The British Sundial Society
BULLETIN

An Equation of Time table as printed by John Sturt, who also engraved it. It is undated but was probably produced in the early 1700s, earlier than the "1750-1850" in the British Museum's catalogue description. The size of the print is 366 × 239 mm, suitable for pasting inside the pendulum door of a longcase clock.

John Sturt (1658-1730) was apprenticed to Robert White, himself an apprentice of the celebrated David Loggan. He worked in Golden Lion Court in Aldersgate St., London. His topics were mainly related to the Church and books on penmanship. He ran a drawing school in St Paul's Churchyard from 1697 to after 1710. (source: DNB.)

The underlying data for the table, which uses the Julian calendar, looks as though it was that produced by John Flamsteed in around 1702 and first published by John Smart. Note that the chart also gives the method of checking the isochronicity of a clock against sidereal time, as observed by the stars.

Image courtesy of the Board of Trustees of the British Museum. Accn. no. 1958, 1006.2853, CAI.2853. Thanks to Andrew James for making me aware of the print.

Front cover: *The Glengarry polyhedral sundial in a typically Scottish setting—note the Saltire! See the story on page 44. Photo from Dennis Cowan.*

Back cover: *One of two architectural drawings from made at the University of Vilnius, based on the Tower of the Winds. See the story from Darek Oczki on page 35.*

CONTENTS

EDITORIAL

We enter the 25th anniversary year of the Society with no sign of running out of interesting things to report about sundials. The run of back issues of the *Bulletin* occupies about 16 inches of space on my book shelves and they represent a large amount of effort from many authors, all of whom I thank.

There cannot be many journals which carry articles on topics with such a wide spread of time—from prehistory to dials made in the last few months. One new dial in this issue (page 21) even includes both these extremes and in between we have early dials which have been excavated, found in old drawings and literature, or were just waiting in museums and private collections for someone to look at closely and describe properly.

Researching sundials takes you to places that you might not normally visit and there is no doubt that the more closely you study a sundial the more that you see and the more interesting they become. The development of the internet has provided the means to discover new dials, and details about known ones, that otherwise would remain hidden. Even watching TV can suddenly throw up a dial which 25 years of BSS Recorders have missed. So I would like to encourage members to research at least one sundial, old or new, each in the coming year and then to report on it in these pages. That should keep the *Bulletin* full for another quarter-century!

Erratum

In the article on *The Reworking of Mass Dials* by Tony Wood in the previous issue (*BSS Bull.*, 25(iv), pp. 40-41 (Dec 2013), the statement that Lamas was "near Sandringham" was made. In fact it is about 50 miles away though the rest of the story is true.

TWO CONICAL SUNDIALS WITH MISSING GNOMONS IN THE ARCHAEOLOGICAL MUSEUM OF ATHENS

EVANGELIA PANOU[*], EFSTRATIOS THEODOSSIOU[*], VASSILIOS N. MANIMANIS[*] AND KONSTANTINOS KALACHANIS[*]

[*]Department of Astrophysics-Astronomy and Mechanics, School of Physics, National and Kapodistrian University of Athens, Panepistimiopolis, Zographos 157 84, Athens, Greece.

Assumptions that Facilitated the Use of Sundials

The Greek astronomers, in their efforts to make their sundials as accurate and precise as possible, worked on the parameters that affected the precision of their measurements. Much discussion took place about whether a sundial could be placed at any point on Earth with the same method, without its precision being influenced by the size and shape of the Earth.

Pioneering realizations and assumptions pertaining to the size and shape of planet Earth, which facilitated the mounting and the use of sundials, were articulated by the great astronomer of the 2nd century Claudius Ptolemaeus (Ptolemy) in his opus *Great Mathematical Syntaxis* (the Almagest). Among other assumptions, Ptolemy noted that the size of the Earth was negligible compared with the sizes and the distances of the fixed stars. He argued that the Earth could be regarded as a point in a cosmos that extended up to the fixed stars.[1] Similarly, sundials could be regarded as being placed at the centre of the Earth, thus yielding with precision the path of the solar disc as represented by the path of the shadow of the instrument's gnomon.

In general, the projection of parts of the solar path on the Earth's surface through the shadow of a gnomon was simplified considerably by using the following assumptions, which were accepted by the astronomers of the Hellenistic period.[2]

1. The point the gnomon is placed on the Earth's surface can be regarded as being the centre of the Earth.
2. The horizon of the place bisects the celestial sphere.
3. The longest day of the year is equal in length to the longest night of the year.

Vitruvius, and Ptolemy after him, pointed out that the two important factors that determined the solar path as observed from any place on Earth were the geographical latitude of that place and the obliquity of the ecliptic.[3] The gnomon, maybe even the primitive sundials, helped to establish the values of these two parameters and to construct the sundials of the lists.

