perpendicular to the plane of the dial indicates the current time. Note that the moon does not give enough light to cast a visible shadow for most of the month so this dial relies on estimating the moon's direction, rather than on a shadow.[3]

The time indicated by the dial is related to the solar or local apparent time. However, variations in the moon's orbit will have a far greater influence on the closeness of the time indicated by the dial to clock time than the effects of the Equation of Time. The actual moon's phase can be one day (or occasionally two days) before or after that found by the GN method.

A further feature of the dial is the two sets of ringed 'S' near New and Full moons. These indicate the dates where Spring tides may be expected.[4]

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CHURCH ORIENTATION

JOHN WALL

By far the majority of vertical sundials in the United Kingdom are located on the south-facing walls of parish churches. There is a convention that churches are aligned east-west with the result that they provide a highly convenient south facing aspect for the setting up of a vertical sundial. But is this invariably the case? This article addresses two related questions: why are the majority of churches so oriented, and what are the implications of exceptions to this rule in our understanding of vertical sundials in general?

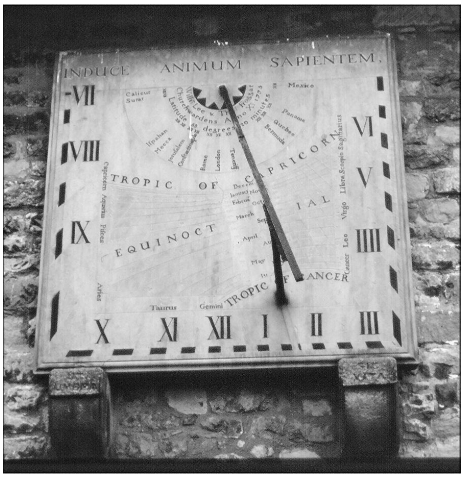

Fig.1. Sundial on the southerly wall of Eyam parish church, Derbyshire. The gnomon is markedly offset from the noon line to compensate for the declination of the wall towards the west.

EXPLANATIONS

There was a time when some scholars assumed that churches in the United Kingdom are aligned east-west because the city of Jerusalem in Palestine, the epicentre of Christendom for two millennia, lies to the east. (In fact that is at best only a very general and imprecise statement. For example, my home town of Kirkbymoorside in North Yorkshire lies on latitude 56° 16' N whereas Jerusalem lies on latitude 31° 47' N. If the axis of our parish church of St Mary was aligned on Jerusalem it would deviate from true east by an angle of approximately 30°.) On the contrary, as soon as the early Christian church spread beyond the geographical area of Palestine, the idea and practice of the congregation, and hence the church, 'facing Jerusalem' appears to have ceased.

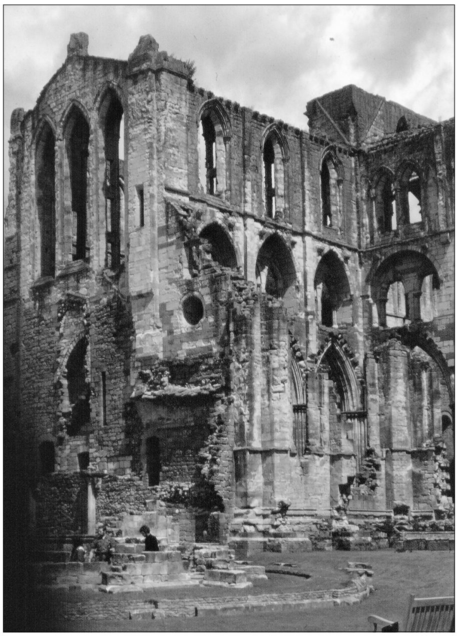

Fig. 2. The 'ritual east end' of Rievaulx Abbey church, Ryedale, aligned north-south.

It is significant that orientation in ritual observance, prayer, the burial of the dead, and the siting of places of worship, is not confined to the Christian religion. For example, orientation of a kind is of the first importance in the case of a Moslem mosque. It is common knowledge that Moslems in the United Kingdom turn to face Mecca, the birthplace of the prophet Muhammad, at times of prayer. To be more precise, this orientation is towards the Ka'bah at Mecca, a type of temple which was adapted by Muhammad as a mosque. It had formerly been a pagan temple with its entrance to the east. The essential feature of a mosque is the *mihrab*, a niche or recess in the wall at right angles to a straight line aligned in the direction of Mecca. Since most mosques are rectangular it is this 'south' wall that is oriented towards Mecca. However, since Mecca lies on latitude 21° 26' N such orientation has an even more southerly aspect than Jerusalem in the case of Christianity. I will be interested to learn if there are sundials on the walls of any mosques in the United Kingdom and, if so, whether they are declining dials to accommodate such a marked deviation from due east.

Quite apart from the veneration of holy places in the East, most religions, including 'paganism' attribute a special significance to sunrise *per se*, and in particular to sunrise at the time of the equinox. (In this connection many scholars interpret Stonehenge as a type of giant sundial.) This would be quite sufficient to account for the orientation of religious buildings in general, and consequently the fortuitous mounting of sundials on their south facing walls.

In a small number of churches, whilst the orientation of the nave is approximately due east, the alignment of the chancel is inclined by some degrees east of south. An example is shown in Fig. 1. The popular explanation of this phenomenon, especially in the case of churches on a cruciform plan, it that it is designed to symbolise the drooping of the head of Christ on the cross. There is no credible documentary evidence for this claim and in most cases the most probable explanation for the deviation is the physical nature of the site that made it difficult or impossible to line up the chancel with the nave. Indeed, where a church as a whole, or its chancel alone, markedly departs from an east-west alignment it is usually found that there is some physical obstruction presented by the contours of the site that dictates a deviation from the norm. Although the church at Rievauix Abbey in North Yorkshire (Fig. 2) is a monastic and not a parish church, it is a good case in point. Because of the restricted nature of the site, hemmed in between the river Rye on the west and the valley escarpment on the east, its alignment is almost exactly north-south.

Fig. 3. Sundial over the porch of Pickering parish church, Ryedale. The gnomon is offset from the noon line to compensate for the declination of the wall towards the west.

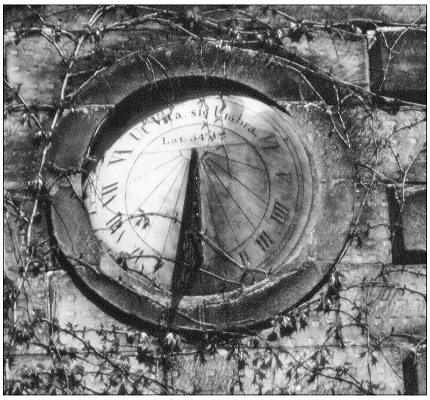

Fig. 4. Sundial on the southerly wall of The Georgian House, West End, Kirkbymoorside, Ryedale. The whole dial is canted so as to compensate for the wall's declination towards the west. Are there any examples of sundials on churches that employ this stratagem on their southerly walls? see note below.

In general, our United Kingdom churches have their axes near enough east-west for any deviation to be unnoticeable to most people. However, such orientation is by no means accurate, and in some cases the deviation is very considerable. One attractive explanation in such cases is that the church has been built so that its axis is towards sunrise on the feast day (the patronal feast) of the particular saint in honour of whom the church was dedicated. Although it is just possible that this direction was adopted occasionally, the theory is open to serious objections. In the writings of the early Church Fathers there are no directions or decrees for so placing churches, and no hint that they were ever so placed. On the other hand, the influential canonical author William Durandus (1230-1296) distinctly says that churches are to point to sunrise at the equinoxes and not the solstices. In the case of major deviations, the exceptions to the theory are so numerous as to be in the majority. Even in the case of Rochester Cathedral, where the orientation is reasonably correct for its feast day, there can be hardly any doubt that it deviates so far to the south in order to accommodate its cramped site. Another possible explanation for instances of marked deviation of the axis of the chancel is the difficulty of continuing the line of the nave when the chancel is rebuilt and its arch blocked off so that the nave can continue in use for worship.

IMPLICATIONS

Whether a direct-south vertical sundial on a south-facing wall of a church is accurately telling the time according to the sun may be established at apparent noon. That is most readily determined by amending noon, according to the clock, to take account of differences plus or minus dictated by longitude and the equation of time. If the shadow of the gnomon then falls precisely on its vertical meridian, the 12-hour line, the church is exactly aligned east-west, whether or not the maker was aware of this or took it for granted. If the shadow declines to any extent to the right or left of a vertical meridian then the church is not accurately oriented and the maker/diallist was ignorant of the fact. For our part, we can only make use of such a dial as at best an approximate teller of the time. On the other hand, if we have the pleasure of reading a sophisticated east or west declining dial then not only is the church not aligned east-west but the maker/diallist was knowledgeable enough to be aware of the fact, and to what degree the church is 'mis-oriented'. There is just such a west-declining dial, beautifully crafted, over the south porch of Pickering parish church in Ryedale (see Fig. 3). It has the added advantage of recording the latitude of Pickering as part of its furniture.

On some churches which are not aligned exactly to the south, the sundial maker has chosen to make a direct south dial and to cant it out from the wall. This stratagem is also sometimes used on non-ecclesiastical buildings, as shown in Fig. 4.

To sum up. It is unwise to assume that every church, whether parish, monastic or diocesan, is correctly oriented, or that sundials on their south-facing walls always take account of any deviation from the norm. Similarly, if a sundial is incorporated in the south facing wall of the chancel of a church, it is unwise to assume that the chancel is correctly oriented even if the nave is blameless in this respect!

It is conceivable that we might wish to install a sundial on the wall of our local church for the first time, for example to commemorate some portentous event such as the Millennium. We would be well advised to check the orientation of both nave and chancel first, and to allow for any deviation, before we proceed. Whilst there is nothing more rewarding than a carefully-crafted, newly installed sundial, there is nothing more embarrassing than one that turns out not to tell the right time!

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Note: Our Registrar Patrick Powers informs us that there are 261canted out dials in the Register although not all are on churches. *Ed.*

ORIGAMI SUNDIALS

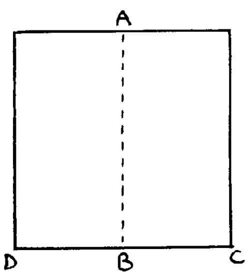
PETER RANSOM

It has been one of my ambitions for a while to make an origami sundial that does not involve any cutting or tearing. This summer I achieved that ambition – in fact I managed to discover three totally different origami sundials! The folding instructions for an equatorial dial follow, this being the first one that I discovered and refined after trialling a few ideas. It was presented for the first time as a short workshop at the BSS Newbury meeting on 24 September 2005 and is, I believe, an original design since I can find no reference to an origami sundial totally folded with all its hour lines from a piece of unmarked paper.

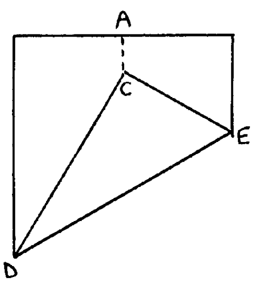
Although any square piece of paper can be used, I like to use origami paper since it is coloured on one side, folds well and makes a suitably sized sundial. Standard origami paper comes in 15 centimetre squares and can be obtained from specialist paper shops, Hobbycraft or from the British Origami Society via the internet at
www.britishorigami.org.uk.

The following instructions are taken from one of the four A6 booklets produced so far in the origami sundial series (details on how to obtain them at the end of the article). Since these origami sundials are low-tech dials, I took the decision to draw and write the booklets by hand rather than use the computer since I find the hand-eye-brain coordination gives me time to think and absorb the geometry of the situation more thoroughly than doing it on a computer.

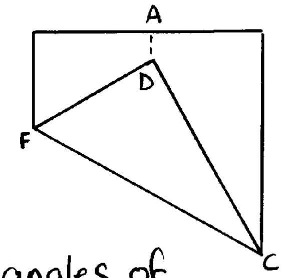
1) Fold a square piece of paper in half then open it out.



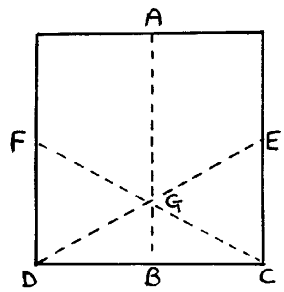
2) Now fold the bottom right corner onto the centre fold so the crease goes through the bottom left corner D.



3) Open the fold out and repeat with the opposite corner.
This makes angles of 60° and 30° at the corners.

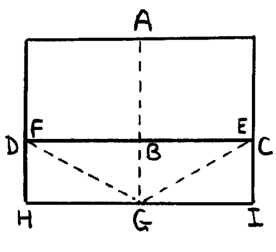


4) Open the paper out.
You should now have this fold pattern.

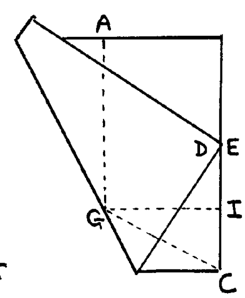


Why this fold gives a 30° and 60° angle can be proved using trigonometry or geometrically. The geometrical proof is quite elegant: imagine the three diagrams in steps 1, 2 and 3 being superimposed on each other. Then the triangle formed by the three sides CD is equilateral so since the folds AB, DE and CF are lines of symmetry, they bisect the 60° angles. The trigonometric proof can be found in the booklet *The Mathematics of Origami Sundials*.

5) Fold the bottom edge upwards so C meets E and D meets F.

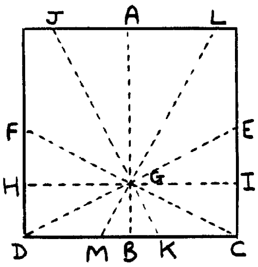


6) Fold corner D onto E.
Open it out.
Repeat, folding corner C onto F.

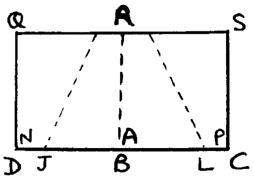


The folds in steps 5 and 6 effectively bisect the angles at G, thus giving folds that give the hour lines for 6am, 8am, etc. For your first origami dial you might like to then move on to step 8 rather than fold these angles in half to get all the hour lines, which will be at 15°.

7) Open it out to get this fold pattern. The creases through I, C, K, B, M, D, H are the 6am, 8am 10am, noon, 2pm 4pm and 6pm hour lines. To obtain the odd numbered hours fold GH onto GD, GD onto GM etc.

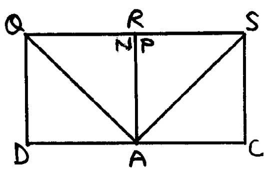


8) Fold in half, top to bottom.

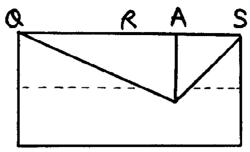


Folding the gnomon was a challenge, making sure that it could be done so that it was perpendicular to the dial plate and centred on G. My first attempts resulted in failure and frustration then all of a sudden the solution stood out when I read about how to fold a bat mask!

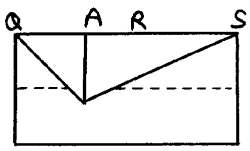
9) Fold P to R then N to R.



10) Now fold edge QA onto edge QS. Unfold.



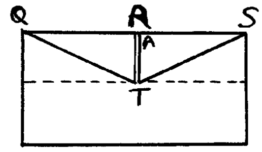
11) Fold edge SA onto edge SQ. Unfold.



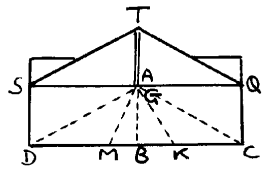
Steps 10 and 11 pre-crease the gnomon and step 12 produces the perpendicular gnomon.

12) Simultaneously fold QA and SA onto QS. A will rise upwards to form a triangle perpendicular to the paper.

Crease firmly along each side of RT.



13) Turn the model over. Fold SQ onto HI so the tip of the gnomon is vertically above G.



For clarity mark and number the hour lines. Use a glue stick to hold all the creases firmly together. If another dial is made they can be stuck back to back with the winter time shadow falling on the underneath. They will be self-supporting at 54°.

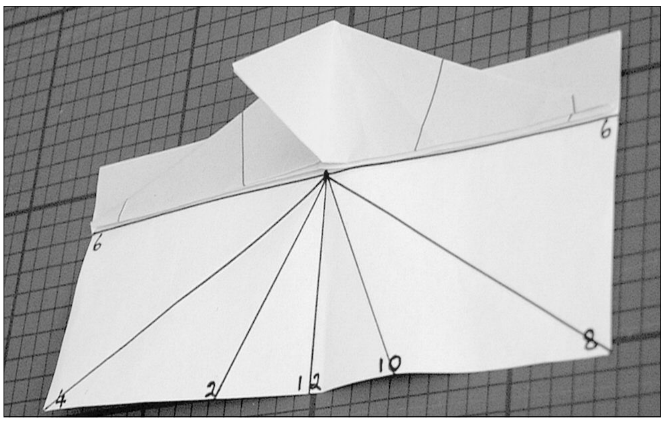


Fig. 1. The completed dial with 2 hour intervals.

This final step allows the gnomon to be placed perpendicularly over G.

Although in true origami no glue is used, it is necessary here to stop the paper unfolding and to give a firm edge to the gnomon.

I then had the problem of inclining the gnomon at the angle of latitude to the horizontal. One of our technology teachers kindly cut a number of right-angled wooden wedges with 52° and 38° angles so that the single sided dial could rest or be glued on a wedge. However I realised that if I made two dials and stuck them together, back-to-back, then the underside would act as a dial in the winter time as well as acting as a support that looked about right. A bit of algebra and trigonometry proved that the angle on the gnomon would be 54° - just right (within a couple of degrees) for most of the UK! The proof of this can be found in the booklet *The Mathematics of Origami Sundials*. In fact I then worked the mathematics backwards to see how I could fold the gnomon to obtain whatever angle I wanted (within reason – low gnomon angles result in short gnomons). However in the true origami spirit no measurement should be used, so although it is possible in principle, I do not bother too much with this, being satisfied with 54°.

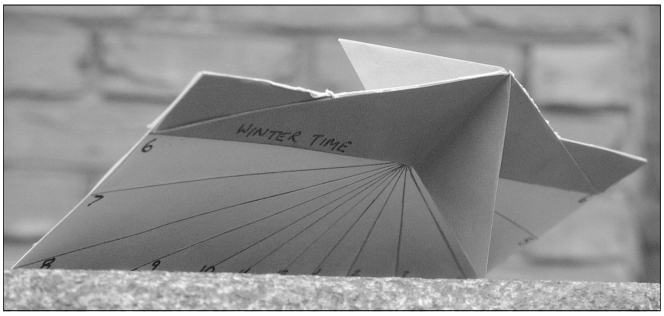


Fig. 2. The resulting double-sided equatorial dial is shown side on here.

