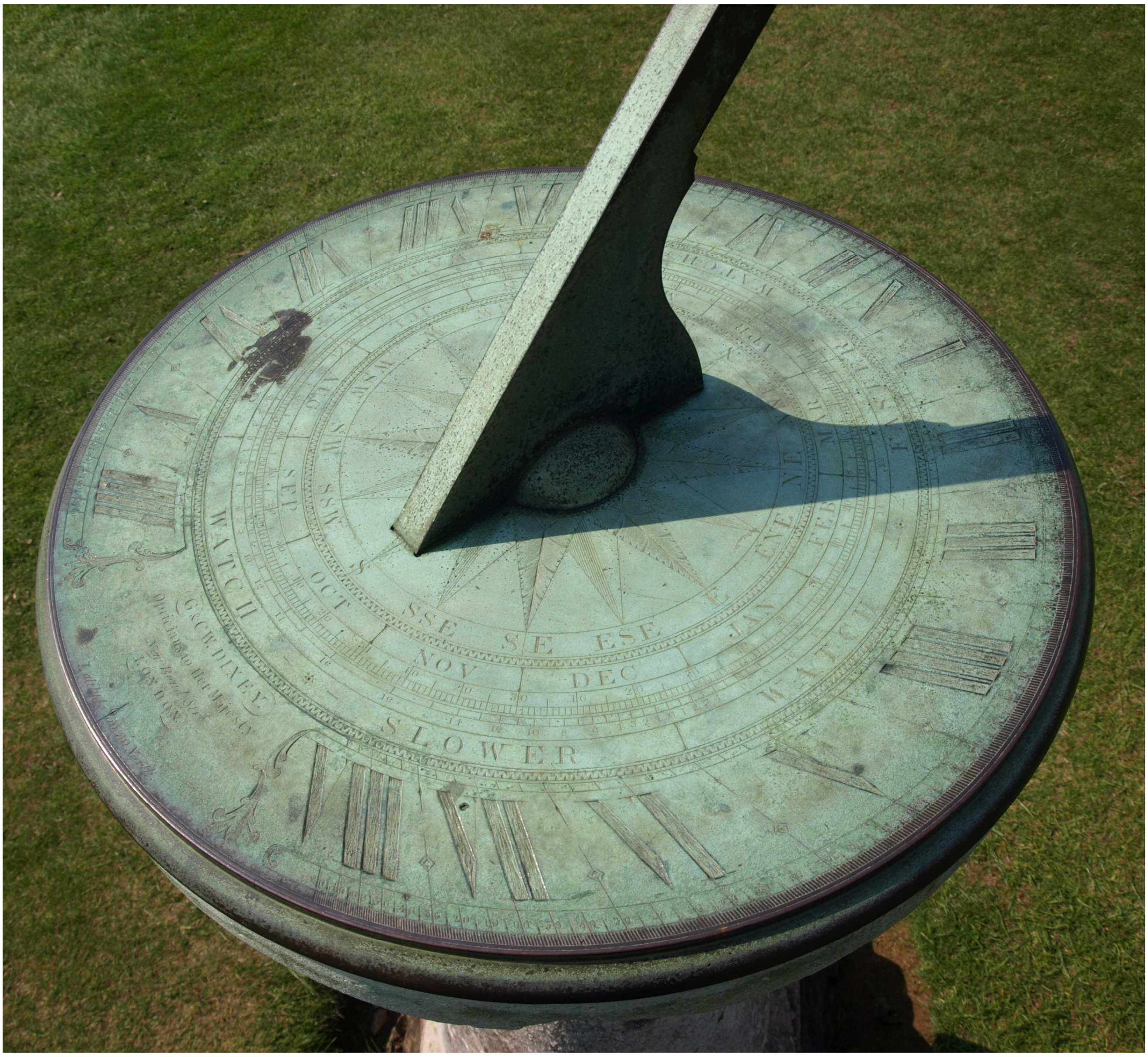
The British Sundial Society
BULLETIN



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GUIDELINES FOR CONTRIBUTORS

1. The editor welcomes contributions to the *Bulletin* on the subject of sundials and gnomonics; and, by extension, of sun calendars, sun compasses and sun cannons. Contributions may be articles, photographs, drawings, designs, poems, stories, comments, notes, reports, reviews. Material which has already been published elsewhere in the English language, or which has been submitted for publication, will not normally be accepted. Articles may vary in length, but text should not usually exceed 4500 words.
2. Format: The preferred format for text is MS Word or text files sent by email to *john.davis51@btopenworld.com*. Material can also be sent on CD or as a single-sided typescript, single- or double-spaced, A4 paper.
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 separate jpg (do not over-compress) or tif files—do not embed them in Word files. For email attachments, do not exceed 10 Mbytes per message. Tables should be treated as figures and numbered as part of the same sequence. Drawings and diagrams should be in clear, strong black lines (not pencil) 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…). Label the top of the figure if it is not obvious. 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. Mathematics: symbols used for the common dialling parameters should follow the conventions given in the Symbols section of the *BSS Glossary* (available online on the Society's website). Consult the editor if in doubt or for help in laying out equations.
5. 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.
6. References: Sources are referred to in the text by a superscript number. They are listed in numerical order under the heading 'References' (or 'References and Notes') at the end of the article. The *Bulletin*'s convention is as follows:

   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: *Bicton Park Botanical Gardens is quite close to the Exeter Conference site. This fine dial (SRN 2085) is signed "G and CW. Dixey. Opticians to Her Majesty, New Bond Street London". The queen in question would have been Victoria. The dial is very like ones signed by the Troughtons and it is possible that its manufacture was out-sourced to their workshops. Photo: John Davis.*

Back cover: *Chris Daniel and Ian Butson have recently discovered this previously unrecorded stained glass dial at Tyttenhanger House near St Albans in Hertfordshire. Now hanging back-to-front in a north-facing window (this picture is reversed), it may have been made for this building around 1675. Research is on-going. Photo: Patrick Powers.*

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

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CONTENTS

EDITORIAL

The subject of 'peer review' has been in the national news lately, with articles on such diverse subjects as climate change and the testing of drugs being challenged. Does this affect us? The *BSS Bulletin* lies somewhere between a magazine and a learned journal. Our articles are not, as a general rule, refereed by a panel of experts though the Editor does call for help where he is uncertain of the accuracy of something proposed for publication, particularly in the areas of astronomy or mathematics. But where an author puts forward an opinion, that is only rejected if it is demonstrably wrong. So, when considering the contents of any *Bulletin*, readers are reminded of the motto of the Royal Society, 'Nullius in verba' or, loosely translated, 'take no-one's word for it'! This is not to say that we do not try to be authoritative, just that other opinions are always welcome.

This issue contains two sets of 'multiple articles' where two or more authors have contributed to different aspects of a dialling problem. Collaboration between diallists is one of the great advantages of belonging to a society so it is very much hoped that other examples of it will appear in the future.

THE SUNDIAL AS AN AEOLIAN HARP

ALLAN MILLS

"The strains of the Aeolian harp and the Woodthrush are the truest and loftiest Preachers that I know left on this earth"
Henry David Thoreau

Many beautiful and unusual sundials have been featured in these pages, but considerably less attention has been given to their supporting structures. Thus, just a few classical designs of pillars seem to serve the majority of horizontal garden dials. However, could a suitable support complement a dial by demonstrating some other natural phenomenon that operates independently of Man? It seemed to me that the aeolian harp might fulfil such a purpose.

THE AEOLIAN HARP

The aeolian (or wind) harp was known to the ancient Greeks, who named it after their god Aeolus, the Keeper of the Winds,[1] for it is played entirely by a breeze without the intervention of any human musician.[2] The natural response of stretched strings to moving air generates a series of matched harmonics (see below) so that a properly designed aeolian harp capriciously produces a haunting and mysterious sequence of melodious notes and chords at low intensity.[3] With the eclipse of Greek civilisation the instrument was forgotten, but was rediscovered and publicised by the remarkable polymath Athanasius Kircher at the beginning of the 17th century.[4,5]

Fig.1. Prototype of a horizontal garden dial incorporating an Aeolian harp.

The design of the aeolian harp was improved in the 19th century by a number of Continental makers of musical instruments,[6] and a number of designs were evolved.[7] It is currently enjoying a modest revival, and is most often seen today as a rectangular box about 36 inches long, 6 inches wide and 3 inches deep. The top is of thin pine and acts as a sound board, so that (with the addition of a sound hole) the enclosure acts as a sound-box to amplify the notes generated by a number of fairly heavy lightly-tensioned strings held across two hardwood bridges resting on the sound board. Many beautiful aeolian harps are offered for sale on the Web: for example by Robert Corrigan[8] in the USA. It is intended that instruments of this form be positioned in the draught created at the bottom of a partially-opened sash window, or held in a sliding door. Orientation is not important, so long as a current of air is directed over the strings by the funnel formed between the soundboard and a sloped covering panel. It will be obvious that elegant instruments of this type are not intended for long-term outdoor exposure.

Theory of the Aeolian Harp

The noises of the wind are everywhere, being generated whenever it blows through trees and hedges or (giving purer tones) over telephone wires. Towards the end of the 19th century, when great scientists were not obliged by sheer weight of information to be specialists in a single field, we find Lord Rayleigh[9] investigating these 'aeolian tones'. It might be thought that a stream of air meeting a cylindrical wire or rod would simply divide and then join up again, perhaps leaving a little 'backwater' just ahead of the obstacle. Rayleigh used light reflected from a tiny silvered bead to study the airstream moving over a stretched string positioned across his fireplace, and showed that what happens is much more complex and interesting. Little whirlwinds are formed in the air, first on one side of the cylinder and then on the other, and these are shed in such a way that they pass along with the wind in a double series, those on one side spinning one way, those on the other in the opposite direction. This phenomenon is so important to the theory of flight – and aerodynamics in general – that these 'streets' of eddies are nowadays more generally known as von Kármán vortices after a pioneering aerodynamicist.[10]

Every time this alternation of flow from one side to the other occurs an impulse is given to the surrounding air and a wave is propagated. If many pulses arrive at our ears at regular intervals, and are in a suitable frequency range, we hear a sound of definite pitch. Rayleigh showed the alternating pulses also cause the obstacle itself to rock from side to side perpendicular to the direction of the generating airstream. The phenomenon is not limited to strings and wires: something as massive as a flagpole can behave in this manner in a strong wind, and in the fluttering of the flag we can almost see the whirls chasing each other down the sides.[11] A stick moved through water may be seen to shed alternating vortices in the same way.

However, regular vortices form only when the ratio of the flow speed of the air to the diameter of the cylinder falls within a certain range. When the air is moving very slowly the flow becomes laminar, and vortices do not form. Too fast, and the current becomes turbulent and irregular. Working in the 19th century, Strouhal found the relationship:

$$f = 0.185\ v/d$$

where f denotes frequency in cycles/second (nowadays written Hz),
v denotes velocity of wind in cm/sec,
d denotes diameter of the wire in cm.

The constant of proportionality is called the Strouhal number.

Resonance

Opposed pairs of von Kármán vortices are generated by the lip of a whistle or organ pipe when a controlled stream of air is directed upon it. If their frequency matches that of the integral pipe then the note is reinforced and the pipe sounds out strongly.[11,12] Pipe and lip tone are said to be in 'resonance'.

Stringed musical instruments do not normally employ a closely matched resonator: instead they incorporate a light but strong wooden *soundbox* of size and shape that experience has shown to give a broad and pleasing response with moderate amplification across the frequency range. It achieves this by coupling the small area of a vibrating string to a much larger area of a thin, rigid material, and thence to a comparatively large volume of air. It is usually made with at least one side of thin fir to act as the soundboard, and the strings are coupled to it by a notched wooden strut known as a *bridge*. The violin family are normally fitted with a *sound post* beneath the bridge, both to help support it and to conduct additional sound to the opposite wall of the soundbox, the face of which is perforated by two mirror-image *f-holes.*

The aeolian harp incorporates a soundbox of this nature, but the strings are usually stretched across two bridges and a single circular sound-hole is conventionally placed at the centre. A string reacts particularly strongly if the rate of vortex shedding controlled by the Strouhal formula matches (or is an integral ratio of) its 'mechanical' frequency controlled by length, mass and tension. Of course, the energy put into a string by a current of air is only a fraction of that generated by plucking or bowing, so an aeolian harp must be expected to be quite soft.

Harmonics of Stretched Strings

Pythagoras (572-497 B.C.) is credited with the first recorded acoustic experiments. He showed that the lowest note emitted by a stretched string – the *fundamental* or *first harmonic* – is in harmony with the higher note emitted when the vibrating string is clamped by a movable bridge or a fingertip placed at its centre, thereby dividing it into two equal parts. The ratio of the two lengths involved is exactly 2:1, and holds independently of the frequency ('key') to which the undivided string is originally set. Pythagoras found that dividing the string into other whole-number parts gave further harmonious notes, and that 2,3,4,5,6,7 and 8 equal divisions were sufficient to produce the range of notes used in the music of his time. The eight notes gave rise to the name *octave* for the interval, a name we still use today.

Little was added in the centuries following Pythagoras, the next significant advance being made by the astronomer Galileo. (He was both the son of a professional musician and a very capable luthier himself.) Galileo, and independently Mersenne, showed that the fundamental frequency of a stretched string is given by:

$$f = \frac{n}{2}\frac{1}{l}\sqrt{\frac{t}{m}}$$

where f denotes its frequency in cycles/second, or Hertz (Hz)
l denotes its length in centimetres
t denotes its tension (grams × 981 to give force)
m denotes its mass per unit length in grams per cm
n is an integral whole number 1, 2, 3 . . . .

Contemporary Tuning

Unfortunately, simple whole-number relationships between notes cause problems when musicians wish to play in different keys with instruments (e.g. the piano) tuned beforehand to a given key.[12,13] Playing certain notes and chords together then causes dissonance and beats, so from the 18th century western music has settled on 12 notes in the octave all tuned to intervals of the same ratio (the twelfth root of two). Apart from the octaves, the strict Pythagorean relationships have been sacrificed.

Wind Tones

It was observed by the Greeks that, unlike plucking or bowing, the wind blowing over a stretched string tends to excite the higher harmonics (overtones) rather than the fundamental. So, independently of the basic frequency, these would be simple Pythagorian whole-number ratios that generally sound harmoniously together. However, the rarely heard 7- and 9-fold harmonics might also be excited at a low intensity, adding to the 'strange' quality of the sound. The secret of a melodious aeolian harp is then to have strings of equal length but varying diameter (controlling mass per unit length) and then adjust their tension until on plucking or bowing all sound the same chosen note – or (for the thickest strings) the octave below. The strings should be long, heavy and not too tight, for the aeolian tones will always be higher, and highly tensioned strings are both hard for the wind to excite and could break a lightly constructed soundbox. Intensity will never be high, but may be augmented by having several similar strings. It has been recommended[13] that such a pair should not be arranged side-by-side, for it is possible for such a combination to vibrate in anti-phase and so reduce the net emission of sound.

It will be appreciated that it is perfectly possible to build an instrument embodying strings of varying length, just as in a conventional harp. It will sometimes play sweetly – but can also generate discordant shrieks! Such an instrument is best called a 'wind harp', reserving the term aeolian for a design with strings of equal length.

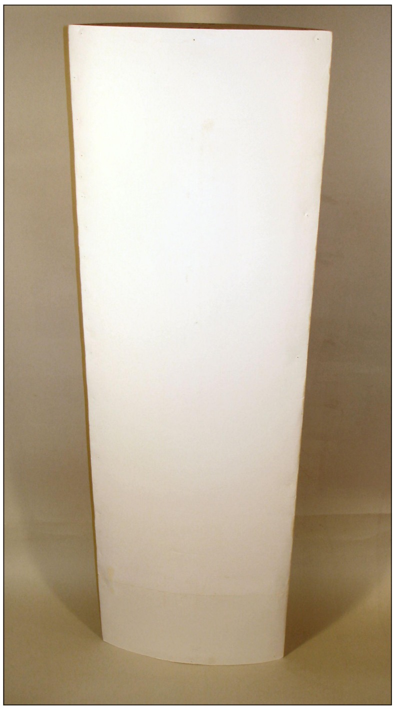

Fig. 3 (above). Interior of a soundbox, showing support for bridge

Fig. 4 (left). One of the soundboxes.

Prototypes

It is wise when proposing any new instrument to first construct a prototype from relatively inexpensive materials. The good sense of this approach was proved by the first sundial/aeolian harp to be made. Based on the usual rectangular pattern with wires between nearby sloping vertical panels, it took a gale to make it sound! This suggested the need for a design incorporating a curved venturi to capture, guide and concentrate any breeze, smoothly funnelling it over a set of wires held in its narrowest part – the 'throat' of the venturi. The first model also demonstrated the need for a large and efficient soundbox with a membrane coupled to the vibrating strings.

A VENTURI-TYPE AEOLIAN SUNDIAL

A sundial employing a vertical aeolian harp to support a horizontal dial is shown in Fig. 1. As an untried venturi design, it was made from inexpensive materials that allowed practical testing although unsuitable for long-term exposure outdoors.

The Soundboxes

Four pieces of ¾ inch chipboard were cut to the outlines shown in Fig. 2. It will be seen that when the more steeply curved portions are arranged to face each other over a small gap they define a two-dimensional venturi section. The opposite edges were given a shallower curve, for the sake of appearance, strength, and a slightly greater interior volume in the final soundbox. These end-pieces were held 38 inches apart by four glued and screwed softwood struts. Those at the sharp edges were planed lengthwise to coincide with the curves, but the two at the broad edges were simply set back ⅛ inch to clear the soundboards, as indicated in Fig. 2. The result is shown in Fig. 3, where it will be seen that a protruding plywood support was inserted 1.5 inches from the top to resist the downwards thrust of the strings on the bridge which will later be placed here: a similar support was placed towards the base of the structure.

The two wooden carcases were covered with a dense white cardboard available at stationers as 'Dalerboard' mounting board. It was sprayed with water to temporarily increase its flexibility, then secured with white glue and brads across each side so as to meet at the sharp edges. Upon drying, it shrank to give a taut, resonant diaphragm that could be trimmed exactly to size. A layer of medium-weight wall-lining paper completed the two soundboxes (Fig. 4). Matching *f*-type soundholes were subsequently cut in the shallower outer faces, the central strut precluding a circular aperture.

Bridges and Strings

Four 0.25 inch high bridges were cut from beech to match the curve of the soundboard, as well as having a tapering

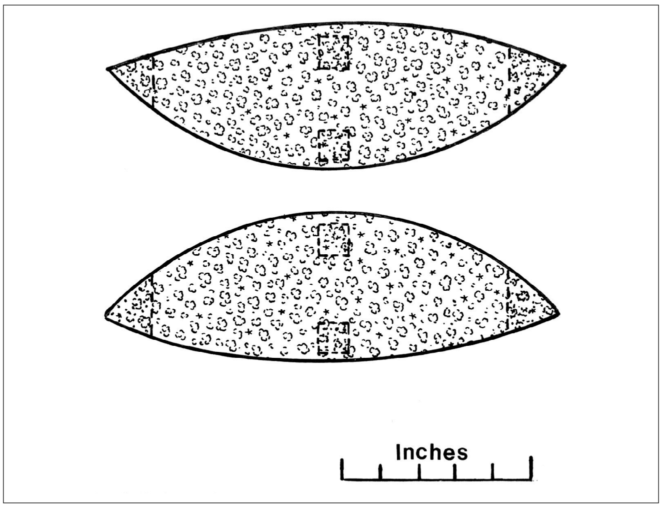

Fig.2. End-pieces of the soundboxes.

Fig.5. Soundbox with tensioned brass strings.

triangular section. Notches for four strings were filed 0.5 inches apart (Fig. 5), while the opposite bridge was given three notches between these points. This allowed the two sets of strings to rest side-by-side when the two soundboxes were subsequently fixed opposite one another. Fig. 5 also shows how the strings were held and tensioned by brass woodscrews positioned within a recess cut into matching end-plates. Cross-holes were drilled into the plain portions of the shanks of the screws to enable the strings to be threaded through. (Square-topped zither pins might be used in a final model.)

Strings for violins and guitars are too short, while those sold for orchestral harps are extraordinarily expensive. The most practical material I have found is hard-drawn brass wire, available as a packaged set of five sizes (0.4, 0.6, 0.8, 1.0 and 1.25 mm diameter) from the Scientific Wire Company.[14] Various gauges were fitted as shown in Fig. 5, and attempts made to tune them all to the same low fundamental. (The enamelled copper wire used for electronic circuits is not suitable; being soft, it will stretch and relax if put under tension.)

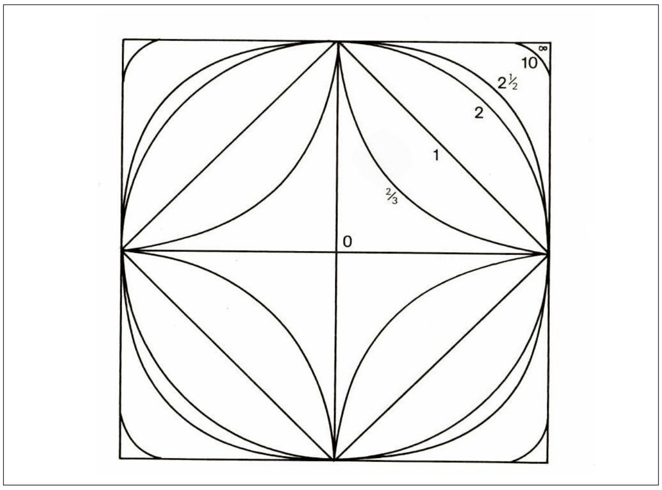

Fig. 6. A 'classic' ellipse with n=2 bounded by sub- and super-ellipses.

Entablature and Base: the 'Super-Ellipse'

The two soundboxes are to be held facing one another at a minimum distance of 0.5 inches to form a venturi with the tensioned strings at its narrowest point. The outline of the ends of the resulting structure falls within a rectangle 14 × 7 inches, and a piece of thick chipboard could have been cut to this shape to act as the linking entablature. However, the shape known as a *super-ellipse* was thought to be preferable in this situation, mediating harmoniously between the curved sides of the soundboxes and the proposed circular sundial.

To understand the super-ellipse we must first note that the ordinary ellipse[15] is but one member of a family of closed curves obeying the following general formula:

$$\frac{x^n}{a^n} + \frac{y^n}{b^n} = 1$$

where '*a*' and '*b*' are arbitrary constants that represent the two semi-axes of the curve and '*n*' is any positive number. When $n = 2$ the equation is that of a classic ellipse with its centre at the origin of the two coordinates (Fig. 6). However, it is less generally known that as *n* decreases from 2 towards 1 the resulting curves become more pointed at the ends: the Danish designer Piet Hein[16] called them '*sub-ellipses'*. If *n* increases above 2 the classic ellipse develops flatter and flatter sides, becoming more like a rectangle (Fig. 6). Hein named these curves '*super-ellipses'.* That with $n = 2.5$ defines a shape that is satisfyingly intermediate between the ellipse and the rectangle – or circle and square when $a = b$. This curve has been enthusiastically adopted in many modern Scandinavian designs from furniture to traffic islands, and has already been featured in the *Bulletin* by Andrew James.[17] The first quadrant of the super-ellipse falling within a 14 × 7 inches rectangle was calculated from:

$$\frac{x^{2.5}}{7^{2.5}} + \frac{y^{2.5}}{3.5^{2.5}} = 1$$

using a scientific pocket calculator. It was then plotted on inch graph paper and its tracing used to sketch in the remaining quadrants, inverting the pattern when necessary. A pair of the resulting shapes was cut from chipboard and used at both top and bottom to secure the soundboxes 0.5 inches apart.

A substantial base was made by cutting and superimposing two larger super-ellipses from the thick chipboard. As all ellipses of the same exponent nest one within another, all that was required to mark them out was to draw appropriately adjusted dividers around the perimeter of the entablature super-ellipse.

The Celtic Harp Sundial

A conventional horizontal dial 9 inches in diameter was laid out by well-known methods[18] for my home latitude of 52.5° N. The stile is commonly supported from below at the lati-

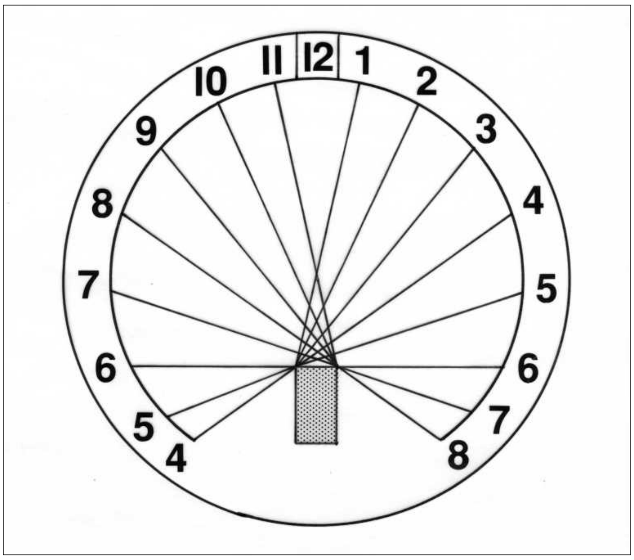

Fig.7. Pattern of hour lines for a horizontal dial at 52° N with an overhanging gnomon, shown here with an exaggerated thickness.

tude angle, so as to point upwards at the northern celestial pole and give the familiar triangular gnomon. However, although the *stile* must always point in this direction in the northern hemisphere, there is no reason why it must be supported from below. In the present dial it was desired to employ the stylized silhouette of a Celtic harp as the gnomon, with the straight edge of its soundbox forming the stile. The hour angles are exactly the same, but the origins of the corresponding hour lines for an overhanging gnomon of finite thickness differ from the conventional diagram shown in ref. 18, p.41. The pattern for such a gnomon is shown in Fig.7: note how the shadow-casting edge changes below the 6 – 6 line. A view of the dial used with the prototype aeolian harp sundial is shown in Fig. 8.

Performance and Improvements

The card and paper soundboard of the prototype looked fine to my eyes, but its soft and absorbent nature made it a poor resonator, much too heavily damped to effectively amplify the low intensity of sound from windblown strings. Probably, too, the bridge supports could be omitted in a design made from metal sheet. It has been found that the solid nylon monofilament sold as 'strimmer cord' in diameters of 1.3 and 1.5 mm (and more) may be preferable to brass wire.