Some of the Greek astronomers who determined by measurements the obliquity of the ecliptic were: Oenopides of Chios (5th century BC), the first person who measured the obliquity according to Theon, Eratosthenes (246–194 BC) and Hipparchus (2nd century BC), who adopted the value 11/83 of the semicircle arc.[3] The obliquity of the ecliptic was also described by the Greek philosopher Plato[4] (427–347 BC) in his dialogue *Timaeus* (39c).[5]

The notion of the geographical latitude in Hellenistic geography was often expressed in terms of the relation between the longest and the shortest duration of the day, whilst its dependence on the angular distance between the place and the equator was first discovered from observations of the length of the gnomon's shadow in various places at noon near the equinox. The geographer Strabo in the 5th chapter of Book 1 of his *Geographica* noted that Pytheas of Massalia recorded the ratio between the gnomon's length and the length of its shadow at noon during the equinox in Massalia (modern day Marseilles) in the 4th century BC[6] and that Hipparchus worked on the determination of geographical latitudes expressed in degrees north of the equator, with each degree corresponding to one of the 360 parts of the circle.

Conical Sundials

The special characteristic of the conical sundials is the conical shape of the dial surface, which is a part of a conical surface with its axis parallel to the axis of the Earth. Its upper part has a plane portion that is parallel to the horizon, while its frontal part has another flat surface which is parallel to the equator. The hour lines and the date curves of conical sundials form a special grid of lines which have been approximated with acceptable precision by arcs of conic sections that connect the respective hour points. The shape of the grid depends on the position of the cone's vertex, on the conic surface and on the position of the gnomon's base. The orientation of the sundial is defined by the position of cone's vertex. The sundial has a southern orientation (*i.e.* it faces towards the south) when the vertex is above the horizontal surface and a northern orientation when the vertex is below the horizontal surface. Additionally, there is the possibility of the cone's vertex being a point of that surface ('celestial sundials').

The conical sundials of the National Archaeological Museum of Athens with index numbers 3156 and 3157 that are examined in this paper are of southern orientation. The conical surface of the dial is formed by a generatrix (corresponding to the line of the meridian) as it rotates around the cone's axis, which is the axis of the Earth. The curves of the dial's surface are circular arcs with the same curvature with the frontal circular curved surface of the sundial. The hour points, which are the intersections of the date curves with the hour lines, are at equal distances from one another. The distance between the curve of the winter solstice and the curve of the equinoxes along the meridian line is shorter than the distance between the curve of the equinoxes and the curve of the summer solstice.

The complete description and study of the conical sundials requires the geographical latitude of the place of operation (φ), the angle (ω) between the cone's axis and the generatrix of the dial's conical surface, and the gnomon length d.

Calculation of the Characteristic Parameters of Conical Sundials

i) Calculation of the latitude φ

The geographical latitude of the place of operation of the sundials must be calculated from their geometrical characteristics, since the gnomon has been lost. The latitude can be calculated from the following relations:

$$\tan\varphi_1 = \cot\varepsilon\,\cos[180°\,(l_x/l_I)\,\text{I}\Theta/(\text{I}\Theta+\text{IX})] \qquad (1)$$

$$\tan\varphi_2 = -\cot\varepsilon\,\cos[180°\,(l_\theta/l_I)\,\text{IX}/(\text{I}\Theta+\text{IX})] \qquad (2)$$

where φ_1, φ_2 are the geographical latitude, ε the obliquity of the ecliptic, IX the distance along the meridian hour line from the curve of the winter solstice to the curve of the equinoxes, IΘ the distance along the meridian hour line from the curve of the equinoxes to the curve of the summer solstice, l_x the length of the arc on the curve of the winter solstice, l_I the length of the arc on the curve of the equinoxes and l_θ the length of the arc on the curve of the summer solstice.

ii) Calculation of the angle ω between the axis and the generatrix

This angle is obtained from the following formula (the quantities are defined as above):

$$\tan\omega = \frac{\text{I}\Theta - \text{IX}}{\tan\varepsilon\,(\text{I}\Theta + \text{IX})} \qquad (3)$$

iii) Calculation of the length d of the gnomon

The gnomon length d is calculated from the latitude φ and the angle ω through the formula:

$$d = \text{K}\Gamma\,(\sin\omega)/(\sin\varphi) \qquad (4)$$

where:

$$\text{K}\Gamma = \frac{\text{IX}\cos(\omega - \varepsilon)}{\sin\varepsilon\,\sin\omega} - (\Gamma\text{X} + \text{IX})$$

Here ε is the obliquity of the ecliptic, IX the distance along the meridian hour line from the curve of the winter solstice to the curve of the equinoxes, ΓX the distance along the meridian hour line from the sundial's upper edge to the curve of the winter solstice, KΓ the cone's generatrix (coincides with the meridian line) and K is the apex of the cone.