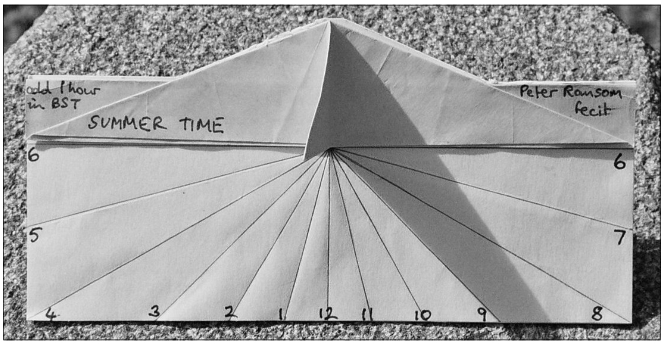


Fig. 3. Here is the view of the top half of the dial at 9am.

Note the shadow to read is the one that passes through the base of the gnomon where the 6am, 6pm and noon lines intersect. I have not yet managed to fold a gnomon like a thin rod!

So far a polar dial and a cross dial have been folded and variations on these are being explored.

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The four 8-page A6 origami booklets (*The Origami Equatorial Sundial, The Origami Reversible Polar Sundial, The Origami Cross Sundial* and *The Mathematics of Origami Sundials*) are now available from the author at a cost of £4 (UK), €8 (Europe) or $10 (elsewhere) per set, which includes post and packing. Sterling cheques drawn on a British bank or cash please!

READERS' LETTERS

Sundial Delineation Using Vector Methods

I read Tony Wood's article with considerable interest. My comments relate to the second paragraph statement "The approach is believed to be new and results in simple equations for direct plotting of hour and declination lines". I suggest that the author read the several articles[1-3] by the writer published in NASS *Compendium* and to the writer's self-published 2003 book *Sundial Design* which is based on the applications of matrices (a vector can be considered to be either a one-row matrix or a one-column matrix). Computer programs can be written using martrices directly which leads to much simpler programs than those involving algebraic equations. Alternately, the MATLAB language can be used.

1. 'Sundial Operating Limits' 3(1), pp. 2-7.
2. 'Sundial Design Using Matrices', 5(3), pp. 12-16.
3. 'Equatorial Projection Sundial Projection Vectors' 12(1), pp. 16-23.

Hal Brandmaier
63 Florence Road
Harrington Park, NJ 07640, USA

Tony Wood responds:

Hal Brandmaier's letter points out that my claim to a 'new' approach for sundial delineation is not really justified as he has previously used essentially the same methods. However, I would like to take this opportunity to explain a little bit about the thinking behind my mathematical doodling.

It seems that at least four of us have used similar methods in recent years; a reaction against the spherical trigonometry of astronomy and the realisation that simpler mathematics will suffice:

1. Tony Belk has used essentially 3-dimensional co-ordinate geometry with its associated direction cosines.

2. Hal Brandmaier uses vectors but has adopted the column vector notation and the associated use of matrices for axis transformations.

3. I have vectors but with the 'unit vector **i**, **j**, **k**' notation combined with trigonometry/co-ordinate geometry for axis transformations (which are all essentially 2-dimensional results).

4. A recent communication (CD) from Antonio De Vicente Candiera in Spain proceeds along broadly similar lines but invokes 'astronomical' diagrams (and even partial differentiation at one point!). As it is in Spanish I can't make full and fair comment.

[This is a shortened version of the letter—Ed.]

Kew Garden Cross Dial (1)

Douglas Bateman's article about the Boys Dial at Kew included a footnote about the pedestal – from Kew Bridge. There is a survivor pedestal at Hidcote Manor (NT), Gloucs, in their famous gardens. It bears the inscription on the square mount stone 'PAYNE 1789 KEW BRIDGE'. The baluster pedestal indeed appears identical to that at Kew.

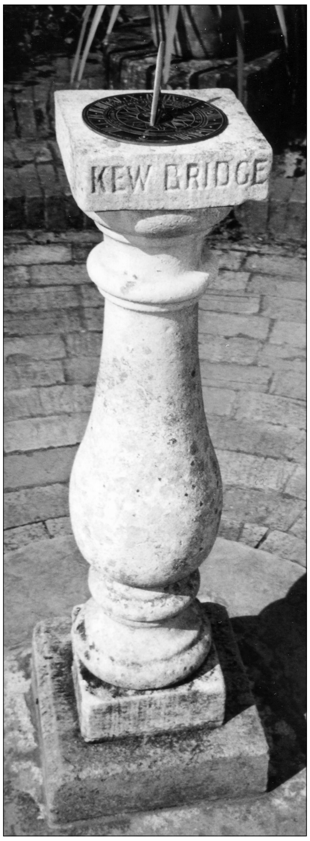
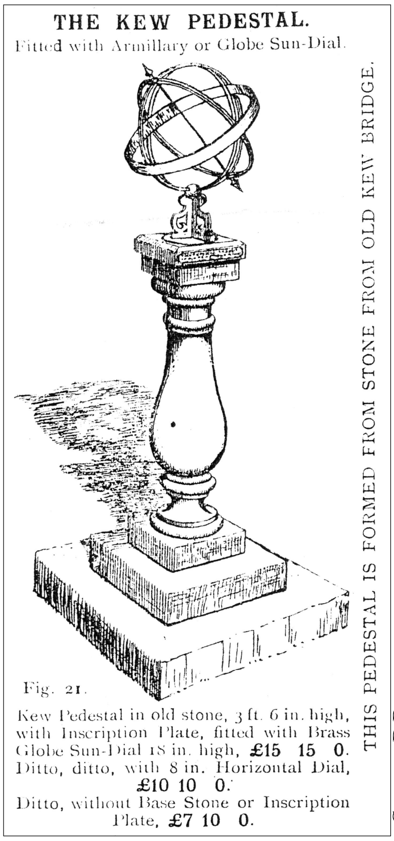


Photo: Jill Wilson



Courtesy D Bateman

Which raises the questions: Who was Payne? Why 1789 and were the pedestals originals or replicas? Were the mount stones individually lettered? It would have been an expensive operation for Francis Barker. The dial at Kew has a further stone above the top square part.

Francis Barker advertised 'The Kew Pedestal' made from the old Kew Bridge at £7 10 0 and also a 'Kew Pattern Pedestal' in 'Stonette' which was 3ft 2 ins. high compared with the original 3ft 6ins. But may have lacked a lower plinth, at least the pictures imply this. The replica pedestal was £3 0 0.

Like the Kew sundial, the one at Hidcote is essentially a 'garden ornament', brought out from the storage shed for use when the garden designers require a 'focal point'. The photograph was taken last year and it was my third or fourth visit to the Gardens. The dial appears in the book about Hidcote but in the 1920s was in another location. It now sports a nicely polished modern dial which points in the right direction.

Tony Wood
Churchdown

Redacted

Redacted

Doug Bateman responds:

Would C V Boys have condoned the errors? Was it indeed intended for some other location (with the 'typo' you suggest)? Did he commission it, give it a cursory inspection when made, and hand it over to others to install?

Perhaps they just trusted some surveyor who got it wrong, and they never checked. I find it hard to imagine a ceremonial handover with Boys and Director present if they were aware of the errors.

The inscription refers to the donation of the pedestal and the 'Office of Works' supplying the base and capital. The uncomfortable alignment of the dial on the capital suggests that they were not well coordinated!

Earth's Rotation

John Wall's Reader's Letter in the December Bulletin asked for possible effects on sundials of a change in the earth's rotation. In reply, the worst effect (and one which would devastate the BSS) is as follows.

The moon rotates in such a way that it always presents the same face to the earth. For instance, we never see the far side of the moon. Likewise, if the earth rotated so that it always presented the same face to the sun (preferably where I live), sundials would not have evolved, simply because it would tell the same time all the time. However, the effects of less drastic changes to the earth's rotation will be more interesting to hear about in the Bulletin.

Norman Darwood
Southampton

THE DIAL STILL LIVES!

IAN BUTSON

Following on from Mike Cowham's article *The Portable Sundials of the Mary Rose*[1], members of the Society may be interested to know that the portable sundial is still in use.

On a recent visit to Kentwell Hall at Long Melford in Suffolk, a dial very similar in form to those described by Mike was seen being used. Kentwell Hall is one of England's finest moated Tudor houses in a parkland setting. Tudor life and ways are re-enacted here by enthusiastic participants who dress, live and demonstrate various aspects of Tudor times.

On the occasion of my visit, the man shown using the dial in Fig. 1 had been demonstrating how various mineral ores could be fired in small crucibles to produce their oxides, these being used as colouring materials. After a while, he took out a small bag, produced the dial and decided it was time to break for "some posset and a goblet of mead". The bag can be seen in his right hand in Fig. 2, with the dial lid in his left hand. The dial is a modern reproduction[2], with a fold-down gnomon simply hinged to the dialplate with two wire hoops. It is believed that these reproductions were commercially made around 1986 by Bryant Precision Engineering of Bournemouth but that the firm is no longer in existence.

Fig, 2 (above). The replica with bag and lid just visible.

Kentwell Hall is open from March through until October annually, with a number of historical re-enactments during this period. It is recommended as a 'day-out' with many aspects of the past to see.

REFERENCES

1. M. Cowham: 'The Portable Sundials of the Mary Rose', *BSS Bull*, 17(ii), (June 2005).
2. H. Higton: *Sundials – An illustrated history of portable dials*, pp. 41-44, Philip Wilson Publishers, London, (2001).

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AN IRISH DIAL

PETER RANSOM

Last year I bought a slate dial plate at auction. What attracted me was the detail of the engraving which included a maker's name and equation of time. The gnomon was missing and there were a couple of paint splodges, but the dial plate itself was relatively undamaged.

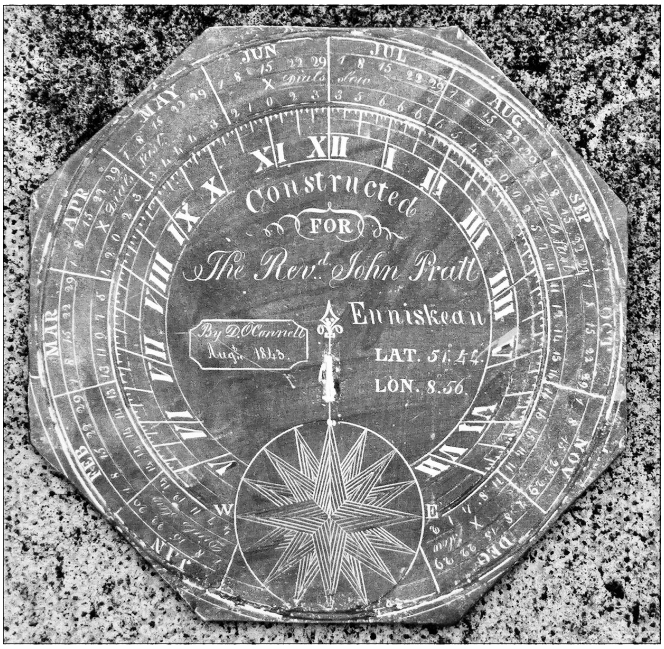

Fig. 1. The unrestored dial plate dusted with talc to bring out the detail.

The plate (Fig. 1) is octagonal with each side 3¾ inches (95 mm) and thickness 3/16 of an inch (5 mm). The central inscription reads "Constructed for The Revd John Pratt, Enniskean LAT 51° 44'. LON 8° 56' by D. O'Connell, Aug[t] 1843". Enniskean is in County Cork at the southern part of Ireland. The map (Fig. 2) indicates its approximate position.

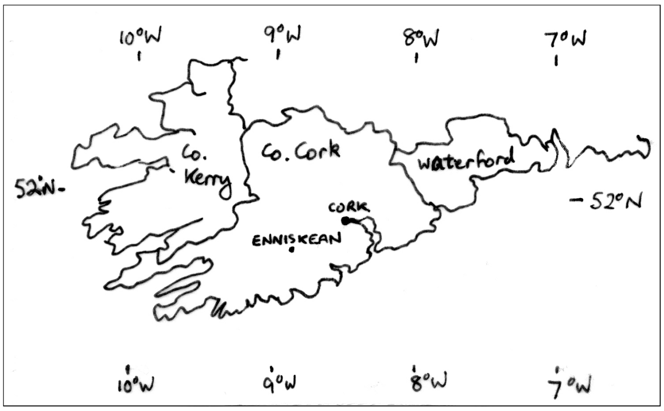

Fig. 2. Map showing position of Enniskean.

The hour lines run from 5am to 7pm using Roman numerals with IIII for 4. The hours are divided into half hours, quarter hours and 5 minute divisions. There is a 16 pointed star at the gnomon root with the west and east points marked with W and E respectively. The equation of time ring is divided into 4 concentric circles reading from the outer ring inwards, month, date, dials fast or dials slow, and the adjustments. For those interested in the details of the equation of time these are as follows.

JAN					FEB					MAR				
1	8	15	22	29	1	8	15	22	29	1	8	15	22	29
		Dials slow												
4	7	11	12	14	14	14	14	14	13	13	11	9	7	5

APR					MAY					JUN				
1	8	15	22	29	1	8	15	22	29	1	8	15	22	29
		X	Dials		fast							X	Dials	
4	2	0	2	3	3	4	4	4	3	2	1	0	2	3

JUL					AUG					SEP				
1	8	15	22	29	1	8	15	22	29	1	8	15	22	29
slow											X	Dials fast		
3	5	6	6	6	6	5	4	3	0	0	2	5	7	11

OCT					NOV					DEC				
1	8	15	22	29	1	8	15	22	29	1	8	15	22	29
												X	slow	
11	12	14	15	16	16	16	15	14	11	11	8	4	1	2

Interesting to note that February 29 is included!

I wanted the dial restored so contacted John Davis who agreed to clean it up and provide a replacement gnomon. He discovered that the gnomon was originally a slate one since there was a sliver of slate left in the gnomon slot in the dial plate. Since neither the engraving on the plate nor the XII was interrupted by a gnomon gap we surmised that the gnomon was probably fairly thin and not much wider than the slot into which it had been inserted. This formed the basis of the replacement gnomon held in place by its tenon passing through a small metal plate and secured with a tapered peg.

John suggested that I contact Michael Harley in Ireland since he has such a fantastic knowledge of Irish dials. Michael was very helpful in providing pictures of slate dials and their gnomons so we were able to make an informed decision on the gnomon. He was interested to learn of the dial and there is now a picture of the unrestored dial on his website.[1] A few months after first contacting him Michael sent me the following image of a document he came across in the National Museum of Dublin:

2445 NMD094 DIAL - HORIZONTAL PEDESTAL
By Dan O'Connell, Teacher of Rathmines N.School. 1853.
525x520. 4:1853. S.
Dark grey slate; square; with "Geographical Clock,
..Almanack..Circumferentor"; (Reg.F1963:185, Daingen).
(Source: Townland Shrule; Parish Shrule; Barony
Kilmaine; County Mayo); main dial of concentric
circles, diameters 515-350, with divisions from hours
V-XII-VII to 5 minutes; most bands divided into
monthly sections, 2 with Arabic numerals, 1 with
"dials slower than watches or clocks", "dials fast",
"dials slow", "dials fast" at regular intervals, 1
with names of months, 1 with Zodiac signs & dates....

...also figure-of-eight with time of sunrise & length
of day; at the bottom of the dial, where the circles
are incomplete, is another circle, diameter 140, with
hollowed interior, & the names of various cities on
extended radii; 2 more hollowed circles, diameter 105,
are incised near the bottom circle, both with Roman
numbers; inscriptions on the dial include: "A Horizon-
tal Dial, Geographical Clock, Perpetual Almanac,
Quadrant of Altitude"; "A D Circumferentor Calculated
for the latitude of Dublin"; "To find the age of each
revolving moon, The index for the month to the Epact
join; The sun, bate 30, to the month day add, Or take
from 30, age or change is had."; date given in form
"April A.D. 1853"; central compass card arrangement,
with 2 circles, outer diameter 70; gnomon gone.

Is this the same gnomonist? Perhaps: the evidence is that the material used – grey slate – is the same, the divisions from hours V-XII-VII to 5 minutes are the same, and the equation of time seems to be a larger version with zodiac signs. There is a difference of 10 years in the date, so that does not contradict the possibility that these dials are by the same person. D. O'Connell is not listed in *Vulgar & Mechanick*[2] but it is quite possible that he did not make his living by constructing dials – the museum document mentions their D. O'Connell was a teacher of Rathmines N[ational?] School. Searching for Rathmines School on the internet yields a number of hits, mainly Rathmines School in Dublin but there is nothing linking this D. O'Connell with the school.

I decided to test the accuracy of the construction for latitude 51° 44' by scanning the dial then using some dynamic geometry software to measure the angles. Scanning the dial was more successful than I expected – by the time I did it a lot of the talc had dropped out but the results were enhanced by using Adobe Photoshop to increase the brightness and contrast until the details of the hour ring could clearly be seen. The picture was then pasted into Geometer's Sketchpad, a dynamic geometry software package that facilitates the teaching of geometry in schools and allows me to analyse dials! By setting this picture as the background you can then draw on it and even superimpose a Cartesian grid which allows the equation of lines and curves to be calculated by the software. The following picture shows what I do to measure the angles as accurately as possible, though this accuracy depends on where one places the end points of the line segments. I selected the line segment tool and clicked on the end of the 6 am line, then on the end of the 6 pm line. The line segment AB is then constructed. The software then constructs the midpoint of that line which I joined to the end of the noon line. Line segments were then constructed from the end of each hour line to the midpoint of the 6 am – 6pm line. The software was then used to measure the angles between each line segment to two decimal places (the default accuracy used). These results are shown at the edge of the picture. The whole software is dynamic, so if one point is moved ever so slightly the whole diagram will change. This means that if I found I had not placed point A precisely at the end of the 6 am line then all I have to do is to grab it and move it to where I want and the midpoint will change and all the angles will automatically change – a great time saver!

I also calculated these angles using latitude 51.73° (51° 44'). The results of the calculations and measurements are given in the following tables.