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An aeolian harp/sundial intended for permanent installation in a garden must, of course, be constructed from more durable materials than the above prototype. It is thought that copper sheet (as used for roofing) and Canadian Douglas fir plywood might make a good combination but – alas – increasing arthritis makes it unlikely that I shall be able to accomplish this. I would, of course, be pleased to advise anyone contemplating such a project, and would begin by recommending that arrangements be made for tuning the harp without the extensive dismantling required by the above design. Holes drilled through a larger end-piece at the upper end might allow the strings to be brought through to fixing/tuning screws hidden within a cutout space in the entablature. This would facilitate direct tuning so that

Fig. 8. Entablature: a super-ellipse of exponent 2.5 supporting the 'Celtic harp' sundial.

Strouhal numbers of strings matched the velocity of an average breeze through the instrument.

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A VERTICAL SOUTH SUNDIAL INDICATING THE EQUATION OF TIME AND ITS TERMS

ORTWIN FEUSTEL

Two recurring astronomical phenomena cause the difference between Local Apparent Time (LAT) and Local Mean Time (LMT): first, the velocity of the earth along its elliptical orbit is not uniform (resulting from Kepler's second law) and second, the sun's right ascension does not change at a constant rate, because the sun apparently moves along the ecliptic, not the equator (resulting from the projection of the orbital motion onto the equator). Therefore, the Equation of Time (EoT) results in the superposition of a 'Kepler' term with an all the year round period and an 'ecliptic' term with a half-year period. Following the definitions for the anomalistic[1] and the tropical[2] year, we will use 'anomalistic term' for the Kepler term related to the apsides (perihelion and aphelion) and 'tropical term' for the ecliptic term related to the vernal point.

The sundial described in this paper and shown in Fig. 1 indicates, in addition to the EoT as a figure-of-eight curve, the curves of the anomalistic and tropical terms integrated into the 10:00 and 14:00 CET (Central European Time) hour lines, respectively. Hence it is possible to read, from the shadow of a small spherical nodus, the effects of Kepler's second law and the obliquity of the ecliptic on sundial time at any given instant.

The EoT and Its Terms as a Function of Time

The formulae used in this and the following sections are extracted from Refs. 3 and 4. The function int(x) delivers the largest integer number $\leq x$. The function int(x, y) delivers the remainder of x divided by y; the result has the same sign as x.

To calculate the time-varying EoT values, it is necessary to convert the date to a time T in Julian centuries (36525 days) from the standard epoch J2000.0[5]

$$T = \frac{JD0 + N - 2451545.0}{36525} \tag{1}$$

The Julian Day number[6] $JD0$ corresponds to January 0.0 of a given calendar year Y and N represents the count of days (1 to 365) from the beginning of this year. For a given year in the Gregorian[7] calendar, $JD0$ can be calculated as follows

$$JD0 = \mathrm{int}(365.25 \cdot (Y-1)) - A + \mathrm{int}(\frac{A}{4}) + 1721424.5 \tag{2}$$

with the intermediate quantity

$$A = \mathrm{int}\left(\frac{Y-1}{100}\right) \tag{3}$$

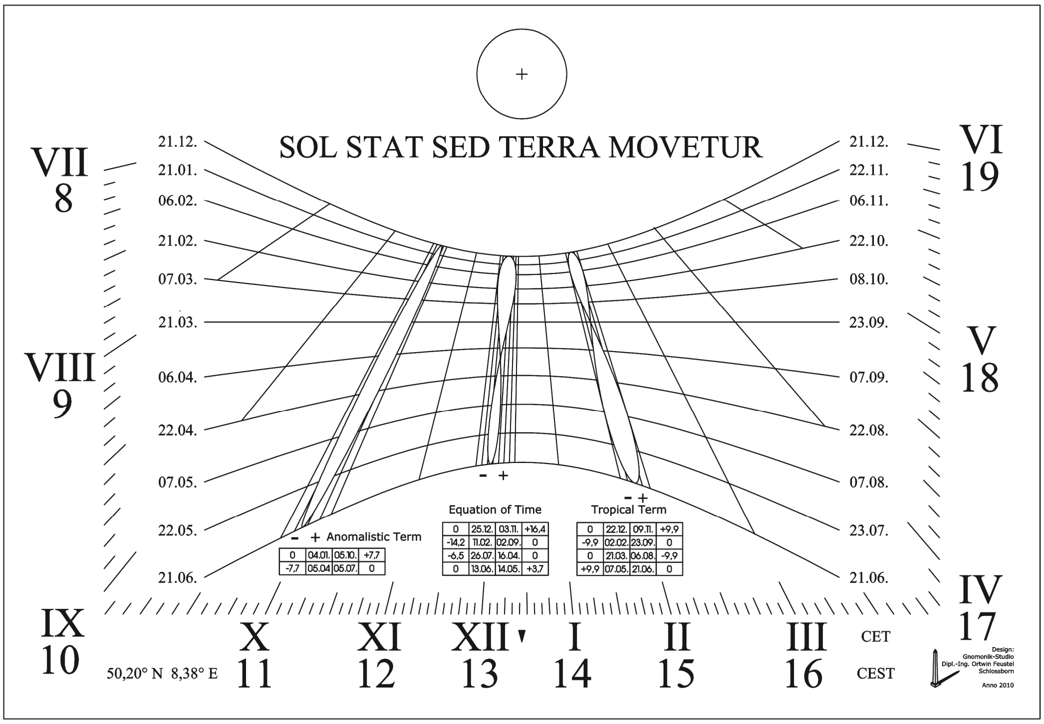

Fig. 1. The face of a vertical sundial with correction of local time, eleven declination lines, CET and CEST time scale, the Equation of Time as a figure-of-eight curve, the anomalistic EoT term as an ellipse, the tropical EoT term as a lemniscate, three tables for the zero and extreme values of the EoT as well as their terms, with a triangle indicating the true culmination of the sun. The plate measures 980 mm × 675 mm. The polar-pointing gnomon would be fixed at the small cross of the circle's centre.

Examples for $JD0$ are:

Y	2010	2011	2012	2013
$JD0$	2455196.5	2455615.5	2455926.5	2456292.5

Equation (1) then gives L , the mean longitude[8],

$$L = \mathrm{mod}(280.46 + 36000.770\,T, 360) \qquad (4)$$

and G, the mean anomaly[9]

$$G = \mathrm{mod}(357.528 + 35999.050\,T, 360) \qquad (5)$$

These values combine to give Λ, the ecliptic longitude[10]

$$\Lambda = L + 1.915 \sin G + 0.020 \sin 2G \qquad (6)$$

$(L - \Lambda)$ represents the anomalistic EoT term, expressed in minutes,

$$EoTa = 4(-1.915 \sin G - 0.020 \sin 2G) \qquad (7)$$

Using the values of Eqn. (6), the tropical EoT term (also expressed in minutes) is

$$EoTt = 4(2.466 \sin 2\Lambda - 0.053 \sin 4\Lambda) \qquad (8)$$

The sum of (7) and (8) yields the Equation of Time

$$EoT = EoTa + EoTt \qquad (9)$$

The graphical representation of (7) to (9) as a function of the day number, N, is shown in Fig. 2.

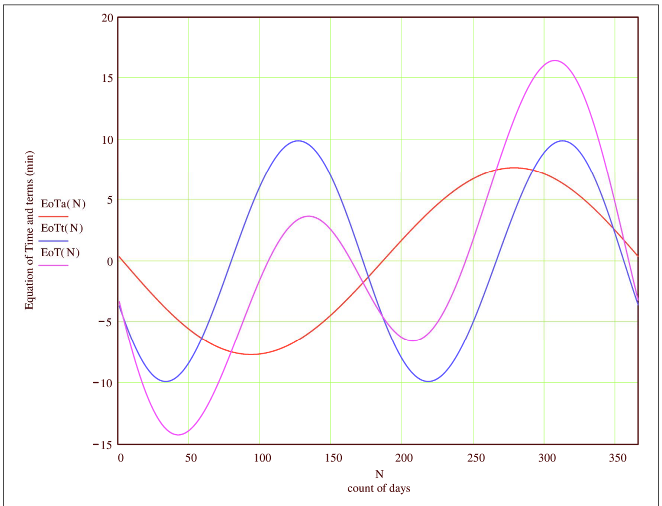

Fig. 2. The Equation of Time EoT(N) results from the superposition of the anomalistic term EoTa(N) and the tropical term EoTt(N). These two sine-shaped term curves are phase-shifted and have different amplitudes; the anomalistic term's duration of period is about twice the tropical term's duration of period. The calculations refer to the year 2010.

The EoT and its terms as a Function of the Sun's Dec^n

Representing the curved lines of the Equation of Time and its terms on a dial face requires the sun's declination δ as a function of the obliquity of the ecliptic ε and the ecliptic longitude Λ

$$\delta = \arcsin(\sin \varepsilon \sin \Lambda) \qquad (10)$$

The obliquity of the ecliptic is given by

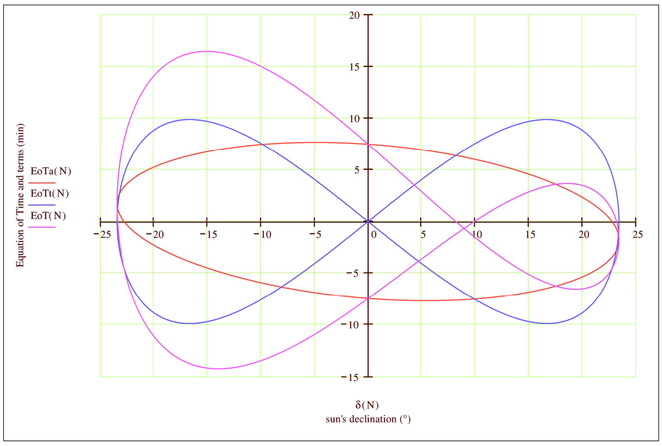

Fig. 3. Graphical representation of the Equation of Time as well as the anomalistic and tropical terms as functions of the sun's declination in 2010.

$$\varepsilon = 23.4393 - 0.01300\,T \qquad (11)$$

and the ecliptic longitude refers to Eqn. (6).

The Equation of Time and its terms shown in Fig. 3 have been calculated using Eqn. (1) to (11). The shapes are a figure-of-eight curve, an ellipse and a lemniscate for the functions $EoT = f(\delta)$, $EoTa = f(\delta)$, and $EoTt = f(\delta)$, respectively. It should be noted that the 'waist' of the analemmic curve is not situated on the axis of abscissa and that the axes of the ellipse do not align with the coordinate axes.

Date Dependence of the Characteristic Values

To provide a quick overview, the zero and extreme values (in minutes) of the Equation of Time and its terms are arranged on the dial face (see Fig. 1) in three small tables below the summer solstice line corresponding with positions of values along the curves. These values are listed too in chronical order in Table 1. The particular dates, day numbers and time values are rounded up; therefore they can vary slightly from year to year, especially around leap years.

The earth takes 182 days to pass from perihelion (nearest to sun on January 4) to aphelion (furthest to sun on July 5) and 183 days from aphelion back to perihelion. From Kepler's second law, the orbital velocity reaches its maximum at perihelion and its minimum at aphelion: the periodic function of the anomalistic term has its zeroes at these two points. At the equinoctial points (equinoxes on March 21 and September 23), where the ecliptic interesects the celestial equator, the sun is on the equator. At the solstitial points (solstices on June 21 and December 22) the sun comes to a 'standstill': at these four instants the periodic function of the tropical term has its four zero points. These four half periods have different lengths; the 'warm' season has a duration of 186 days and the 'cold' season is 179 days.

The zero points of the terms do not coincide because the line of apsides (the line connecting perihelion and aphelion) and the line of solstices (the line between the summer and

date 2010	*N* count	half period	half period	Δ apsides solstices	*EoTa* min.	*EoT* min.	*EoTt* min.	comment
04.01.	4				0			perihelion
02.02.	33						-9.9	first minimum
11.02.	42					-14.2		main minimum
21.03.	80						0	vernal equinox
04.04.	94				-7.7			minimum
16.04.	106	182				0		first zero point
07.05.	127		92				+9.9	first maximum
14.05.	134					+3.7		secondary maximum
13.06.	164					0		second zero point
21.06.	172			14			0	summer solstice
05.07.	186				0			aphelion
26.07.	207					-6.5		secondary minimum
06.08.	218		94				-9.9	second minimum
02.09.	245					0		third zero point
23.09.	266						0	autumnual equinox
06.10.	279	183			+7.7			maximum
03.11.	307		90			+16.4		main maximum
09.11.	313						+9.9	second maximum
22.12.	356						0	winter solstice
25.12.	359			13		0		fourth zero point
04.01.	4		89		0			perihelion
21.03.	80						0	vernal equinox

Table 1. Key dates in 2010.

Note: Fig. 4 shows that, in the year 1246, the apside line and solstice line coincided.

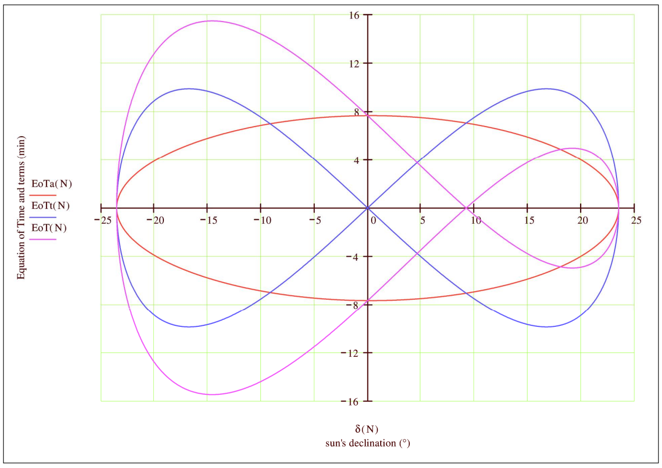

Fig. 4. The calculations of Equation of Time, anomalistic ellipse and tropical lemniscate with Eqn. (1) and (4) to (9) refer to the year 1246;[11] all curves are exactly symmetrical with respect to the abscissa.

winter solstices) do not coincide: this results in the different lengths of the seasons. The time between the summer solstice and aphelion amounts to 14 days and the time between winter solstice and perihelion is 13 days.

CET/CEST Scale

The time scale of the dial is marked CET and CEST, symbolizing the zone time which is applicable. It does not mean correct time since the Equation of Time has to be taken into consideration. Supplementing the sundial's indicated time with the actual EoT value gives standard time CET/CEST = sundial reading - EoT value.

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1. Anomalistic year: time interval between two transits of the earth through the perihelion.
2. Tropical year: time interval between two transits of the mean sun through the vernal point.
3. B.D. Yallop, C.Y. Hohenkerk: *Astronomical Phenomena. Explanatory Supplement to the Astronomical Almanac*, edited by P. Kennet Seidelmann. University Science Books, Sausalito, CA, (1992).
4. J. Meeus: *Astronomical Algorithms*, 2nd edition. Willmann-Bell, Inc., Richmond, Virginia, (2000).
5. J2000.0: abbrevation for JD 2451545.0 corresponding to 1 January 2000, 12:00 UT.
6. Julian Day number *JD*: continuous count of days and fractions thereof from 1 January 4713 B.C., 12:00 UT; this method of counting, usual in astronomy, was suggested in 1581 by Joseph Justus Scaliger (1540-1609), a French scholar. The Julian Day regularly begins at 12:00 UT.
7. Until 4 October 1582, the Julian calendar was valid. The Gregorian calendar is taken into account since 1582 October 15. England has introduced the Gregorian calendar only two centuries later.
8. Mean longitude *L*: angular distance from the vernal equinox if the earth moved with a uniform velocity in a circular orbit in the plane of the celestial equator around the sun.
9. Mean anomaly *G*: angular distance from the perihelion if the earth moved with a uniform velocity at a circular orbit in the celestial equator plane around the sun.
10. Ecliptic longitude Λ: angular distance from the vernal equinox at the ecliptic measured eastward in the direction of the annual circulation around the sun.
11. For a Julian year: $JD0 = \text{int}(365.25\,(Y + 4715)) + \text{int}(14\times30.6001) - 1524.5$; $Y = 1246$ yields the value $JD0 = 2176158.5$.

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GLEMHAM HALL SUNDIALS

JOHN DAVIS

Glemham Hall, near Little Glemham in Suffolk, is an elegant red-brick Elizabethan mansion which has some intriguing sundial connections. It originally belonged to the Glemham family. Sir Thomas Glemham earned a reputation as a stubborn fighter in the Civil War and eventually died fighting in Scotland in 1648. The Glemham family retained the estate until 1708/9, when it was sold to Dudley North, the son of the second Baron Guildford, a City of London magnate. North's wife, Catherine, was the eldest daughter of Elihu Yale, founder of the famous American university college. North set about refurbishing Glemham with a grand Georgian front and suitably lavish furnishings, some of which have since been purchased by Yale College. When the male line of the Norths eventually died out in 1829, Glemham Hall was passed to the 8th Earl of Guildford before it was sold to the Cobbold family (famous for the Tolly Cobbold brewery) in the 1920s. It still belongs to a branch of the Cobbolds.

The Horizontal Dial

A small, unsigned horizontal dial in the walled garden (Figs. 1a,b) probably dates to about Sir Thomas Glemham's occupancy of the Hall. Although simple and with a broken gnomon, it is carefully inset into the capital of an ancient pedestal which appears to be constructed of two smaller pedestals on top of each other. The dial features the inward-facing Roman numerals to be expected of the 17th century and has the origin of delineation offset from the centre of the plate towards the south, showing that it is not from the very beginning of that century. It is delineated to quarter-hours and has a gnomon gap, not always seen on small, early dials. In fact, the two origins of delineation are very clearly shown by two small holes at the 'toe' of the gnomon. These indicate that some form of template was probably used to lay out the dial. The dialplate is in remarkably good condition with only a light greenish patina. If it is assumed that the dial has been in position for all its life, this would be a testament to the clean Suffolk air.

The Vertical Dial

The south side of the house has a large painted dial on a rendered panel (?) in the brickwork (Fig. 2). The inscription at the top reads "D·N 1769". The D·N stands for Dudley North (not Day and Night, as the current owner is apt to tell some gullible visitors!) but it is unclear to which of three generations of that name it refers. It must have been repainted several times since its installation, as shown by the fact that the gnomon origin is now slightly too high for the hourlines even though there is a spot between the D and the N for it. It is a remarkably slender gnomon which could well be original. One other uncommon feature of the dial is that the numerals are painted to align along the hourlines.

Fig. 1a, b. The early horizontal dial at Glemham Hall.

Fig. 2. Left—the south front of Glemham Hall with the vertical dial and mysterious circular marking on the brickwork. Right—close-up of the dial inscribed "D • N 1769".

Above the window to the right of the dial is a circular mark on the brickwork of the façade. Clearly something has been attached to the wall at some earlier time. Whether this was an earlier dial or, perhaps, an heraldic plaque is not known.

The Elihu Yale Connection

Elihu Yale (1649-1721) was born in Boston, Mass., but he returned to England with his parents when only 3 years old. He never returned to America but joined the British East India Company, eventually became the Governor of Madras and amassed a private fortune. He was generous to both family and friends: a donation led to the building of Yale College in the USA. Many items of furniture at Glemham Hall came from him, either directly or through his daughter. These include some tapestries which went to Yale College in the 20th century.

The most important Glemham Hall dial is sometimes known as "Elihu Yale's sundial" although the exact connection is unconfirmed and the whereabouts of the dial are currently unknown. It featured in an article on Glemham Hall in Country Life in 1910[1] and a very similar picture (probably taken by the same photographer on the same day) appears as a contemporary postcard (Figs. 3 & 4). The dial is mounted on one of the famous John Nost lead figures, this one called the 'Old Blackamoor' by Roger Bowling in his articles[2] on these 'sundial supporters'. Thus the dial dates from the early 18th century and is contemporary with Yale and the period when Dudley North was improving the Hall.

As an aside, another version (SRN 3802) of this figure is shown as fig. 1 of reference 2 and is known to be in Wiltshire. This 'Wiltshire' Blackamoor supporter was previously at Hampton Court Palace and it now supports a dial by Daniel Delander with arms for John, the 1st Duke of Marlborough.

The Glemham Blackamoor seems to have found its way to Jonathan Edwards College at Yale University not long after the Country Life photograph. The evidence for this is another postcard, now in the possession of Fred Sawyer, of the dial in the courtyard at the College (Fig. 5). Although this postcard is undated, its general style suggests that it is from the 1920s or '30s, about the time that the Earl of Guildford was selling the Hall to the Cobbolds. Fred Sawyer reports that he never saw the dial in the time that he was at the University and that enquiries to the Master of Jonathan Edwards College drew a blank. This is most disap-

Fig. 3 (above). Picture of a Van Nost dial supporter at Glemham Hall, from Country Life, 1910.

Fig. 4 (below). A postcard of the dial in Fig. 3, probably from a photograph at the same date.

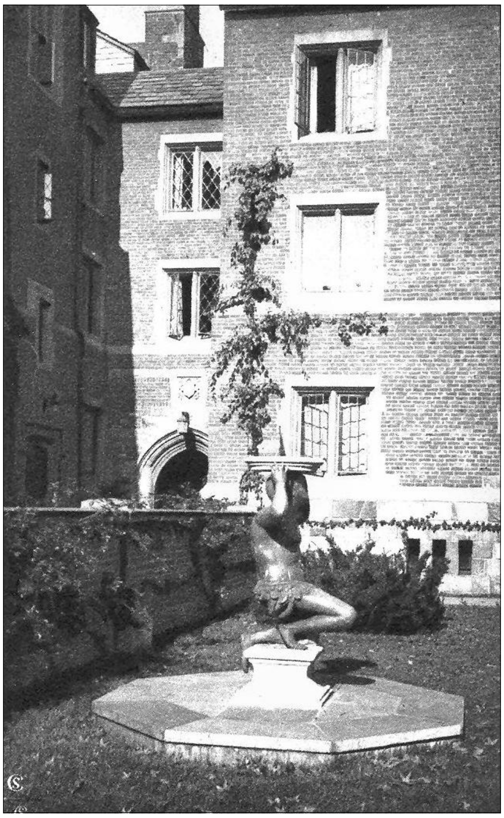

Fig. 5. An Americal post-card of the dial in the courtyard of Jonathan Edwards College, Yale University. It is believed that this is the dial which was originally at Glemham Hall.
Courtesy F. Sawyer.

Fig. 6. Advertisement by T. Crowther & Son Ltd from Country Life (2 November 1972). It shows a different Van Nost figure (note the position of the right hand) but carrying a dial with a comparable gnomon.
Courtesy R. Crowther.

Fig. 7. A modern dial at Glemham Hall. Ignore the lead dial and concentrate on the 'Three Graces' pedestal.

pointing because it is a large and important piece: a close examination would reveal details of the actual dial. It is to be hoped that it will resurface at some time – it is too big to lose and surely no-one would melt it down for its lead.

Very little can be seen of the dialplate of the 'Elihu Yale' dial in the available pictures. It is apparent that the gnomon is large and finely pierced. The other known Van Nost pedestals[2] support dials by a number of different makers so it is not possible to speculate who made the 'Yale' dial. Very confusingly, another of the Blackamoor series was sold in 1972 from Hampton Court Leominster (not the Palace) with a dial by "David Muir, London"[3] As can be seen in Fig. 6, this is a different version of the supporter as the figure has his right hand underneath the plate holding the dial. But the rather elegant gnomon on this dial could possibly be in the same style as that on the Yale/Glemham version.

A Final Dial

There is one final dial at Glemham Hall (Fig. 7). This is a rather indifferent modern horizontal dial but it does have an interesting pedestal, of a 'Three Graces' design. A similar—though less revealing—Three Graces pedestal was offered by Francis Barker & Son in their 1907 sundial catalogue,[4] priced at 35 guineas in Portland stone. It is possible that the Glemham pedestal is a modern composite design – do readers know of other examples?

Acknowledgements

It is a pleasure to thank Fred Sawyer for his inputs on the Yale dial and permission to reproduce his postcard of it. Also, Richard Crowther kindly suppled the image of Fig. 6 and some valuable background material on the Van Nost pedestals.

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2. R. Bowling: 'Sundial Supporters Revisited', *BSS Bulletin*, 19(iii), p.125 (Sept 2007) and references therein.
3. Richard Crowther, private communication.
4. I am grateful to Mike Isaac for a copy of this catalogue.

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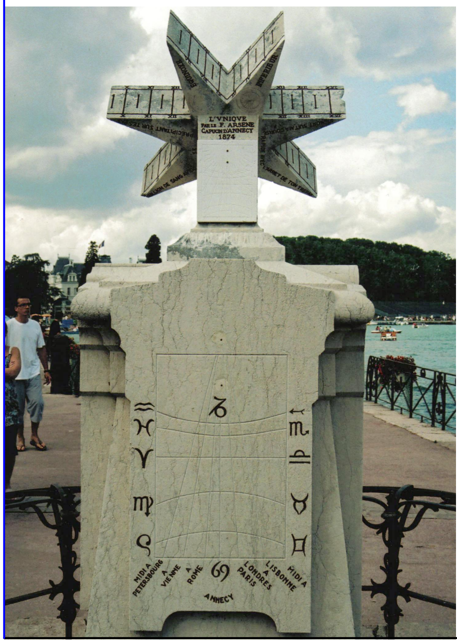
Postcard Potpourri 16 – Lake Annecy, France

Peter Ransom

This postcard features the impressive multiple dialled structure on the banks of Lake Annecy in the Haute-Savoie (74) *departement* of France. The card is dated 1908 and although there are some gnomons missing today, the railings around the structure are still present.

The dial is dated 1874 and it was named *L'Unique* on 22 July 1876. Frère Arsène (Jean-Marie Dumurgier, 1808-1879), a Capuchin monk, is credited with this dial. It features an equatorial dial on top of the 7-pointed star and each of the 'points' of the star acts as a gnomon on the dial plates engraved on the sides of the star. There are dials everywhere one looks: underneath the star for the winter months, on the block that supports the star and on the large pedestal itself. Annecy's local noon is 25 minutes before London and the large south-facing dial includes lines that show noon at St Petersbourg, Vienna, Rome, Paris and Lisbon as well as London and also includes the signs of the zodiac.



Further details about the dial can be found at http://annecymaville.over-blog.com/article-6949762.html or in the book *Cadrans Solaires des Pays de Savoie* by François Isler.

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A Felt Sundial

Of all the possible materials with which to make a sundial, woollen felt is one of the less likely. But, as we see here, it is possible. The dial was delineated for Moscow (56º N, 37.5º E, GMT +3 hr) by Alexei Kroutiakov with the actual design and construction by his sister Ann. With the help of a metal stiffener in the gnomon, it indicates accurate time with its minimalistic layout. How many other sundials would survive the washing machine?