Fig. 1. Conical sundial 3156 of the National Archaeological Museum of Athens.

Sundial 3156 of the Archaeological Museum of Athens

The ancient Greek conical sundial without a gnomon of the National Archaeological Museum of Athens (Fig.1) with index catalog number 3156 is located in the Museum's yard. It was recovered from the ancient Dionysus Theatre, which is located under the southern cliff of the Acropolis, and dates from the Roman or the Hellenistic period.[7] It is made of white marble; its weight is approximately 80.0 Kg.

The sundial's height ranges from 47.0 to 50.0 cm, its width from 41.0 to 43.0 cm and its depth from 15 to 30 cm. The depth of the construction's top is 31.0 cm and the depth of its base 28.0 cm.

The sundial is incorporated into a base that bears to the left and right two feet of a lion. These feet are 26 cm high, 12 cm wide and 6 to 16 cm deep. On the foot on the right-hand side (*i.e.* the left foot) 4 toes are easily discernible, while on the other foot the toes cannot be discerned due to the wear of the surface. The distance from the lowest part of the base to the lowest point of the dial surface is 27 cm.

The conical surface, *i.e.* the 'plate' of the sundial, 3.5 cm thick, is preserved in rather good condition. All the lines carved upon it are easily discernible: the 11 hour lines and the curves of the summer solstice, the winter solstice and the equinoxes. The horizontal gnomon of the sundial has been lost; in its place, at the centre of the top view of the construction and at a distance of 2.0 cm from the upper dial surface, there is a hole in the shape of a rectangle with

Number of hour line (left-to-right)	From the winter solstice curve to the equinoctial curve IX (cm)	From the equinoctial curve to the summer solstice curve IΘ (cm)	From the winter solstice curve to the summer solstice curve XΘ (cm)
1st	5.5	9.0	14.5
2nd	5.1	10.9	16.0
3rd	5.0	12.0	17.0
4th	5.1	11.9	17.0
5th	5.0	11.4	16.4
6th *	5.5	11.6	17.1
7th	5.6	11.2	16.8
8th	6.0	4.5 (alterations)	10.5 (alterations)
9th	unmeasurable	unmeasurable	unmeasurable
10th	unmeasurable	unmeasurable	unmeasurable
11th	unmeasurable	unmeasurable	unmeasurable

Table 1.
Lengths of the hour lines of the sundial no. 3156.

* The sixth hour line corresponds to the meridian hour line

dimensions 3.5 by 4.5 cm. The distance from the gnomon hole to the lower point of the conical surface is 20.3 cm, to the leftmost point of the curve is 23.0 cm and to the rightmost point of the curve is 24.5 cm.

On the dial surface, between the 6th and the 7th hour line, there is a crack. Alterations can be also observed at the end of the 1st and the 2nd hour lines, and much heavier ones in the case of the 8th to 11th hour lines.

The lengths of the hour lines from left to right are listed in Table 1, measured from the winter solstice curve to the curve of the equinoxes and from the equinoxes curve to the summer solstice curve.

The lengths of the successive arcs formed on the curves of the equinoxes and solstices from the intersections of the hour lines with them are given in Table 2, together with the

angles (θ) formed between successive hour lines according to the formula

$$\theta = (l_I - l_x) / IX$$

where l_x is the length of the arc on the curve of the winter solstice, l_I the length of the arc on the curve of the equinoxes and IX the length of the hour lines from the curve of the winter solstice to the curve of the equinoxes. (5)

Other characteristic distances on the dial surface along the meridian line are the distance from the upper edge of the dial to the curve of the winter solstice (3.2 cm) and the distance from the curve of the summer solstice to the base of the dial (3.5 cm). Conical sundial 3156 is not in very good state and does not have a gnomon; therefore, it is not possible to compute the obliquity of the ecliptic ε.

Between the hour lines:	Lengths of arcs on the winter solstice curve l_x (cm)	Lengths of arcs on the equinoctial curve l_I (cm)	Lengths of arcs on the summer solstice curve l_0 (cm)	Angle θ (degrees)
Edge – 1st	1.2	2.1	–	9.38
1st – 2nd	1.5	2.6	–	12.36
2nd – 3rd	1.6	2.9	~ 6.0	14.90
3rd – 4th	1.6	2.7	6.0	12.36
4th – 5th	1.7	2.9	6.0	13.75
5th – 6th	1.8	3.0	6.0	12.50
6th – 7th	1.8	3.0	6.4	12.28
7th – 8th	1.8	3.1	5.5	12.41
8th – 9th	unmeasurable	unmeasurable	unmeasurable	–
9th – 10th	unmeasurable	unmeasurable	5.5	–
10th – 11th	unmeasurable	unmeasurable	unmeasurable	–

Table 2. Lengths of arcs on the curves of the sundial no. 3156.