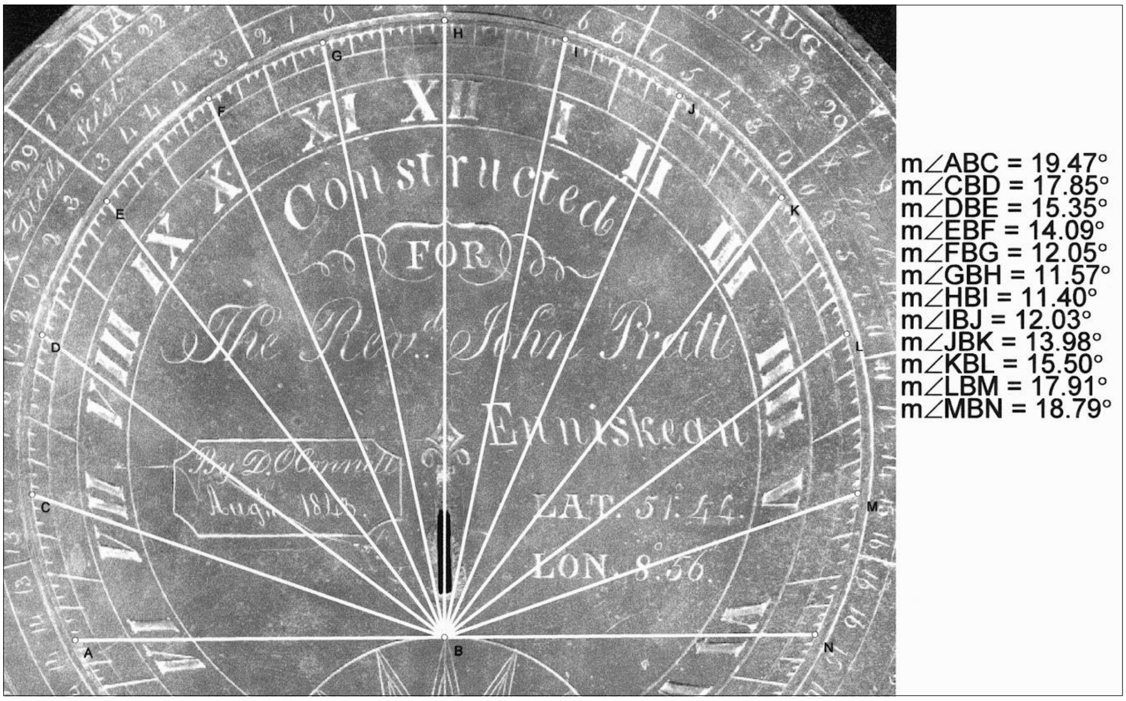

Fig. 3. Screen-shot from Geometer's Sketchpad showing an imported picture of the dialplate with over-drawn hourlines with their calculated angles.

Morning hours

time	6-7	7-8	8-9	9-10	10-11	11-noon
Measured	19.47°	17.85°	15.35°	14.09°	12.05°	11.57°
Calculated	18.84°	17.49°	15.53°	13.76°	12.50°	11.88°
Difference	0.63°	0.36°	-0.18°	0.24°	-0.45°	-0.31°

Afternoon hours

time	noon-1	1-2	2-3	3-4	4-5	5-6
Measured	11.40°	12.03°	14.08°	15.40°	17.91°	18.79°
Calculated	11.88°	12.50°	13.76°	15.53°	17.49°	18.84°
Difference	-0.48°	-0.47°	0.32°	-0.13°	0.42°	-0.05°

With only one exception, all within half a degree of what they should be – remarkable accuracy! I have not checked the subdivisions – within the limits of accuracy that one can measure half a degree is excellent.

If anybody can provide more information about either D O'Connell or the Rev John Pratt I would be delighted to hear from them. My grateful thanks to John Davis and Michael Harley for the restoration work and information about the dial.

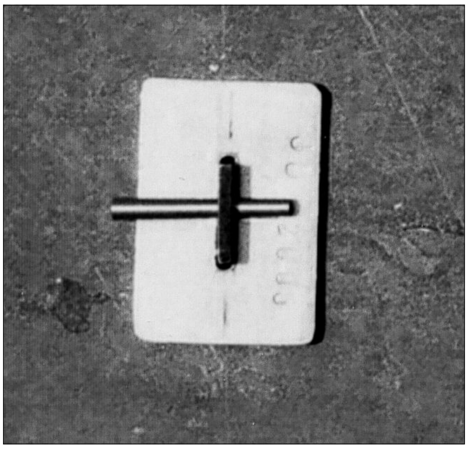

Fig. 4. The underneath of the restored dial plate showing the gnomon fixing.

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1. M. Harley's website is at: http://homepage.ntlworld.com/michael.j.harley/cork/cork.htm
2. J.E. Burnett & A.D. Morrison-Low: *Vulgar and Mechanic – The Scientific instrument trade in Ireland 1650-1921*, Royal Dublin Society, (1989).

Peter Ransom
pransom@btinternet.com

A NEW SHOPPING CENTRE DIAL

continued from page 32

the dial design. The hours are shown in large Roman numerals which are neatly cut out of stainless steel and welded to the equatorial band. Unfortunately, someone has made the rather elementary error of specifying the use of the numeral '1' instead of the letter 'I' so that, for example, noon is X11, one o'clock seems correct as 1 and two o'clock reads 11, which must confuse observers who are not familiar with the sequence of numbers on a sundial! A less serious error is that one of the 'X's is upside down, presumably because the steel sheet was placed the wrong way up and would otherwise have had the thick and thin strokes reversed.

The dial also has a rather neat Equation of Time graph engraved on it. The x-axis is labelled 'GMT' and the curve is labelled 'Solar Time' which would be correct but for the fact that the curve does not include the longitude correction of nearly six minutes appropriate for the location 1° 24' east of Greenwich. The makers are shown as Heron Metal Craft but the telephone number engraved on the dial no longer connects to them so it has not been possible to advise them of the errors. Still, it is good to have another public dial!

from a Kentish Lad

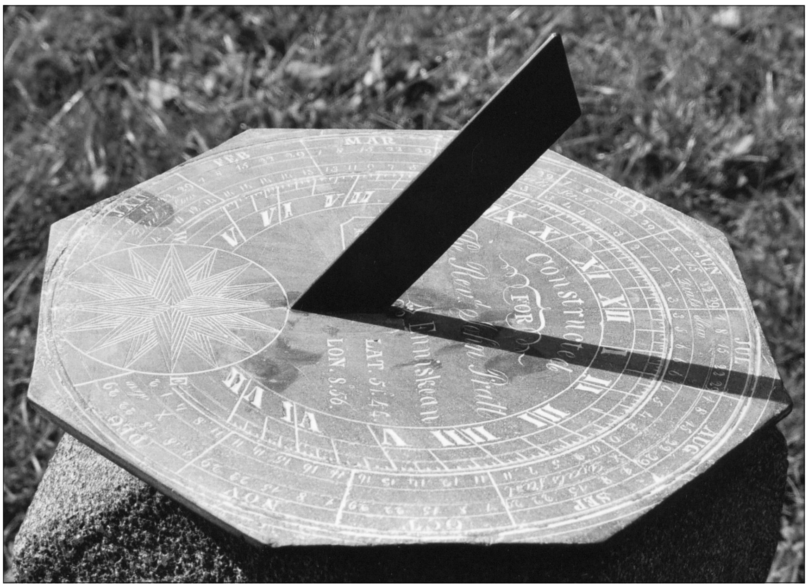
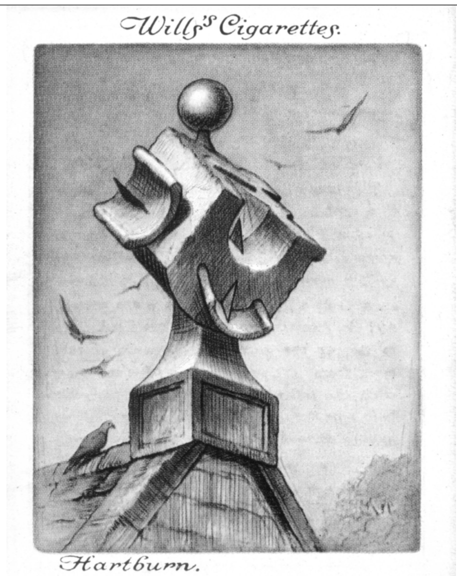


Fig. 5. The restored dial.



The dial on St Andrew's church, Hartburn, Northumberland. SRN 0235.

SUNDIAL DELINEATION USING VECTOR METHODS
Part 3

TONY WOOD

*[Readers are reminded that the meanings of symbols used in this paper do not follow the normal BSS convention. See the first part of the series (Bull. **17**(iii) pp.121-127) for their definitions here. Ed.]*

DECLINING-INCLINING DIALS

Inclining includes both reclining and proclining dials. The suffix R is used as reclining dials are more common and are considered in the examples drawn. The reclining/proclining angle (γ) is a rotation about the Ox_D axis of a vertical declining dial as described above. Proclining is a positive rotation, reclining is negative (see Fig. 15).

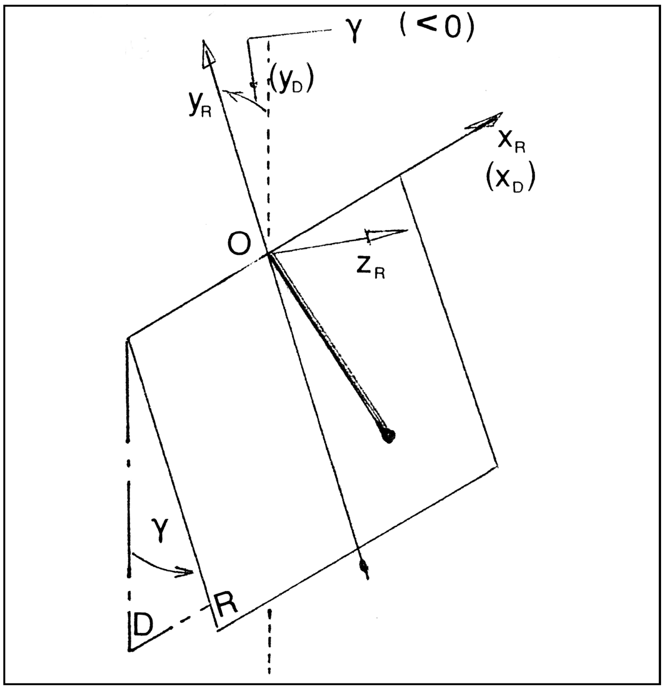


Fig. 15. Declining-reclining dial – axis system and inclination angle.

The relevant vector components of the shadow plane in reclining axes are:

$x_R = p\cos\alpha\cos\delta - (-q\cos\lambda - p\sin\alpha\sin\lambda)\times\sin\delta$

$y_R = (-p\sin\alpha\cos\lambda + q\sin\lambda)\times\cos\gamma$
$\quad + [(-q\cos\lambda - p\sin\alpha\sin\lambda)\times\cos\delta + p\cos\alpha\sin\delta]\times\sin\gamma$

$z_R = [(-q\cos\lambda - p\sin\alpha\sin\lambda)\times\cos\delta + p\cos\alpha\sin\delta]\times\cos\gamma$
$\quad - (-p\sin\alpha\cos\lambda + q\sin\lambda)\times\sin\gamma$

Equating to the dial plate components *(x, y, z)*$_R$ *= (s, t, 0)* and eliminating p and q, we have for the hour lines:

$$y_R = \frac{-\cos\delta\sin\alpha + \sin\lambda\sin\delta\cos\alpha}{(\cos\lambda\cos\gamma + \sin\lambda\cos\delta\sin\gamma)\times\cos\alpha + \sin\delta\sin\gamma\sin\alpha}\times x_R$$

The declination lines are derived from the ray line in declining-reclining dial plate axes, viz:

$x_R = p\cos\varepsilon\cos\delta\cos\alpha + (n - p\sin\varepsilon)\times\cos\lambda\sin\delta + p\cos\varepsilon\sin\lambda\sin\delta\sin\alpha$

$y_R = [-p\cos\varepsilon\sin\alpha\cos\lambda + (n - p\sin\varepsilon)\times\sin\lambda]\times\cos\gamma + [-(n - p\sin\varepsilon)\times\cos\lambda\cos\delta - p\cos\varepsilon\sin\alpha\sin\lambda\cos\delta + p\cos\varepsilon\cos\alpha\sin\delta]\times\sin\gamma$

$z_R = [-(n - p\sin\varepsilon)\times\cos\lambda\cos\delta - p\cos\varepsilon\sin\alpha\sin\lambda\cos\delta + p\cos\varepsilon\cos\alpha\sin\delta]\times\cos\gamma - [-p\cos\varepsilon\sin\alpha\cos\lambda + (n - p\sin\varepsilon)\times\sin\lambda]\times\sin\gamma$

and equating to the dial plate components $(x, y, z)_R = (s, t, 0)_R$ we have the parametric equations below. The condition $z_R = 0$ enables us to eliminate p but the equations become unwieldy and p is retained as a common multiplier to be evaluated separately. The declination lines are therefore given by the parametric form (parameter α):

$x_R = p(\cos\delta\cos\varepsilon\cos\alpha - \cos\lambda\sin\delta\sin\varepsilon + \sin\lambda\sin\delta\cos\varepsilon\sin\alpha) + n\cos\lambda\sin\delta$

$y_R = p[\sin\delta\sin\gamma\cos\varepsilon\cos\alpha - (\cos\lambda\cos\gamma + \sin\lambda\cos\delta\sin\gamma)\times\cos\varepsilon\sin\alpha + \cos\lambda\cos\delta\sin\gamma\sin\varepsilon - \sin\lambda\cos\gamma\sin\varepsilon]$
$\quad + n\sin\lambda\cos\gamma - n\cos\lambda\cos\delta\sin\gamma$

where

$$p = \frac{n(\sin\lambda\sin\gamma + \cos\lambda\cos\delta\cos\gamma)}{[\sin\delta\cos\gamma\cos\varepsilon\cos\alpha + (\cos\lambda\sin\gamma - \sin\lambda\cos\delta\cos\gamma)\times\cos\varepsilon\sin\alpha + \cos\lambda\cos\delta\cos\gamma\sin\varepsilon + \sin\lambda\sin\gamma\sin\varepsilon]}$$

Note: although two calculations are required for each point on the declination line, a ready check is provided since a point so determined using α will lie on the corresponding hour line.

The equinox line ($\varepsilon = 0$) is:

$$y_R = \frac{-\cos\lambda\sin\delta}{\sin\lambda\cos\gamma - \cos\lambda\cos\delta\sin\gamma} \times x_R + \frac{n}{\sin\lambda\cos\gamma - \cos\lambda\cos\delta\sin\gamma}$$

Sub-style angles: For a declining-reclining dial the successive rotations of the dial plate are:

$180° - \lambda$ about Ox_G $\quad\delta$ about Oy_V $\quad\gamma$ about Ox_D

and the corresponding vector components of the gnomon are:

$x_R = n\cos\lambda\sin\delta$ $\quad y_R = n\sin\lambda\cos\gamma - n\cos\lambda\cos\delta\sin\gamma$ $\quad z_R = -n\cos\lambda\cos\delta\cos\gamma - n\sin\lambda\sin\gamma$

The sub-style angle η_R is $\arctan(y_R/x_R)$, i.e.

$$\eta_R = \arctan\left\{\frac{\sin\lambda\cos\gamma - \cos\lambda\cos\delta\sin\gamma}{\cos\lambda\sin\delta}\right\}_{PV} - 180°$$

The corresponding time T_{24} is found as before, using the hour angle equation. Firstly the shadow angle corresponding to the sub-style angle is

$$\alpha_S = \arctan\left(\frac{\cos\lambda\sin\gamma - \sin\lambda\cos\delta\cos\gamma}{\sin\delta\cos\gamma}\right)$$

and then

$T_{24} = 18 - (1/15)\times\alpha_S$

The angle of the gnomon to the dial plate (ζ_R) is then:

$\zeta_R = \arcsin(-\cos\lambda\cos\delta\cos\gamma - \sin\lambda\sin\gamma)$

The sub-nodus co-ordinates $(x_n, y_n)_R$ and the nodus height above the dial plate $(z_n)_R$ are again found from the gnomon vector components by choosing a value for n, (remembering that it will usually be negative for south sector facing dials and positive for horizontal and north sector facing dials.), giving

$(x_n, y_n)_R = (n\cos\lambda\sin\delta,\ n\sin\lambda\cos\gamma - n\cos\lambda\cos\delta\sin\gamma)$ and $(z_n)_R = -n\cos\lambda\cos\delta\cos\gamma - n\sin\lambda\sin\gamma$

Illumination Times

The horizon limit L_H is as defined in the horizontal dials section.

The sun position limit L_S is found as in the declining dial section with the ray line vector component z_R now being

$z_R = -n\cos\lambda\cos\delta\cos\gamma$

This gives the sun position limit as

$T_{24} = 18 - \alpha°/15$

where

$$\alpha = \arccos\left\{\frac{-\tan\varepsilon\left[\sin\lambda\tan\gamma + \cos\lambda\cos\delta\right]}{\sqrt{\left[\sin^2\delta + \left(\cos\lambda\tan\gamma - \sin\lambda\cos\delta\right)^2\right]}}\right\}_{PV,1} + \arctan\left\{\frac{\cos\lambda\tan\gamma - \sin\lambda\cos\delta}{\sin\delta}\right\}$$

(Note that for the arctan term the signs of the numerator and denominator must be inspected to ensure the resultant angle is in the correct quadrant.)

To be continued

DIAL DEALINGS

MIKE COWHAM

The year has been about average for sundial sales with few exceptional pieces and no large collections offered. However, I have managed to select some that to me were quite interesting. These are not necessarily the most expensive dials but generally those that are a little different. All auction prices given include the buyer's premium of 20%.

Bonham's, 23 March 2005

In this sale, the first of the year, there were only six sundials. An English slate garden dial was from an unusual maker ***A D Nithsdale*** and was dated ***1843***. It was sold very reasonably at £120.

A boxwood diptych dial, Fig. 1, was attributed to Walter Hayes. It attracted my attention because of its exceptionally large compass and its similarity to several similar-looking magnetic azimuth dials. I did not view this sale and only have Bonham's photographs to go on but it appears that this really *is* a magnetic azimuth dial. In addition it has the more usual string gnomon for use on both the horizontal and vertical faces. Due to the lack of space in the lower leaf the main hour scale was that on the vertical. The lower leaf was calibrated with hours lines in the small spaces around the compass but these were totally useless, particularly around noon and 6am/6pm. The additional semi-circular scale on the lower half of the lid appeared to be that of a clinometer but its plummet was missing. Due to its rarity this fine dial fetched £1920.