ENGLISH MASS & SCRATCH DIAL PREVALENCE – A PRELIMINARY COMPARISON WITH FRANCE

CHRIS H.K. WILLIAMS

As we deepen our understanding of English dials a broader question beckons. Was England typical of, or different from, the rest of Europe? Hitherto there has been no substantive or authoritative answer. The root cause has been the relative paucity of Continental evidence. French mass dial listings, recently increasing by 150-200 a year, now constitute the first corpus of Continental evidence with the potentiality of rigorous statistical analysis. This article discusses the French database and undertakes a preliminary England–France comparison.

The former state of play was outlined in our earlier review of Continental mass dial listings.[1] It discounted the significance of England's domination (by two to one) of recorded dials. England is the first, and only, country to have been fully surveyed. Whereas English listings mirror (virtually) all survivals, Continental listings understate the true level by a large factor. The review also noted that the sheer geographical spread of mass dials across the length and breadth of Europe is consistent with their widespread and common usage as well as a shared common heritage. So although any 'England different' hypothesis could be confidently rejected, any 'England typical' hypothesis was, in reality, no more than suggestive and unproven. As will be seen, comparison of the English and French databases casts a new and most illuminating light.

To the end of 2008, some 1360 dials had been recorded on 836 French churches.[2] Unfortunately, in common with English practice, churches without mass dials have not been specifically recorded. This is a serious loss of information – as the true sample size is unknown and because churches without dials are just as important as those with. As a result, neither dial survival nor the survey rate can be estimated. Pending the retrieval of churches found not to have dials, the full potentiality of the French database cannot be realised.[3] As neither the timeliness nor completeness of any prospective retrieval can be guaranteed, the scale of the database is sufficient to warrant immediate – albeit frustratingly constrained and partial – analysis.

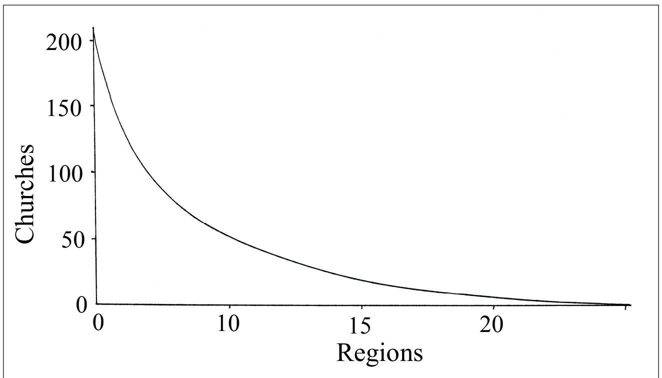

Fig. 1. French churches with listed mass dials in 2008.
Note: The distribution by department is flatter with a more elongated right hand tail (see also Ref. 4).

In order to maximise both the proportion of available data being used and the geographic coverage achieved, a regional, as opposed to departmental, segmentation was adopted.[4] There is a considerable variation in listing density (Fig. 1); a variation more reflective of varying survey rates than actual dial survival. In the current circumstances, it can only be a matter of judgement as to what constitutes a statistically-adequate listing. The top seven regions have been chosen for analysis.[5] Collectively, they provide a good 'representative' geographical coverage (Fig. 2).

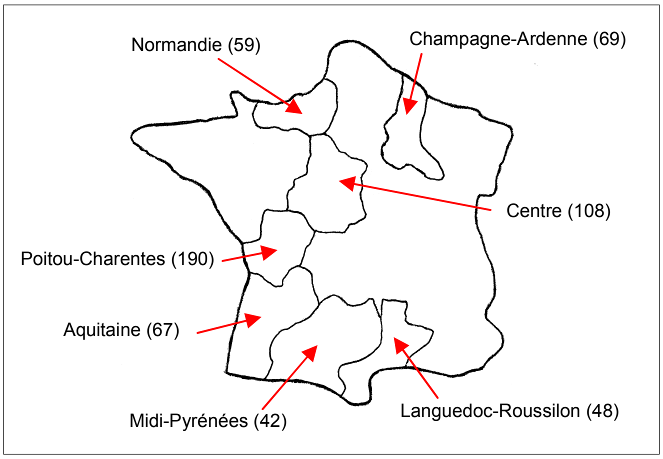

Fig. 2. French regions investigated.
Note: The number of churches with listed mass dials in 2008 are indicated parenthetically.

These regions listings are examined (Fig. 3) in the only currently feasible way – a frequency distribution for churches with dials. All the distributions have a similar profile. Variable sample size has no discernable impact. Most regions are almost identical to another. There can be no doubt that a deep underlying consistency and commonality is embedded in the listing data. Without the previously discussed enhancements to the database, we cannot take the statistical investigation of French mass dials any further. However, the full importance of this limited analysis goes

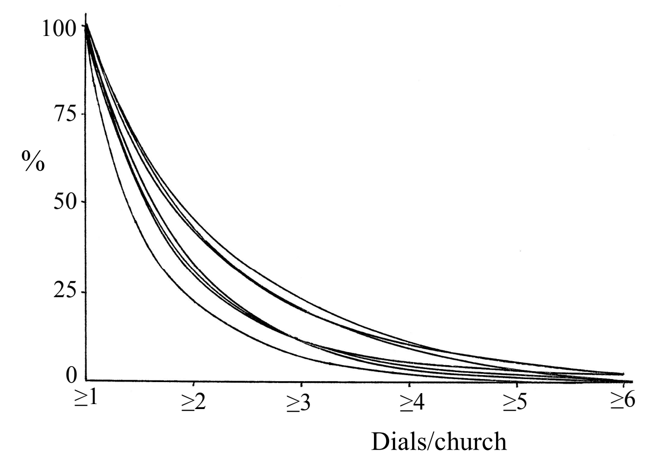

Fig. 3. French regional cumulative frequency distributions of dials per church for churches with mass dials.
Notes:
1. The distributions cover Fig. 2 churches and are truncated (at 1) because surveyed churches without dials have not been recorded (see main text).
2. The lower bound represents Aquitaine.
3. The central band represents Champagne-Ardenne, Languedoc-Roussillon and Normandie.
4. The upper band represents Centre, Poitou-Charentes and Midi-Pyrénées.

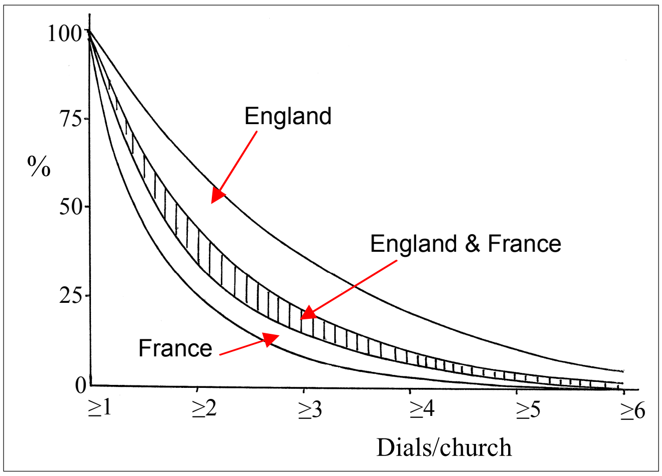

Fig. 4. England and France compared – cumulative frequency distributions of dials per church for churches with mass dials.
Notes:
1. The French 'crescent' comprises the upper and lower bounds shown in Fig. 3.
2. The English 'crescent' is definitionally identical to the French. (The full non-truncated English distributions are, of course, known.) It encompasses 80% of all counties, excluding those where dial loss is virtually absolute. Its upper and lower bounds indicate a post-1650 dial loss of 40 and 90% respectively.

beyond what it directly reveals about French dials to what is indirectly revealed by the data's similarity or otherwise to England's.

England and France are compared in Fig. 4. What do their 'crescents' tell us? Their similar profiles, adjacency and overlap indicate a broad underlying similarity in the pattern of surviving mass dials. Much of the two countries are identical – the regions of Poitou-Charentes, Centre and Midi-Pyrénées are the same as a third of English counties. Although the English 'crescent' has been constructed for comparative purposes, our analysis and understanding of the English database is orders of magnitude greater than that currently possible on the French. We therefore know the English 'crescent' is consistent with previous estimates of original dial prevalence and life cycle model parameters.[6] So Fig. 4's true significance is that, by implication, similar dynamic forces must have shaped France's dial prevalence – surviving and original. This is the first real evidence that English mass and scratch dial findings are of wider European significance.

It is worth exploring what 'are of wider European significance' might mean. Beginning with what it is not: it most definitely does not mean slavish replication of all the detail of our English findings. That would be absurd. We have previously established regional English variations in dial loss, perhaps also in original dial prevalence, and suspect their presence in dial displacement.[7] It would be a most extraordinary coincidence for this to be even approximated elsewhere. French 'crescent' regional variation overlaps, but is different. It is only to be expected that the mix of life cycle model parameters varies across the length and breadth of Europe.[8] The European significance of English findings applies not at the detailed, but at the fundamental and structural, level.

At the fundamental level the key point is the universality of mass dials; all churches once had them, most had several. This has been statistically proven for the English evidential period and the case made for earlier times.[9] This article indicates French dial survival to be consistent with it. If it holds for England and France, why not elsewhere? If it holds for the only two countries with 'adequate' data, surely the presumptive working hypothesis should, as we await the effective surveying of the Continent, be the universality and multiplicity of mass dials.

Turning to the structural level, the earlier emphasis on life cycle model parameter magnitudes varying geographically is without prejudice to the model's validity. Mass dial prevalence is only explicable in terms of the dynamic interplay of redundancy, displacement and loss. Returning to Fig. 4, the implication is fewer surviving French dials in the areas being compared. In the absence of any French parameter estimates we do not know why. It might be due to a higher rate of loss; or an earlier displacement reducing the accumulation of redundant dials; or a slower rate of redundancy; or any number of combinations (contributory and offsetting) thereof. The life cycle model is universally valid and applicable: its parameter magnitudes are case-specific and empirical. Currently, we only have English parameter estimates; without local corroboration their 'export' needs to be handled with care.

Attainment of a critical mass threshold in French listings heralds the commencement of substantive Continental investigation. This article's preliminary analysis points to a broad underlying similarity between the French and English databases. It thus appears our English findings – hitherto the only and for the foreseeable future the most comprehensive ones – gravitate towards the typical rather than different end of the spectrum, thereby assuming a wider European, rather than purely national, significance. It is hoped future French database enhancement will enable this article to be further developed. It must also remain a fervent hope viable data sets will accrue elsewhere on the Continent.

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2. Listings to 2007 are published in the 2008 *'Inventaire des cadrans canoniaux de la Commission des Cadrans Solaires',* Société Astronomique de France, (2009). Listings are by department. There is a brief description of location and appearance, but this article confines itself to prevalence. Listings in 2008 have been provided by Denis Schneider (personal communication).
3. See Chris H.K. Williams: 'The Geographical Distribution of Surviving English Scratch (Mass) Dials', *Bull BSS,* 20(ii), 75-6, (2008) for a fuller discussion of the implications of 'lost information' and its subsequent retrieval from individual recorders. It is hoped to undertake a similar exercise with French recorders.
4. With 20 regions rather than over 90 departments, small departmental listings are pooled into larger, statistically more meaningful, regional samples.
5. This draws the line at 42 churches. However, actual sample size is, because of the (unknown) number of surveyed churches without dials, somewhat higher – hopefully taking us to the point where the law of large numbers begins to bite. The seven regions account for 75% of all listings. A departmental approach on the same criterion would halve the data used.
6. The life cycle model has been the key to unlocking and understanding the evolution of dial prevalence – original and surviving. Dial prevalence is determined by the dynamic interplay of the model's parameters – redundancy, displacement and loss – all active in the mass dial era, only loss thereafter. See Chris H.K. Williams: 'The Life Cycle of English Scratch (Mass) Dials', *Bull BSS,* 20(iv), 164-5, (2008). For model parameter estimates see Chris H.K. Williams: 'The Prevalence of English Mass (Scratch) Dials c.1650 – Part 1' & 'The English Scratch and Mass Dial Era: The Evidential Period c.1250 to c.1650', *Bull BSS,* 21(ii) & (iv), 43-4 & 18-9, (2009).
7. Chris H.K. Williams: 'The Prevalence of English Scratch (Mass) Dials c.1650 – Part 2', *Bull BSS,* 21(iii), 34-5, (2009).
8. Although dial style is beyond this article's scope, it and its evolution, in common with all other artistic/cultural endeavours, will also have varied across the length and breadth of Europe.
9. Final ref. in note 6 and Chris H. K. Williams: 'The English Scratch and Mass Dial Era: Origins to c.1250', *Bull BSS,* 22(i), 14-17, (2010).

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SUNDIALS AND FORTS IN NORTH WALES

IRENE BRIGHTMER

The location of a sundial within a former fortification occurs at least three times in North Wales, the forts and the dials varying in age and type. One of them has just been recorded for entry in the next BSS Register, but the other two are already in the Register and are associated with mediaeval churches built within Roman forts. One is a very fine vertical dial, while the other is a modern mass-produced horizontal dial on a much older pedestal.

At Holyhead in Anglesey, the recently re-painted vertical dial (Fig. 1, SRN 2736) has a Welsh inscription, one of very few, and is on the south transept of the large mediaeval church. Mrs Gatty (1900) was informed that it had been written by a 6th century Welsh bard and provides the translation:

"Man's life, though be prolonged it may,
Draws to its close by night and day."

Fig. 1. Dial on St Cybi's Church in Holyhead, with a rare Welsh inscription.

St Cybi's Church was built on the site of an early Christian monastery of the 6th century, which itself was within the walls of a Roman coastal fort of the 4th century. The fort had been established to protect North Wales from Irish

Fig. 2. Sundial with replacement dialplate in St Mary's churchyard, Caerhun, Conwy.

Editor's note: this design of dial plate is often seen on internet auctions claiming to be 18th century but is probably early-C20.

piracy. The enclosing wall survives almost completely as the churchyard wall, with herringbone masonry typical of Roman work.

At Caerhun in the upper Conwy valley is the small mediaeval church of St Mary, with what is possibly a replacement modern cast dialplate (SRN 2333) in the churchyard near the western porch (Fig. 2). It sits on a very simple pedestal which may be the re-used base of a churchyard cross. The church is situated in the northeast corner of the 1st century Roman fort of Canovium which was built to defend the river crossing at a strategic point in the road network. The present-day road to the church crosses the remains of the rampart of the fort, and re-used Roman material can be found in the walls of the church and the lychgate.

The third fort dates from 1775 and has a vertical declining dial (Figs. 3 & 4) dated 1898 above the archway of the north gate. Fort Belan is located on a sandy spit at the western mouth of the Menai Strait, almost touching Anglesey, and is cut off from the mainland by high spring tides. It was originally built to accommodate the Caernarvonshire Militia and in response to the threat posed by the American War of Independence, apparently the only fort for this purpose on this side of the Atlantic. Later it served as a garrison against Napoleon and was also used in the Second World War by all three armed services. In the 1890s a watch house was built over the north gate, and the sundial is contemporary with this structure.

Fig. 3. Sundial of 1898 over the gatehouse of the 1775 Fort Belan, Caernarvonshire, North Wales.

The dial provides the latitude of 53° 7′ and helpfully tells us that we are "Slow of Greenwich 17 mins". The dial is of slate, engraved and painted, with a bronze gnomon carrying the maker's name: "Made by F. Barker and Son 12 Clerkenwell Rd London". The editor has pointed out that the gnomon bears some resemblance to the unusual one on the Negretti and Zambra dial in Devon, reported in the *Bulletin* in 2006 (18(iii), p.110), especially the cast-in feet, although it does not have a knife-edge style.

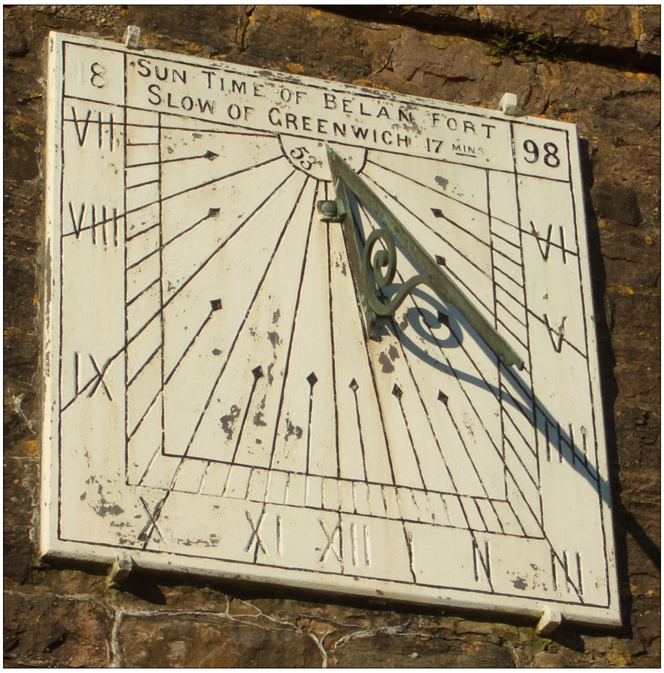

Fig. 4. Sundial at Fort Belan, Caernarvonshire, N. Wales.

Described as 'every child's dream fort' it is surrounded by ramparts, has 35 cannons, a drawbridge and lookout towers. Adjacent to it is a dockyard from the 1820s. The whole complex is Grade One Listed which one can hope will help to protect the sundial.

Fort Belan near Caernarfon provides self-catering accommodation within the fort around the year (see www.fortbelan.co.uk).

How many more sundials in Britain are associated with forts?

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THE HORIZONTAL QUADRANT
Part 1 – Introduction and Instruments

MICHAEL LOWNE and JOHN DAVIS

There are a great many types of instrument called a 'quadrant', the majority of which are effectively altitude sundials[1] for indicating the time. Many of these are named after their inventors or an early maker (e.g. Gunter's and Sutton's quadrants, or simply the 'horary' quadrant). The 'horizontal quadrant' (HQ) which is the subject of this paper is one of the less common types though the authors believe that it is actually a rather useful device which deserves to be more widely known.

At first sight, the name 'horizontal quadrant' may appear to be a misnomer on two counts. First, the instrument is held vertically when initially finding the altitude of the sun and it can be held at any angle thereafter. Secondly, most of the actual instruments consist of rather more than a quarter of a circle and so some early devices were called a 'triens', representing a third of a circle. Actually, the 'horizontal' part of the name comes from the fact that the grid of lines on instrument's face represents a stereographic projection of the sky onto the plane of the horizon (the 'horizontal plane') of the user. And the 'quadrant' derives from the fact that the circular projection of the whole sky is folded over so that it can be drawn within a quarter of a circle.

The most well-known of the horizontal quadrants is sometimes called Delamain's quadrant, after the 17th-century mathematician Richard Delamain.[2] This device has many similarities to William Oughtred's 'Horizontal Instrument' (HI) – related to the more common double horizontal dial – and, as a result, there was a notorious priority dispute between these two authors.[3] The recent monograph[4] on double horizontal dials by the authors also contains details of horizontal quadrants and the known devices are catalogued there with a reference number of the form HQ-n, where 'n' is a number currently in the range 1 to 9. This reference number is shown in Table 1 which lists the known instruments.

The double horizontal dial and the horizontal quadrant share the same basic horizontal stereographic projection of the sky. The major difference between them is that the double horizontal dial indicates the sun's position (and hence the time) by its azimuth whereas the horizontal quadrant uses the sun's altitude.

General Description

A drawing of the most common form of quadrant is shown in Fig. 1, based on the instrument by John Allen, HQ-1 in Table 1. In essence, it is a stereographic projection of the sky on the plane of the horizon for a particular latitude, folded in half along the meridian or noon line, (the straight line at the left-hand side), so that both the morning and afternoon times are represented on the one projection. The method of drawing the stereographic projection has been published by Lowne in an earlier *Bulletin* paper on the double horizontal dial[5] and repeated more recently.[4]

Lines running more-or-less top to bottom and concave to the noon line are the time lines, labelled IIII-XII for the morning and 12-8 for the afternoon hours. Crossing these are lines of declination marking the annual excursion of the sun throughout the year: they are labelled with calendar

Desig^n^	Maker	Material	Date	Location	Comments
HQ-1	John Allen	Brass	1633	Brussels	Prototype instrument?
HQ-2	Henry Sutton	paper on wood	1658	Oxford	Inverted projection
HQ-3	[Francis] Pigot	Brass	c. 1655	Newdigate Colln	Sights on rule
HQ-4	John Prujean	paper on wood	c. 1670	Newdigate Colln	Oughtred's version
HQ-5	Anon	Silver	c. 1635	Unknown	Speculative
HQ-6	Anon	Paper	1689-99	No examples known	Advertised by Lea[C2]
HQ-7	J Brown(e) attrib.	Boxwood	mid-C17	London Sci Mus	Large
HQ-8	Christopher Schissler	Gilt brass	1569	Germanisches National-museum	Triens, distancia arcs
HQ-9	JA Linden	Gilt brass	1596	British Museum	Compendium, calculator diagram

Table 1. List of known horizontal quadrants.

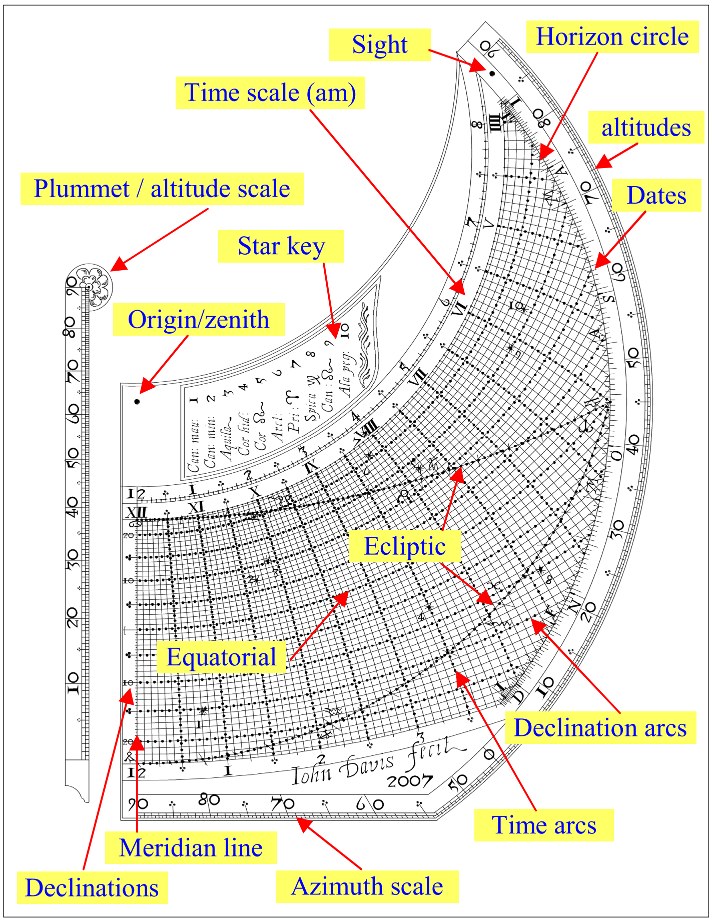

Fig. 1. Schematic drawing of a horizontal quadrant, based on the John Allen example (HQ-1) in Brussels.

dates from summer solstice to winter solstice and back, around the curve at their ends which represents the horizon. Two curves which cross the declination lines are the ecliptic, the annual path of the sun. They meet the meridian at the extremes of the sun's declination, (23½° north or south of the celestial equator) and the horizon line at the equator, the position of the sun at the equinoxes. They carry the symbols for the signs of the zodiac and are divided to show the celestial longitude of the sun. Around the curved limb is a calibration for altitude which is indicated by a plumb-bob or plummet when the sun is sighted through two small apertures positioned on the back of the instrument. The scale along the lower straight edge of the instrument shows the azimuth of the sun (with the zeroes at the E and W points, as was common on many sundials). The use of the dial to find the time is explained later.

Some of the quadrants do not follow this format and are described individually.

European Precursors

The principles of the stereographic projection were known to the ancient Greeks but devices using it are believed to have come to Europe from the Islamic world in the 14th century. These early devices were mainly astrolabes which used stereographic projections onto the equatorial plane. One of the earliest European types of device to use a horizontal projection was the *compast* of Georg Hartmann from Nuremburg, working in the 1520s.[6] This device used the full circle of the projection but since it is symmetrical about the meridian line, it may be folded in half without any loss of information. Philip Apian, writing in 1586,[7] describes a number of variants of this folded projection which he calls a *triens* and attributes to his famous father, Peter Apian. The most recognisable of the designs has arcs for the sun's declination crossed by arcs for the time in equal hours (Fig. 2a). Other variants show unequal, Italian and Babylonian hours. (Figs. 2b, c and d, respectively.)