Latitude φ_1 (°)	33.58
Latitude φ_2 (°)	32.65
Angle between the axis and the generatrix ω (°)	47.12
Gnomon length d_1 (cm)	10.43
Gnomon length d_2 (cm)	10.69

Table. 3. Sundial no. 3156: Values of characteristic parameters ω, d and φ for obliquity $\varepsilon = 23° 27' = 23.45°$.

Fig. 3. Conical sundial 3157 of the National Archaeological Museum of Athens.

Three other sundials have been retrieved from the ancient Dionysus Theatre under the Acropolis, of which one is conical and retains its gnomon: it is the sundial with index no. 3158, which is kept in the storage room for sculptures of the National Archaeological Museum of Athens. Although the value for ε has been computed from our measurements and from detailed calculations of 3158's geometrical characteristics,[8] this value cannot be used with certainty for further computations of the characteristic parameters of sundial 3156. The discovery of the sundials in the same location does not necessarily mean that their characteristics are the same. Besides, sundial 3158 was not constructed for the geographical latitude of Athens, but for latitude $\varphi = 40.5$ degrees.

Table 3 gives the values for the characteristic quantities of the sundial obtained from the formulae 1–4. The value of the obliquity of the ecliptic for the period of the dial's construction was taken as equal to 23° 27′.

We observe that the two values for the latitude, as well as the two values for the gnomon length, are close to each other, a fact that testifies to the quality of the geometrical construction of the sundial and to the accuracy in time measurement.

Sundial 3157 of the Archaeological Museum of Athens

The ancient Greek conical sundial without a gnomon of the National Archaeological Museum of Athens with index catalog number 3157 (Fig. 3) was also recovered from the ancient Dionysus Theatre, and dates from the Hellenistic or the Roman period.[9] It is made of white marble and incorporates a marble base. The whole construction has the shape of an approximate rectangular parallelepiped; its weight is approximately 48.2 Kg.

The sundial's height ranges from 28.8 cm on the right to 29.5 cm on the left. Its depth at the right-hand side of the dial is 26.8 cm, while at the left-hand side is 26.0 cm. The width of the front side is 34.2 cm and the width of the back side is 34.1 cm. The difference between the two sides, especially in the height, is due to the fact that the whole construction consists of two united pieces, with the left piece making for about a quarter of the total volume. The line of separation between the two pieces lies along the surface of the dial between the 3rd and the 4th hour line.

There are alterations visible in the top view of the sundial. A prominent one can be observed at the right back edge, involving the loss of a marble piece in the shape of the base of a sector of a circle with radius 3.0 to 3.5 cm and height 5.5 cm. Obvious alterations also exist in the front. The edge regions to the right and to the left of the dial's surface respectively show loss of pieces and have pointed protuberances. The left-hand side of the dial has maximum depth 26.5 cm and minimum depth 22.5 cm, while the right-hand side has maximum depth 26.8 cm and minimum depth 19.0 cm. Along the line of separation between the two pieces there is also loss of small quantities of marble; most prominent is the loss of a small piece of marble to the right of the 3rd hour line on both sides of the curve of the equinoxes. A smaller loss is located to the right of the 3rd hour line on the summer solstice curve.

Fig. 2. Drawing of the line grid for sundial 3156.

Number of hour line (left-to-right)	From the winter solstice curve to the equinoctial curve IX (cm)	From the equinoctial curve to the summer solstice curve IΘ (cm)	From the winter solstice curve to the summer solstice curve XΘ (cm)
1st	5.9	2.8	8.7
2nd	5.4	7.3	12.7
3rd	5.2	7.1	12.3
4th	5.0	6.8	11.8
5th	4.8	6.8	11.6
6th *	4.8	6.8	11.6
7th	4.8	6.9	11.7
8th	5.1	7.0	12.1
9th	5.3	7.0	12.3
10th	5.5	7.4	12.9
11th	5.7	6.8	12.5

Table 4. Lengths of the hour lines for sundial 3157.

∗ The sixth hour line corresponds to the meridian hour line.

The sundial's base bears lion's feet with four toes on both the left-hand and the right-hand side. The dimensions of the base are: width 34.1 to 34.2 cm and depth 26.0 to 26.8 cm. The foot on the left-hand side (*i.e.* the right foot) is 29.5 cm tall, 9.5 cm wide and 6 cm deep, while the foot on the right-hand side has dimensions 28.8 by 9.5 by 6.7 cm, respectively, with some surface alterations. The distance of the lower part of the base from the lowest point of the dial surface is approximately 13 cm.