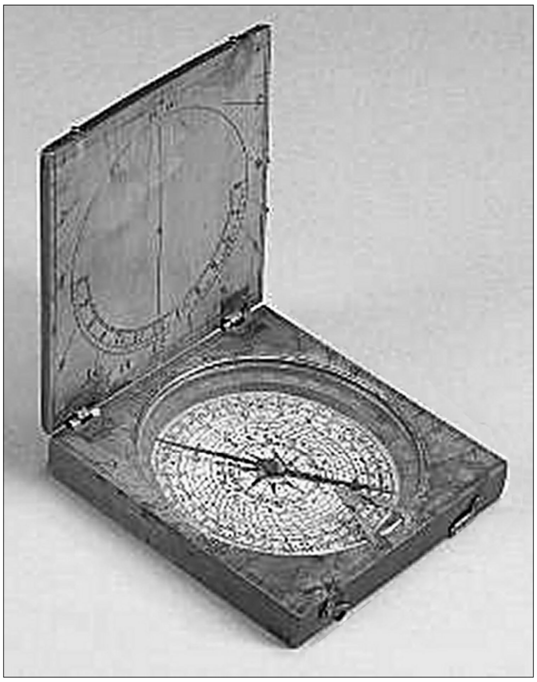


Fig. 1. Boxwood dial possibly by Walter Hayes.

Fig. 2. Ivory diptych dial by Thomas Tucher.

The sundial of the sale was an ivory diptych dial by ***Thomas Tucher*** of Nuremberg (1620-1645), Fig. 2. Its scales included horizontal dials for three different latitudes from its string gnomon, a pin gnomon dial at the top of its lid showing the zodiac signs, a scale of Nuremberg hours (starting at sunset) and probably a scale of day lengths, plus a table of towns and their latitudes. In front of the main compass were two scaphe dials probably for Nuremberg and Babylonian hours. The ivory tablets were well decorated and coloured. It made £3120.

Christie's, South Kensington, 7 April 2005

The dial that took my attention in this sale was a complex astronomical ring dial in brass by ***Charot AParis,*** Fig. 3. Unusually, it was engraved with the latitudes, not of French towns, but far away places such as *Chandermagore 22° 51', Agra 26° 40', Delhy 28° 20'* and *Siam 14° 15',* so probably made for use in India. François and Jacques Charot were recorded as working in Paris from around 1732 to 1800.[1] This dial was probably made before the early 1750s when the French were ousted from India by Robert Clive. It was sold for £10,800.

Christie's, South Kensington, 29 June 2005

A universal equinoctial dial by the maker ***Cam, Rue de le Paix, 24. Paris***, Fig. 4, was from the mid-nineteenth century. Cam, previously unknown to me, was an optician and

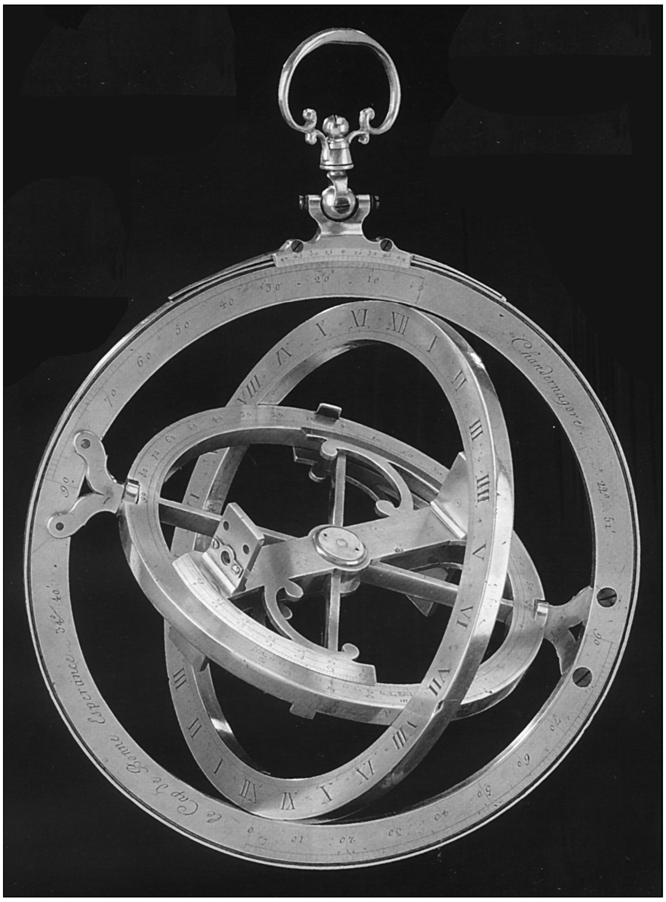


Fig. 3. Astronomical ring dial by Charot.

maker of dials from 24 rue de la Paix, working around 1850.[1] This is a substantially made dial with three levelling screws and twin spirit levels. This dial sold for just £600.

A twentieth century mean time sundial by ***Negretti & Zambra***, Fig. 5, is interesting for the fact that its gnomon is varied in thickness to compensate for the equation of time. This equatorial dial is the invention of Major General Oliver CMGRA. It sold for £780.

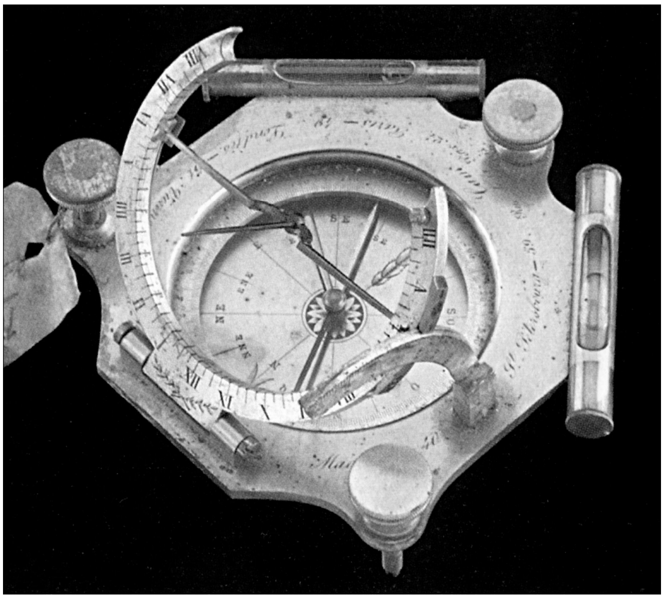


Fig. 4. Universal equinoctial dial by Cam.

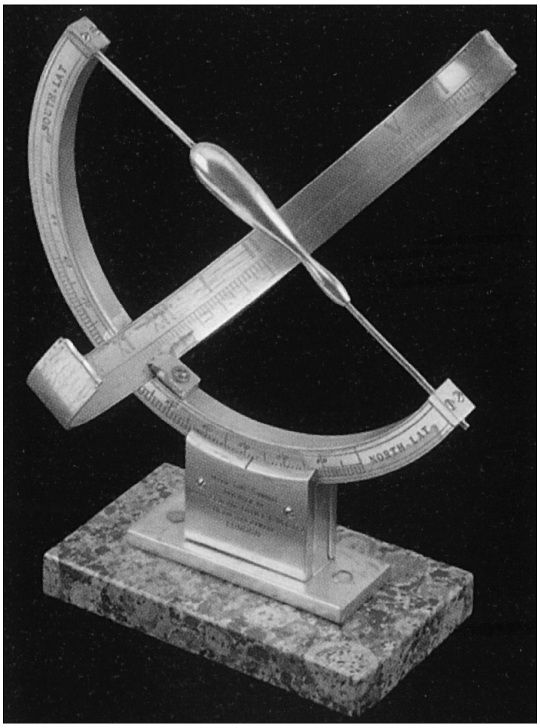


Fig. 5. Equatorial mean time dial by Negretti & Zambra.

Another mid eighteenth century equinoctial dial, signed ***Langlois AParis aux Galleries du Louvre***, Fig. 6, was finely made from silver. Its main distinguishing features are its tall plummet with its stand and three levelling screws, so it was obviously intended to be a precision dial. Its lists of 47 towns and their latitudes cover the range from *Lima Perou 12°* to *Stockolm 59° 20'*. For such a dial to be used in the southern hemisphere, e.g. Lima, it would be necessary to read the hours in reverse, unless the chapter ring could be re-mounted backwards. This dial realised £7800.

Fig. 6. Universal equinoctial dial by Langlois.

Fig. 7. Silver equinoctial dial made for Lima.

Sotheby's, 29 September 2005

This was mostly a sale of clocks and watches but it had just one dial. This was an unusual form of the equinoctial dial in silver, made in the Spanish style but it could possibly have been made in south America, Fig. 7. It was signed ***Juan Matheo de Mendosa*** and was engraved on the reverse ***LIMA***. Its anti-clockwise chapter ring tells us that it was primarily designed for the southern hemisphere. Under its lid were engraved various towns from both hemispheres with their latitudes. The photograph shows the dial wrongly erected. It should not be supported by its lid, which should be fully opened, but by the small recessed arm to the left of the chapter ring set on a scale of latitudes on the lower tablet, and the gnomon should be turned through 90°. Estimated £4000 - £6000, it sold for £4800.

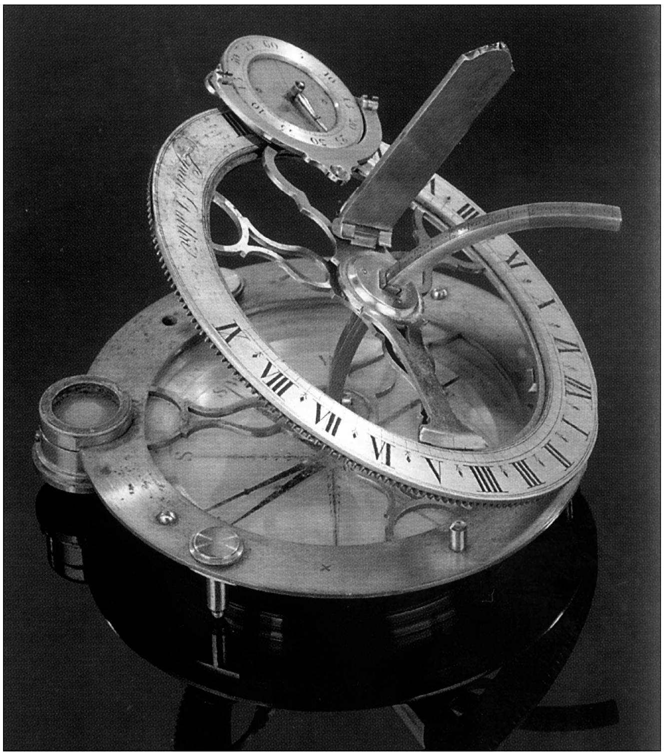


Fig. 8. Universal equinoctial mechanical dial made by Lynch of Dublin.

Christie's, South Kensington, 29 June 2005

In this sale were several dials, three of which caught my attention. The first was a good silver universal equinoctial ring dial by ***G Adams London*** of just 4" diameter. On its reverse was the usual altitude quadrant operated from a pin gnomon. This dial made a healthy £6600. Instruments by George Adams always attract keen prices and one like this, in silver, was obviously made for one of his wealthier clients.

A universal minute dial from Irish maker ***Lynch Dublin***, Fig. 8, was particularly interesting because such dials are quite rare and Lynch is the only maker of these dials that I know in the British Isles apart from two or three made in London by Thomas Wright.[2] Several of these Lynch dials are in museums in Ireland and it was nice to know that they are not all 'in captivity'. In the photograph the dial's gnomon is folded down around the small minute dial. In use, this would be erected such that the light passing through its pin-hole aperture would fall onto an inscribed line on the vertical 'finger' near to its centre. To achieve this, the minute dial is rotated around the periphery of the main chapter ring where its small pointer is geared to it. The dial sold at around twice its top estimate at £7800.

An unsigned universal equinoctial ring dial in this sale, Fig. 9, was rather unusual in that its pin-hole gnomon could also be adjusted for the equation of time. It slides as normal in the slot across the bridge of the dial but instead of having just the months it has a graph showing the EoT so that the gnomon can be set precisely.

The dial that I really want to highlight from this sale is a fine looking universal equinoctial ring dial signed ***LeMaire AParis***, Fig. 10. Its style is most unusual with scales that I

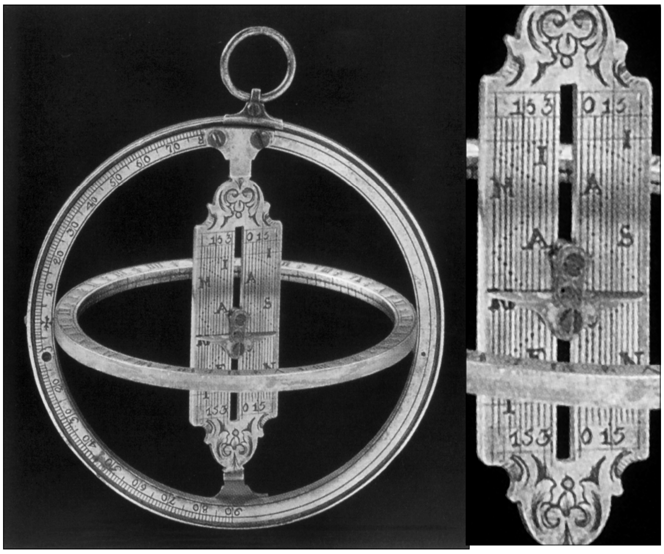


Fig. 9. Unsigned ring dial with EoT correction.

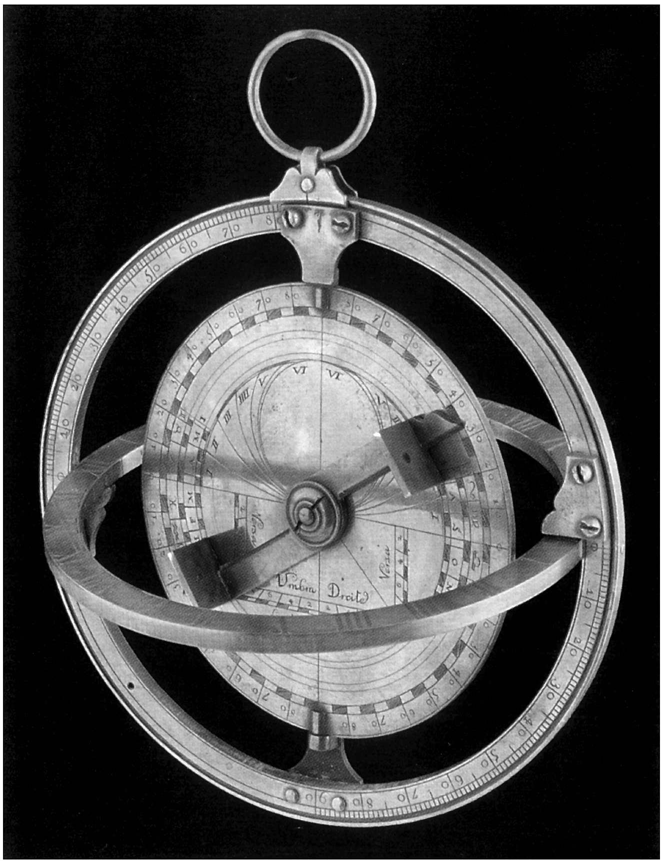


Fig. 10. Unusual astronomical ring dial signed 'LeMaire AParis'.

have not seen on such dials before. Instead of the usual format of three pivoted rings, this has two rings with a central plate supporting an alidade. Its front obviously shows temporary hours above with a shadow square beneath and its reverse has a Rojas projection, similar to that seen on some quadrants and astrolabes. Unusually for such a precision dial the hours were not sub-divided making a nonsense of its potential for accuracy. I did not view this sale but a friend who did suggested that he could not really see how such a dial could have been used. This started my alarm bells ringing, then another friend told me that this was one of the dials made in the 1970s by the forger Williams who was later imprisoned for his fakes. These 'reproductions' were uncovered in 1975 by the late Alain Brieux, an instrument and book dealer from Paris. He published his findings[3] citing 21 instruments from this, then unidentified, forger. These all turned up in the same year, 1971. Since this time over 30 forgeries by Williams have been identified. This particular dial was described and illustrated by Brieux in his publication. He shows the forged dial signature against genuine Le Maire ones done on an old copper plate and the two are very different. Christie's obviously heard of the doubts expressed by several people and wisely withdrew the dial from this sale. Hopefully, this is the last that we will see of it, but it is a good reminder to us all that such fakes do exist and are likely to escape detection, even by some experts.

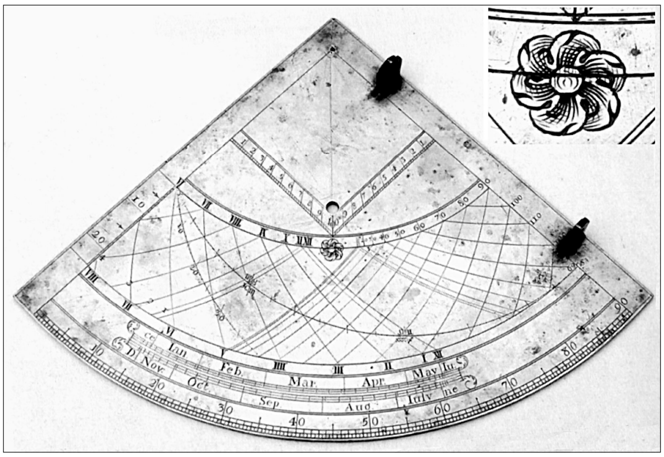


Fig. 11. Unsigned brass quadrant with attractive flower motif.

Tesseract

Instrument dealer Tesseract of New York produces regular catalogues that are worth browsing. Their catalogues almost always contain some fine dials.

In their Spring edition was an unsigned but very attractive brass Gunther quadrant, Fig. 11. Its distinctive feature, a six-petalled flower punched at its centre, has been seen on at least two other quadrants. One of these is in the Museum for the History of Science in Oxford made of wood and the other has been illustrated by me.[4] My own feeling is that these quadrants come from northern England, perhaps somewhere on the north-east coast. Tesseract's price for this fine example was $6500.