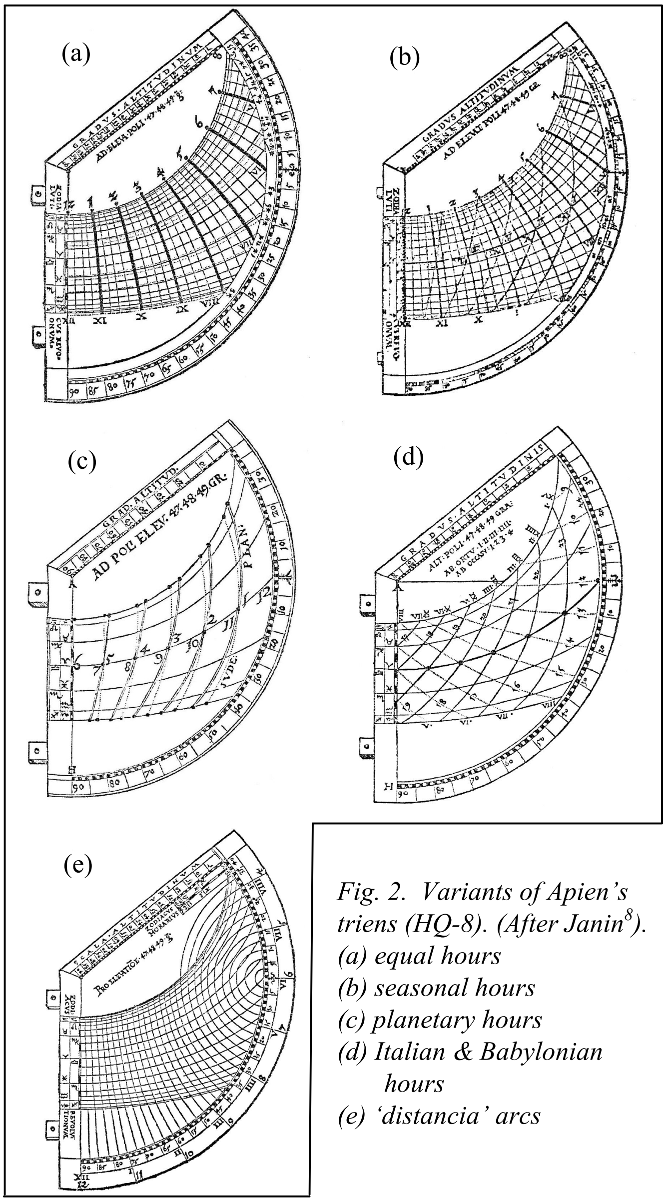

Fig. 2. Variants of Apien's triens (HQ-8). (After Janin[8]).
(a) equal hours
(b) seasonal hours
(c) planetary hours
(d) Italian & Babylonian hours
(e) 'distancia' arcs

A very unusual variant shows the sun's position on the hectemoros arc, from the east or west points of the horizon (Fig. 2e). It is a device of this type for which we have an actual example, made by Christopher Schissler for Augsberg in 1569 (HQ-8 in Table A1). The side of the instrument used for telling the time is shown in Fig. 3. It would have originally been fitted with a plumb-bob and cord passing through the aperture at the centre of the projection and fitted with a sliding bead indicator. This is a stereographic plan of the sky but, whereas the usual type of altitude dial

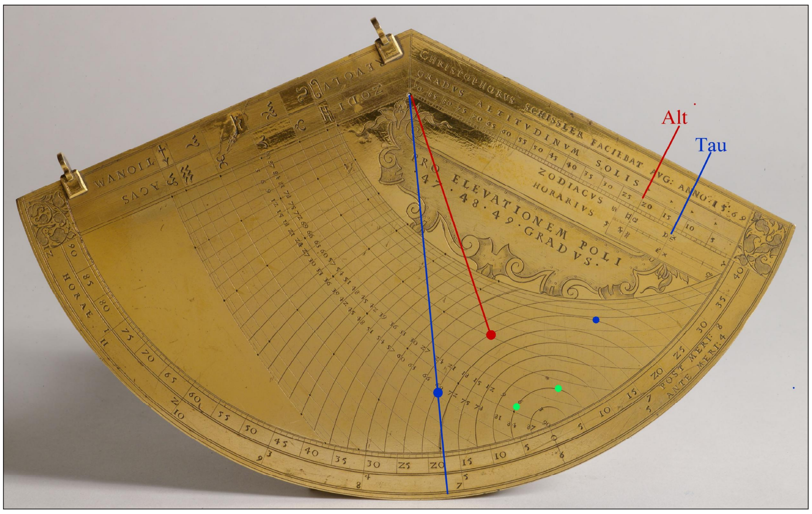

Fig. 3. Schissler's triens. The photograph has been annotated to show an example of its use (see text). Courtesy of the Germanisches Nationalmuseum, Nuremburg.

would carry hour lines and arcs of declination, here the hour lines are replaced with arcs which (on the sky) represent arcs of constant radii from the east or west points of the horizon. These arcs are drawn for every third degree and are numbered both from the horizon point and in the reverse direction from the meridian. The angular distance of an arc from east or west point is referred to by Janin[8] as 'distancia' for which the symbol *D* is adopted here. The relation of *D* to the latitude, φ; the sun's declination, δ; altitude, *a*; and hour-angle, *h,* is expressed, using a subsidiary quantity *P*, by the equations:

$$\tan P = \cos\varphi.\sin\delta/(\sin a - \sin\varphi.\sin\delta)$$

$$\sin D = \sin a/\sin(90+P-\varphi) \quad (1)$$

$$\sin h = \cos D/\cos\delta \quad (2)$$

Eq. 1 derives *D* from the local circumstances of latitude, declination and altitude and Eq. 2 relates the hour-angle, and hence the time, to *D* and declination. Note that latitude does not enter into Eq. 2 as the east and west points of the horizon are common to all latitudes. On the projection, the distancia arcs are drawn centred on a line perpendicular to the meridian, passing from the centre through the east and west points. The distance of the centre of an arc from the projection centre is given by $R/\cos D$ and the radius *r* by $r = R\tan D$ where *R* is the triens radius from centre to horizon.

The declination arcs are drawn for the declination of the sun at its entry into each sign (ZODIACUS REVOLUTIONUM) and are divided into thirds (intervals of ten degrees of solar longitude or approximately ten solar days). Other scales include one for the altitude of the sun (GRADUS ALTITUDINUM SOLIS) and below this is another scale of signs of the zodiac (ZODIACUS HORARIUS) folded back upon itself at the equinoctial signs. The time scale is around the periphery, labelled with both morning and afternoon hours (HORAE ANTE MERI, HORAE POST MERI), uniformly spaced about the centre of the projection. Inside this is the altitude scale of degrees with zero at the 6am–6pm point. It is read from the cord hanging freely when sunlight is allowed to pass through one of the sighting apertures and fall on the other.

The method of use is indicated by Janin. It involves two settings of the bead on the cord.

1. The altitude as measured by the quadrant is transferred to the altitude scale and the sliding bead on the cord is set accordingly. The current position of the sun is selected on the arcs of the zodiacal signs, and the cord moved around until the bead rests on it. The calibration of the distancia arc at that position is noted.
2. In the second setting the cord is moved to the ZODIACUS HORARIUS scale and the bead set at the position of the current sun's sign.
3. The cord is stretched out straight and moved around until the bead rests on the distancia arc previously found.
4. The time is read on the hour scale around the periphery. Although the time scale is calibrated only in hours it is possible to obtain greater precision by reading the angle on the altitude scale, subtracting from 90º, converting to time and applying as an hour angle to 12 noon.

In step 1, the centre of the projection is the zenith but in step 2 it represents the pole of the sky. The steps correspond to Eq. 1 and Eq. 2.

Fig. 3 shows an example of the dial in use. Suppose the sun's altitude is measured as 20° when the sun is just entering the sign of Taurus. The red symbols show the settings of the sun's altitude with the bead set on the altitude and meeting a distancia arc. The blue symbols indicate the bead set to the appropriate zodiacal position for sun's entry into Taurus and placed on the distancia. The indicated time is about 7:10am or 4:50pm. The calculated times for these conditions are 7:07 and 4:53 at a latitude of 48º.

There is ambiguity in the positioning of the bead in step 3. The bead will meet the distancia arc in two places, as indicated by the smaller blue dot on Fig. 3, so that two time readings are possible, equally spaced either side of 6am or 6pm. In this instance it should be apparent which one is correct but at smaller values of *D* (shown by two green dots), it may not be obvious. The ambiguity is only present in summer months: from autumn equinox to spring equinox time values later than 6am or earlier than 6pm are the only ones possible. The ambiguity could be resolved by taking another altitude reading a few minutes later. The derived time value which gives a later time is the correct one.

Another difficulty can occur at low declinations of the sun and times within about three hours of noon. In step 2, it is possible for the bead to fall in the area of the projection where the distancia arcs are not drawn. They should have been continued out to the horizon circle.

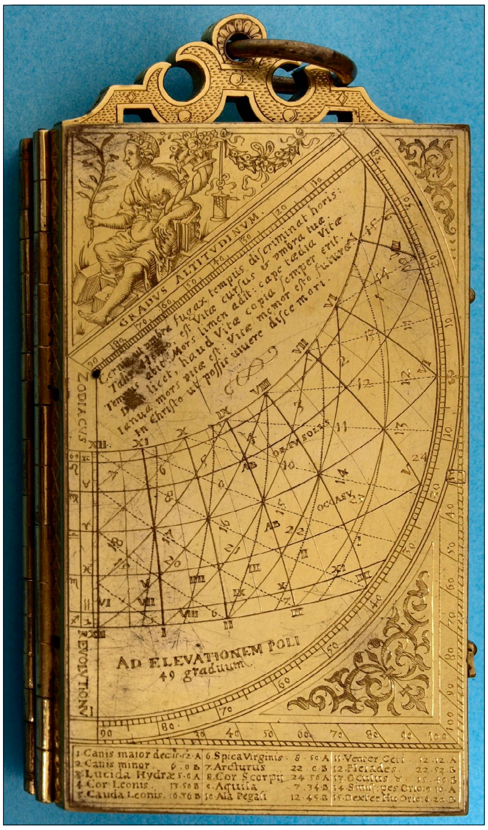

Fig. 4. The folded horizontal stereographic projection on the outside of J.A. Linden's 1596 compendium. Courtesy of the Trustees of the British Museum.

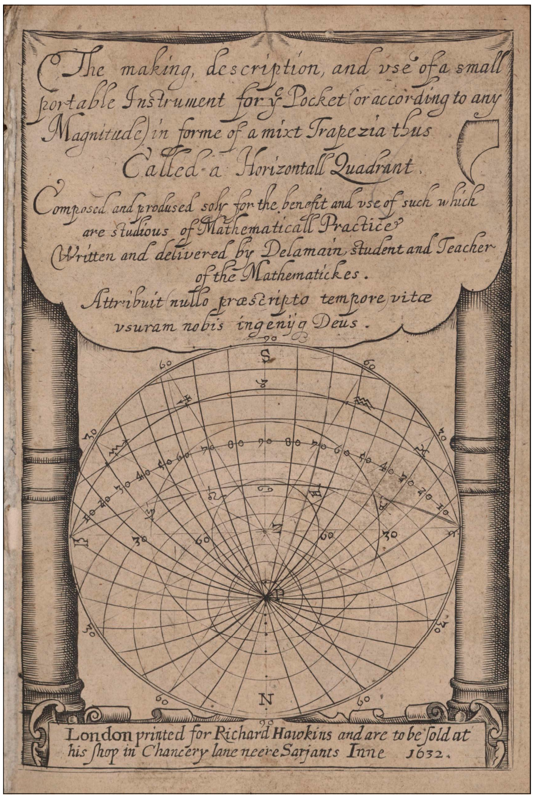
The making, description, and vse of a small portable Instrument for ye Pocket (or according to any Magnitude) in forme of a mixt Trapezia thus Called a Horizontall Quadrant.
Composed and prodused soly for the benefit and vse of such which are studious of Mathematicall Practice
Written and delivered by Delamain Student and Teacher of the Mathematickes.
Attribuit nullo praescripto tempore vitae vsuram nobis ingenij Deus.
London printed for Richard Hawkins and are to be sold at his shop in Chancery lane neere Sarjants Inne 1632.

Fig. 5. Title page of the first edition of Delamain's book on his horizontal quadrant.[10]

Another version of a triens can be found on the outside of a compendium by Johann Anton Linden of Heilbronn, dated 1596. The device, which is in the British Museum and is of gilded brass (Fig. 4, HQ-9 in Table 1), has numerous other instruments including an astrolabe and several sundials. The 'triens' is described by Ward[9] as a calculator diagram as it has lines for most of the variants shown by Apian all on the same face and hence it may be used for converting the sun's position from one system to another.

English Developments

Although 'quadrant' forms of the horizontal stereographic projection were known – even if not widespread – in Europe at the end of the 16th century, there is no indication that this information had spread to England and so the developments here may be regarded as independent. The first publication of a horizontal quadrant here was Richard Delamain's 1632 book[10] *The making and use of a small portable instrument....called a Horizontal Quadrant* (Fig. 5). This 105-page book contributed to the acrimonious priority dispute with William Oughtred who claimed[11] (correctly) that Delamain's device was simply half of his own 'horizontal instrument'. The story of the dispute has been well described by Turner[3] and was the subject of a mock trial by Fred Sawyer at the 2007 BSS Conference. The details will not be repeated here.

The frontispiece of Delamain's book is a small (15.5 × 10 cm) copperplate engraving of his device (Fig. 6). The engraving includes the altitude alidade or rule pivoted at the centre of the projection and an advertisement for Elias and John Allen. Based on stylistic grounds and the existence of a real device (see below) it is believed that the plate for this engraving was made by Elias Allen's apprentice John Allen. It is probable that his master was engraving the early horizontal instruments for William Oughtred at this time, with direct assistance from Oughtred, and this could have been the route by which practical information passed to Delamain.

It has been suggested[2] that an example of Delamain's quadrant made in silver was "sent to the Duke of York by the King just before his death". No silver Delamain's quadrants

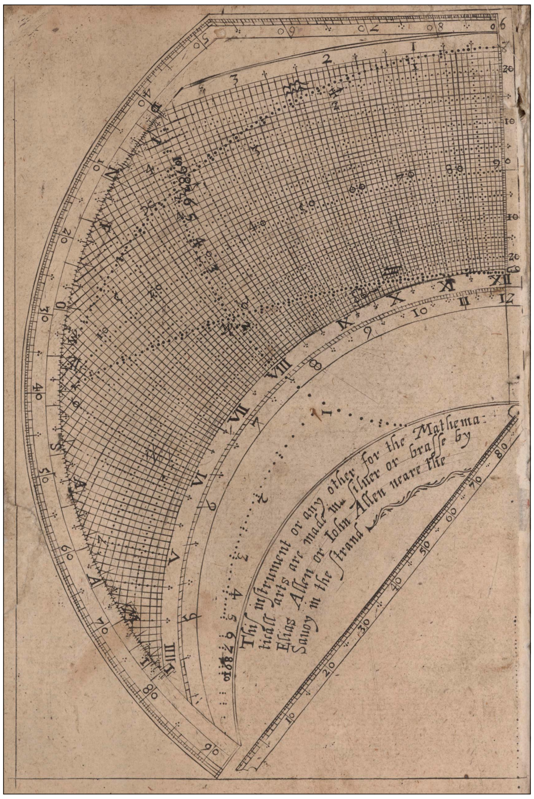

Fig. 6. Frontispiece engraving from Delamain's 'Horizontal Quadrant'.[10]

are known so this must remain speculative, though the possibility is recorded as HQ-5 in Table 1.

The Delamain instrument has a very appealing shape, being cut so that it only includes that part of the stereographic projection which encompasses the sun's path throughout the year. It does, however, have some strange features. Notice the scale around the limb which is discontinuous near the top left corner: the values around the curved part on the left are for reading the altitude with the rule/plummet when the device is held vertically whereas the values along the straight, top edge are for the sun's azimuth. The altitude scale has to be carefully arranged to allow for the alignment of the sights and the centre of gravity of the plummet which is slightly offset from the fiducial edge. In a variant to the design, Delamain describes a second set of pinhole sights mounted on the alidade (not shown in the frontispiece drawing). The added weight of these sights would affect the centre of gravity even more.

The hour arcs of the instrument are numbered for normal, equal hours, [12]-3 along the winter declination arc and IIII-XII along the summer one. There is a second scale inside this numbered [4]-12 which is based on the hour lines of a normal horizontal dial, centred on the pole of the world. Its use is not clearly explained. In addition to the standard stereographic projection, there are three dotted arcs which are numbered for the length of the shadow of a vertical gnomon, as measured by the altitude rule.

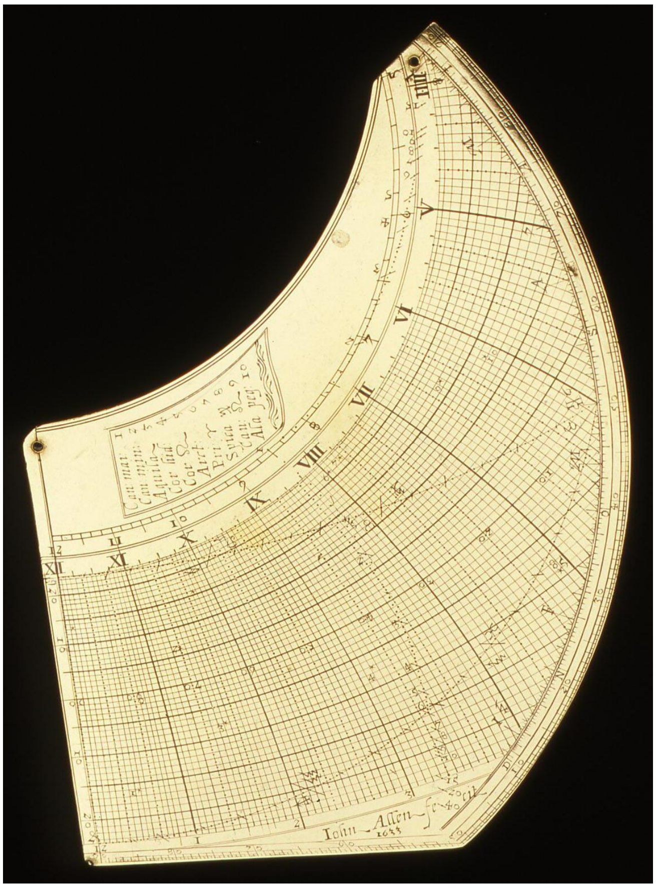

Fig. 7. A Delamain's quadrant by John Allen. Courtesy of Musees Royaux d'Art et d'Histoire, Brussels (Inventory no. 5846). Note: photographic distortion.

A brass horizontal quadrant signed by John Allen is in the Musees Royaux d'Art et d'Histoire, Brussels. (Fig. 7, HQ-1 in Table 1.) Unfortunately, the sights and the rule/plummet are missing but otherwise the quadrant is in excellent condition. It is dated 1633, the year after Delamain's book and also the year after John Allen made the first dated (but probably not the first) double horizontal dial. It follows the design of the frontispiece engraving very closely, both in general format and in the lettering style. One addition is the positions of ten numbered stars (one of them shown incorrectly).

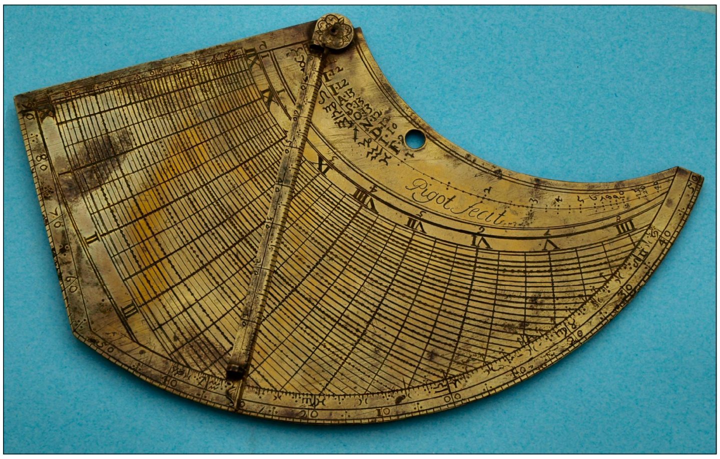

Fig. 8. A brass Delamain's quadrant by Francis Pigot. Now in the Newdigate Collection, Arbury Hall. Courtesy of Lord Daventry.

Only one other brass horizontal quadrant is known from the 17th century. This is by Francis Pigot and is in the Newdigate collection. (Fig. 8, HQ-3 in Table 1.) Pigot was not a professional instrument maker – this is the only known instrument by him. Taylor[12] describes him as a mathematical practitioner (fl.1653-56) who advertised that he could teach the use of mathematical and surveying instruments and who published an almanac for Ludlow, near to his home of Cleobury Mortimer, Shropshire. The calculated design latitude for the quadrant is 52.4° which suggests that he made it for his own use (Ludlow is 52° 22′ N). Although not as well engraved as the John Allen example, Pigot's device retains its sights and altitude alidade. This latter accessory features the second set of sights which are described in Delamain's book, although not drawn in the frontispiece engraving. Their use, to measure the angular separation of stars, is illustrated elsewhere in the book by a woodcut engraving but the method looks to be most impractical (see below). The form of Pigot's device is generally similar to Allen's. One difference is the angle scale on the limb which is now continuous and serves as both an azimuth and altitude scale though it does not allow for the offset centre of gravity of the alidade. Another difference is the numbering of the hour arcs along the summer declination line – the inner scales of Arabic numbers is for the afternoon hours and align with the Roman ones for the morning hours.

A very large (radius c.500 mm) horizontal quadrant in boxwood is in the London Science Museum. (Fig. 9, HQ-7 in

Fig. 9. The unsigned (but attributed to John Browne) boxwood horizontal instrument HQ-7 in the Science Museum, London.

Table 1.) Although unsigned and undated, it is plausibly attributed to John Brown(e).[13] It has some differences to the Delamain design and, unlike the single-sided brass examples described above, it features a series of circular scales and a set of star tables of the reverse. The device is finely engraved and makes use of a plumb-bob and bead rather than an altitude rule so it is capable of giving accurate results.

John Brown (fl.1648-95) had been apprenticed to his father, Thomas Brown(e) who was also renowned for his wooden instruments. Thomas Browne had been associated[12] with Delamain and his circular calculator, another device where Delamain claimed priority over Oughtred, in this case for his *circles of proportion*. Thus it seems possible that there is a link between Delamaine's design of horizontal quadrant and Browne's.

William Oughtred did not publish any description of a quadrant based on the horizontal stereographic projection. This gap was filled by his son-in-law Christopher Brookes who was apprenticed to Elias Allen and later became the resident instrument maker in Oxford. Brookes published a tract[14] called *A new quadrant....* in 1649, attributing its invention to Oughtred. The text contains no illustrations and was clearly meant to accompany an actual instrument but none is known. It is quite difficult for a 21st-century reader to understand and it refers to part of the projection as a "reverted tail".

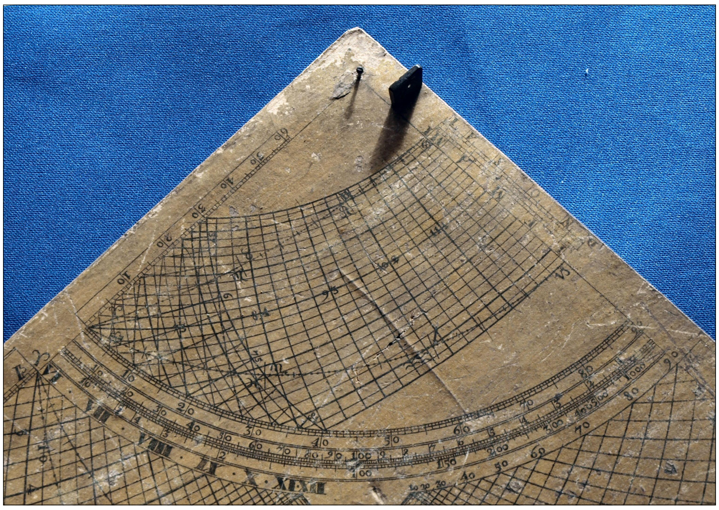

Fig. 10. John Prujean's 'Oughtred quadrant' HQ-4, now in the Newdigate Collection. Courtesy Lord Daventry.

Brookes' successor in Oxford, John Prujean, was another of Elias Allen's apprentices. Prujean issued an advertisement[15] in 1701 listing the instruments he could supply and it included "Oughtred's Quadrant" as well as "His [Oughtred's] Double Horizontal Dial" and some 18 other instruments, many of them attributed to an inventor – Delamain is not amongst them! In this case, we have a single example known, in a paper-on-wood quadrant and again in the Newdigate Collection (Fig. 10, HQ-4 in Table 1). The horizontal projection can be seen to be only a minor part of this instrument which includes two other forms of quadrant; a Gunter's quadrant around the outside and a Sutton's (or Collins') quadrant on the verso. Prujean issued a simple unillustrated broadsheet[16] describing the uses of his Oughtred's quadrant so clearly he was expecting to sell a number of them, though only this single example is known, in contrast to the Gunter's and Sutton's quadrants which are more common.

There are a number of differences between the Prujean *Oughtred's quadrant* and Delamain's design. The first is that it is constrained to occupy a quarter of a circle. This is achieved by reflecting the part of the projection which lies beyond the Prime Vertical back into the quadrant – this is Brookes's "reverted tail". The result is that the design is fits neatly into the available space but with a rather confusing web of lines in the corner. The second difference is that Prujean (or Oughtred) has selected to use the 'other' half of the projection, putting the meridian line on the right hand side of the projection. It is immaterial which half of the projection is drawn so one wonders if this choice was made simply to be different.

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15. D.J. Bryden: 'Made in Oxford : John Prujean's 1701 catalogue of mathematical instruments', *Oxoniensia*, 58, 263-85, (1993).
16. J. Prujean: *A ſhort Deſcription of a Quadrant of the particular Aſtrolabe inverted*. Broadsheet issued by "John Prujean in OXON". Published with *Oughtreds Quadrant*. Copy in Christ Church Library, Oxford, Press Mark Hyp.B.225. (c.1701).

To be continued

UPDATE ON THE TYWYN DIAL

MIKE COWHAM

I reported on the discovery of an Irish-style dial that was found at Towyn in a previous issue.[1] It had been used as a milestone and was then built into the fabric of Ynysmaengwyn Hall, about 1 mile away. It was discovered after demolishing the hall and clearing the site. This dial has now been moved from its rather vulnerable position outside the local Tourist Office and has now been placed safely inside St Cadfan's Church.

After visiting the dial to photograph it for inclusion in *Time Reckoning in the Medieval World*,[2] I suggested to the church that this was a historically important local object and that it should be stored in a safe environment, such as the church. St Cadfan's Parochial Council were enthusiastic and Mike Edwards wrote to Tywyn Town Council to see if they would agree to it going into the church. They readily accepted this and, after obtaining a faculty for it to be sited in the church from the Bangor Diocese, a place was made available near the Cadfan Stone in the north aisle of the church.

Lifting the stone out of the ground.

The dial's new position, next to the famous Cadfan Stone.

It was lifted out of the ground on 19 February 2010 using a forklift truck by two men and a lady driver. They were most surprised to see how large the stone really was. Only about half of it had been showing above ground. Its overall height has previously been recorded as 2.6 m.[3]

The base of the stone was then drilled so that the stone could be placed on a spindle and a supporting bracket was made to secure it to the church wall.

The dial now stands next to the Cadfan Stone, illuminated from one side to show its remaining markings most clearly.

ACKNOWLEDGEMENTS

I would like to thank Mike Edwards and Meryl Gover for sending me these pictures and details of the dial's removal to its new abode.

REFERENCES

1. M. Cowham & W. Linnard: 'The Recently Discovered Irish-Style Dial at Tywyn', *Bull. BSS* 21(iii), 36-38 (2009).
2. D. Scott & M. Cowham: 'Time Reckoning in the Medieval World', BSS Monograph No. 8, (2010).
3. W. Gwyn Thomas: 'An Early Sundial from the Towyn Area', *Arch. Camb.* **138**, 111-113 (1989).