The dial surface is 0.3 cm thick and is preserved in rather good condition. The 11 hour lines, the curves of the solstices and the equinoxes are clearly visible, with the exception of the edge of the 1st hour line and the respective arc of the summer solstice curve, which are missing. In the place of the lost gnomon there is a square hole with a side of 4 cm; along its brink there are traces of metal. The hole's distance from the lowest part of the dial along the meridian hour line is 15.9 cm.

The lengths of the hour lines from left to right are listed in Table 4, measured from the winter solstice curve to the curve of the equinoxes and from the equinoxes curve to the summer solstice curve.

The lengths of the successive arcs formed on the curves of the equinoxes and solstices from the intersections of the hour lines with them are given in Table 5, together with the angles (θ) formed between successive hour lines according to formula (5).

Other characteristic distances on the dial surface along the meridian line are the distance from the upper edge of the dial to the curve of the winter solstice (4.1 cm) and the distance from the curve of the summer solstice to the base of the dial (0.3 cm).

Between the hour lines:	Lengths of arcs on the winter solstice curve l_x (cm)	Lengths of arcs on the equinoctial curve l_I (cm)	Lengths of arcs on the summer solstice curve l_0 (cm)	Angle θ (degrees)
Edge – 1st	1.6	2.1	broken	4.86
1st – 2nd	2.0	3.1	broken	11.67
2nd – 3rd	2.2	3.1	4.6	9.92
3rd – 4th	2.1	3.2	4.8 (missing middle part)	12.61
4th – 5th	2.0	3.1	4.6	13.13
5th – 6th	2.3	3.2	4.8	10.74
6th – 7th	2.1	3.1	4.5	11.94
7th – 8th	2.3	3.3	4.6	11.23
8th – 9th	2.3	3.2	4.6	9.73
9th – 10th	1.9	3.1	4.8	12.50
10th – 11th	2.1	3.1	unmeasurable	10.05

Table 5. Lengths of arcs on the curves of the sundial 3157.

Latitude φ_1 (°)	36.21
Latitude φ_2 (°)	35.64
Angle between the axis and the generatrix ω (°)	22.77
Gnomon length d_1 (cm)	14.58
Gnomon length d_2 (cm)	14.79

Table 6. Sundial no. 3157: Values of characteristic parameters ω, d and φ, for $\varepsilon = 23° 27' = 23.45°$

Sundial 3157 is not in a very good state and does not have a gnomon; therefore, it is not possible to compute the obliquity of the ecliptic ε. Although it was also retrieved from the ancient Dionysus Theatre under the Acropolis, it could well have different construction characteristic values from sundials 3156 and 3158.[10]

In Table 6 are given the values for the characteristic quantities of the sundial obtained from formulae 1–4. The value of the obliquity of the ecliptic for the period of the dial's construction was taken as equal to 23° 27′.

We observe that the two values for the latitude, as well as the two values for the gnomon's length are close to each other, a fact that testifies to the quality of the geometrical construction of the sundial and to the accuracy in time measurement.

Conclusions

Conical sundials 3156 and 3157 were constructed for similar values of geographical latitude. The angle ω was calculated with great precision, a fact indicated by the almost identical values obtained for the gnomon's length and for the latitude. The gnomon length for both sundials was excellently approximated for the given dimensions of the marble constructions. The similar values of the geometrical characteristics of the two sundials strengthen the probability that they were constructed by the same person with negligible construction errors, since the value of the obliquity of the ecliptic was known in the time of the construction. Although they were found in Athens, their operation latitude does not coincide with the latitude of Athens, $\varphi = 37° 58′$; however it does not differ considerably, so it is possible that they were used in the region of Athens with acceptable precision. Their operation latitudes of 33° to 36° correspond to parts of the Mediterranean. If they were constructed for these regions, it is possible that they were brought to Athens as loot. Another possibility is that their constructor was not an expert in marble sculpting and therefore he was not accurate as far as the geometrical characteristics are concerned. Again, the minor deviation of the operation latitudes of these sundials could be explained by a tendency of the Athenians to disregard the great precision in the operation latitude in order to use them in various locations, especially to the south of Athens. Athens was a powerful state in these years and is very probable that the Athenians were looting various objects that could testify to their power, sundials being among them.
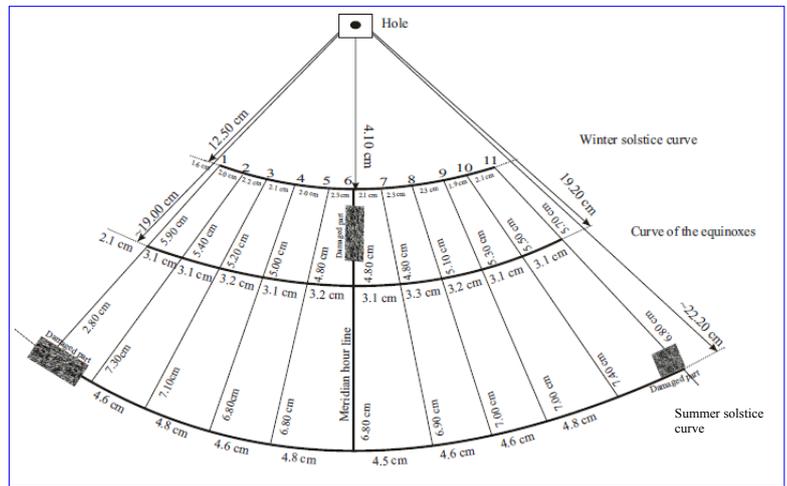
Fig. 4. Drawing of the line grid for sundial 3157.