In their Summer catalogue is a fine late seventeenth century horizontal garden dial by ***Henry Wynne***. Wynne's work is

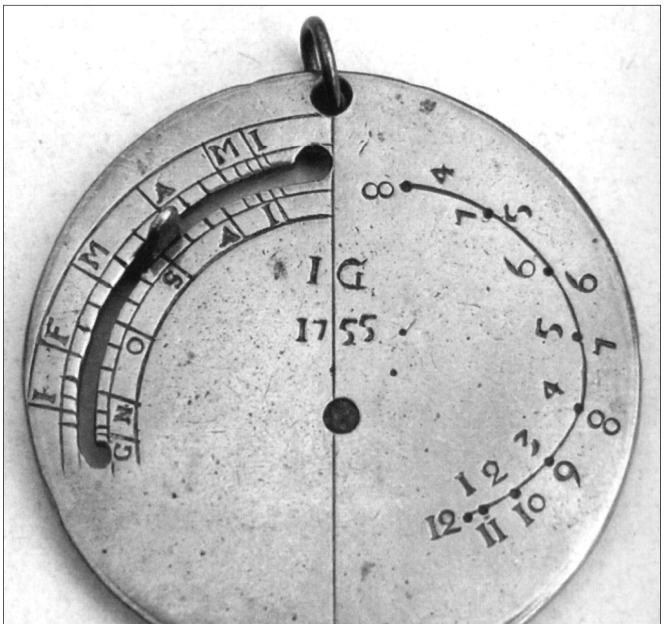


Fig. 12. Disc dial signed IG 1755.

always exceptional, particularly for his engraving. This fine dial was offered for just $3200.

They also offered a rather unusual vertical disc dial, Fig. 12, where the pin gnomon slides up an down in an arc to set it for the correct month. Its hour scale is on the far side of the same face and in its centre is engraved '***IG 1755***' but this maker has still to be identified. Their asking price was $1350.

ACKNOWLEDGEMENTS

I would like to thank the following for allowing me to use their photographs: Bonhams London for Figs. 1 & 2; Christie's South Kensington for Figs. 3, 4, 5, 6,8 , 9 & 10; Sotheby's London for Figs. 7. Tesseract New York for Figs. 11 & 12. These pictures remain their copyright and may not be reproduced without their permission.

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3. A. Brieux: 'Une Officine de Faussaires' *Art & Curiosité.* **55,** 34-42 (1975).
4. M. Cowham: *A Dial in Your Poke*, Mike Cowham, Cambridge, 2004.

English summary of text from 'Une Officine de Faussaires' article

Alain Brieux describes this particular dial signed by the esteemed maker Pierre Le Maire. He has never seen a dial like it, a cross between an astronomical ring dial and an astrolabe. Then during 1971 other instruments of questionable provenance started to appear. These were also studied by Anthony Turner and Francis Madison (MHS Oxford).

Three main points were made:

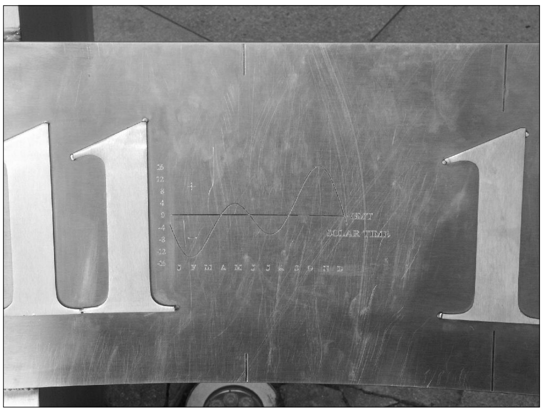
1. All of these instruments appeared in 1971.
2. All material was a constant thickness, 1.65mm.
3. The style of engraving of certain letters and numbers were the same on all instruments.

Brieux lists 21 dials and says that those that he numbered 12-21 are all fake and 1-10 are very suspect. Madison also came to the same conclusions. Brieux illustrates several of these instruments plus a genuine engraved copper plate where Le Maire (or his engraver) had been practising his signature. The fake signature is also shown which differs quite considerably from the Le Maire original.

A NEW SHOPPING CENTRE DIAL

A new shopping centre called Westwood Cross opened recently in Ramsgate, Kent. It uses images of Viking longboats as its logo, building on a strong local connection dating back to the landing of the Danish brothers Hengist and Horsa at nearby Ebbsfleet in AD 449. Hengist went on to be the first Saxon king of Kent and, in 1949, the 1500th anniversary was celebrated by the landing of a replica longship which is still on public display.

In the precinct is a large equatorial dial which doubles as a set of public benches. Naturally, the dial is shaped like the prow and ribs of a longship! A similar structure representing the stern, though not incorporating a dial, is located in the middle of a roundabout a couple of hundred metres away.



Above: the Westwood Cross equatorial dial.

Left: detail of the hour ring and Equation of Time graph between the noon and one o'clock hour-lines.

The dial is well made in stainless steel and quite popular with weary shoppers, though it seems likely that not many of them know what they are sitting on. There is at least one major error with the

continued on page 25

HENRY WYNNE'S DOUBLE HORIZONTAL DIALS – UPDATE

JOHN DAVIS and MICHAEL LOWNE

In our 2003 paper[1] describing Henry Wynne's 1685 double horizontal dial originally made for Staunton Harold in Leicestershire, we 'faked' a picture of the dial in front of the Lion Front there, in the position that it occupied in 1951, just before it was moved to Norfolk. Since then, research has continued and we are highly indebted to local historian Dr Irene Brightmer for further information about the dial in the 19th and 20th centuries.

Amazingly, the dial is actually shown on the 25 inches to the mile First Edition Ordnance Survey map of 1881 (Fig. 1). The position of the dial to the south of the Lion Front is remarkably similar to our faked picture, if a little further from the house. An undated photograph (Fig. 2) in the Leicester Records Office confirms this position, to the west of Staunton Harold church. Another photograph, c. 1900, (Fig. 3) shows the dial viewed from nearer to the house, looking outwards towards a now-demolished Orangery. Other photographs also exist, such as a postcard by E Martin of Melbourne, Derbyshire, and in an article in *Country Life* for 5 April 1913.

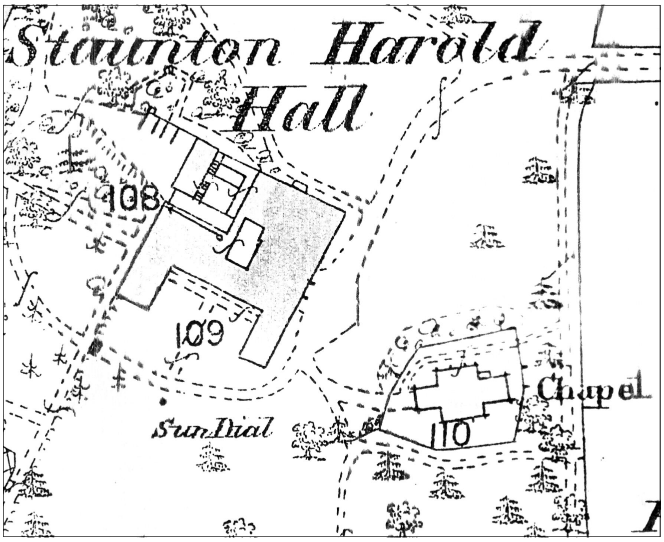


Fig. 1. Part of the 1881 First Edition OS Survey map (25 inches to 1 mile) showing the position of the sundial.

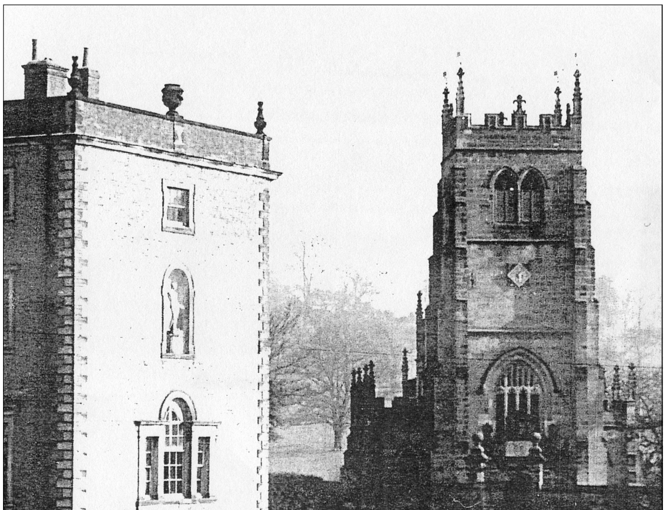
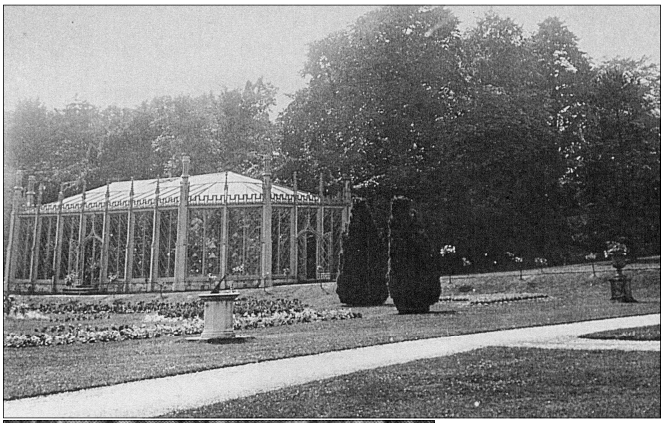


Fig. 2. The dial in position to the west of Staunton Harold church. © Leicester Records Office.



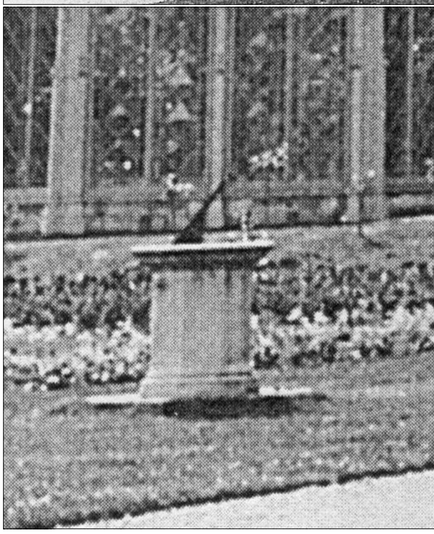


Fig. 3a (above). The Staunton Harold dial viewed from the Lion Front and looking towards the Orangery, now demolished. (c. 1900, from the archives of the late Dorothy Watson).

Fig. 3b (left). Magnified view of the dial.

The Staunton Harold dial was almost certainly commissioned by the first Earl Ferrers, Robert Shirley (1650-1717). A painting of the Earl, who is an ancestor of the present owner of the dial, is in the Long Gallery at Sudbury Hall, Derbyshire. It is by John Michael Wright (1617-1694) and is shown in Fig. 4. Another painting of the Earl is in a private collection.

The slightly earlier (1682) Wynne double horizontal dial at Wrest Park, Bedfordshire, was also described in the earlier papers[1,2] and has also featured in the recent book *Sundials of the British Isles*.[3] The dial on display in the English

Fig. 4. The 1st Earl Ferrers, painted by John Michael Wright (1617-94). Photo: © M.I. Brightmer 2004.

Fig. 5. The Wynne DH dial at Powis Castle, October 2005. The gnomon remains bent…..

Heritage garden is actually a resin replica but on the original marble pedestal. The original dial is in store.[4] A second replica, and the mould, is believed to be on display at Fort Cumberland, Portsmouth. In 2004, another dial originally from Wrest Park was sold by Sotheby's.[5,6] This was the magnificent Tompion dual-latitude Equation dial and which is dated to the first decade of the 18th century. A sundial seems to be visible in front of the house in Johannes Kip's c.1715 engraving from Leonard Knyff's original painting[6] but it is not known if it represents the Wynne or the Tompion dial. The purchase of a second very high quality dial when the Wynne dial was only about 20 years old can perhaps be put down to the requirement to have the equation of time engraved on the dialplate. The Wrest Park Wynne does not have an EoT scale whereas the Staunton Harold one has the unique linear scale along the style face.

A further Wynne DH dial mentioned in our earlier paper, the one at Powis Castle (NT), Welshpool, has also appeared in *Sundials of the British Isles*.[7] This dial has long had a serious kink to its gnomon. At the time that the book was in preparation, the dial was away for restoration so the writers confidently wrote that "It is shown here with a bent gnomon but this has recently been restored." Unfortunately, this is not the case as the National Trust's curators and 'professional' restoration advisors thought that it was supposed to be like that and even advanced the view that the angle of the upper section was "appropriate for Constantinople"! Whilst it has to be admitted that close inspection of the metal at the bend does not reveal obvious or recent damage, it is a sad reflection of the Trust's knowledge and care for the nation's dialling heritage. They now take the view that the bend is "part of the dial's history" and so it should be conserved as it is, rather than being restored. Would they take that view if it were a vandalised painting?

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7. Ref 3, p. 100.

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DOUBLE TROUBLE

The realization in bronze of the Henry Wynne Replica dial

TONY MOSS

The background to the re-creation of this beautiful and complex sundial has been extensively covered by John Davis who, in consultation with Michael Lowne, created the TurboCAD® files from which the film artwork was generated.[1] The latter was a very long story in itself but not for coverage here. (Fig. 1.) It was in mid 2002 that John contacted me to enquire if I would be interested in recreating a 30" diameter bronze dial. As I had recently completed a 48" diameter stainless steel item for Melton Mowbray Rotary Club,[2] the idea of 30" of the more-familiar bronze seemed easy by comparison and I readily agreed.

Fig. 1. The Wynneing Team! L to R: Tony Moss, Michael Lowne and John Davis.

Creating the bronze disc and the gnomon casting were all assessed as being straightforward pattern making in wood before casting at a local foundry (Fig. 2). After some discussion, the chosen metal was to be LG2 which is a leaded gunmetal with a pleasant golden hue and good weather resistance comprising 5% tin, 5% zinc, 5% lead and the remainder copper. Patterns were made from MDF and painted in standard foundry colours which tell the foundryman how they are to be treated. Brick red = body casting, yellow = to be machined. Special router cutters had to be made in my workshop to create the slight 'draw' angle which would allow the patterns to be withdrawn from the moulding sand.

The foundry in South Shields is attached to an engineering company and their offer to rough-machine the disc on their vertical spindle lathe, a 'merry-go-round', was readily accepted. This operation would have been *possible* in my workshop but would have stretched even the Bridgeport milling machine to its limits. Finishing to a suitable surface for etching and shadow casting was done by hand in my workshop.

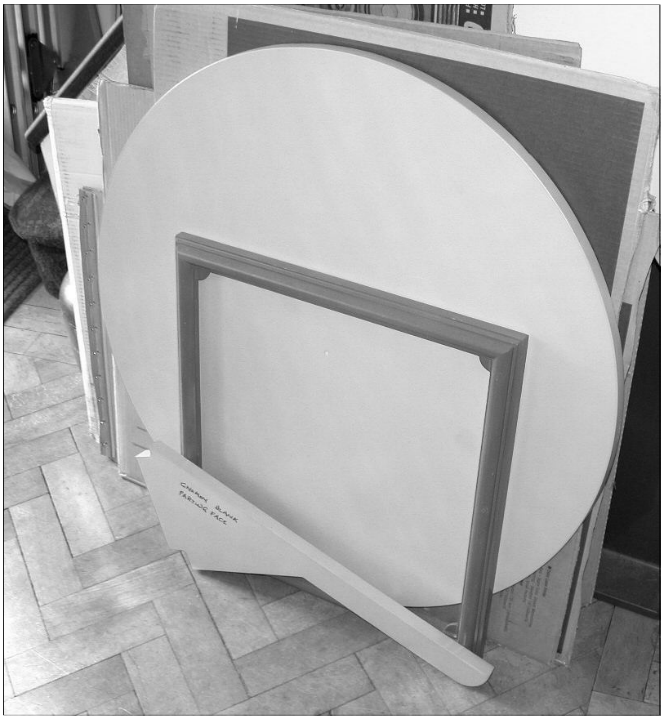
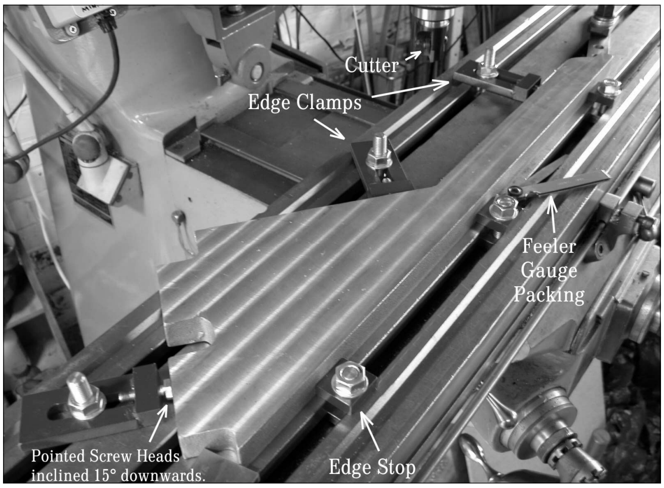
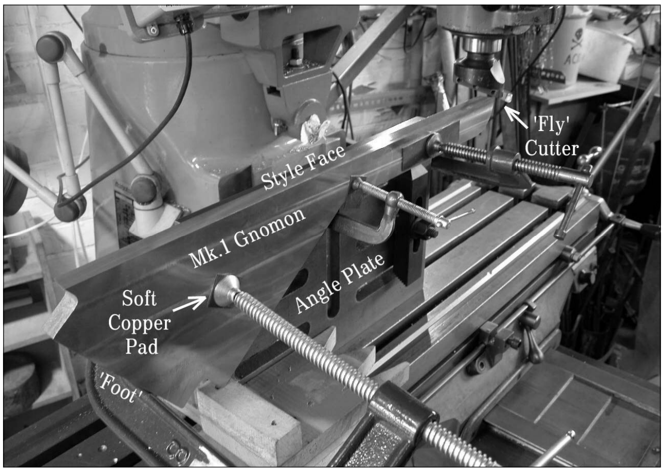
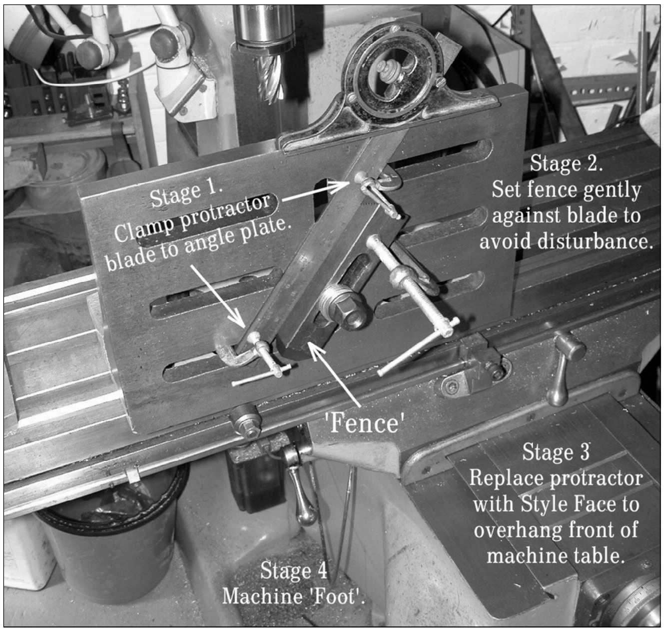


Fig. 2. Wynne & a vertical dial frame patterns for casting.