MINUTES OF THE 21st ANNUAL GENERAL MEETING

Exeter University, Devon - 11 April 2010

1. About 60 voting members were present for the meeting, which was opened by the Chairman, Christopher St J H Daniel, at 1:00 pm. He thanked Patrick Powers and Martin Jenkins for arranging this very successful Conference, and expressed his appreciation for the many overseas visitors who had attended.

2. No apologies for absence had been received.

3. The minutes of the 20th Annual General Meeting, held at the Cumbria Grand Hotel, Grange-over-Sands, Cumbria, had been published in the *Bulletin* of September 2009, were taken as read, and were approved by a show of hands. There were no matters arising and the minutes were adopted.

4. Council member's reports

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

SECRETARY ***Graham Aldred***

Review 2009-2010

The last year has seen some progress in the administration of the Society. The single large task of Secretary and Conference Organiser has at last been divided so that an average retired person with other interests and commitments might just consider doing one. This split has provided an opportunity to review and revise various internal administrative processes with a view to greater effectiveness and ease of take over by a successor. The domain renewal process is just one of these with very far reaching effects. There is much more to do. The BSS acquired an official address. Having been affiliated with the Royal Astronomical Society for some years they have agreed to the use of their address on a 'care of' basis for our legal purposes. Appeals to members to volunteer for any Council or Specialist role had a zero response so the outlook is dire. Although the Society has been in existence for 21 years, Council decided two years ago to select our 25th year as a milestone anniversary. Suggestions for how we could celebrate and commemorate the occasion would be most welcome.

The Society's administration and core activities could not function without the free provision of computer facilities and software by the volunteers. Sometimes a member's personal computer system is not adequate for the BSS task. In these cases the BSS will purchase PCs and software which become registered Society assets. The Webmaster and Treasurer positions have both recently been equipped with new PCs.

The legal rights to the BSS logo have been renewed for the next 10 years. The failure to renew the BSS domain *sundialsoc* was caused by an unpredictable combination of events for which both the BSS and the web hosting company share responsibility. A process for remembering very infrequent (5 or 10 years) future events, independent of staff changes, has now been set up.

Tony Moss has produced an excellent graphical explanation 'How Sundials Work' that has recently been added to the BSS web site where it provides an important educational feature and is much appreciated. The main BSS promotional leaflet has been revised and reprinted.

Restoration Enquiries and Grants

Several new requests for advice have been received during the year and two potential projects are ongoing and being progressed by their owners/custodians either to obtain permission, in the case of a church, or to agree to an estimate with a restorer. Two sundials are known to have been restored without a supporting grant. The restoration of the vertical declining sundial (1738) on the church of St Nicholas, Leicester, in the city centre has been partially supported by a grant from BSS of £400. The dial numerals and lines have been regilded and the corroded mounting pins have been replaced. The Society has received letters of thanks from the church authorities and the BSS will be cited in the list of those who have supported the much more extensive restoration activities on this old church.

BULLETIN EDITOR ***John Davis***

Our new printers continue to perform well and four issues of the *Bulletin* have been printed crisply and delivered on schedule. With a combination of contributions from our regular authors and a few new writers, some from overseas or outside the BSS, there has been no difficulty in filling the pages, although the Editor would always be pleased to receive more material to publish. As always, I am very grateful to all the authors and the proof readers.

Just one new monograph was published in 2009 (No. 5, *The Double Horizontal Dial* by Davis & Lowne) but another is almost ready to go and a further two are in the pipeline for 2010. The timetable of other titles extends to 2013 so authors should book their slots now.

Kevin Karney has bravely taken on the leadership of the project to produce an electronic archive of all the back-issues of the *Bulletin*. With very significant help from Elaine Hyde, the early issues (actually, Margaret Stanier's personal copies!) have all been scanned and indexing is now underway.

REGISTER ***John Foad***

The Register now contains a record of 6460 dials, with a photograph (or photographs) for some 67% of them.

Much of this year has been taken up with the fascinating work of entering your new reports and photos. Queries from a number of members were answered, many on indi-

Statement of Financial Activities for the Year Ending 31 December 2009

	Unrestricted Funds	Restricted Funds	2009 Total Funds	2008 Total Funds
	£	£	£	£
INCOME RESOURCES				
Subscriptions	12248	-	12248	11381
Donations and Gift Aid	-	2382	2382	5954
Events (note 6)	34935	-	34935	30634
Interest received	719	-	719	3244
Other income	1819	-	1819	3368
	49721	2382	52103	54581
RESOURCES EXPENSED				
Direct charitable expenditure	41386	384	41770	46965
Administration	5808	-	5808	4112
	47194	384	47578	51077
NET INCOMING RESOURCES FOR THE YEAR	2527	1998	4525	3504
Prior year adjustment	(383)	-	(383)	-
	2144	1998	4142	3504
Fund balances brought forward	75474	6705	82179	78292
FUND BALANCES CARRIED FORWARD	£77618	£ 8703	£86321	£82179

Balance Sheet at 31 December 2009

	Notes	2009	2009	2008	2008
FIXED ASSETS					
BSS Library	3		16635		16635
CURRENT ASSETS					
Charities Office Investment Fund		58262		57558	
Bank deposit account		11004		5907	
Bank current account		420		2079	
NET CURRENT ASSETS			69686		65544
TOTAL ASSETS LESS CURRENT LIABILITIES			£86321		£82179
Represented by:					
UNRESTRICTED FUNDS					
General Fund			77618		75474
RESTRICTED FUNDS					
Andrew Somerville Memorial Fund		7555		5557	
St Katherine Cree Restoration Fund		1148		1148	
			8703		6705
TOTAL FUNDS	4		£86321		£82179

The accounts were approved by the Trustees and signed on their behalf on 11 April 2010.

G STAPLETON
Treasurer

C St J H DANIEL
Chairman

NTS FOR 2009

NOTES TO THE ACCOUNTS AS AT 31 DECEMBER 2009

1. ACCOUNTING POLICIES

a) Basis of preparation of accounts

The accounts of the Society are prepared in accordance with the Charities' Act 2006 and under the historical cost convention, modified to include the library at valuation. The charity has taken advantage of the exemptions in Financial Reporting Standard No.1 from the requirement to produce a cash flow statement on the grounds that it is not a large charity. The accounts are prepared in accordance with Recommended Practice, and on a receipts and payments basis.

b) Fund accounting

Gift Aid income and costs directly associated with the fund are allocated to the Andrew Somerville Memorial Fund. All other income and expenditure is accounted for within the unrestricted fund.

c) Loans

Loans are written off as expenditure when made and are credited as income when repaid.

2. AUTHORISED LOANS AND GRANTS

No loans were made or repaid during the year

BSS LIBRARY

The BSS Library is stated at valuation, based on the 2003 value calculated by Roger Turner Books, and modified to take accounts of the effects of inflation and new purchases.

4. MOVEMENT ON ACCUMULATED FUNDS

	Total Funds	Unrestricted Funds	Restricted Funds	
			Somerville Memorial	Cree Restoration
	£	£	£	£
Balance 1 January 2009	82179	75474	5557	1148
Net income resources	4142	2144	1998	-
Balance at 31 December 2009	£86321	£77618	£7555	£1148

There were no transfers of assets between funds during the year under review. (2008 : none)

5. TRUSTEE REMUNERATION AND EXPENSES

None of the Trustees received any remuneration during the year. (2008: None)
None of the Trustees were paid any allowances during the year. (2008: None)

6. EVENTS

	2009			2008		
	Income	Costs	Profit/ (loss)	Income	Cost	Profit/ (loss)
	£	£	£	£	£	£
Grange/Sands	17288	17374	(86)	-	-	-
Anglia	9515	9468	47	-	-	-
Exeter (2010)	8132	741	7391	-	1000	(1000)
Latimer	-	-	-	13708	16704	(2996)
Alsace	-	-	-	16926	16706	220
	£34935	£27583	£7352	£30634	£34410	£(3776)

vidual dials, but also summaries showing dials by area, by maker, and even in one case by gnomon and dial-plate materials commonly used in the late 18th century! Queries on the database are simple – please ask.

Alongside this, organisation of the Noel Ta'Bois archive was completed, and preparatory work was done towards a 2010 publication of the Fixed Dial Register.

Successful trials have been run of electronic reporting – that is, sending reports and photographs as attachments to an email, with no need for paper copies. I would encourage all members to use this method from now on. If you wish to do so, please contact me for the necessary formats. However, traditional reporting, with a printed report and printed photographs, will still be welcomed for as long as it is wanted.

Although not directly related to the work of the Registrar, two further items should be mentioned. A revised edition of the *Dialling Miscellany* was prepared and distributed with the September *Bulletin*. This will be repeated on an occasional basis, possibly every three or five years. Microsoft Office 2007 was acquired at favourable Charities rates for use by Council members, in line with our policy of remaining with up-to-date software.

MASS DIAL GROUP ***Tony Wood***

Entries to the Register for E. Yorkshire, W. Yorkshire, Lancashire, Cheshire and Dorset have been completed and the original reports deposited at the Borthwick Institute Archive in York.

The Register printouts are available as indexes for public consultation. Alan Cook has produced an Appendix to Monograph No.3, thereby completing the survey of Yorkshire mass dials. This is a significant effort and Alan is to be congratulated. Discussions are in hand over its publication.

Bob Adams has allocated Mass Dial Register Numbers to all the Lincolnshire dials in his latest revision. Discussions are in hand over its publication. The Noel Ta'Bois Archive of mass dial pictures has been put into county order on CD thanks to John Foad, who also managed to rotate a few to 'right way up'. The 800+ colour slides represent a remarkable collection. Chris Williams is pursuing his statistical analysis and publishing the results.

Current counties being entered are Essex and N. Yorkshire.

Reports continue to trickle in; NADFAS and a small but select band of members being the main contributors.

Correspondence with Johan Wikander over Scandinavian mass dials also continues, with progress over interpreting runic symbols on dials there and in England.

Museums Survey

The Survey is nearing submission for publication. I collated the replies to my enquiry forms, Ian Butson has prepared a fully cross-referenced text and Jill Wilson is doing the final editing. It will appear under our three names and join the queue for publication in due course, but should be out of our hands later this year.

ADVERTISING ***Mike Cowham***

In the last year we have carried adverts in each issue of the *Bulletin* for Green-Witch. They continue to 'pay' us in dials that we can use as prizes for members, such as the winner of the Photo Competition. As the cost of each quarter page advert is about £50, we get an average of one dial for each advert of theirs that we print.

Unfortunately, there seem to be few customers interested in advertising in the *Bulletin* and it is difficult to sell them the idea that it could be profitable for them.

We have placed adverts with other journals, mainly to get additional members. We did a reciprocal with the AHS and placed a small advert with the U3A magazine, which produced one new member. More recently we placed a half page advert with the Government and Public Services Journal (GPSJ), not so much for new members but to make their readers aware of our existence. Their readers include people in government buildings, hospitals, universities, schools and many other public institutions. There must be many out there who would consider commissioning a sundial on some public building and this will give them an introduction to our Society and to its dial makers. This advert is to be published this Spring at the same time as an article on sundials by our Chairman.

Response rates to paid adverts have not been very good, in fact, advertising is not cost effective. I have proposed various incentive schemes which might encourage potential members to join which the Council will reconsider at the next meeting.

SUNDIAL SAFARIS ***Mike Cowham***

Our Safari last September to East Anglia went very well but, probably due to it being a UK destination, was not so well supported as in previous years. Another factor may have been the general lack of money. It has not been possible to get together a suitable visit for this year.

A considerable amount of work is necessary to achieve a smooth running Safari, often requiring at least two visits beforehand and having someone local available to make the detailed arrangements. This was simple for East Anglia, the Safari locations being only 1 to 2 hours from my home. Safaris abroad are more of a problem and someone local is of vital importance in such arrangements. I had a Safari planned to go to the Czech Republic but arrangements there did not give me quite the confidence that I required. This Safari is still possible but, as one of the main museums that I want to visit is temporarily closed, the earliest that this visit could be made is 2011. I will also need to make another visit there to check on local facilities, particularly in and around Prague.

Other visits that I have looked at include a visit to the Perche area of France, where I have a local SAF member helping out, but it is not likely to take place until 2011, probably in May or June. Due to the relatively large area to be covered it may be necessary to fly into one airport and out of another. I also looked at a visit to Northern Spain but I still need more support from someone on the ground to make this one work.

If any Members would like to suggest other Safaris I will be pleased to consider them. I have had a suggestion of Mallorca but, as I have never been there, I would need a substantial input from someone else. St Petersburg has also been mentioned, but from my experience, there are not many dials around except in the Hermitage Museum.

In the UK, I see a possibility of a Safari to Gloucestershire (which seems to have the highest concentration of dials in the UK), maybe a Safari to Kent/Sussex, one to Durham/ Northumberland and perhaps one to Cumbria. If anyone would like to help with these, I will be pleased to help with planning them for future occasions.

TREASURER ***Graham Stapleton***

It is cheering to report that although there has been a recession, Society funds have not been subject to any sort of excitement and are in a good state. As for all of us, earned interest has all but dried up; however, Council members and the Specialists have played the major part in maintaining our position. Amongst these are the reduction of printing costs, the level of sales holding up well, and a useful addition to the Andrew Somerville Memorial Fund by excess funds from the Anglia Safari.

Under the new Charities Act, the level of our income now requires us to have our accounts checked externally by an Independent Examiner every year. Our accountant's final report was not available at the time of going to print, but will be on display at the Conference and appear in the next *Bulletin*. [See pp.26-7 of this issue. Ed.]

Lastly, an appeal to spend our money. A part of the Andrew Somerville Memorial Fund is set aside to assist dial restoration projects and academic studies of gnonomics. The sum available is not large, but it has scarcely been touched. If you hear of a project to restore a dial, do let me know.

BIOGRAPHICAL PROJECTS ***Jill Wilson***

I am continuing to amass biographical information about both new and already known past sundial makers with a view to producing a third edition of the *Biographical Index* at some future date. My grateful thanks are given to all those who let me know of their discoveries – I should be far less well-informed without their help. In addition, I have been giving some assistance to the team preparing the results of the Museum Survey for publication.

MEMBERSHIP ***Jackie Jones***

There are now 457 members of the Society; 319 are in the UK and 71 in Europe. Of the 67 members in the rest of the world, there are 36 in the USA, 8 in Australia, 4 in Canada and the rest spread far to include Russia, Japan and South Africa.

Since the last annual meeting, we have welcomed 20 new members – the same as during the previous year – but there has been an increase in those leaving. Unfortunately, a number have resigned due to ill-health and others have left for financial or work-related reasons. The membership total is 14 less than last year.

New members are often recruited via an existing member, often at lectures; the new information leaflet being produced should help to spread the word. Many members find us through the web site; when the new one goes live, I hope it will increase our profile.

THE BSS-SOTI SUNDIAL TRAIL COMPETITION
Patrick Powers

This joint Sundial Trail Competition was run again in 2009. Seven trails were submitted by the deadline of 31 January. They can be accessed through the links on http://www.sundials.co.uk/competition2009.htm

Istanbul (pdf)	Apt, France (pdf)
West Northumberland	East Lothian
Houston	Seattle
North-east Massachusetts	

Two entries were submitted in a non-standard PDF format and, although this is not the usual form, they were accepted. The judges have completed their assessment and the two winning entries will be announced at the conference.

CONFERENCE ORGANISATION ***Patrick Powers***

Work has continued throughout the year to organise the present conference and to set up arrangements for subsequent ones. This year's visit to Exeter represents our second visit to the University and is our twenty-first annual conference. By our practice of moving to different venues each year there is always an element of having to organise these meetings from scratch each time. However, this year we have acted upon comments received and have placed particular emphasis on giving more information about the arrangements by running a special conference web page and upon trying to improve the process of switching between lecture presentations.

The organiser would like to receive input from members about their perception of this latest conference.

WEBMASTER ***Richard Mallett***

As we have now been with our current website hosting company for two years, it is a good time to see how the popularity of the website has improved over that time. The statistics for the first and second years are as follows :-

	2008-9	**2009-10**
Unique visitors	29,632	30,368
Visits	3,8581	40,918
Pages	153,542	156,294
Hits (= Files downloaded)	560,884	619,401
Bandwidth (= MB downl'd)	6,550.12	8,997.00

Tony Moss's page on 'How Sundials Work' has been added to the website (thanks Tony) and has proved very popular, pushing the February bandwidth to 1830 MB. More improvements are planned for the next few months to build on this success.

SUNDIAL DESIGN COMPETITION 2010 ***Tony Belk***

There have been 14 entries including 3 Restoration and 4 Amateur. They are of a good standard and distributed from London to Burnham on Sea, Welshpool and Glasgow. The judges will meet at Exeter to plan their programme of visits.

5. Treasurer's Report ***Graham Stapleton***

The Treasurer had no points to raise that were not already covered in his written report, and there were no questions from the floor.

6. Election of Officers

The following had put themselves forward for re-election. There being no alternative proposals, they were proposed and seconded from the floor, and accordingly appointed:

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

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

Audit. Geoff Parsons audited the accounts for 2009 and had kindly agreed to do so again for this year. He was not able to be present at the meeting, but his appointment was approved in his absence by a show of hands.

7. Any Other Business

7.1 The Chairman read a statement which is appended to these Minutes, giving his intention to stand down at the next AGM, when he will have completed twenty-one years in the position.

7.2 Doug Bateman suggested that the name of the Society's web site should be changed to *britishsundialsociety* or even *thebritishsundialsociety* as being more accurate and more aesthetically pleasing. David Brown added that he used the full name of his company as his web address, which he found satisfactory. Graham Aldred stated that the subject would be discussed at the July meeting of the Council, where such matters should be decided. Patrick Powers commented that the present name had been in use for some twelve years, was well established, and that there seemed little reason to change. Finally, it was suggested that we might have both; but it was pointed out that both are already in use by the Society.

The Chairman closed the meeting at 1:15pm.

*****

CHAIRMAN'S CONFERENCE ADDRESS

Following the sad and untimely death of Dr Andrew Somerville, one of the principal founding members of the British Sundial Society, I became his successor and have now had the privilege of being Chairman of the Society for twenty years. During this time, I have been supported by a number of dedicated and hard working members of Council, as well as others. These include David Young, another principal founding member of the Society, who was Hon Secretary for ten of these years and, unofficially, was the first Registrar until Gordon Taylor formally established the post. He also started the 'Safari' tours, now in the able hands of Mike Cowham. Douglas Bateman, too, was Hon Secretary for ten years, also having the responsibility for organising our annual conferences, with great success. Charles Aked, also a principal founding member of the Society, was the first Editor of the *Bulletin*, followed by Margaret Stanier and, more recently, by John Davis, who has brought this publication up to its present very high standard. The Registrars have included Gordon Taylor, Ian Wootton, Patrick Powers and John Foad, the current Registrar, all of whom have raised the standard of our sundial records and the resulting publications.

Of course, there are many others, whose names I would like to have mentioned, who have unstintingly supported me in keeping the Council and the Society heading in the right direction, including the Treasurers, Membership Secretaries, Webmasters and organisers of special events. I am indebted to all these members of the Society, who are all volunteers, who all have other lives, who all have their own problems, and to all of whom I give my sincerest thanks. Without them, this Society might not now exist!

However, after these past twenty years, I feel that the time has come for me to retire from the position of Chairman and to let someone else take the reins. Consequently, this will be my last year as Chairman and I will not be seeking re-election at the AGM in 2011. Sadly, I believe that there are some members of the BSS who take the Society for granted. More than once, I have appealed for your help in running this organisation and for 'new blood' on the Council; but there has been no response. When I specifically appealed for a new Hon Secretary to succeed Doug Bateman, so that he could take the retirement he had so desired and earned, again, there was no response. In this dire situation, it was Graham Aldred and Patrick Powers, who, out of loyalty to the Society, finally took over the respective tasks of Secretary and Conference Organiser – even though Graham already had the responsibility for sundial Restoration projects and for the Society's Library, and Patrick had only just retired from the Council after eleven years as Registrar.

The Chairman's job is not normally onerous, calling for the chairing of three meetings of the Council per year, usually held in the offices of the Royal Astronomical Society at Burlington House in London. The Hon Secretary organises these and the minutes are taken and produced by the Minutes Secretary. Just occasionally there is a requirement to write a letter or two; but otherwise there is little or no paperwork involved. There is, of course, the need to liaise with members of the Council, who are relatively independent, with e-mailings, primarily to ensure the smooth running of the organisation. Also, the Chairman is normally expected to chair the principal events at the annual conference and to make the customary after dinner toasts.

Personally, I have found my twenty years as Chairman of the Society most rewarding and I am very proud of this organisation. We have a marvellous Membership. We set out to achieve high standards, which we have done with remarkable success; but I believe that we have also maintained a reputation for being friendly and welcoming, and for our sense of fun. I should like to think that my successor would continue to encourage this ethos. Now may not be the right moment; but, in the near future, we will need another Hon Secretary to take over from Graham Aldred, who would like to get his life back, and we will certainly need a new Chairman.

Please take this appeal seriously and consider offering your services to the administration of the Society…otherwise there may come a time – perhaps sooner than you think – when there might not be a British Sundial Society at all! As the late President Kennedy could well have said: ask not what your Society can do for you; but what *you* can do for your Society. Thank you.

C. St J. H. D. 11 April 2010

The 21st Annual BSS Conference,

Exeter University, 9 to 11 April 2010

Chris Lusby Taylor

The terrace outside the bar at Holland Hall had magnificent views of Devon and faced the sunset. Here Jackie Jones and Johann Wikander plus Stuart Allen (?) discuss proceedings.

The gods smiled on us: the sun shone, the sunset was spectacular and sundials were seen at their best. Full marks, too, to Patrick Powers for organising the whole event and to our local members who laid on an excellent sundial tour. The programme included the well-loved mix of talks, demonstrations, exhibitions and a local tour, with opportunities to renew old and make new friendships, though I heard several bemoan the speed with which it was suddenly all over. Even sundialists have yet to master the passage of time, it seems.

Exeter's beautiful campus is even more hilly and the roads and paths more convoluted in reality than on the map, but by teatime everyone had found our base camp. After an early dinner we roped up and walked from Holland Hall (named, one supposes, for our faithful American friends) to the lecture rooms for the first talks.

Chris Daniel welcomed us, particularly thanking the effort made by our many foreign visitors, including Marg Folkard who came all the way from Australia and others from Europe and America.

The first speaker was Ben Jones who lives near Exeter and specialises in stone carving and lettering. If his work is good enough for the cathedral it is surely good enough for sundials. He asked us to look at

lettering as sculptural elements, not mere text to be read. His slides showed the freedom one has to use different letterforms, sizes and so on to enhance appearance and accentuate meaning while retaining legibility. He pointed out that, unlike the printed page, the 3D form of a sundial can offer new possible ways to read a text such as upside down or in an endless circular band.

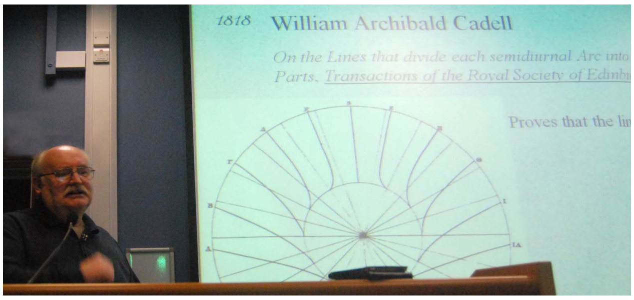
Next, Allan Mills, whose talks are the most varied imaginable, proposed

that sundial pedestals can be made to incorporate an aeolian harp so that the wind will make aethereal music. He came to this by considering that sundials use the natural phenomenon of sunlight, so it would be complementary if the pedestal could also use a natural phenomenon such as the wind. An aeolian harp consists of a stringed instrument placed so that the wind can excite the strings. The soundbox amplifies the music. Allan showed us models he has constructed in wood and card with the strings in a vertical venturi to accellerate the wind. He has experimented with durable string materials and currently favours strimmer nylon cable. No doubt he will return with a fully musical model next year. (See p.2 of this issue for a full description.)

The evening ended with a plea from Kevin Karney for assistance in indexing all past issues of the *Bulletin*. While we now have all issues in machine-readable form we lack a high quality index. Kevin pointed out that a full text search, as is now possible, is not the same thing. It will throw up many irrelevant uses of a word or phrase and might miss an article that uses a synonym. Unfortunately, though, too few members present agreed with the need and/or were prepared to devote sufficient time to the project. So we ended with Kevin rather disheartened and convinced the project could not go ahead.

Actually, the evening didn't end there as the bar was still open, but it's difficult to report on the many private conversations it hosted except to note that one new member commented to me on how friendly the Society is.

Next morning, assuming our brains were refreshed by the sea air, Fred Sawyer treated us to one of his masterly expositions. This was on the history of the understanding of how



Fred Sawyer (left) is one of our most regular overseas attendees.

Jos Kint, below, was making his first and a very welcome visit.

to draw the antique unequal hour lines on a plane sundial. These lines divide the time from dawn to dusk into 12 equal parts. The sunrise, midday and sunset lines are straight. But are the others? And if not, what shape are they? This question has, as Fred showed with his usual thoroughness, a fascinating history. The ancient Greek and Romans left dials but no instructions for drawing them. Later Arabic writers correctly stated that they are not straight but Europeans kept getting it wrong and failed to find non-parametric equations for the lines until Hugo Michnik (of bifilar fame) succeeded less than a hundred years ago. So, now that we have equations we can at last plot these lines accurately. Fred concluded by doing so and showing how a 'T' shaped gnomon can show both unequal hours and modern equal hours on the same, and

beautiful, dial.

Johan Wikander was back with an update on the dial he showed us last year and news of three new dials from much further north in Norway. Last year's dial has what he believes to be a runic letter 'k' but other scholars have publicly doubted that this could be so. He has new evidence that this letter was indeed used in Norway and will be publishing it. From the far north (lat 70.5° N) he showed three very early dials, one marked with hours on one side and tides (the earlier Norwegian time system) on the other. We were amused to learn that an archbishop had written to the Pope telling him that sundials could not be used at these latitudes as the sun sometimes never rose or set. It's true that Italian hours become unusable

in the arctic summer.