REFERENCES
1. Claudius Ptolemy: *Syntaxis Mathematica*. ed. J.L. Heiber, Teubner, Leipzig, (1898).
2. S.L. Gibbs: *Greek and Roman Sundials*, Yale University Press, New Haven and London, p. 8, (1976).
3. Gibbs: *op.cit.*, p.9 (ref. 2).
4. A.E. Taylor: *Plato, the Man and his Work*, Meuthen and Co. Ltd., London, p. 445, (1955).
5. Plato: *Timaeus*, ed. J. Burnet, Platonis opera, vol. 4. Oxford: Clarendon press, (1902).
6. Strabo: *Geographica*, ed. A. Meineke, Teubner, Leipzig (1877).
7. T. Kraus: *Katalog der Einzelfunde*, Series Karthago I, p. 94, (1991)
8. E. Panou, E. Theodossiou, V.N. Manimanis & P.Z. Mantarakis: 'The conical sundial of the Archaeological Museum of Athens with a gnomon', *NASS Compendium*, 20(4), pp. 30–37, (Dec 2013).
9. Kraus: *op. cit.*, p.95, (ref. 7).
10. Panou *et al*, *op.cit.*, (ref. 8).

Evangelia Panou is a physics teacher. She received a masters degree in Environment and Development from the National Technical University of Athens (NTUA) in 2008 and a masters degree in Nuclear and Particle Physics from National Kapodistrian University of Athens (NKUA) in 2010. Currently, she is a PhD candidate at the National Kapodistrian University of Athens (NKUA). The title of her thesis is 'Time measurement from Ancient Greek Astronomers'. Her interests focus on the scientific research field of History and Philosophy of Sciences.

E-mail: *evipanou184@yahoo.gr*

SHERLOCKIAN DIALS

ANTHONY CAPON

The Sherlock Holmes detective stories of Sir Arthur Conan Doyle where published between 1887 and 1927. Many of them first appeared in *The Strand Magazine*, a well known illustrated periodical. Their combination of mystery, deduction and adventure appealed to a wide readership and they became extremely popular and remain so to this day

The contrasting personalities of the two leading characters, Holmes and Watson, have fascinated readers over the decades. The brilliant but eccentric Holmes with a penchant for indoor pistol practice and noxious chemical experiments balanced by the sober Dr Watson who was always trying, usually unsuccessfully, to emulate the deductive methods of his friend, but was ever loyal and dependable. These stories then might seem an unlikely place to look for references to sundials, dealing, as they do, at least in popular perception, with the exploits of Holmes and Watson in the foggy streets of London or on the windswept moors of the West Country. However, sundials do make the occasional appearance as many of the adventures take our heroes to the country villas and estates of the upper middle classes of the time, places where sundials might have been used within living memory to check the households clocks.

The Five Orange Pips

"Put the papers on the sundial," I read peeping over his shoulder.

An instruction to John Openshaw's father, Joseph, received in a letter bearing the initials KKK and containing also five orange pips.

The Dancing Men

"… yesterday morning I found this paper lying on the sundial in the garden."

Hilton Cubitt describing to Holmes and Watson how the second Dancing Men message came into his possession.

The Valley of Fear

"Inside was a beautiful stretch of lawn with an old sundial in the middle, the whole effect so soothing and restful that it was most welcome to my somewhat jangled nerves."

Dr Watson describing part of the garden at Birlstone Manor, the scene of the murder of John Douglas.

The Problem of Thor Bridge

"…and asked me to leave an answer on the sundial in the garden,…"

Grace Dunbar describing to Holmes her relationship with the woman found dead on the bridge, Maria Gibson, the wife of Neil Gibson former American senator but known as the Gold King, one of the world's leading gold magnates.