The smaller gnomon casting initially just presented the usual challenges associated with machining castings. They have no truly flat faces so any attempt to bolt them to a machine table ends in distortion. As a result, after the top surface is machined flat, it will spring back to a curve when the clamps are released. In industry such problems can be overcome by e.g. setting the casting in a shallow tray of 'Woods metal', a high-bismuth alloy (expensive) which melts off again in hot water. As no clamping is needed a truly flat surface can be achieved in one operation which in turn can be firmly clamped down to allow the whole thing to be machined parallel and to thickness…..in theory! In practice, however, machining the second side may release surface tension in the cast metal skin causing more distortion. Several reversals and a series of fine cuts later the casting *may* be true to thickness and ready for profiling. Alternatively, the workpiece could ground to thickness using a special grinding wheel on a surface grinding machine.







Above, top to bottom:
Fig. 3. Second face machined.
Fig. 4. Setup for milling the style face.
Fig. 5. Setup for milling the latitude angle.

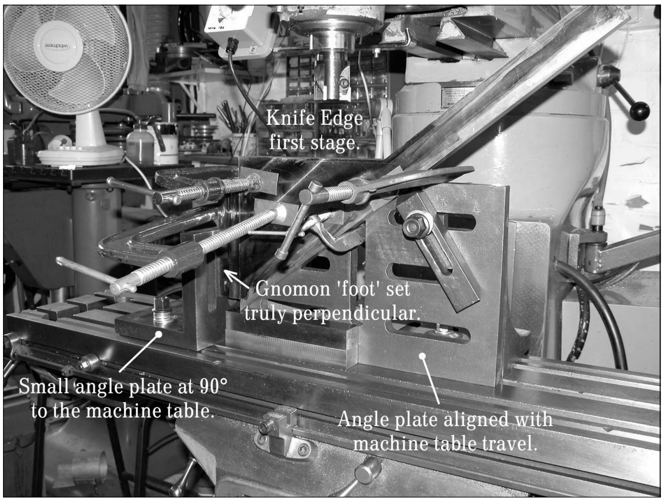
None of the above technology was available to me. No costly Woods metal was to hand and my surface grinder was too small for such a large area. To achieve the first flat surface the casting was to be 'edge clamped' requiring a full day manufacturing a set of clamps and 'stops' (Fig. 3). Doing most machining jobs is usually quick and easy: it is

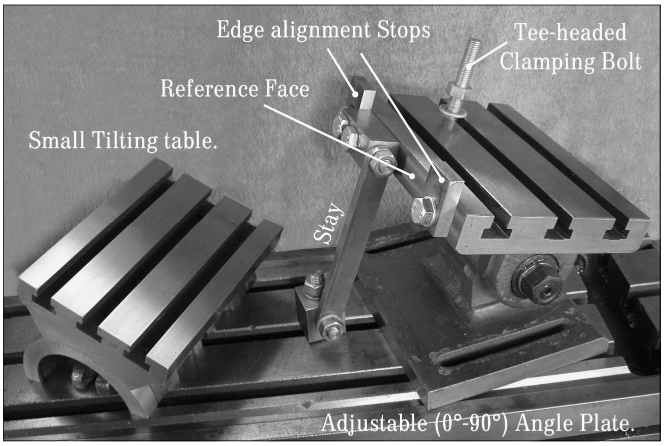
Fig. 6. Milling tenons to thickness.

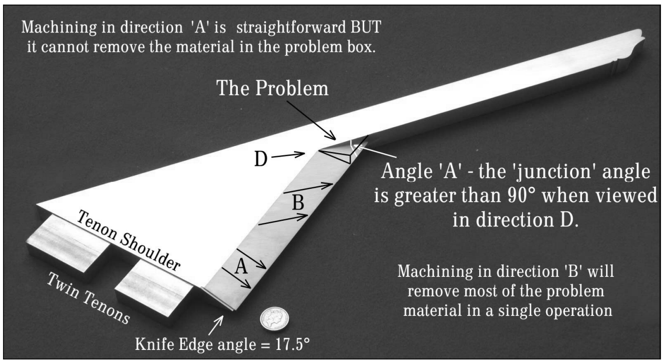
making the things to hold the workpiece securely that takes time. Being held only by the edges necessitated light initial cuts as the Bridgeport's powerful motor was quite capable of flinging the whole casting across the workshop. A 'safety clamp' barely touching the work was a reassurance but had to be moved around as the work progressed. Cutting forces cause the metal to bend downwards unless supported from below so any gaps and hollows had to be filled to prevent this. Several sets of old feeler gauges are kept for just this purpose. It took seven reversals and fine cuts to produce a flat and parallel casting.

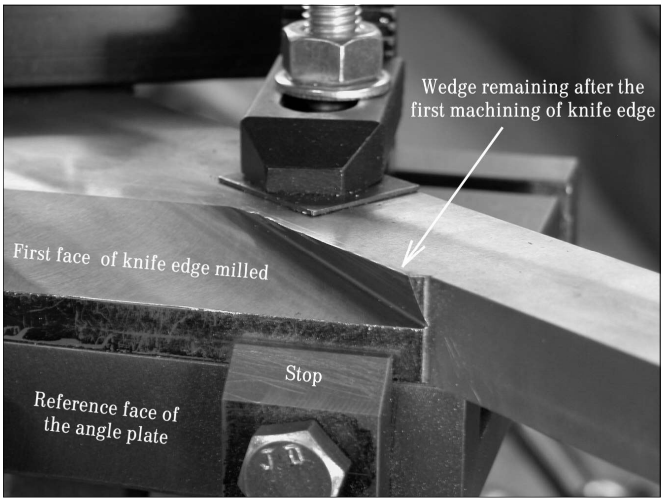
Machining the profile began with the style edge which required my longest angle plate to hold the faces perpendicular to the machine table (Fig. 4). To get the style height angle a steel 'fence' was set on the angle plate using a bevel protractor (Fig. 5). This was much easier and more accurate than attempting to align the heavy gnomon casting directly while manipulating a finely-set instrument with the other hand. After machining the latitude angle it was double checked for accuracy with a vernier protractor as mistakes thereafter could not be rectified. With an accurate 'foot' now machined, it was now possible to machine the cheeks of the twin tenons which would pass through mortise slots in the plate. A precision parallel set in line with the machine table travel served as an alignment fence so that the shoulders of the tenons would form the correct latitude angle with the style edge and also be co-planar with each other to contact the dial plate closely all round (Fig 6).

The vertical knife-edge was begun by first milling a flat at the correct distance from the style origins. To ensure its eventual perpendicularity to the dial face, quite an elaborate setup of two angle plates was required. The larger one held the body in the vertical plane and the smaller one at right angles held the milled foot truly upright (Fig. 7). Having carefully milled the required flat to the point where the ver-









Top to bottom:
Fig. 7. Milling a face for the vertical knife-edge.
Fig. 8. Tilting table and angle plate.
Fig. 9. The Problem!
Fig. 10. The wedge overhang.

tical knife edge would encounter the underside of the style, it should now have been possible to mill the style to width. It was only at this point that I began to wonder how much excess style length was available to serve as a hold-down point during machining. On measuring the film artwork and comparing it with the machined body the awful truth began to sink in.

It was 14 millimetres TOO SHORT!

When and how this discrepancy arose is still a mystery but no matter how many times I checked, re-checked and wished otherwise there just wasn't enough metal to complete the gnomon after several weeks of careful work. All sorts of 'fixes' suggested themselves but any type of join would inevitably show. To cut the artwork to fit was an unworthy 'bodge' for such a prestigious reproduction and so the inevitable had to be accepted:

I would have to begin all over again.

The old pattern was extended and re-cast and about a month later the machined gnomon was again ready for the most crucial operation, the machining of the vertical knife edge. This piece of complex solid geometry had occupied my waking thoughts for weeks prior to the event. Fortuitously, I had recently faced the same problem on a smaller scale for another BSS member which allowed me to devise a sequence of operations to complete the task….or so I thought.

Machining a bevelled edge on a Bridgeport milling machine is elementary stuff. The milling head and cutter can be set at almost any angle and the work passed beneath it. Alternatively, the machine head can remain upright with the workpiece held at the required angle on an adjustable angle plate or tilting table (Fig. 8). For a variety of reasons, the adjustable angle plate was chosen for the job and set to half of the included angle of the knife edge. Additional stops were added to the raised edge (hereinafter referred to as the reference face) of the angle plate to allow what would become the knife edge to be set flush and clamped in place. This whole assembly was then rotated on the miller table so that one of the style edges lay in a vertical plane aligned with the travel of the machine table. The bevelled face was then machined away in a series of careful cuts. Adjustable angle plates are not beyond re-adjusting themselves if too much cutter force is applied so light cuts and a home-made stay ensured that there was less chance of having to begin yet again for a *THIRD* time.

The problems that made this aspect of the job so tricky are summed up in Figure 9. The angle *A* between the underside of the style and the bevelled face of the knife-edge (the junction) is greater than 90° so cannot be machined in a single pass with standard cutters. Because the gnomon was

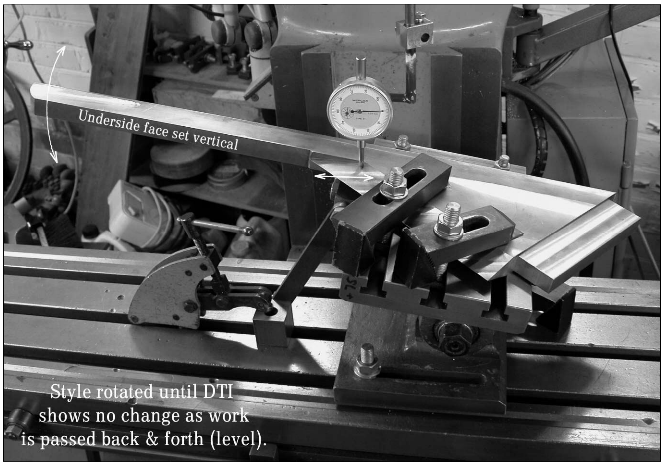


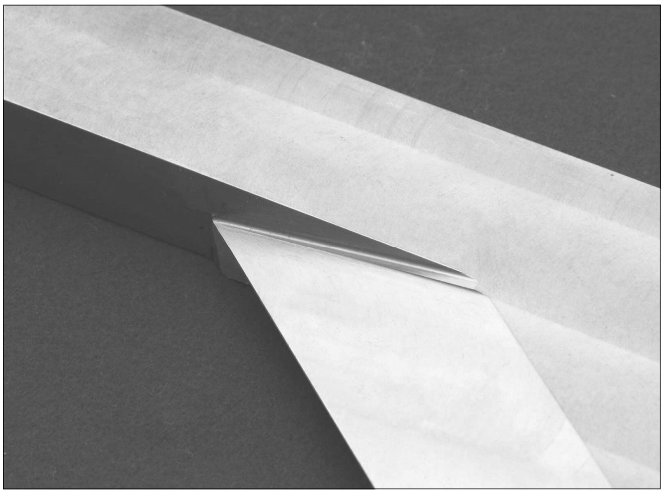
Fig. 11. 'Clocking' the knife edge.

on the tilted angle plate, the style face was also tilted back from the vertical plane as was the underside face of the gnomon. Because the cutter produces either horizontal or vertical planes, a wedge shaped 'overhang' was left when the cutter tip was almost in contact with the junction at the underside (Fig. 10).

The gnomon then was then re-set so that the style face was perpendicular to the reference edge and the plate angle re-set so that the junction was horizontal by using a dial test indicator (DTI) as the assembly was wound back and forth (Fig. 11). This then allowed careful machining of the over-hanging wedge. I had hoped that this would be the final stage but, because of the complex solid geometry, a tiny secondary wedge remained (Fig. 12). More head scratching and angle plate juggling was needed until at last the junction was perfect with every scrap of remaining metal removed by careful machining with no hand finishing needed. The final workshop operation was to profile the tip to the exact shape of the Wynne original (Fig. 13).

My etching facilities are generally limited to 24" x 24" so the etching of plate and gnomon were done by a specialist local company where the job proved to be much more difficult than anticipated. The gnomon in particular is etched on six separate faces with the side cheeks overlapping onto the knife edges. At each etching stage all the previous work had to be 'stopped out' to prevent attack by the etching fluid. This was an anxious process as any exposed parts would be ruined.

Final assembly was achieved when the two mortise slots were milled back in my workshop and numerous taper pins were inserted to ensure a solid and rigid attachment leaving only delivery to John Davis for installation in a special cradle made to carry the dial plate securely to its destination. Certainly 'Wynnifred' (Figs. 14, 15, 16), as this remarkable dial has become known to those of us involved, is among



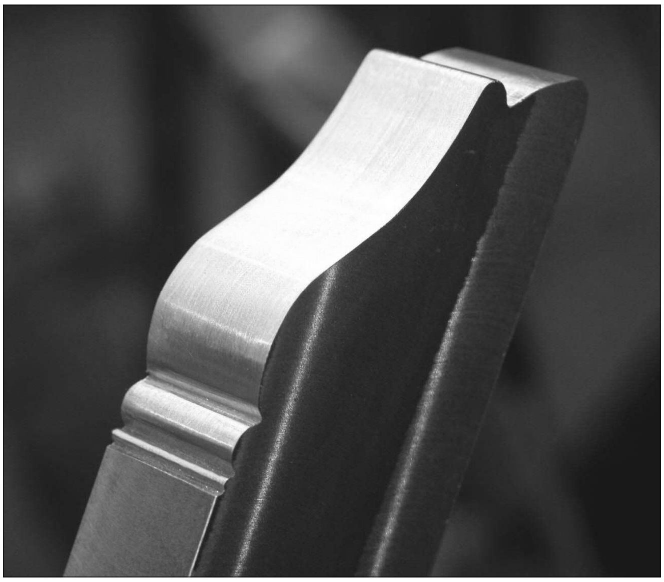


Fig. 12 (top). Oh no! A secondary wedge!

Fig. 13(above). Tip profiling.

the most challenging pieces of work I have ever undertaken and, but for the painful memories associated with repetition of the stumpy gnomon, very rewarding. That 'spare' is certainly the most valuable piece of scrap metal I have ever made.

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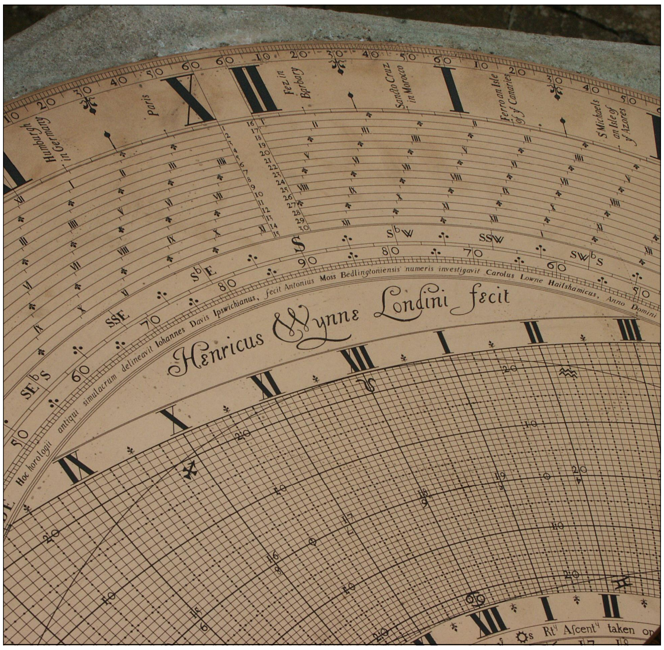

Fig. 16. Close-up of the replica dial showing the facsimile of Wynne's signature and, just above, the Latin inscription of the makers.

Fig. 15 (left). The finished dial installed on the original pedestal, in its home in Norfolk.

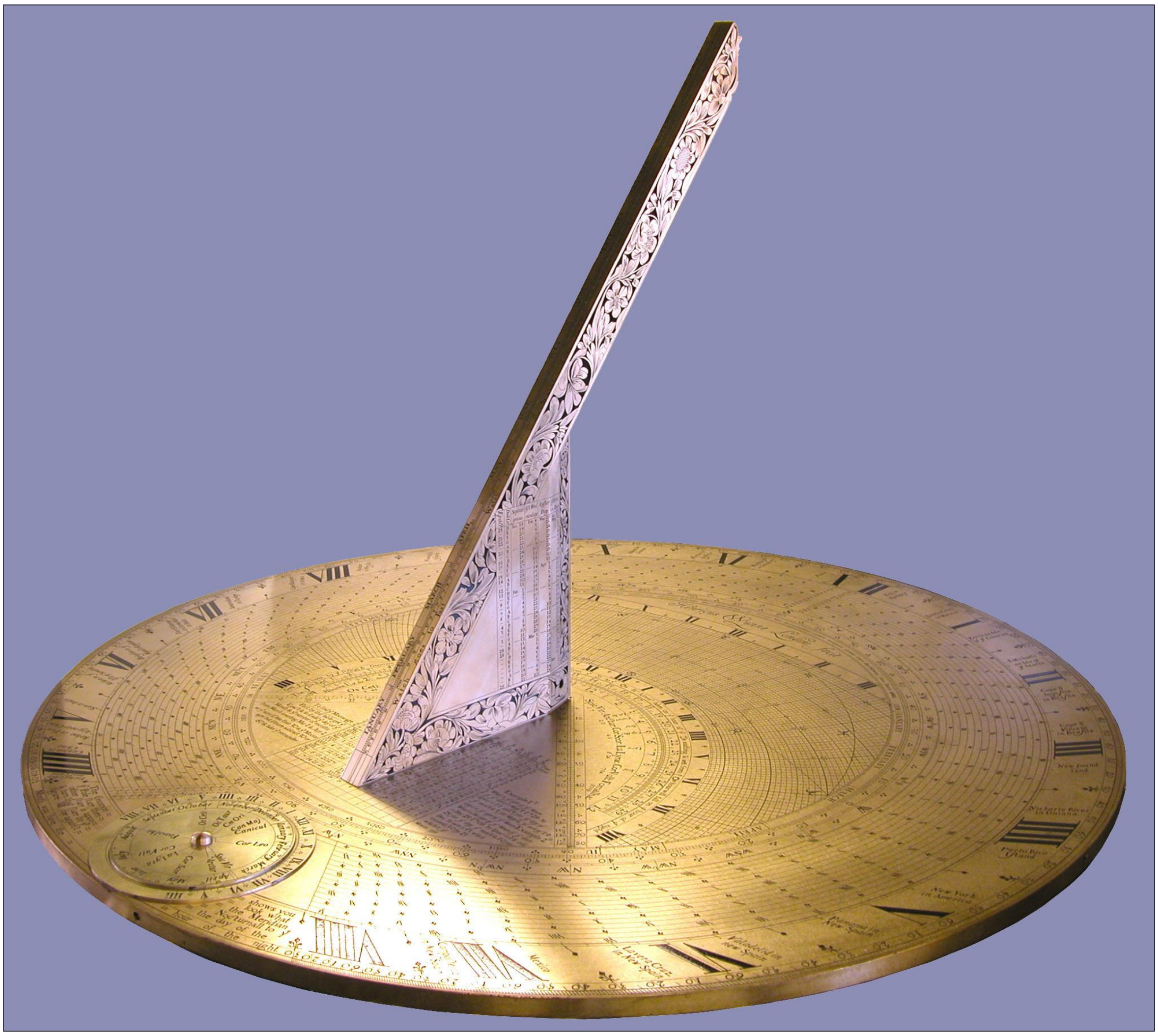

Fig. 14. The finished dial.