Jos Kint, visiting us for the first time from Belgium, next spoke on how he has used a simple sundial to calculate the eccentricity of the earth's orbit and the date of perihelion. By taking nearly 900 observations on 170 days over two years he was able to plot the Equation of Time and thus deduce the eccentricity. His figure of 0.01667 is very close to the correct 0.01671. Another method he used was merely to measure the lengths of the seasons between the solstices and equinoxes. This gave 0.0169 even though the times he measured were, he knows from published information, innaccurate by four hours or more. Jos was clearly thrilled to be able to make real scientific measurements with a watch and a sundial. It's a pity he missed last year's talk by Mark Lennox-Boyd on how the Greeks used sundials to calculate the distance to the moon.

Time for a coffee break and a wander round the exhibit area. As well as the usual suspects – Elspeth Hill's books, Mike Cowham's and Leonard Honey's models, Piers Nicholson's Spot On dials, John

Michael Maltin and Frank Evans

Davis's brass reproduction dials – there were a few new stands, including Michael Maltin's retro-reflecting mirror devices for aligning sundials which everyone puzzled over]see p. 42 and puzzle no more—Ed]. Tony Belk's Photographer's Sundial, as described in the previous two *Bulletins*, was also on show. Of actual sundials, John Davis exhibited two brass dials he has made, both exquisitely etched. Alastair Hunter showed his vertical dial with a circular aperture nodus and David Brown had brought an impressive gnomon of a dial he's working on. In half-

A small selection of sundials from Leonard Honey's ever-popular stand.

inch thick brass, its elaborate piercings were entirely made by waterjet.

Chris Williams next gave us Part III of his statistical analysis of the prevalence of mass dials. With a few assumptions that most present appeared to accept, he showed how the relative survival rates of different styles of dial can be used to prove that dials with a complete circle of hour lines are older than those with a semicircle or quadrant. Further, that these 24-hour dials were replaced by the 6 and 12-hour ones at different dates in different parts of the country. Worryingly, he extrapolated the model of dial loss over time to show that they will all be gone in another couple of hundred years unless we can do something to arrest this.

Apparently nearing the end of the information he can wring out of the English mass dial statistics, Chris is now turning his attention to the Continent. Here, he suspects, there may be just as many mass dials, but they have lacked BSS members to record them.

A change of approach now, with John Lynes suggesting that Brunelleschi may have used his knowledge of sundial geometry in discovering the rules of perspective. Certainly, John showed to our satisfaction that the accepted story of how Brunelleschi first used perspective seems implausible. Further, that a gnomon could serve as a sight to show where on a canvas to put the features in a painting. As with the question of whether artists used camera obscuras, there is, unfortunately, no surviving hard evidence but it was pleasing to think that gnomonics may have been the precursor to linear perspective.

It was time, whatever that means, for lunch. The afternoon was for seeing sundials in the wild, either on local churches or at Killerton House. The dimensions of Devon lanes required that we book several small coaches to avoid the problems we had last year. Each coach had a host – Janet or Martin Jenkins or Ben Jones – who told us what we were

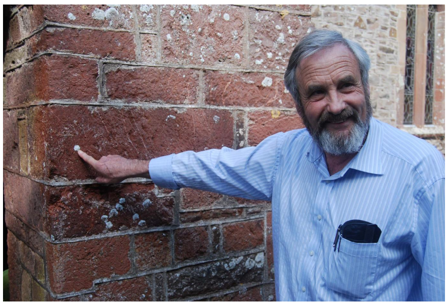
Above: all aboard for the coach trip, with Patrick P on the left shepherding his flock.

At Crediton (right) the newly-restored dial was brought back especially for us.

Is it a bird, is it a plane?..... No, it's the BSS group at N. Tawton admiring a dial.

The beautifully carved slate dial at Bondleigh with a quote from Cicero. The hourlines above the horizontal balance the design but won't see much sun!

Martin Jenkins, seen below at Nymet Tracey pointing to a very doubtful scratch dial, had spent much time with his wife Janet arranging the tour, to great effect.



looking at. Knowing there would be a quiz at the end, we studiously noted such features as the owl in Crediton Church.

The weather was just perfect, so every dial was easy to admire and photograph. Two of the dials exhibited a local oddity: the numbers VI and VII are written IV and IIV (see photograph above).

John Lester has suggested[1] that they are to be read anti-clockwise. What struck many of us was the gruesome message in the numerous skulls, sickles and mottoes such as "This Dyall sayes dy all wee must". More happily, Fred Sawyer was able to tell us that Bondleigh's "Sensim Sine Sensu", a quote from Cicero, means 'Softly, without being perceived' which is rather delightful.

Not content with seeing the seven advertised dials, we examined all the church porches for mass dials. At Nymet Tracey we found one, unless it was a random pattern of scratches in the stone. As Chris Williams has drilled into us, we should record that we failed to find any at the other churches.

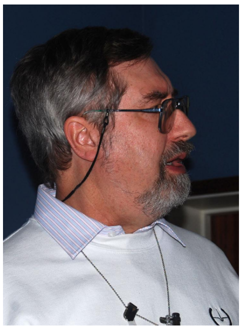
A select group who could not face a bumpy coach-ride travelled to the National Trust property at nearby Killerton House. Here, as well as the traditional delights of a cream tea, we saw a modern armillary sphere and a reproduction of a stolen Benjamin Martin dial, delineated in 1999

Doreen Bower, Catherine Powers and Chris Daniel with the Benjamin Martin reproduction dial at Killerton House.

by our Chairman. His name was discretely added to the side of the gnomon, as well as that of L.D. O'Connell who had *caelavit*, i.e. hand engraved it.

Saturday evening was the occasion for the Conference Dinner and Awards Ceremony. The dinner was excellent, the wine flowed freely, the company delightful. Chris Daniel proposed the toasts and asked Elizabeth Karney to cut the ceremonial cake in honour of the Society's 21^{st} birthday. Piers Nicholson announced the winners of the annual Sundial Trails competition, jointly sponsored by the Society and by Sundials On The Internet. The winners were Woody Sullivan for a trail in Seattle and Dennis Cowan for a trail in East Lothian, an area rich in polyhedral dials. Martin Jenkins then announced the results of the quiz on the afternoon's excursion. He was very disappointed in the poor standard, with even the winner, Graham Aldred, getting a paltry 7/17. There was no photographic competition this year and the results of the sundial design competition have not yet been decided.

Sunday morning's first talk was by John Davis and Michael Lowne, although Michael could only be pre-



sent in the form of a photographic image. They introduced us to the horizontal quadrant, a rare instrument related to Gunter's quadrant and the astrolabe but calibrated for use with the sun, not the stars, so needing only a map of the equatorial region of the heavens. Like other quadrants and astrolabes it is used by first sighting the sun to measure its altitude, then finding the time when that altitude occurs on today's date. The word 'horizontal' refers to the stereographic projection of the celestial sphere onto the local horizontal plane – the device is actually held vertically when used. John was exhibiting a replica he has made. The word 'time' refers to graduations that show Italian, Babylonian, seasonal and/or planetary hours. [See p.18 of this issue for Pt. 1 of the story.]

Next up was Alastair Hunter who was exhibiting a very precise vertical dial he designed and pointed out that a dial readable to one minute must be aligned to three minutes of arc in order to be accurate. He showed how he does this by first

aligning the dial accurately to read noon at the sun's current azimuth, then using a theodolite to rotate it into due south. This can give much more accurate results than a compass, though Frank King pointed out that north-south alignment is only one of nine potential errors.

David Brown now showed slides of interesting sundials he has worked on at Hever Castle and Penshurst Place in Kent. At Hever an apparently Roman scaphe dial was missing its gnomon. David, following the work of the late Noel Ta'Bois, was able to show that the dial is accurately spherical but that the

'hour lines' radiate from quite the wrong place. Penshurst has many fine sundials including two spectacular polyhedral dials, from one of which David had castings made so that the originals could be kept safe. He also showed a dial in the form of an archer that he collaborated on as a memorial to the present owner's father. It is heartening to know that fine, unique, sundials are still being commissioned and that there are still people like David and a few other members able to make them.

After another coffee break, your correspondent took time off from reporting to present his latest dial. By showing how Fred Sawyer's cardioid-shaped equant dial[2] was derived, he applied similar logic to the question of whether a horizontal sundial's polar gnomon can be simply

Left to right: Graham Aldred receives his quiz prize from Janet Jenkins. The anniversary cake with its candle gnomon, delineated by Ben share a joke at the banquet. Conference organiser Patrick Powers celebrates while Catherine chats to Jim Holland. The view from Holland

moved to adjust the displayed time. It can, and the resulting dial, with a movable gnomon, was proof. This is the only fixed horizontal dial that shows mean time and BST of which the author is aware. An article describing it for the *Bulletin* is under preparation.

Marg Folkard has been making sundials in Australia for many years with her partner John Ward.[3] She showed us some of them and details of how they are made. These are truly magnificent dials, many on a monumental scale and in prestigious locations such as the Sydney Botanic Gardens, and it was humbling to see pictures of her standing inside a huge bronze armillary sphere using an angle grinder.

A physicist by profession, her interest in dials started when she read Cousins' book and tried making the examples in it. In her travels she has managed to meet Andrew Somerville, Rene Rohr, Anton Schmitz, the Mayalls, the Daniels and the Dalai Lama. Doug Bateman visited her last year[4] but this is her first visit to a BSS Conference.

They long ago adopted state-of-the-art methods and materials, such as photopolymers for impressing dial designs on sand moulds for bronze casting. Waterjet cutting is old hat now and they are exploring laser cutting, though she insists this is just a "hobby business"! One popular design is a human analemmatic dial with an analemma date scale. I thought this would not work, but Marg assured us it does. Next time you're in Adelaide be sure to look her and John up.

Jones. Andrew Ogden and Gerald Stancey Hall.

As members will know, the culmination of our conference is always the Andrew Somerville Lecture given by an invited speaker. This year David Bryden chose 'A Gallimaufry of Dial Makers and Designers' as his title, helpfully explaining that a gallimaufry is a jumble or miscellany. David is ex-curator of the Whipple Museum and author of its catalogue of over 300 sundials. His main interest is in the Georgian period and he looked at sundial-related patents from that period.

David pointed out that the Circumlocution Office in Dickens' Little Dorrit seems to have been a satire of the Patent Office, which hadn't even existed in Georgian times when you could register a patent without any checks being made. You didn't even have to disclose how the patented device worked until 1778, nor was its novelty evaluated until 1852. But why there were so few patents granted for sundials in that time?

The answer appears to be that a patent was expensive and enforcing it more so, while there were alternative ways to make your name known. As most sundial inventors of today find, peer recognition could be more valuable than costly legal protection. One way to achieve this was through the Society of Arts (later the Royal Society of Arts, it was responsible for the Great Exhibition of 1851) which frequently awarded medals and prizes for inventions submitted to it. From its publications we can see the fate of sundial inventions – most were deemed not sufficiently novel. For instance, in 1835 a Mr Gaussens proposed a way to use a graduated table to align a sundial. Even then this failed to win a prize, yet here we are still struggling with the same issue.

The Board of Longitude also allowed inventions to be submitted and eight people were sure their sundials could tell longitude. The Royal Society was another outlet, but published only one paper on sundials, though we know more were presented to it.

David also spoke of 'ghost' patents which appear in lists or other references although no actual patent has yet been found. An example is a 'floating' pocket dial which carries the legend 'Porter's Patent Pantochronometer' although there was no such patent and several other devices to the same design were made by other makers – there was no law to stop anyone claiming they had a patent!

This was the end of the conference. Patrick's first – let's hope his new-boy enthusiasm doesn't wane; he did a great job. It just remained to hold the Society's AGM, reported elsewhere, have lunch and prepare mentally for the 51 weeks until the next one. I drove home via Wells where I noticed that the cathedral clock, second oldest in the world, was set to BST. That's moving with the times.

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4. D. Bateman: 'Sundials Australia: a visit report', *BSS Bull,* <u>21</u>(ii) p.5 (June 2009).

Pictures from Mike Isaacs, Chris Lusby Taylor and John Davis.

A CHIME DIAL

HEINER THIESSEN

This sundial was inspired by historic attempts to mark solar midday by an acoustic signal, as happened with the noon cannons of the early 1600s, ingeniously equipped with lenses and gunpowder. The Chime Dial design embraces the idea of using modern know-how in the same way that those noon cannons incorporated cutting edge technology of their day, when lenses began to revolutionize our cosmology.

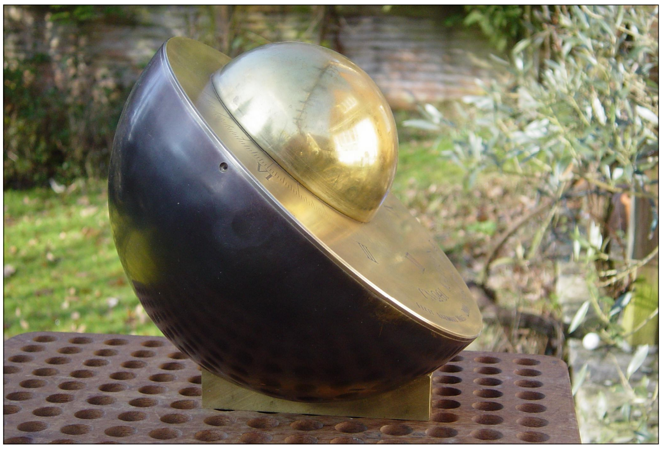

Fig. 1. The complete Chime Dial.

The Chime Dial is an equatorial sundial, reading solar time from spring to autumn equinox. It can also be used to remind the observer acoustically of the apparent progress of the sun's journey across the sky, as our planet keeps turning eastwards.

Essentially, the dial consists of two brass hemi-spheres and a brass dial face. The observer turns the small brass hemisphere (diameter 100 mm) on top of the dial face, until it is aligned to the current angle of the sun, so that a ray of light can travel through its narrow centre gap of only 0.3 mm and then onto the brass dial face itself, highlighting one of the time markings that are engraved at five-minute intervals.

Fig. 2. The Chime Dial indicating the time as 12:30.

Fig. 3. The dial face, with the reflected image of the photographer in the centre.

Alternatively, the small dialling hemisphere can also be set to any chosen time ahead, e.g. to solar midday or any other time before sunset. This is done by turning the small brass hemisphere, so that its narrow gap points towards a chosen time mark on the dial face. As the sun progresses on its apparent journey westwards, it will eventually reach the pre-set hour angle of the dial and a gentle chime will sound to remind you that the sun has reached either your local meridian line at solar noon or simply that it is time to start the BBQ.

The acoustic time signal is obtained with the aid of a Light Dependent Resistor (LDR) that will be hit by the sun at the very moment our day-star's hour angle has advanced to the pre-set time and its light can actually travel through the narrow gap in the top hemisphere, hitting the LDR placed inside the sphere and triggering the desired signal; the sounding of a gentle bell. The multi-choice chime is housed in the larger hemisphere, together with the specifically-designed circuit board.

The sundial's Greek motto reads ΓΝΩΘΙ ΚΑΙΡΟΝ, 'Know thy Time' or more loosely translated 'Know your Opportunity'. This is attributed to Pittakos of Mitilini (approx. 648-569 BC), one of the seven wise men of ancient Greece. The dial was made in 2008 and shows names of designer and maker as well as the year of its creation.

Due to its hemi-spherical base (diameter 200 mm), the dial can be installed at any latitude with the dial face at the appropriate inclination of its co-latitude angle.

The Chime Dial was made by Tony Moss in cooperation with his electronics associate Russell Cook. It was designed by the author.

www.solardials.com

BUILDING THE CHIME DIAL

TONY MOSS

A miniature LDR lies face up and flush with the floor of the small hemisphere to allow equinoctial sunray passage. Initially the sunray, admitted via a milled 0.4 mm slit, was to be further constrained in its passage to the LDR by a 0.5 mm gap between brass 'walls'. Bad idea! At first I was puzzled that the initial test didn't give the sharp cutoff expected but I soon realized that this was due to internal reflection between the walls of the slot no matter how much I textured and blackened them.

With the hard-won and elaborate interior removed and, finally, a pair of blackened brass shims 0.3 mm apart on top of the LDR to limit activation to a minimum, it worked fine. My electronic knowledge began on 2 volt valves, progressed through RAF National Service 'signals' and ended with discrete transistors so I enlisted Russell Cook (sometime design engineer with Welwyn Electric) to assist with integrated circuitry to give us an assembly small enough to fit into a tubular plastic base (4" sewer pipe junction unit). The intention was to trigger the bell push of a commercial wireless door chime for remote operation in the house so a non-metallic base was needed. It all worked well in my workshop with a cheap doorbell unit from the local market but the 'chime' was best described as a tinny squawk.

The dial was delivered to the client with instructions on how to adapt a good quality Friedland wireless unit but this didn't prove possible. Further considerations of battery life etc. suggested a move to mains powered (low voltage), hard-wired operation which has now been tried and tested.

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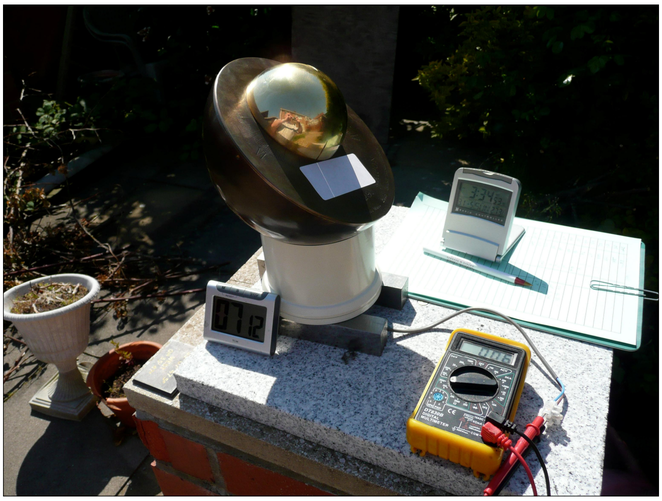
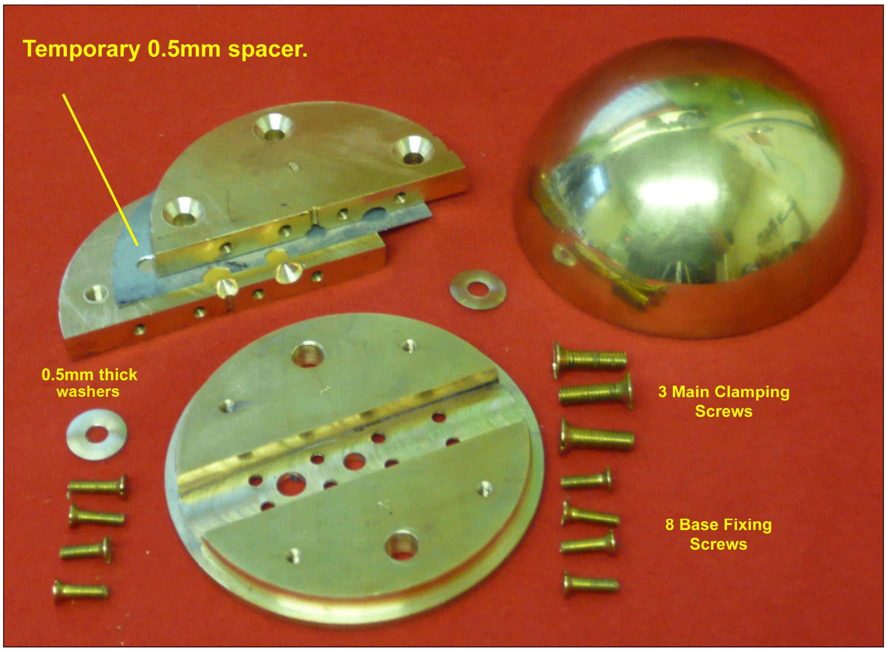
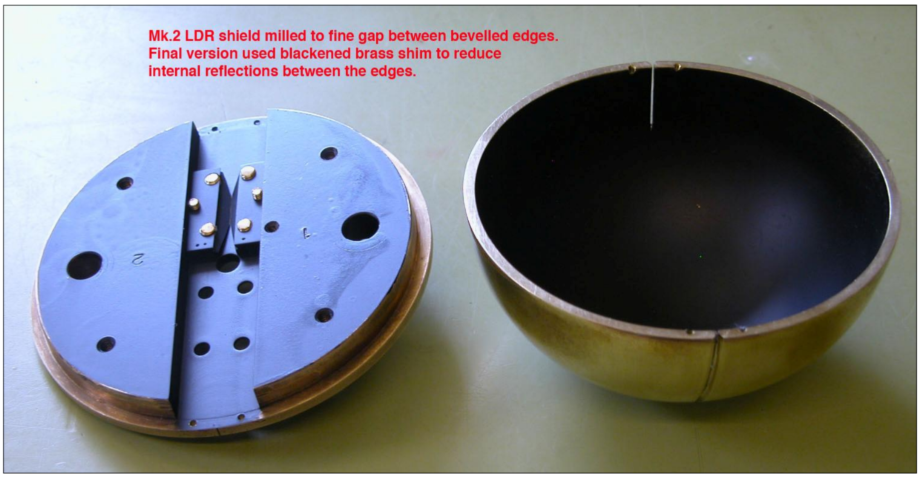


Testing in the sun.



Left: the interior components of the Mk. 1 design.



Above: the mounted LDR.
Right: the mechanical assembly of the Mk. 2 design.

AN UNUSUAL SLATE SUNDIAL

MIKE COWHAM

I received a picture one day sent by Frank King of a slate dial with many rather strange attributes. It belonged to a colleague of his who wanted to know more about the dial. It clearly has some wrong features, perhaps the most prominent being the corner subsidiary dials, three of which did not have their gnomons following north-south alignment, but the remainder seemed worth studying.

The dial is mounted on a wrought iron framework, making the whole assembly look like a table. As far as it is possible to tell, this may have been its original mount; perhaps so made for putting the dial out on the veranda or for use inside a conservatory.

Closer inspection reveals that the dial is signed "G B FECIT" and is dated "1712", so this dial predates the dials of Melville by about 100 years. Some of the spellings also looked odd. Note in particular the spelling of EVROPE but also EUROPE on the top left subsidiary dial and the Latin names for the compass directions of SEPTENTRIO, ORIENS, OCCIDENS and MIDY. It is the MIDY that replaces the more usual 'MERIDES'. Looking closer at the north edge of the main dial, it is possible to see the months of the year and the spellings of some of these are odd. I suddenly realised that the dial is of French origin, and slate is a rather unusual material for French dials.

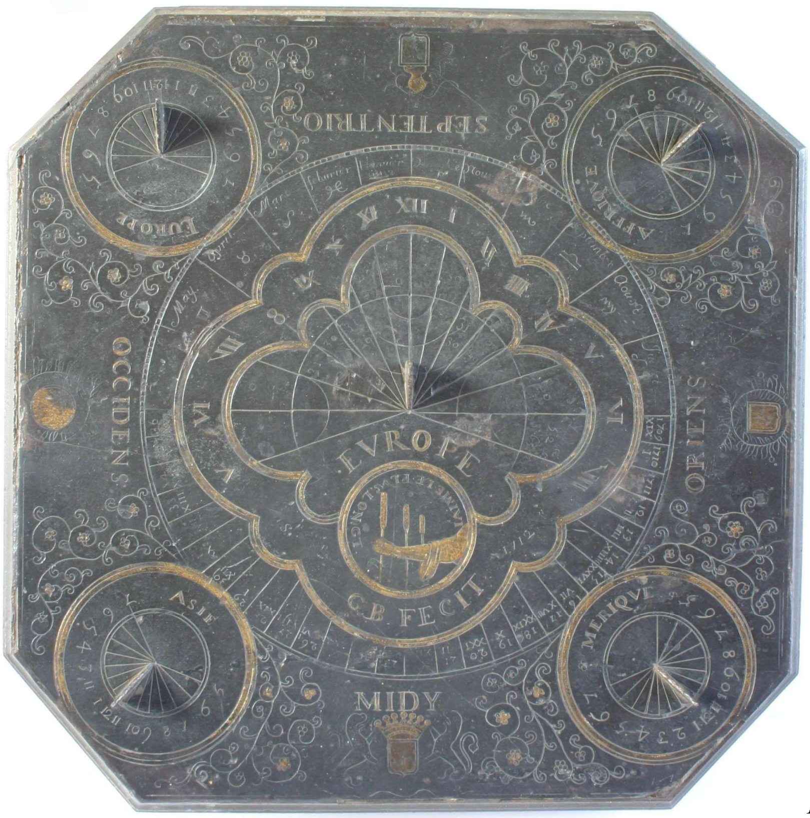


Fig. 1. The ornate engraving of the slate dial.

Fig. 2. The dial mounted on a wrought iron stand.

The general decoration of the dial is somewhat different to the better-known slate dials of Melville (Melvin) of the early 1800s. In many ways, this dial is much cruder, with the surface of the slate still fairly rough and not really polished. The patterning on the dial plate is certainly much more ornate, perhaps rococo(?) and it has an attractive flower pattern around each subsidiary dial. As the engraving is coloured, probably with its original colouring, it seems unlikely that the dial has been outside in the weather for much in its life.

The gnomon angles were measured and each was identical at about 48°. Next, the IX and III lines on the main dial were measured (each giving about 40° from XII) and were calculated as being for a dial for around 57° north. Obviously there is a large discrepancy here! Furthermore, the main central gnomon is the same size as those on the subsidiary dials and is only about one quarter of the size that I would have expected. In the summer the shadow is going to be particularly short.

It is so easy at this stage to ignore the dial and treat it as a rather poor example of dialmaking, but there are other features that are still worthy of our attention. I have already

Top to bottom:
Fig. 3. The engraved months with zodiac signs below.
Fig. 4. The years with Epacts beneath. Notice the Roman numeral XIIIII instead of XV.
Fig. 5. The crest with two lion supporters.

Top to bottom:
Fig. 6. Hand of Ceres holding a stalk of corn.
Fig. 7. The engraving of "L'année" with "52S" and "3 65".
Fig. 8. The engraving of "S^t ------n", possibly the town of the maker, G B.

mentioned the names of each of the months along the north edge of the main dial. Under each of these is a zodiac sigil showing which sign is entered during the month. Below this, inside the inner gold border are some less pronounced characters, the first being the number of days in each month and the second possibly being the number of days in each lunar cycle. The lunar cycle, as we know, has a period of quite close to 29½ days, so, in terms of whole days, alternate months could have the figures of 29 and 30 attached. This would be fine, but in one place there are two consecutive 29s meaning that there also have to be two further consecutive 30s (which are just discernable for December and January). Is this a plain engraving mistake or am I missing something rather subtle?