References then in four different Holmes stories to sundials, but as you can see from the preceding extracts, the sundial features only as a reference point, a place to leave secret messages or as a feature to help set the scene. Our characters are not actually using a sundial as such, a summer house or garden seat for example could have done just as well as a place to leave messages or create the atmosphere of an English country garden.

The Adventure of the Musgrave Ritual

However, there is one Holmes adventure which, while it does not strictly speaking involve a sundial, does lead our detective hero into some consideration of solar altitude and azimuth, shadow length and the theory of similar triangles. It is the *Adventure of The Musgrave Ritual*.

This story was originally published in *The Strand* magazine in 1893 and later incorporated into the collection known as *The Memoirs of Sherlock Holmes*. It is the story of one of Holmes's earliest cases occurring soon after he had arrived in London and was living in Montague Street.

The adventure predates Holmes's meeting with Watson and is related by Holmes to Watson some years after the event when they are lodging in Baker Street. Some Sherlockian scholars have suggested that the story is set in 1879.

The Musgrave of the title is Reginald Musgrave, a friend of Holmes from his student days. He has inherited the Hurlstone estate in West Sussex and the rambling manor house in which he lives is reckoned to be "the oldest inhabited building in the county."

The problem that he outlines for Holmes to solve is the sudden disappearance of his house maid, one Rachel Howells and the long serving butler, Brunton, shortly after he has been caught by Reginald Musgrave studying an ancient Musgrave family document containing a strange riddle or catechism.

The Musgrave Catechism

"Whose was it?
His who is gone.
Who shall have it?
He who will come.
What was the month?
The sixth from the first.

Where was the sun?
Over the oak.
Where was the shadow?
Under the elm.
How was it stepped?
North by ten and by ten, east by five and by five, south by two and by two, west by one and by one, and so under.
What shall we give for it?
All that is ours.
Why should we give it?
For the sake of the trust."

Holmes of course quickly deduces that these lines are intended to guide the reader to a particular point on the estate. A point at which he believes he will find the solution to the mystery.

Fig. 1 shows my own sketch map of the house and grounds based on the text of the story.

The catechism fixes the time at which the observation of the shadow of the elm is to be made as when the sun is "…over the oak…". The location from which the observation of the sun should be made is presumably somewhere on the line joining the oak and the elm ie the sun the oak and the elm are all aligned, effectively fixing an azimuth. We do not have a specific date, only that the month is, "… the sixth from the first." *i.e.* the seventh month, July.

When the sun crosses the line formed by the oak and elm the tip of the shadow cast by the elm gives the starting point for the pacing out of the final directions contained in the catechism. However Holmes has a problem, the elm has been cut down.

Holmes learns from Reginald Musgrave who, as a boy measured it while practicing his trigonometry, that its height was 64 feet. He therefore uses a fishing rod of 6 feet in length to represent the elm and finds that it throws a shadow of 9 feet. From this he calculates the original shadow length (*sl*) cast by the elm using similar triangles:

$$6 / 9 = 64 / sl$$
$$96 \text{ feet} = sl$$
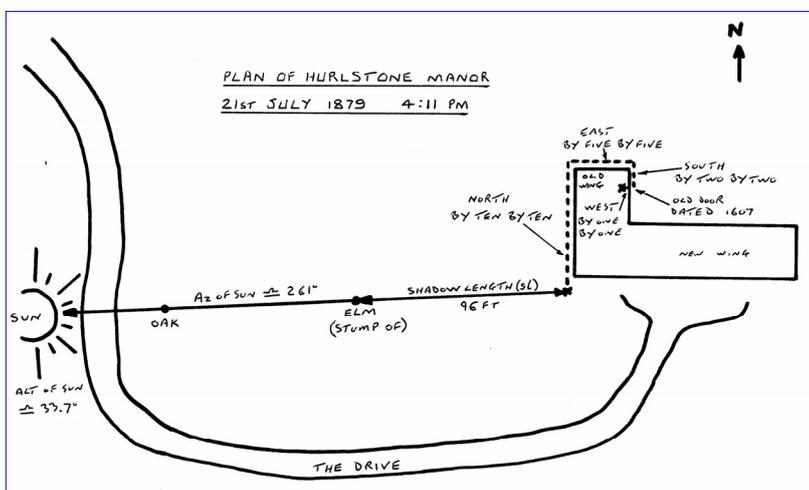
Fig. 1. Plan of Hurlestone Manor.

We know that the 6 foot fishing rod casts a shadow of 9 feet which enables us to calculate the sun's altitude (*alt*).

$$\tan (alt) = 6/9$$
$$alt = 33.69°$$

On the 1st of July 1879 the sun attains this altitude at about 4:22 pm (GMT) on an azimuth of about 265.5° whereas on the 31st July 1879 the time changes to around 4:01 pm (GMT) and the azimuth to roughly 256.6°. This effectively fixes the relative positions of the oak and elm, they must indicate an azimuth within this range.