Fig. 1. The Middle Temple dial, signed and dated Baptista Sutton, 1627. Middle Temple Hall, east window. Even at this early date, Sutton had already adopted the cross patée to represent midday.

Fig. 8. The Widdington dial, 1664, showing the narrow band of unadorned matt paint inside the hour-lines, which appears on London dials after about 1656. The fly is damaged by repairs, but its head is visible just left of centre.

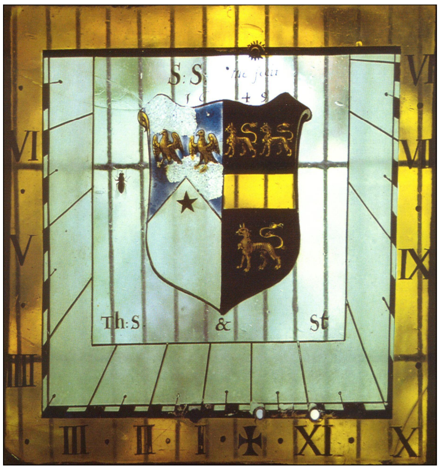

Fig. 4. The Bucklebury dial, made in 1649 probably for a member of the Stephens family, now in Bucklebury church, near Newbury.

Fig. 5. The Blue (or St Clement's dial) made in London in 1656 (Private collection).

Fig. 6. The Non Sine Lumine dial, a direct west dial designed like a mathematical scale; the style of the inscription appears on a number of dials attributed to John Oliver. (Private collection).

GLASS SUNDIAL MAKERS OF 17TH CENTURY LONDON

GEOFFREY LANE

This article is distilled from wider-ranging articles written for the *Journal of Stained Glass*, the first of which appeared in December 2005.

INTRODUCTION

More than 30 glass sundials have come down to us from the century between 1620 and 1720. Add in lost dials known from documentary sources, and the British total for the period is nearer 60. By contrast only a single example from the Elizabethan age has been recorded so far – in 1585 Bernard Dinninkhoff included a tiny circular dial in an elaborate display of heraldic glass at Gilling Castle in Yorkshire. The boom in production coincided with greater availability of clocks and watches (the London Clockmakers' Company was founded in 1631) and tailed off as they gradually became more reliable. Understanding of English glass dials has been hampered by a lack of reliable data on the glass-painters who did (or didn't) make them. Only two makers have become at all widely known – John Oliver in London and Henry Gyles in York. London was the main centre of the trade, and recent research into the careers of its glass-painters has turned up fresh information on the dial-makers and the world in which they worked.[1]

Many of the surviving dials are now familiar from the excellent website operated by John Carmichael, with much input from Chris Daniel.[2] In this article they are identified by the catalogue number given them by Mr Carmichael, with the addition of the letter 'C' – thus Dinninkhoff's dial mentioned above becomes C-41. A page reference is also provided for dials illustrated in the recent *Sundials of the British Isles* (e.g. SBI-10).[3] What follows should, of course, be regarded as a progress report.

BAPTIST SUTTON (by 1600-1667)

Sutton is the first known London maker. He first comes to notice as a glass-painter about 1621; by the later 1620s he had set up shop alongside an older colleague, Richard Butler, in Chancery Lane, Holborn, in the heart of 'legal London'. Both no doubt hoped to find clients around the nearby Inns of Court and Chancery. In 1627 Sutton worked a small but perfectly-formed rectangular dial into an otherwise routine armorial panel for the great hall of the Middle Temple, commemorating Sir Nicholas Hyde, the new Chief Justice of the Common Pleas (Fig. 1). He inserted the date and his Latinised signature, *Baptista Sutton*, on either side of the main inscription. The Hyde dial-panel was probably installed in the large south-facing bay window near the high table, where the resident judges and their guests could learn to appreciate its usefulness in setting their watches – a fairly blatant piece of advertising. (At some later date it was banished to a high east window, over the minstrels' gallery, where it escaped notice until recently spotted by stained-glass historian Brian Sprakes.)

In 1639 the physician Dr John Wyberd published a slim volume on lunar dials, *Horologiographica Nocturna*. After outlining his method, and recommending Elias Allen (no less) as a suitable maker of horizontal dials, Wyberd added these words:

> ...it would be an excellent way to have a Lunar Dyall drawne on glasse and placed in a window after the manner of those Sunne Dyalls which are most accurately made by my loving friend M^{r} *Baptist Sutton*, dwelling at the upper end of *Chancery* Lane, neere Holborne... who likewise will be able to perform these as accurately as the other, if it shall be required of him.[4]

Sutton had evidently made a fair number of dials since 1627. One was for the church of St Magnus the Martyr, at the northern end of London Bridge. The churchwarden's accounts (for 1638-39) neatly explain its purpose:

> Paid Mr Sutton in full for the sunne dyall sett upp in the church window, used to sett the clock by..... 20s.[5]

Up to this point Sutton's output had encompassed large Biblical scenes as well as armorials and sundials, but in 1641 Parliament banned 'superstitious images'. His career still had twenty years to run, and the fashion for glass sundials no doubt helped him survive the downturn in other work. Ironically, one of his clients that year was a Puritan Essex MP, Sir Thomas Barrington; Sutton made him a dial bearing the date 1641 and the arms of Sir Thomas and his second wife Judith, née Lytton (C-149 – Fig. 2). (It survived in a house, Highworth, near Swindon, which was demolished in the 1960s, but has not been seen since). It was almost certainly commissioned for the London house the Barringtons leased and furnished in fashionable Great Queen Street – a short walk across Lincoln's Inn Fields from Sutton's workshop. The London account book kept by the Barringtons' steward has this entry for February 1641:

> It[em] paid for a glass dyall for my M[aste]^{r} his chamber window 6s 8d.

Disappointingly, it fails to identify the maker. However the Barringtons' general cash book includes this a few months later:

> It[em] p^{d} to M^{r} Sutton the dyall maker in full of his bill July 2^{d} 1641, besides w^{t} [?] for London £1 3s 4d.[6]

I suspect this second dial was commissioned for their country home in Essex. The dial illustrated declines about 41º E of due south, about right for Great Queen Street.[7]

Sutton made at least one other dial for a London church – St Giles in the Fields paid him £1 5s 2d in 1649/50 "for a Sunne Dyoll in the South wyndowe over the South church dore".

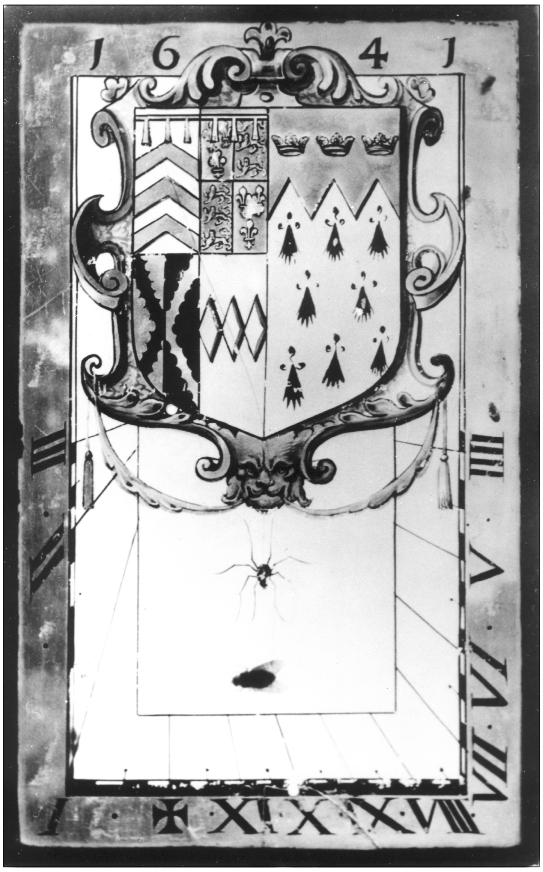

Fig. 2. The lost Barrington (or Highworth) dial, made by Sutton in 1641 for the Puritan MP Sir Thomas Barrington. Photograph: P.S Spokes, 1945, by permission of Mrs A Spokes Symonds.

SUTTON AND HIS 'LONDON DIALS'

Most of the surviving C17 English glass dials are drawn out in a way very similar to Sutton's Barrington dial, and this is particularly true of those traditionally attributed to John Oliver. There is abundant variety in the ornamental details, but surprisingly little in the working parts, something which is easily taken for granted and therefore overlooked. It is therefore possible to speak of 'London dials' as a generic type. Here are the main features the bulk of south-facing dials have in common:

1) the chapter-ring is done in yellow-stain (to resemble a clock-face) and has black Roman numerals (normally Roman) interspersed with black dots marking the half hours.

2) the number XII, the meridian, is replaced by a cross of the type known in heraldry as a cross pattée.

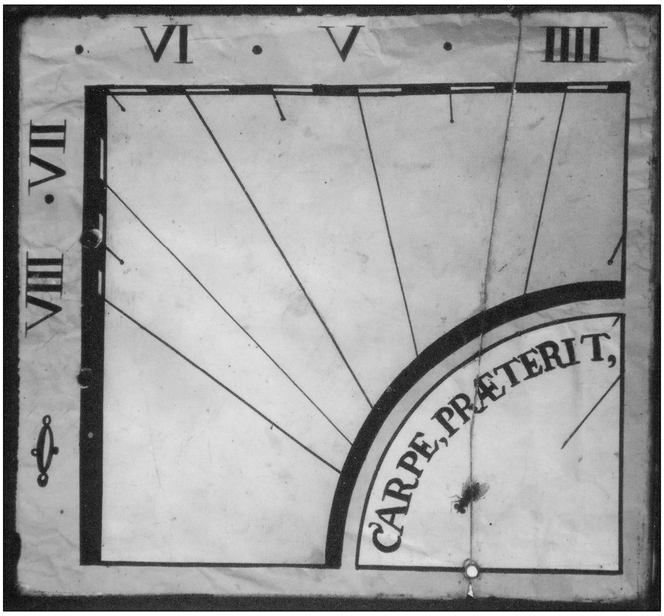

Fig. 3. Dial, possibly by Sutton, formerly in the collection of Dr William Cole (Private Collection).

3) the central area is painted matt white or a pale shade on the back (a method borrowed from inscription panels) to show up the hour-lines and the shadow of the gnomon.

4) the hour lines are interspersed with very short half-hour lines drawn against the outer edge of this zone.

5) the quarter-hours are marked by a black-and-white scale along three sides just inside the chapter-ring.

6) the gnomon (on the outside) is directly attached to the dial by holes drilled in the glass – normally one near the top and three below. The lower holes are hidden in a black strip painted alongside the quarter-hour scale, or on the outer edge of the chapter-ring.

7) the inner field is usually enlivened with a fly, spider and fly, or other small creature, painted on both sides of the glass to increase its lifelike effect (see e.g. Fig. 7).

An attempt to work out a chronology, based on dated dials, suggests that only two important changes were made to this specification over the course of the century:

a) in earlier dials the short half-hour lines have dots on their inner ends, echoing the dots on the chapter-ring and giving the lines a lollipop-look; later these dots disappear.

b) in later dials a second line is drawn around the central field, marking off a narrow strip which is left completely blank, possibly to help the eye catch the gnomon shadow (see e.g. Figs. 8, 9 & 11).

These changes both seem to have occurred about 1655-60, with a slight overlap between the two. Only the four dials attributed to Henry Gyles, and a handful of others, deviate to a marked degree from this regular pattern. Obviously the

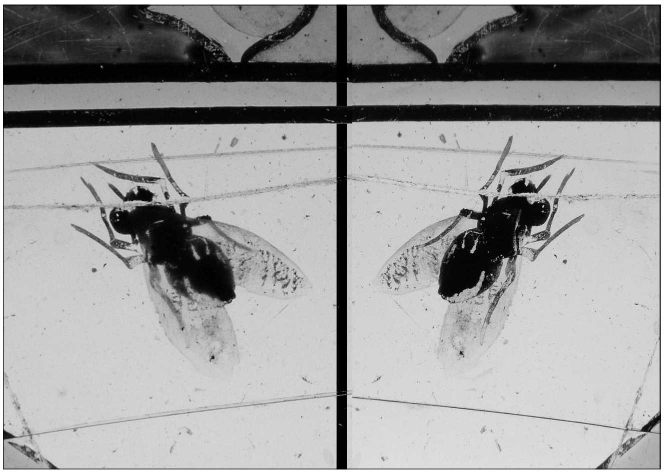

Fig. 7. The Non Sine Lumine dial, detail showing a typical 'London' house fly; the wings are painted on the inside (left) the body and legs on the outside (right) creating a lifelike three-dimensional effect.

full specification can only be expected in south-facing dials resembling clock-faces, but those made for other orientations also tend to conform as far as possible. (Fig. 3) This includes due east (or due west) dials which are designed like mathematical scales (see e.g. Fig. 6 – here the gnomon-mountings were hidden in two black strips, each concealing three holes).

Where Sutton himself acquired his working method is unknown – possibly from printed sources, perhaps a friendly dial-maker. His London successors, it seems, were not particularly adventurous diallists, and content in most respects to follow his example. Since their careers overlapped, this makes it difficult to tell their work apart.

'PHANTOM' DIAL-MAKERS

One dial that may well be by Sutton is the Bucklebury dial, 1649, probably painted for a house or memorial chapel in south Gloucestershire (C-73, Fig. 4). Like the Barrington dial, it commemorates a married couple – Thomas Stephens of Little Sodbury and his wife Elizabeth Stone – but posthumously this time, since Stephens died in 1613. The inscription, *S:S: me fecit 1649*, has sometimes been taken for the maker's signature, but no maker with these initials has been identified, and in any case it seems unlikely the Stephens family would have allowed a mere artisan to place his initials in large letters over their arms. The historian E A Greening Lamborn, solved the problem by suggesting that the panel might have been *painted* by a Stephens descendant, but I think this underestimates the technical challenge involved.[8] In fact, the inscription should probably be read as "SS had me made". Whoever did paint it, the dial, now in Bucklebury church near Newbury, Berks., is a thoroughly professional piece of work.

Another possible Sutton dial is the recently-rediscovered 'Blue Dial' (C-11, Fig. 5). It not only shares decorative features – fantastic masks set amid scrolls – with the Barrington dial, but also many of its dialling details, while the hour line angles indicate that the design latitude and wall declination of the two dials is virtually identical. Its companion-piece was made for the west London church of St Clement Danes, and commemorates repair work of 1655-6 in which the windows were reglazed by William Pollicott, a glazier who lived in the parish, but is not so far recorded as a glass-painter. It's not clear if the dial was made for the church, or for a nearby house, but the two must have been paired early on and have remained together ever since. The initials WP, which appear prominently on the dial, appear to be associated with an unidentified coat of arms displaying three halberds, or pole-axes. These could possibly be 'read' as a heraldic pun on the name Pollicott (i.e. 'Pole-I-got'). The Latin inscription below makes it clear, however, that WP did not himself paint the dial. It says he "had it made" (*fieri fecit*) as a token of love (*pignus amoris*) in connection with a specific date, 3 February 1655 (i.e. 1656 in our terms). What this might have been is an unsolved mystery.

Whoever did paint the Blue Dial probably also painted the Marlborough Dial c.1656 (C-19). The similarities are striking – not only the decorative scrolls and masks, but the distinctive way the yellow chapter-ring is carried past the lead framing and then overlapped by the scrollwork. The dial, still in its original domestic setting, was probably commissioned by the wealthy mercer Thomas Bayly, following Marlborough's Great Fire of 1653 – the oldest part of his house, including the parlour, had been rebuilt by 1656, which is the likely date of the dial too. Bayly must have ordered it from London.

JOHN OLIVER (1616-1701)

Oliver has long been recognised as a maker of glass dials, and the number attributed to him is considerable. But only a handful can be positively identified as his work and they all date from after 1660. Examination of them shows that he scarcely deviated from the pattern already laid down by Sutton. This makes it difficult to tell his earlier work from Sutton's, and prompts speculation that Oliver may have been Sutton's apprentice in the 1630s, or at least learned dialling from him. Both men belonged to the Glaziers' Company, but unfortunately its apprenticeship records are lost. Our first definite trace of Oliver is his marriage to Grace Smith in 1649. They settled in the City parish of Holy Trinity the Less, where five children were baptized 1650-58, and Grace was buried in 1660. Oliver remained rooted in the City throughout his long career, presumably seeking his custom among the City merchants and the Livery Companies to which they belonged. His base in Trinity Lane (roughly where Mansion House underground station now stands) was burnt out in the Great Fire of 1666. In 1668 he joined Robert Hooke and Peter Mills as a City Surveyor, measuring plots so that other fire victims could rebuild, and this led to further appointments in 1675-6 helping Wren rebuild the churches and St Paul's – all of which took Oliver away from active glass-painting.