Around the southern edge of the dial are further marks, some a little difficult to read now, but these are clearly the years from 1709 to 1736 and the Epacts (following the 19-year Lunar cycle) to go with each year in Roman numerals. Note the odd engraving for 1714 where XIIIII is used for XV.

Below 'MIDY' is probably the crest of its first owner. This is now difficult to decipher but the shield is surmounted by a Viscount's crown and either side are lion supporters. The smaller crests on the other four sides are probably just decorative.

However, between 'EVROPE' and 'MIDY' is a further image with a motto around it. This appears to be an arm of a person wearing a cloak and holding an object like an oar.

Fig. 9. The subsidiary dial for Europe with a mixture of Roman and Arabic numerals.

This is probably the hand of the Roman goddess Ceres (Demeter in Greek mythology) holding one of three stalks of corn. The motto reads "I'AIME LE PLVS LONGT" probably meaning 'I love the longest', presumably referring to the stalk of corn rather than the dial's shadow.

Further inspection of the dial reveals various other interesting features. Between the numerals VI and VII in the evening is a word "*L'année*" and beneath this are two numbers which appear to say "52S", the S probably meaning 'semaines' (weeks), and just below that "3(gap)65", telling us that the year consists of 52 weeks of 365 days.

On the opposite side of the signature, balancing the date, is a further inscription, now unreadable but this may be the town of the maker G B, possibly starting with *S*ᵗ and ending in *n*.

The corner dials are puzzles, one each for EUROPE, AFFRIQVE, [A]MERIQVE and ASIE. Obviously, with three of these dials twisted, these are unable to work at all. Furthermore, the hour lines engraved on each and the numerals are the same as for the main dial, but not so accurately or carefully done.

Other oddities that will be seen on close inspection are the use of numeral 8 in place of VIII on the main dial and the use on two of the subsidiary dials of a mixture of Arabic and Roman numerals such that the hours around noon go 10 11 12 I II 3. For the [A]MERIQUE dial the numerals are correct but the afternoon ones are inverted with respect to those for morning.

It is difficult to come to a firm conclusion about the dial but it seems that it was made by a fairly competent engraver – his images are excellent, his scrollwork fine and delicate, and his lettering is well formed – but with a rather shallow knowledge of gnomonics. He has perhaps seen various dials and has probably tried to copy them in his work here.

ACKNOWLEDGEMENT

I would like to thank the owner of this fine dial for allowing me to photograph it and to record its details.

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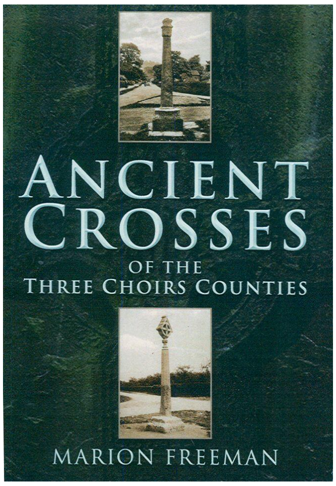
BOOK REVIEW (1)

Ancient Crosses of the Three Choirs Counties by Marion Freeman. The History Press, The Mill, Brimscombe Port, GL5 2QG, Paperback, 128pp, 250 mm × 170 mm, £12.99. (2009) ISBN 978 0 7524 5288 3



In spite of the title, this book is by no means as parochial as might be expected. The 74 pages of text cover the history of British crosses in all contexts, mainly connected with the Church of course, but drawing examples from around the country.

Britain's peculiar history, being conquered in 1066, followed by religious dissension in the sixteenth and seventeenth centuries, has left a variety of crosses in a variety of states. In particular, and of interest to the dialling world, is the fact that many were converted to carry sundials, aloft in many cases but also just used as a pedestal with its plinth and steps to climb up to view the time. Presumably this only happened in Britain – or did it?

The author covers the history of church crosses, wayside crosses, Eleanor Crosses, market crosses and even the elusive consecration crosses, all nicely illustrated. A couple of pictures have gone adrift: Geddington's Eleanor Cross has a picture of the Northampton Cross and the Elmley Castle village cross appears twice (once on the cover) and is wrongly identified within the book. Sadly, the Bewcastle cross doesn't appear, its unique dial not making it conspicuous amongst other Saxon crosses.

However, turning to the sundials, we find over fifty references and at least a dozen photographs of dials although in a couple of cases the author has not recognised them as such. Unless you are looking for gnomon roots and faint markings about ten or twelve feet in the air this isn't really surprising.

The gazetteer section covers Gloucestershire, Herefordshire and Worcestershire with a short description of each cross (or former cross) and most helpfully, the O.S. Landranger map reference.

The *Three Choirs Counties* cover a fair part of the West of England and I am hoping that it will provide a happy source for hunting down dials within a days range.

Tony Wood

See p.52 for another book review.

THE WOODCHESTER ‘UNICORN’ DIAL

TONY WOOD

Fig. 1. Michael Maltin (left) and owner Gerald James frame the gnomon of the Unicorn dial. Photo courtesy of Stroud Life.

Gloucestershire is well known for having ‘lots of dials’ but the Woodchester dial can claim to be the biggest of them all (if we discount the church tower at Horsley[1]). It was formally launched with glorious sunshine in the garden of Mr and Mrs James, North Woodchester (Fig. 1) on 27 September 2009, the day following its presentation at Newbury by Michael Maltin.[2]

Its principal feature (amongst many) is a 17ft gnomon of chromium-plated stainless steel. It weighs a ton and is helical in form, probably originally serving as a grain conveyer prior to its recovery by Gerald James from a scrapyard.

Holding such a weight of steel at the correct angle of 51¾ degrees has required a substantial welded socket set in 4½ tons of reinforced concrete buried 4 feet into the ground (Fig. 2). All this was engineered by Gerald. The alignment and delineation was performed by neighbour Michael Maltin who thereby outlined the garden layout. The garden has a Chinese theme with flowers along the hour lines (Fig. 3); all the work of garden enthusiast, Gerald’s wife, June. The Chinese elements consist of dogs with footballs and wall markers indicating happiness and wealth. Dial furniture is taken literally with chairs and a bicycle (Fig. 4) and a girl at 12 o’clock shading her eyes from the mid-day sun; she has been christened ‘Noon’ (say ‘Hi Noon’!) (Fig. 5)

The dial’s launching involved cheese and wine for all the neighbourhood, descriptive handouts from Michael, a check that Noon was indeed standing in the right place and a visit from the local press, who gave it all good coverage.

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Fig. 2 (above) The ‘unicorn’ gnomon.

Fig. 3. Chinese wall markers for wealth and happiness with floral hour lines.

Fig. 4. Assorted furniture.

Fig. 5 (far right). Hi Noon!

A SIMPLE MERIDIAN INSTRUMENT

MICHAEL MALTIN

The opportunity to construct a very large dial is not given to many and I was indeed fortunate to be involved in the erection of a real jumbo of a dial (now known as the Unicorn dial in view of its 17 ft helical gnomon) that is believed to be one of the largest privately owned garden dials in Gloucestershire, if not in the country.

In the event it proved not to be a great problem. Putting down the hour markers and all the rest of the usual markings was not too difficult: just a case of scaling up from the layout of a normal horizontal dial. However it was obvious from the start that the usual methods of aligning the gnomon by, for instance, the shadow of a plumb line at noon would not be adequate in view of the size of the operation. What was needed was some means of laying down a meridian line over several metres, to which the gnomon's bearing could be referred. A theodolite is, of course, the proper tool here, but unfortunately out of reach of most of us and in any case not the simplest of instruments to use.

An alternative had to be found. It is said that necessity is the mother of invention and a quick donning of the thinking cap came up with the following, which proved to be the answer. Basically, if two mirrors are set at right angles to each other and turned to face towards the Sun they can produce a spot of light (strictly two spots of light) in the direction of the Sun on to any convenient vertical surface. Provided that the junction of the mirrors is in the vertical plane the spots can be moved up and down but it will not be possible to move them laterally; they will remain always directly beneath the Sun. (This is, of course, the opposite of the effect of a single mirror, where the spot will move at twice the angle of the glass if turned horizontally.)

It will be appreciated that this device is, in part, the principal of what is known as a Corner Reflector, but using only two mirrors instead of three. Proper three-mirror devices will reflect light straight back to the source and we are surrounded by examples of this, from 'cat's eyes' in the roads to radar reflectors at sea. (There is even an array on the moon!) Leaving out one of the mirrors, however, enables us to free up one of the axes and so to allow movement in the vertical plane whilst retaining a lock horizontally. In effect, provided the hinge line of the two mirrors is as stated above, the reflected light of the Sun can be 'brought down' to the horizon directly below it, regardless of the heading of the instrument. We can now follow the track of the Sun precisely along the horizon as it slowly moves to the West. Although I say "regardless of the heading of the instrument", the spots of light can drift slightly off south if the instrument is turned slightly when the Sun is very high in the sky during the summer months. This problem can be overcome by fitting a plane mirror to the front of the gadget, producing a third spot of light, which, when lined up with the other two, will centralise everything.

It was said previously that if the mirrors are set at exactly 90 degrees to each other the instrument will produce two distinct spots of light. (Their size, of course, depends on the size of the mirrors.) A refinement here is to be able very slightly to reduce this angle to a little less than a right angle, whereupon the two spots will be seen to merge. (Rather on the principal of a rangefinder: the nearer the target, the smaller the angle.) It is also essential to keep the East-West axis of the instrument precisely horizontal and to this end a bubble level is an essential requirement. The North-South tilt must, of course, remain adjustable in order to allow for the height of the Sun.

A wall can provide a reasonable backdrop if one happens to be available in the right place but for ease of use a vertical plank, set a little above the ground and at approximately right angles to the proposed meridian, will be found more convenient, particularly if it is fitted with a 'target'. At 10 metres from the instrument the spot is travelling at over 40 mm/min and a moveable pointer attached to the board (a bit like a slide rule cursor) will be found of great convenience in following – and eventually retaining – the centre of the spot at the required time. A plumb line dropped from this marker, (left at its noon position) and another plumb line underneath the mirrors will give you an accurate meridian, the two points being joined by rope and pegs.

The first piece of hardware tried was a previously-discarded double prism from an old and broken pair of binoculars. Mounted on a small triangle of metal and with provision to adjust its level and tilt, it proved quite adequate to do the job and was in fact used in the initial setting up of the gno-

Fig. 1. The prototype instrument.

mon. Its main disadvantage was the small size of the prism, making it difficult to pick out the reflected light at a distance. With a larger version, using proper mirrors, this ceased to be a problem.

This instrument was demonstrated at the BSS Newbury meeting in September last year (see pictures in *Bulletin* 21 (iv)) and seemed to be received with a certain amount of interest: hence this rather detailed description for anyone who wishes to construct a similar instrument. When well set up, the accuracy of the result depends almost entirely on the calculation of the moment of local noon and the precision of the timing. A digital watch that can be set precisely is almost essential and a good grasp of simple astro tables a great help!

I am much indebted to Doug Bateman for his great interest and encouragement in this project, without which this article would probably not have been written.

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MERIDIAN MIRRORS

DOUGLAS BATEMAN

Members who attended the Newbury one-day meeting on 26 September 2009 were intrigued by the device demonstrated by Michael Maltin that threw a spot of sunlight on a wall, which was in line with the azimuth to the sun. Obviously, with an accurate clock, a meridian line could be established. Having had experience with optical instruments, I instantly recognised the use of the mirrors as a *retro-reflector*. Whilst a corner cube of three mirrors will return a beam of light back in the same direction to the source, two orthogonal mirrors will return the beam *in same plane* as the source and vertex of the mirrors, see Fig. 1.

Michael's version is made from materials to hand and cost almost nothing although it does contain quite a number of components. Rising to the challenge, my approach was to take something with a ready-made 90º such as an engineering V-block, and add two small mirrors with some double-sided sticky tape. An extra piece of metal is taped to the rear to provide a rest for a spirit level. The only other work was to drill and tap the block for a mounting plate so that the whole could be attached to a camera tripod. The mounting plate is such that the vertex of the mirror V overhangs the tripod legs to allow for a plumb line. The size of the mirrors was calculated to subtend an angle of half a degree (the sun's angular diameter) at a distance of 5 metres. The old imperial 2 inch V block just happens to be a perfect match, as shown in Fig. 2.

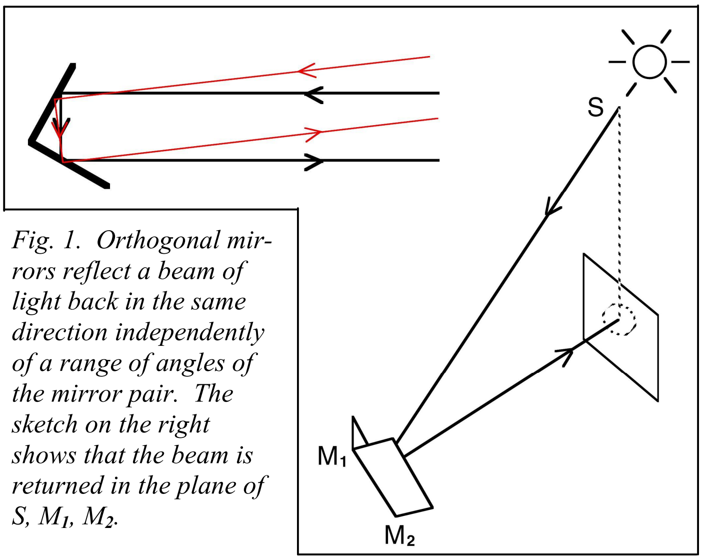

Fig. 1. Orthogonal mirrors reflect a beam of light back in the same direction independently of a range of angles of the mirror pair. The sketch on the right shows that the beam is returned in the plane of S, M_1, M_2.

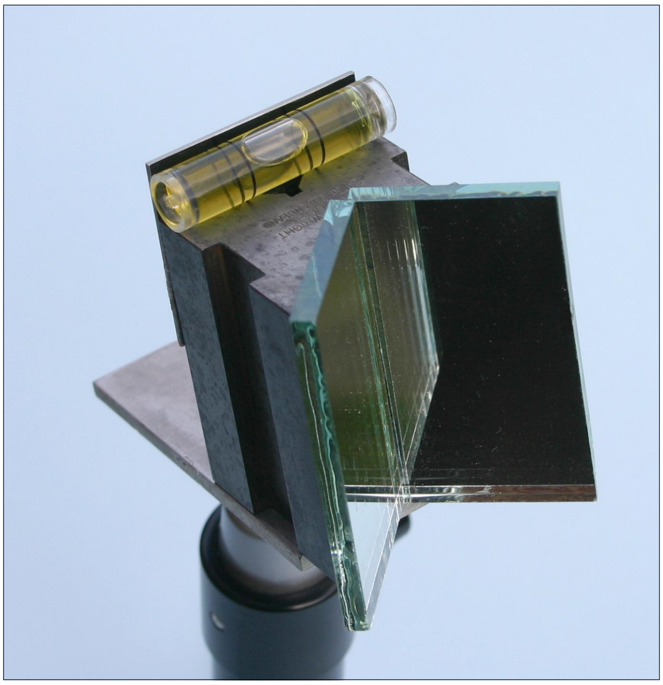

Fig. 2. A pair of mirrors in a V-block. The rear 'ledge' allows for the rotation of the spirit level to accommodate changes in elevation to suit the sun's declination.

A slightly disconcerting feature of this fixed angle of reflection is that if the block and adhesive tape are such that the angle is not exactly 90º the reflection of the sun can appear as two adjacent or badly overlapping patches of light. This does not invalidate the principal as the centre of the two spots of light, by virtue of symmetry, still aligns with the sun's azimuth.

The fact that the mirrors have a finite thickness gives some multiple reflections, which adds to the blurring of the reflected spots. Out of curiosity, and in a quest for perfection, a second version has front silvered mirrors. The latter was achieved by taking the standard mirrors and removing the

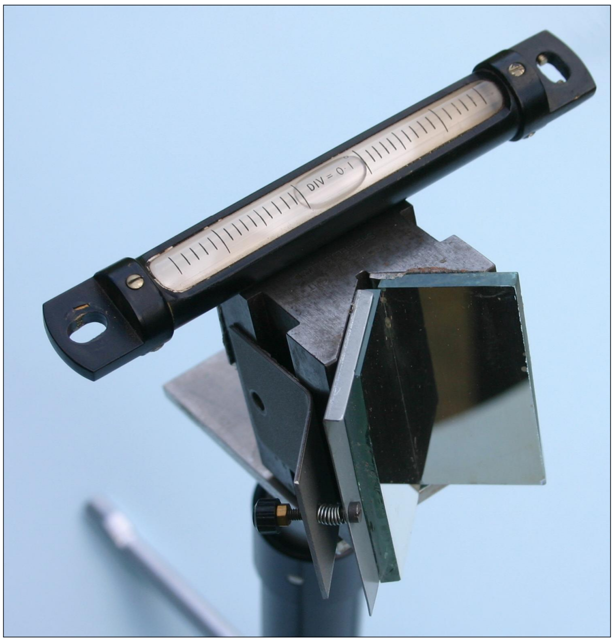

Fig. 3. A version with front silvered mirrors, an improvised hinge and a precision spirit level.

protective backing layers, by experiment, with paint stripper detergent, and the next layer with nail varnish remover (mainly acetone). The resultant finish is good although susceptible to damage from an abrasive cleaner. The other refinement was to attach one mirror to a thin metal sheet so that it could be hinged similar to Michael's version, as in Fig. 3, to give a precise overlap of the reflected spots.

In use, a critical and important point is that the mirror support must be level or, more precisely, the vertex of the mirror system must be vertical. For these mirrors, one assumes that the V blocks are orthogonal and that spirit levels are the most convenient method of setting the block. Levels can be calibrated, even the 50 pence vial in Fig. 2, so that an accuracy of better than a quarter of a degree is easy to achieve, assuming commensurate accuracy with the timing of local solar noon. A benefit of the retro-reflection is that once the reflector has been set for approximately the right direction, no further levelling is necessary, as the sun, shall we say, finds it own direction. Fig. 4 shows the practical setting out of a meridian line.

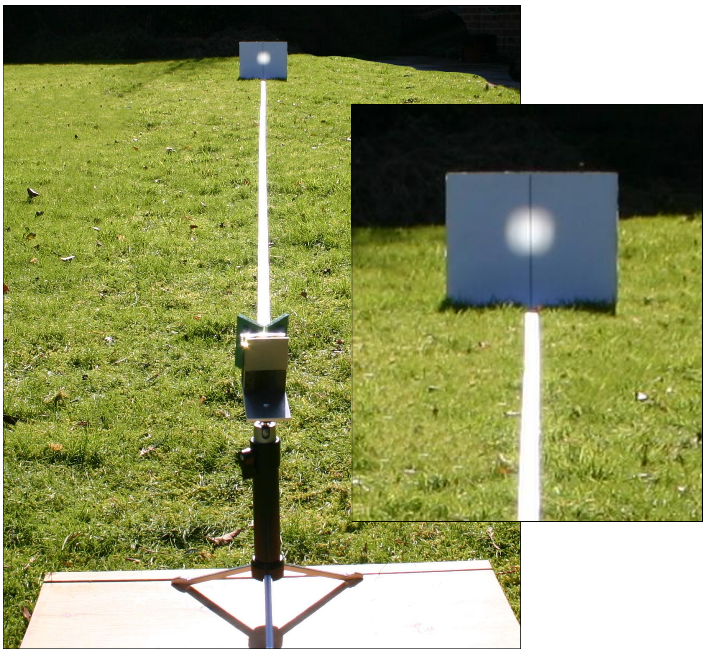

Fig. 4. The extreme simplicity of the method. Once the mirror block has been set up, no other adjustment is necessary. It is just a question of tracking the reflected sunlight with an accurate clock. The board is at 8 metres distance whilst the pre-positioned white tape is purely for illustration.

Fig. 5. The image of the sun from the front silvered version with the reflecting area reduced to a 'pinhole' of 1.5 cm square.

It will be realised that by 'stopping the mirrors down' with a card to restrict the reflecting area, then the mirrors act like a pinhole camera and the reflected spot can form quite a sharp image of the sun, as can be seen in Fig. 5, although the image is much fainter.

In the report to the Newbury meeting mention was made: "Michael Maltin demonstrates his dipleidoscope azimuth-finder".[1] (A large model of a dipleidoscope was indeed shown, but it is the prototype meridian instrument in the illustration.) Although both instruments reflect two beams of light, they work on quite different principles. The dipleidoscope relies on the visual alignment of virtual images of the sun by looking into the instrument (with filters to prevent damage to the eye) and can give very precise alignment of a transit. However, its *accuracy* is only as good as its predetermined meridian. The mirrors, on the other hand, give real images on a card, nor is it necessary to look in the direction of the sun.

Michael Maltin's ingenious meridian instrument, which I have called 'meridian mirrors', is a very convenient method of determining the sun's azimuth over almost any length of baseline given the precise moment of local noon. The instrumental accuracy is determined by setting the vertex of the mirrors vertical, which in turn, depending on the quality of construction of a frame or V block, can be easily set with a spirit level to give an accuracy of 0.25º, or even better with an engineer's level.

ACKNOWLEDGEMENT

To Michael Maltin for demonstrating his idea at the Newbury Meeting, lending me his prototype, and inspiring me to join in the experimentation with, as far as I know, an entirely original method of finding a meridian line.

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A THIRD WEST INDIES DIAL

TONY WOOD

Following the article in the March 2010 *Bulletin* about two West Indies dials in Gloucestershire,[1] a third recently appeared (Fig. 1). Only on my computer screen I'm afraid but certainly from the West Indies. Downloaded and tweaked, the maker's name was revealed as DICAS, together with "Latt 22°" which was quickly confirmed by the bunching of the hour lines around noon and provoked questions as to where it was made for. Somewhere to the West? Somewhere to the East? There were several possible locations but the Turks and Caicos Islands in the West Indies turned out to be the answer, as confirmed by the owner who said that was where it was found.

Fig. 1. The Dicas dial plate. Photo by the owner.

He had contacted me to find out if I could help with its identification. As can be seen in the picture, the gnomon is missing and the dial itself is somewhat worn but not beyond restoration if desired. Contacting Jill Wilson and John Davis soon had the answers for my enquirer. John Dicas (w.1774-1797) was a Liverpool maker of scientific instruments, and particularly hydrometers, and he obtained a patent in 1780 for a hydrometer with sliding rules. These were used to assess alcohol content and must have been very accurately engraved.[2]

The sundial is the first by him that has come to light and so he has not yet appeared in the Society's *Biographical Index*.[3] On his death, the business apparently passed to his two daughters Ann and Mary, who were later joined by Mary's husband, John Arstall. They later traded as just Dicas & Co. and seem to have disappeared around 1837 although a successor company run by Benjamin Gamage (Ann's husband) sold hydrometers marked "Gamage late Dicas" up to around 1851.[4] It is suspected that, as the dial is simply signed DICAS, it is probably from the period when Ann and Mary were running the business (Fig. 2).

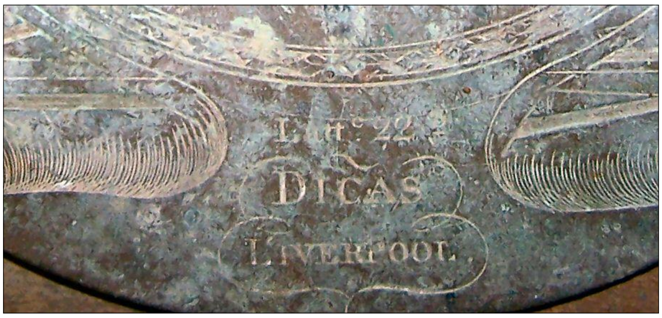

Fig. 2. Close-up of the signature.

The long gnomon base has meant that the gnomon root is well to the south on the plate with the 6am – 6pm line near the bottom of the picture. The time divisions go down to five minute intervals and the "DICAS LIVERPOOL" signature is boldly engraved, together with the latitude setting of 22°. There is an eight-point compass star centrally and the engraving of the hour numerals is aligned with the hour lines, a difficult task and all beautifully done.

Who in the West Indies would have such a dial? Somebody wealthy, possibly the Governor? It may have been a sugar plantation owner as in the case of the Snowshill Manor dial.[1]

All fascinating speculation and we hope the owner will let us know if he intends to have it restored or can find out anything further.

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Acknowledgements to 'robert', Jill Wilson and John Davis.

Tony Wood
Churchdown

AN OBELISK SHAPED SUNDIAL WITH WIND INDICATOR IN THE MAINFRÄNKISCHES MUSEUM WÜRZBURG, GERMANY

FRAUKE VAN DER WALL and GERHARD G. WAGNER

[Frauke van der Wall is a curator at the Mainfränkisches Museum Würzburg and Gerhard Wagner is responsible for the horological and technical description. Ed.]

In 2007 the Mainfränkisches Museum Würzburg was bequeathed a unique sundial with 11 indications (Figs. 1 and 2). It is made from typical local, Franconian sandstone and probably dates back to 1742.[1]

Figs. 1 & 2. Overall view of the sundial from the north (left) and south (right).

Structure

The unusual construction consists of several elements standing on top of each other: the pedestal is 89 cm high and shows recessed rectangles as decoration. On top of a moulding sits a flat block with three dials on the south side. It is surmounted by an almost square and slightly smaller block with a dial on each side on top of which stands the obelisk with a dial on each side as well. The obelisk is separated from the blocks below by a small moulding. It is topped by a sculpture showing the head of a Turk with turban-like headgear and a tassel hanging down at the back. A steel vane extends out of the head. This rotating vane is connected to a rotating hand on the dial indicating the direction of the wind using gearing inside the stone structure.

This dial on the block below the obelisk has the form of a compass rose. Its measurements are 54 × 54 cm and the stone structure is about 2.55 m high (without the vane).

The structure shows 11 different dials in all, ten sundials with gnomons and one mechanical wind indicator in form of a compass rose with a rotating hand. All the dials are engraved into the sandstone as fine lines and were filled with a light colour contrasting with the stone. Parts of the colouring are still recognizable. The sundial has been partly destroyed on the surface where the sandstone has loosened in layers. The head especially shows deep cracks probably caused by rain that penetrated the stone and then froze. Former renovations are evident on different parts of the surface. The iron parts of the gear are badly damaged and corroded by water trapped in the cavity. The pins and points of the gear wheels are partly broken.