Four glass dials can be reliably attributed to Oliver:

1& 2) Two small quarry (diamond-shaped) dials at Northill, Beds. (C-96 & C-103; SBI-231), the first of which is almost imperceptibly signed J Oliver and dated 1664 (SBI-232); they were evidently presented to the rector when Oliver painted the imposing armorials in Northill church which also bear his signature and the same date.

3) The larger rectangular dial (C-57) painted for the Weavers' Company, who employed Oliver as their glazier when they were rebuilding after the Great Fire; a date of 1669 is often quoted, but 1672 – when the hall was completed – is more likely.

4) A lost rectangular dial in an oval setting painted for Lambeth Palace perhaps about 1669, known from a sketch by the artist Frederick Sydney Eden (C-31); this attribution goes back many years but its origins are lost; at one time the dial was apparently displayed alongside panels depicting the arms of Archbishop Sheldon and the Sheldonian Theatre in Oxford[9] – possibly Oliver's name appeared on one of these.

Working outwards from these, other dials have been given to Oliver on stylistic grounds – in the first place other very similar quarry dials at Groombridge (C-66) and Chicksands (C-154), the undated Hexagon dial (C-32) and perhaps the Oxford scale dial dated 1648 (C-44). Oliver was in dial production at a fairly early date if this last is accepted. Another group appear to share with the second Northill dial and especially the Groombridge dial a particular form of cursive handwriting; they include the privately-owned *Non Sine Lumine* dial (C-29, Figs. 6 & 7) and the Tredegar (or Welsh) dial of 1672 (C-62). A third group of rectangular dials in oval surrounds share the general appearance of the Lambeth dial, including several which include a winged hourglass – this device appears on the Widdington dial (C-28, Fig. 8), dated 1664, which conveniently falls two or three years after Sutton is last known to have been active. Some 'Oliver' dials show markedly inferior workmanship, particularly in the lettering (e.g. C-56). If they really are from Oliver's workshop, it is possible they date from a time when he was preoccupied with other work. Presumably in such cases the Master (who alone knew the secrets of dialling) sketched out the working-parts but left it to an apprentice or journeyman to complete the decorative part of the job.

RICHARD DUTTON (bef. 1640-1686)

Baptist Sutton had ceased work by about 1662, and had died by November 1667, when administration of his estate was granted to his daughter Mary Dutton (1632-90). Her husband Richard had probably been Sutton's apprentice. He seems to have taken over Sutton's later premises near Leather Lane, erecting over them a Sign of the Dial to announce his trade. Besides inheriting Sutton's clients among the Inns of Court, Dutton obtained several commissions for City churches and company halls, when they were rebuilt following the Great Fire of 1666. He almost certainly painted a fine dial about 1671 for the Pewterers' Company (Fig. 9). With its motto *Sic Vita* ('so is life') and its motif of a spider advancing on a fly, it might easily have been attributed to Oliver, but the company's records show that the company employed Richard Dutton in 1671, specifically to paint glass for its new hall. The sturdy-looking classical pediment behind the company's arms probably continued onto neighbouring panes on either side; if so, it was already incomplete in 1902, when this illustration appeared in a history of the company.[10] The south-facing dial was apparently destroyed in World War II.

Fig. 9. The lost Pewterers' dial, made in 1671, probably by Richard Dutton, as illustrated in 1902 (author's photo, courtesy of the Society of Antiquaries). The classical pediment may have extended onto neighbouring panes.

In 1676/8 the Fishmongers paid Dutton £2 6s "for a Dyoll in the Court Room", and he probably painted another for the Girdlers' Hall, where rebuilding was not completed until 1681-3. This dial also fell victim to enemy bombing, and we only have an outdoor picture which was reproduced in *The Builder* in 1917 (Fig. 10). F S Eden wrote a brief description in 1935: "... the Company's arms ... in enamel colours and yellow stain are on a scrolled shield in the centre square with the proverb *TEMPUS*

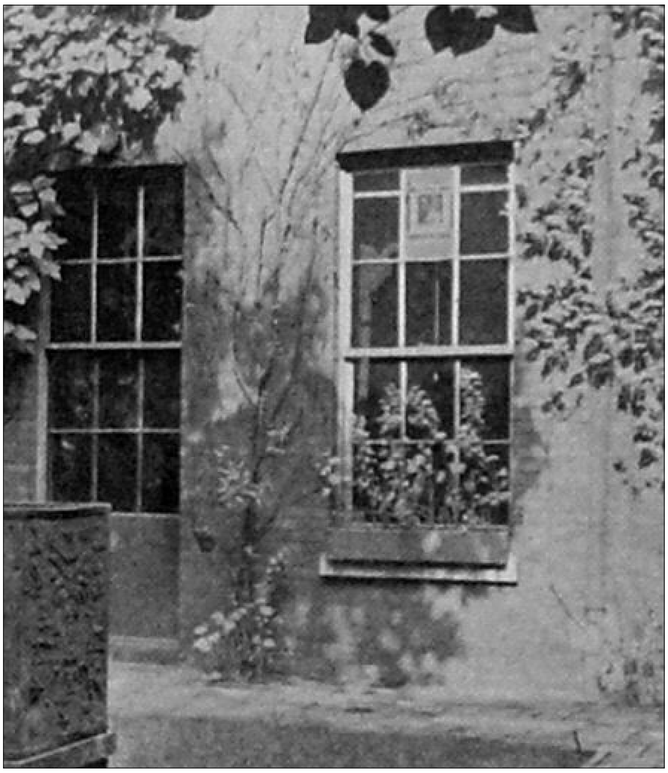

Fig. 10. The lost Girdlers' dial, made about 1683, seen in the upper sash of one of the Court Room windows. The photo (courtesy of the Society of Antiquaries) was published in The Builder *to illustrate an article on Girdlers' Hall in October 1917.*

OMNIA RUMINAT along the top", but unfortunately he did not supply an illustration.[11] There is no documentary evidence for the maker (which means it was probably donated), but Dutton's only rival, John Oliver, had almost completely given up this kind of work by the 1680s.

WILLIAM PRICE (c.1644-1710)

Price was a close colleague of Dutton's. There are few traces of independent work by him before Dutton's early death in 1686, but thereafter he flourished with little competition. In 1700 he advertised in the *London Gazette* as "*William Price*, Glazier and Glass-Painter, near *Hatton-Garden* in *Holborn*, London; where Gentlemen may have Church-History, Coats of Arms, Dials &c. Painted upon Glass, in what Colours they please, to as great a Perfection as ever".

In 1702 Price painted an elaborate south-facing dial for Gray's Inn Hall, which has not been seen since it was taken down in World War II. F S Eden, who considered it "perhaps the finest specimen in London of a glass sundial", painted a careful copy to illustrate a *Country Life* article in 1935 – unfortunately it was only reproduced in monochrome (Fig. 11) and Eden's original ink-and-watercolour version has not so far been traced.[12] In the past this fine dial has been attributed to Henry Gyles of York (Price's exact contemporary), but the published Gray's Inn accounts

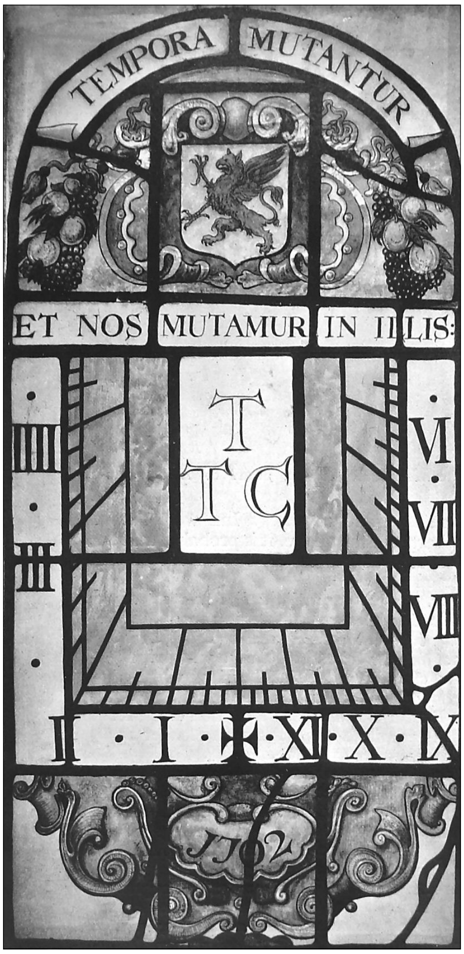

Fig.11. The missing Gray's Inn Hall sundial, made in 1702 by William Price the elder, not seen since it was taken down in the Second World War; mono reproduction of a hand-painted illustration by Frederick Sydney Eden.

clearly show that Price took over Dutton's regular work there, and was paid £15 16s 6d in 1701-3 "for Glass-painting in the Hall and Chappell windows".[13] So far this is the only dial positively identified as the work of Price. If we compare it with Sutton's 1641 dial, we see that so far as the dialling is concerned little has altered in over sixty years.

Price reissued his advertisement in 1705, jointly with his son Joshua. They claimed their firm could also work in other materials: "…and draws Sun-dyals on Glass, Wood, or Stone &c." Joshua Price (1672-1722) carried on where William left off; in 1719-21, when Gray's Inn had problems with its horizontal sundial in Coney Court, it paid the clock-maker Henry Smith £4 14s 6d for the repair and fitting a new gnomon, but "Price ye Glass-painter" was then paid £2 10s "for delineating 2 Sundials & fixing of an Horrizontal Brass dial in Coney Court"

HENRY GYLES (1645-1709)

Gyles lived in York; there is no evidence he ever worked in London, which the Glaziers' Company would have opposed, though friends kept him informed of developments in the capital. He is included here for completeness and to point up various ways in which he differed from the London glass dial makers. Gyles belonged to a group of Yorkshire *virtuosi*, who discussed dialling among other mathematical and scientific topics. His four known dials are quite distinct from their London counterparts: the half-hour lines are drawn on the chapter-ring and terminate in decorative finials, as on clocks of the period; he adopted the cross pattée only very late in his career, marking midday numerically at least until 1687, when he painted the fine Christ dial for University College, Oxford (C-46; Fig. 12).

Fig. 12. Dial donated by Henry Gyles to University College , Oxford, on completion of his altar window for the college chapel in 1687. His method of marking midday and the half hours differs significantly from London practice.

In the Gray's Court dial (1690 – C-5) he used a cross fitchy (pointed at the base), and secured the gnomon by only two holes, both drilled in the central picture. Gyles is not known to have enlivened his work with flies, spiders or similar creatures. Decoratively, his work is much more sophisticated and literary in tone – this is particularly clear if one compares his early Nun Appleton dial (signed and dated 1670 – C-6) with, say, Oliver's Weavers' dial of 1672.

MATHEMATICAL PRACTITIONERS

In the 1950s, the geographer Eva Taylor compiled an extensive directory of instrument-makers and other practical mathematicians whose collaborations (often across barriers of class and culture) played such an important part in the early development of modern science. Prof. Taylor included Sutton, Oliver and Dutton for a variety of reasons, although she knew little of their glass dial work or the connections between them.[14] The following summarises her findings, with added comments in square brackets:

Baptist Sutton wrote a learned article on logarithmic scales – e.g. Oughtred's Circles of Proportion and Gunter's Line of Numbers – which Wyberd appended to his 1639 book on moon-dials mentioned above.[15] [Taylor concluded from this that Sutton was a scale-maker, apparently overlooking Wyberd's recommendation of him as a maker of glass dials]. He later assisted Wyberd in experiments to obtain precise measurements of liquids.[16] Sutton was the original owner of a fine copy of the *Compleat Surveyor*, by the printer turned surveyor and diallist William Leybourne, now in the British Library; his signature: *Baptista Sutton: liber ejus 1653* is on the title page.[17]

[Taylor speculated that Baptist was either father or uncle of the fine instrument-maker ***Henry Sutton***, and by implication of Henry's supposed brother or kinsman William, who followed the same trade, and belonged to the same livery company, the Joiners. The ages are about right, but no Henry or William appears among Baptist's children christened at St Andrew's Holborn 1624-40. In any case, when ***William Sutton*** was apprenticed in 1642, he was recorded as the son of Henry Sutton, yeoman, of Kingston-on-Thames.[18] This older Henry could perhaps have been Baptist's brother, but no evidence of any link has come to light so far, and Sutton is after all a fairly common name].[19]

John Oliver caught Taylor's eye because he became a professional surveyor, working with Robert Hooke [and probably William Leybourne]. Taylor knew Oliver was a glass-painter and dial-maker but [oddly] placed him in the Painter-Stainers' Company. She discovered that he also practised map-engraving in his later life [but incorrectly gives the selling-addresses of his maps and other prints (various establishments around Ludgate Hill) as his home address].[20]

Richard Dutton made a series of slides [in December 1672] for the Scottish astronomer James Gregory to project with his dioptric lantern. [This was an early magic lantern, a device only invented about 1659 – the London optical instrument makers Richard Reeves and Christopher Cock were selling them from about 1663. Cock, who made Gregory's lantern, told Gregory's London contact, John Collins, that Dutton was "the sole Glasse Painter we have", suggesting that Dutton was the only London maker of such slides].[21] Dutton later displayed proposals for William Leybourne's 1682 book *Dialling, plain, concave, convex etc*., at his shop "at the Sign of the Dial" in Holborn. [Taylor concluded that Dutton was "probably a dialmaker", though she did not know of his relationship to Sutton].[22]

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SIS INVITATION LECTURE EVENING

DESMOND QUINN

On 18 November I was invited, together with John Moir, to represent the BSS at the 13th Annual Invitation lecture of the Scientific Instrument Society. The lecture, entitled '*Artist and Engineer - Saga of the French instrument industry in the 19th Century*' was given by Dr. Paulo Brenni. The august headquarters of the Society of Antiquaries of London, at Burlington House was the venue for the talk, after which we enjoyed a very good buffet supper and chatting with new found friends.

Dr Brenni charted the development of scientific instrument production from its early days before the French Revolution until the end of the 19th century, when there was a relative decline resulting from intense competition from outside the country. Before the revolution, scientific instrument production was poorly organised, perhaps partly because of a preoccupation with elegance in whatever they produced - something which happily continues to this day. The result was that much of France's requirement had to be imported from Britain. Following the Revolution however, an impetus was provided by the new Republican government to rationalise all forms of measurement, also to examine the subject of meridians and astronomy generally. Most instrument production was now centered around Paris, and by the middle of the 19th century international trade fairs were showing France as an important producer of scientific instruments. Not only had the production much increased but the development of many branches of science was being pioneered. High quality French optical instruments for example were displayed at the Crystal Palace International Fair, as were wireless and electrical goods, engineering equipment and associated measuring instruments. The Bourdon tube for measuring pressure was produced at this time. Towards the end of the century, inevitably, subcontracting and mass production crept in, as with other nations. With the rise in German precision manufacture and also competition from America, France tended to lose some of its prestige. In Dr. Brenni's museum in Florence, however, the instruments are mostly French, which says much for the importance of French manufacture.

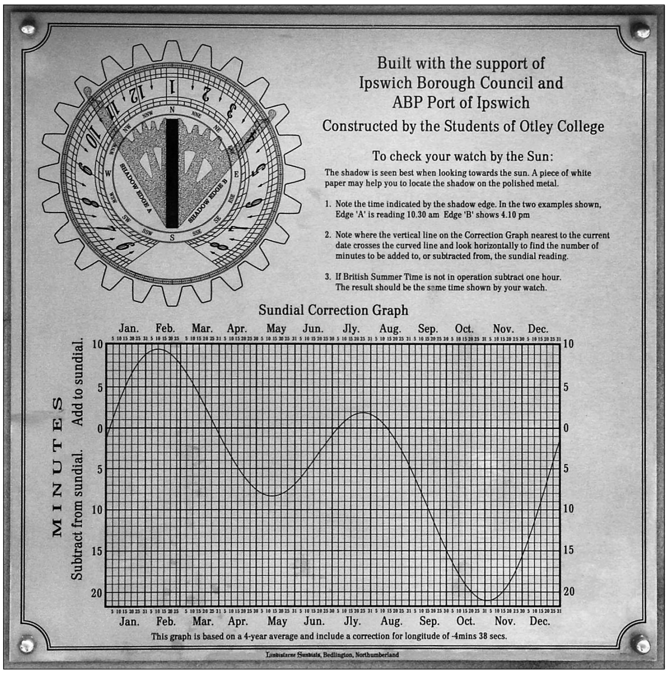
Whilst Dr. Brenni's talk was primarily about instruments, he also spoke at length on the people who made them - their working conditions and family orientation. This latter was probably an influencing factor in the emphasis on elegance – 'artist and engineer' .

The evening was altogether most interesting and enjoyable and showed the merit of the association between our two Societies. Our grateful thanks are due to the Scientific Instrument Society.

A NEW 'ROTARY' DIAL FOR IPSWICH

A new public sundial officially received 'first shadow' in September 2005. This is the second dial sponsored by the Rotary organisation, the first being at Melton Mowbray in 2003.[1] This one is on the quayside of the new Ipswich marina and was, in the words of the inscription, "Presented to the People of Ipswich by the Four Rotary Clubs, celebrating 100 years of Rotary, 1905-2005." The dial also carries the Rotary motto of "Service above Self".

This large stainless steel dial was made by Tony Moss of Lindisfarne Sundials and features a massive cast stainless steel gnomon which is anchored deep into the concrete infill of the brick pedestal. Both the gnomon and the dial-plate itself carry the shape of the Rotary gearwheel emblem. The etched dial features both the old, in the form of a compass rose pattern based on the St. Michael's Mount



dial by Troughton, and the new, in a timescale laid out for British Summer Time.

The location of the dial is an almost perfect one from an 'hours of illumination' perspective, with a clear horizon allowing very nearly sunrise to sunset visibility. This will continue into the future as there is a local bye-law that requires any future building to maintain a clear line-of-sight from the Old Customs House, seen in the picture to the north of the dial, to the Malthouses 200 yards to its south.

The meridian for the dial was laid out with the assistance of a mid-1800s theodolite (and the NASS Dialists' Companion computer program). This set out two painted lines on the ground for lining up the octagonal paving slabs and brickwork pedestal. The actual brick-laying was done by the students of Otley College. When the dial was initially placed on the pedestal, it was accurate to about two minutes of time before the final tweaking.

The dial is surrounded by a set of eight cast iron bollards, very much in keeping with the nautical location. It is accompanied by a very clear informative plaque. This includes full details of how to read the shadow of a sundial, something which we take for granted but which the modern public finds confusing. The local longitude correction is combined with the EoT values to give an exemplary 'correction graph'

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From our East Anglian reporter.

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