The Dials on the South Side

The lower flat block shows only three dials on the south side, the other sides are decorated by recessed rectangles framed by a narrow moulding. The different dials are separated by a protruding slab which is rectangular on the upper surface and semicircular below. In the upper part there are two south dials with the hours 6-12-6 and a gnomon for the geographical latitude of about 48°. This dial is located on the vertical part as well as on the horizontal part, on the latter it is engraved back to front. The third dial which is orientated downwards shows a night dial with the hours 6-12-6. It is made for the geographical latitude of about 48° as well.

The second almost cubic block has the following measurements: height 32 cm, width and depth each 29 cm. On the south side above the south dials of the lower block is situated the wind dial in form of a compass rose with eight points and a diameter of 25 cm. It is marked clockwise: “NORD / N:W / WEST / S:W / SUD / O:S / OST. / O:N”. The rotating iron hand is connected with the vane through contrate gearing positioned in the hollow blocks. A metal shaft goes through the head and the obelisk until it reaches the dial work. The gearwheel with 24 screwed-in pins is fixed with a flange to the shaft with four screws although this is a later replacement, presumably for a normal gear-wheel. The gear mounted on the wind hand shaft also has 24 teeth meshing with the 24 pins at 90 degrees. A movement of one tooth by the vane means a change in the direction of the wind by 15 degrees, which is a third of the wind direction indicated on the compass rose. The movement of three teeth consequently covers an eighth of the horizon. It is significant that on the compass rose the wind directions of "WEST" and "OST" (east) seem to be reversed. But this is explained by the transmission of the gear rotation. This way the wind direction is shown correctly on the compass rose. It can be more precisely read than by just looking at the vane. This is a very rare if not unique construction within a sundial and deserves special attention. A compass with wind rose is well known on portable sundials of the 16th century. Several of these are in the collection of the Mainfränkisches Museum Würzburg.[2] They were used for forecasting the weather.[3]

On the south side of the obelisk above the wind rose is an inclined south dial with gnomon and the indications 6-12-6. It is also constructed for the geographical latitude of about 48 degrees.

The Dials on the East Side

The east side on the lower block (right hand side of the south dial) shows an east dial with its measuring scale and the hours 4-11. The gnomon is a simple triangular element at 6. The dial is read under the gnomon's point.

The arch-shaped inclined east dial on the obelisk on top shows the hours 12-6 with a triangular gnomon fixed at the 6 position.

The Dials on the West Side

On the west side of the lower block (left of the south dial) is engraved a west dial with the indications 1-8. The gnomon is as on the opposite east dial a triangular element, under which the time is shown (see Fig. 3).

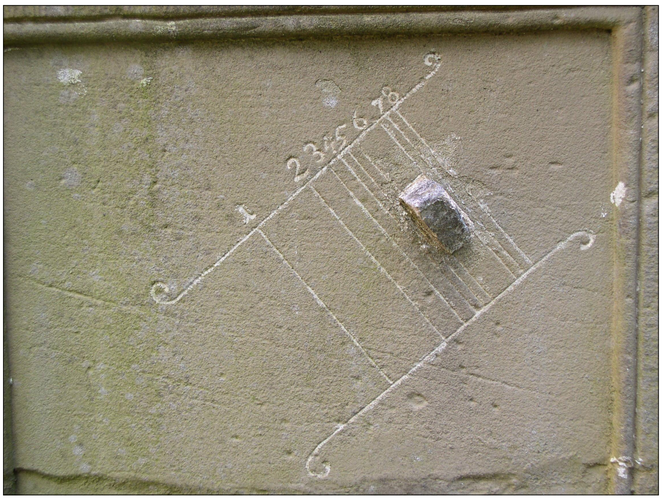


Fig. 3. The lower west dial.

The arch-shaped inclined west dial on the obelisk on top shows the hours 1-6 with a triangular gnomon fixed at the 6 position.

The Dials on the North Side

The north side of the lower block shows a north dial as was usual by the compass makers of Augsburg and Nürnberg with the indications of 8-4 on the right side and on the left side in opposing order 4-8 with the gnomon pointing up (see Fig. 4).

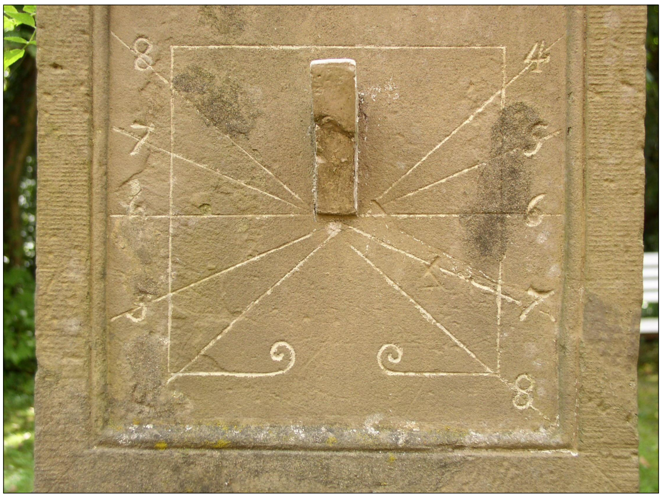


Fig. 4. The lower north dial.

The same dial is shown on the inclined surface on the north side of the obelisk.

In Germany, cube-shaped sundials with dials on all sides were already known in the 15th century (most likely from Nürnberg) but they became more common only in the late 17th and in the 18th century. On the sides of the obelisk the dials are situated on inclined surfaces. This construction is quite unique and indicates a late dating. The head in the form of a Turk can be associated with the wars against Turkey 1697-1718, which were won by Prince Eugene. Thus it can be assumed that the sundial was made in the first half of the 18th century. The construction of the dials and wind vanes are already described in the works of the Würzburg mathematician Kaspar Schott in 1661 and 1668 as well as the mechanical gearing in 1664.[4] The gearing of this indication "in order to explore the wind without leaving the room" is similarly described by Nicolas Bion in 1741 (the first French publication dates back to 1709).[5] See Fig. 5. Here the shaft with gearwheel for the vane shows a pinion instead of a pinned wheel as in the Würzburg sundial. The pinion is longer than the diameter of the toothed dial train so that this construction as shown by Bion obstructs itself. This mistake was probably caused by the technical incompetence of the illustration's engraver. In the French edition of 1752 Bion refers to M. Ozanam who already published this type of construction in the second volume of his "Récréation Mathématiques".[6] This shows that this gear construction was well known in the scientific publications since the second half of the 17th century, especially in the first half of the 18th century.

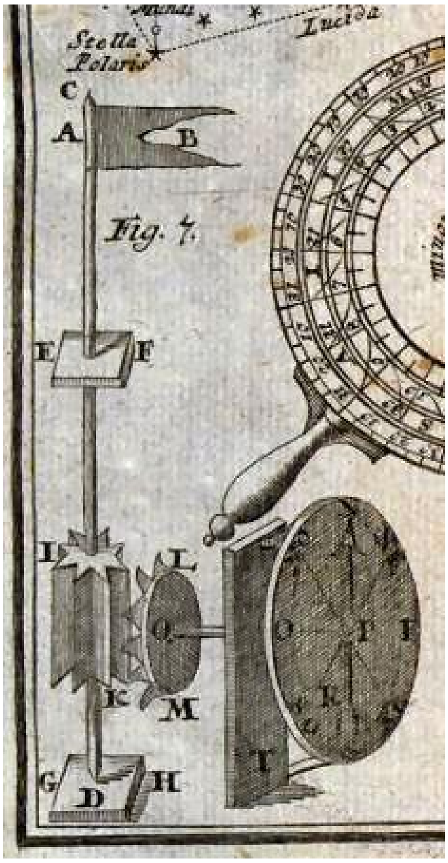


Fig. 5. Geared wind vane by Nicolas Bion, 1741. See Ref. 5, Plate XXVIII, Fig. 7.

Besides the dial indications, the Würzburg sundial is sparsely decorated, increasing slightly from bottom to top. The pedestal is decorated on all four sides only by a recessed rectangle. A moulding of several steps separates the pedestal from the first block with the south dials. On this block and on the one on top of it the central rectangular fields are moulded and surrounded by a narrow moulding. The obelisk sits on a projected moulding. The sides of the obelisk show recessed central fields surrounded by a narrow ledge. The top sides and the lower corners have inserted arched contours. The impressive decorative copestone of the sundial is formed by the head of a Turk with a huge moustache and the turban-like headgear with tassel. He was positioned on top of the obelisk looking to the north. It is not known if this was the original direction.

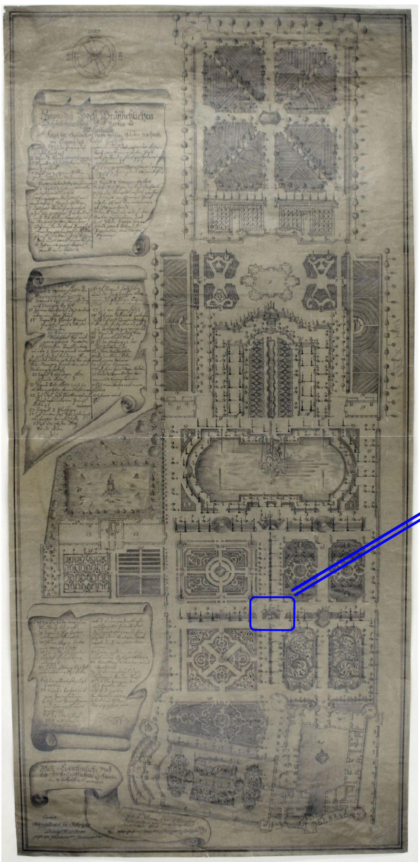
Historical Sources

The layout and construction of this sundial with mechanical wind dial seems to be quite unique on the continent if not worldwide. We could not find a comparable piece: even the specialists of the German Society of Chronometrie[7] and the British Sundial Society could not trace any similar devices. In Scotland, some weathervanes are known which show a comparable mechanical transmission to a compass rose above the fireplace inside the house. There is, of course, no combination with a sundial. A sundial with a vane on top can be found for example in Appleby, Cumbria, but here there is no link to a sundial. There are also a large number of multiple dials, particularly in Scotland, but these do not carry a vane.[8] Special wind meters seem to have existed in some baroque gardens. One of those in the garden of the cloisters of the Cistercian in Waldsassen is described in a travel book of the middle of the 18th century.[9] A mere wind vane with mechanical gear and dial on a compass rose has survived in the Museo di storia della scienza in Florence, Italy.[10] The wooden construction consists of a compass rose with movable hand on a curved pedestal and the wind vane directly on top of the compass rose. This wind dial is 125 cm high and thus is quite easily moved and can be positioned as needed. But since the compass rose is printed on cardboard it is not made for permanent use outside.

Some references to a sundial with wind vane were found in the Fürstlich Wiedisches Archiv in Neuwied. But they do not allow a definitive interpretation of the actual construction so far. In the garden of the castle Mont Repos there existed a sundial of which two dials had already been repaired by the famous clockmaker Christian Kinzing in 1766.[11] In 1779 there is an account by Hermann Achenbach which reads: "a sundial at the pleasure garden of the castle of Mont Repos, repaired, two new hands made for it, and a wind hand, and set up again at the appropriate place".[12] This account leaves room for different interpretations though: the two hands could mean two new gnomons as well as rotating hands on a compass rose. The wind vane may not necessarily have been connected to a gear and dial. Moreover, on a plan of the garden dated 1777 the most interesting part is missing where probably this sundial had been added after printing.[13] Only the top of a vane is still visible.

Because of the many indications and the rather sparse decoration on the one hand and the design of the Turk's head on the other hand, the Würzburg sundial was very likely built in the first half of the 18th century. The complicated design with 10 sundials which allows reading of the solar time all day long demands a high degree of astronomical and mathematical knowledge by the designer. The mechanical wind vane on the contrary almost looks like a gadget in order to astound the onlooker, which surely was evoked by this sundial, with a surprising effect. This sundial could only have been made for a very learned customer who was enthusiastic about science, had the necessary money, and who could offer an adequate location where the sundial was in the sunlight the whole day. It would not have to be overshadowed by a building or high trees for example. It must have been a very impressive park. Taking into consideration all these requirements plus the local sandstone there are not many locations in Franconia where this very special scientific instrument could have been situated.

And in fact, a discovery in the state archive in Würzburg proves this suspicion: there is a garden plan of the castle in Wiesentheid (Fig. 6), still belonging to the family of the Earl of Schönborn. This plan was originally drawn, signed and dated in 1760 by Johann Prokop Mayer, a famous 18th-century German gardener and the chief gardener of the Würzburg garden at the Princebishop's Palace Residenz. The original plan was burnt in World War II, but it was traced exactly in pencil on semitransparent paper in 1920



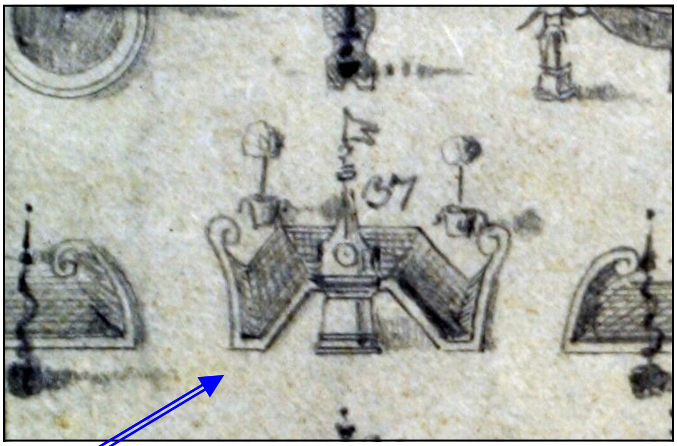


Fig. 6. (left) Plan of the garden in Wiesentheid by Johann Prokop Mayer 1760, copied by Ludwig Marchner 1920 (State archive Würzburg).

Fig. 7 (above). Detail of Fig. 6.

by Ludwig Marchner, the Earl's surveyor. This is the plan that survived and today is kept in the state archive in Würzburg.[14] The plan shows very precisely the state of the garden in 1760. All the details are numbered and explained in a key. The sundial was situated in front of the north-west corner of the castle on the crossing of the main central axis and the first embankment and is marked "37" (Fig 6, ringed, and Fig. 7, detail). The key of the plan refers to the sundial as 'wind clock' ("Winduhr"). In 1954 Max Domarus had already drawn special attention to this detail of the plan. He supposed that this so called 'wind clock' in its baroque housing probably was a special ornament in the garden.[15] The indication as 'wind clock' in the key of the plan by Mayer proves that this wind dial was regarded as the most striking element of this sundial by the contemporaries. This is why the vane surmounting the ball shaped top and the wind dial in form of a compass rose on the block of the sundial are clearly visible. Because Domarus had not seen the sundial itself and the key calls it 'wind clock' he interpreted the whole construction as just a wind dial in a baroque housing. The drawing on the plan shows the sundial in a reduced form: there is the high pedestal, then the block with the wind dial and the obelisk with a ball shaped piece on top surmounted by the vane. Even with the one block with three south dials missing it is beyond all doubt that it shows exactly this sundial since the whole construction is so unique. It is interesting that the wind dial is shown on the south side of the sundial, which is the correct position. This also underlines the realistic reproduction, almost a copy of this sundial at the specific position in the garden. (There is a compass rose on the top hand left corner of the plan which shows the alignment of the garden. The draughtsman changed the directions south and west, whereas north and east are marked correctly.)

There is a printed plan of the garden in Wiesentheid by J. Le Seurre dating from 1730, where this sundial was not yet shown.[16] So it must have been set up at this particular location between 1730 and 1760. In the state archives of Würzburg there are still the accounts of the court of Wiesentheid[17], and research has been done covering the years from 1730 to 1760. Unfortunately no clear proof could be found concerning the making and the positioning of the sundial. But there is indirect proof of a sundial maker who lived in the city of Bamberg and who had worked on several occasions at Wiesentheid. It can be concluded that between 1737 and 1742 several sundials had been worked on in the garden at Wiesentheid: on 16 September 1737 Caspar Sandner, the innkeeper of the 'Ochsen' in Wiesentheid had been paid carriage and board because he transported "Mr. Pattert who makes the sundials in the nobleman's garden to Bamberg with three horses on September 16th".[18] In the year 1738 Johann Georg Neßtfell, court cabinet maker at Wiesentheid, had to make "2 small slides for a sight ordered by Mr. battert".[19] These transactions are proof of repeated work by Mr Pattert in Wiesentheid although he is not mentioned otherwise. Moreover it proves that the sundial maker had known Johann Georg Neßtfell who had outstanding astronomical knowledge and built a famous mechanical planetarium in 1755-61 which today can be seen in the Bayerisches Nationalmuseum in Munich. There is a great possibility that Neßtfell and Pattert could have discussed the construction of the different dials of the sundial. In June 1739 again carriage was paid for transporting a clockmaker to Bamberg without naming a particular person.[20] In 1740/41 the locksmith Anton Föchel or Fäsel (?) was paid for the making of a stone drill "which was used by the stone-mason to drill the windrose".[21] This entry probably refers to the drills through the head, obelisk and block with the compass rose that were necessary to install the gear for the dial of the wind vane. The same stone-mason presented an account in 1741/42 "for 2 little hooks or clamps 2 brass bearings(?) 2 little disks made from wood used on the new clock on the circular flower bed".[22] These pieces probably are parts of the bearing device of the mechanical parts of the wind dial. The description "the new clock on the circular flower bed" must refer to a freestanding sundial in the garden, probably to the obelisk shape which is shown on the plan of 1760 and named 'wind clock'. It is very unlikely that this refers to another sundial which was painted on the wall and which is also mentioned in the accounts on several occasions.[23] The mechanical pieces must have been mounted during the final set up of the sundial so that its construction had been finished by 1742.

The commission and building of this sundial were undertaken during the lifetime of Rudolf Franz Erwein von Schönborn (1677-1754), who devoted himself with utmost passion and huge amounts of money to the furnishing of his garden into a baroque garden with thousands of exotic plants and many sculptures. He was described by Domarus as "the greatest garden enthusiast of the Schönborn family".[24] So it is more than likely that he commissioned this special sundial as a highlight within the furnishing of his garden even if this can not as yet be proved by archival evidence.

A sundial maker named Pattert or Battert can be verified in the archive of the city of Bamberg.[25] The index of the parish registers (the so called "Röttinger-Kartei") lists several generations of a family named Battart from 1648 onwards. Johann Leonhard is listed as son of court clockmaker and footman Johann Battart (1686 – died before 1728) in 1724. He is mentioned until 1783 and he is referred to as clockmaker and watchmaker. His date of birth is still unknown but it is very likely that "Mr. Pattert who makes the sundials in the nobleman's garden" (see above) and who was transported to Bamberg in 1737 can be identified as Johann Leonhard Pattert. The name B(P)attert is recorded in horological publications as well. Zinner names a "Ioan. Pattart" who was working around Bamberg in the 18th century.[26] Two of his sundials are known: one is the horizontal dial in the garden of the former office building of Cremsdorf near Höchstadt built of Solnhofen limestone and signed "Pattart fecit". It was made during the lifetime of abbot Christian Ernst von Guttenberg (1689-1715) so this must be an example of Johann Battart senior. The second horizontal dial is located in the castle of Aschbach and is signed "IOANN PATTART Bamberg Fecit sub 50 Gra. 1752". This piece could be an example by the younger Johann Leonhard and proves he made sundials. The same sundials are mentioned by Abeler[27] but he lists the name as Ivan Pattart (probably a mistake on Abeler's part). Ivan is the Russian version of Johann.

On the basis of all this archival and published material it very likely that Johann Leonhard Pattart was the maker of the obelisk shaped sundial with wind dial. The final proof, however, is as yet missing. After all it seems certain that it was built in Wiesentheid. The most important proof is the mention of the stone drill for use on the wind dial. An account for the sundial itself is still missing, which is surprising, because it must have cost a fortune! But maybe it was paid from another, private account the records of which are not in the state archive.

The delineation of the scale on the dials of 48 degrees does not correspond exactly to the sundial's position in Wiesentheid. Würzburg as well as Wiesentheid are located on the geographical latitude of 49 degrees. Possibly this could have been caused by an inaccuracy of construction by the stone mason.

The garden in Wiesentheid was changed into an English landscape garden in the first half of the 19th century.[28] At that time many of the sculptures were sold or destroyed and the stones used for building streets. The sundial was probably taken away from the garden then as well. Its whereabouts for about 150 years are not known until it was placed in a private garden in Würzburg and finally joined the collections of the Mainfränkisches Museum in 2007. Before it can be set up again it must be restored. An adequate location, where it will be well protected as well as where it can be seen by the public, is still to be found.

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The author wishes to thank Mr. Ian D. Fowler, Friesenhagen, very much for proofreading the English version of this article. Picture credits: Figs. 1-4, Mainfränkisches Museum Würzburg; Fig. 5, Library of the University of Würzburg, Math 9 115b; Figs. 6-7, State archive Würzburg, Schönborn-Archiv, maps and plans, K I / 41.

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NEW DIALS

Newton Abbot, Devon

We are usually rather sniffy about garden centre dials but this one has the potential to be rather good. Spotted the day after the Exeter Conference, the dial is being built just outside the new garden centre of the Trago Mills retail outlet at Newton Abbot, Devon. The building conveniently faces very close to south so the dial is only a degree or two from being perpendicular to the doorway.

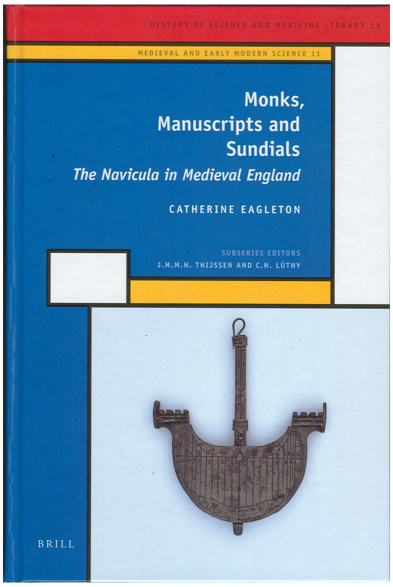
The bottom section of the gnomon consists of two thin sheets of stainless steel as facing on a thicker backing piece. A slot through this piece allows a narrow line of light to pass through the edge of the gnomon onto the meridian line at solar noon, just like the Spot-on sundial design. Additionally, a nodus in the form of a small cylindrical cross-bar is fitted and the solstice and equinox declination lines are placed to show the shadow. The top of the gnomon is a separate piece but this looks to be merely for constructional convenience.

At present, the hour points and declination lines are merely painted on the brick pavers. Let us hope that some nice recessed stainless steel furniture will be fitted. The designer is currently unknown.

JD

BOOK REVIEWS (2)

Monks, Manuscripts and Sundials: The Navicula in Medieval England, by Catherine Eagleton. Brill Academic Publishers. Hardback, 165 × 245 mm, xi + 292pp, greyscale images throughout, ISBN 978 9004 176652. Price £85.26 (2010).



Despite, or perhaps because of, its extreme rarity, the *navicula* or 'Little ship of Venice' is illustrated in many modern dialling books where its intriguing shape makes it a favourite for portable dial enthusiasts. Only five medieval examples, all thought to have come originally from England, are known and it was rarely described in the early dialling books of the 17th century, having already become obsolete. It might have been thought that there was insufficient material for a whole book about this one dial type but this volume, resulting from the author's doctoral research at the Whipple Museum in Cambridge, proves otherwise.

After the introductory sections, the book begins with a detailed descriptions of the five known medieval examples. Even one of these is only known through an article published in the *Gentleman's Magazine* in 1787 with its whereabouts now unknown. Considering their age, and the fact that one was found in an excavation, they are in remarkably good condition.

The earliest printed description of the navicula is in Oronce Finé's 1532 *Protomathesis*. But the key sources on the subject are a number of fifteenth-century manuscripts. It is here that the real strength of the book lies – the author has uncovered nine previously overlooked sources and identifies no less than 16 manuscripts, mainly in British libraries but also in other collections. In an impressive and thorough study, she has considered these in detail, transcribing their rather difficult handwriting and translating some of them from their highly-abbreviated medieval Latin. One of the previously-published manuscripts, translated by Robert Gunther no less, was found to have omitted a page of text and a diagram. It seems that the 16 MSS, which describe the making or use of a navicula, or both, fall into five groups, from different original sources as the various scribes copied and recopied them gradually introducing changes. About half the book is devoted to appendices dealing with these manuscripts, most of which probably originated in English monasteries. Although some are in collections with other astronomical material, others are accompanied by scripts on subjects as diverse as tables of the names of kings or "charms against fleas"!

What is deduced from this material is that the navicula was (probably) not at all as rare as has generally been thought.

One group of manuscripts describes how to draw templates for the two main scales, something that a maker would only need to do if making several instruments. The geometry of the medieval navicular is significantly more subtle than it appears at first sight or as drawn by many modern authors. Its two zodiac scales, for setting the tilt of the mast and the position of the bead, have significant differences. The two other contemporary types of instrument which are described in accompanying manuscripts are the horary quadrant and the cylinder dial (Chaucer's *chilindrum* or shepherd's dial), both also devices relying on the sun's altitude. It seems that dials with polar-pointing gnomons ('scientific dials', in modern terminology) were unknown in England at that time.

The book also looks at the relationship of the navicula with two other early universal altitude dials which use a similar geometry, a rectilinear *organum ptolemei* (not to be confused with the astrolabe-like instrument of the same name) and the Regiomontanus dial. The conclusion reached is that the navicula pre-dated these two devices. There was also a small revival of the navicula in the sixteenth century – perhaps created by Finé's description – but the small number of resulting devices are termed "ship-shaped dials" here as the detailed geometry of the scales described by Finé was over-simplified rather than exactly following that described in the earlier navicula manuscripts.

The weak point of the book is that it displays a heavy bias towards the academic studies of the literature and against the artisans who actually made the devices. The astronomical theory of how and why the device works is only very briefly touched on: look elsewhere if you want to see modern methods or equations for laying out the scales. (Peter Drinkwater's treatment of Oronce Finé's work, which Eagleton does not cite in the bibliography, includes a good geometrical construction and Jan Kragten has produced a full mathematical analysis in *De Zonnewijzerkring*.) The techniques by which brass devices were made is ignored, as is the subject of who the craftsmen were and what else they might have made. This, though, leaves something for future researchers to study.

For anyone serious about the origins of sundials in Britain and the methods of academic research into them, this book is highly recommended. Despite its price, my copy had some printing problems and the text could have done with more proof-reading, both difficulties arising from low-volume book production, so perhaps it is best to borrow a library copy.

John Davis

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