If we now consider the altitude variation over the month of July on a fixed azimuth (let us choose 261°) we find that it is approximately 6.5° which translates to a 23.6 foot variation in the position of the tip of the shadow of a 64 foot elm tree.

Holmes does not appear to have considered any of this but simply starts pacing out the riddle's directions from his calculated position of where the elm tree's shadow would have fallen on the particular day that he is visiting Hurlstone. We cannot, from the text, even be sure that his visit takes place in July.

Perhaps we should not be surprised by Holmes' apparent lack of astronomical knowledge because his friend Watson once drew up a list itemizing the strengths and weaknesses in the great detective's general knowledge and his rating of Holmes' knowledge of astronomy was nil.

However, in the story, although not in a specifically astronomical sense, Holmes does refer to "… the personal equation, as the astronomers have dubbed it." This being, in its original sense, the concept of measurement variation between different observers in measuring, for example, the altitude or azimuth of a star or its time of crossing the meridian. So Holmes might have had more knowledge of astronomy than Watson gave him credit for. Be that as it may he does not seem to have considered the effect on shadow length of the date of an observation.

Another point, connected with the date of the observation, is the fact that the riddle's composition has been dated to the middle of the 17th century, according to Musgrave. This would mean that it was drawn up at a time when the Julian calendar was in effect, resulting in the actual Gregorian dates corresponding to 1st and 31st July 1650 becoming 13th July and 12th August 1879, further complicating the identification of the correct date on which to observe and measure the shadow of the elm.

One more point which it occurs to me would in practice confound Holmes' attempts to follow the riddles directions, is the growth of the elm tree over some 230 years. Surely the tree would have been much smaller and therefore thrown a shorter shadow in 1650 than it did in the 1860s when a young Musgrave measured its height at the request of his tutor.

Conclusions

First, Sir Arthur does not appear to have checked very carefully whether or not the details of the story make sense. Apart from the point about the date I have been unable to reconcile the paced distances and directions with the house and grounds as described in the text. I have indicated my best fit on the plan.

Secondly, Sir Arthur, like many good story tellers, clearly believed that maintaining a brisk pace in the narrative and allowing his lead character, Holmes to solve all apparent problems with his great deductive powers, this was what his readers wanted, and he was right.

Epilogue

Holmes does find the missing butler and also some 'treasure', however the maid is never heard of again. The treasure turns out to be the crown jewels of Charles I which had been hidden at Hurlstone by his supporters during the Civil War. The catechism is a 'coded' guide to its recovery.

All in all, a splendid story and one with a little extra interest perhaps to the sundiallist.

anthonycapon@btinternet.com

TWO TOMPION SUNDIALS ON DISPLAY IN CALIFORNIA

DOUGLAS BATEMAN

During November 2013, The National Association of Watch and Clock Collectors of America ran a major symposium on the subject of Time For Everyone, the venue being the California Institute of Technology, Pasadena. The topics ranged from the origin of the universe and the arrow of time, human perception of time and time intervals in biological processes. Other sessions covered the more mechanical aspects culminating in atomic clocks. Keynote speakers were Dava Sobel, author of *Longitude*, and Nobel Laureate William D. Phillips (a shared prize on the subject of laser cooling of atoms in atomic clock technology). Of the 290 attending 24 were from the UK. British speakers were well represented: William J.H. Andrewes, formerly curator of the David P. Wheatland Collection of Historical Scientific Instruments, Department of the History of Science, Harvard University; Anthony Turner, historian (currently based in France); Jonathan Betts, Senior Curator of Horology, Royal Museums Greenwich; Chris McKay, author of a book on the Westminster Clock (Big Ben); Dr James Nye, Kings College London, and Electrical Horology Group, Antiquarian Horological Society; and David Rooney, Curator of Transport, Science Museum (formerly Curator of Timekeeping, Greenwich). (Andrewes is known for patenting an unusual 'geographical' sundial, see the report by Irene Brightmer.[1])

The symposium was privileged to have a large exhibition of timekeepers by Thomas Tompion, of the 'Golden Age' of British timekeeping. This was made possible by the generosity of the philanthropist, Dr John C. Taylor OBE, an inventor of a key safety component in practically every electric kettle. To the wider public, Dr Taylor is becoming known for his extraordinary clock and automata called a Chronophage which has a grotesque grasshopper-like insect 'consuming' time. The grasshopper has a historical link to the escapement designed by John Harrison who won the longitude prize with a practical design for a clock that would work at sea. The Chronophage has become a popular tourist attraction in Trumpington Street, Cambridge. For the Pasadena exhibition, a number of Tompion clocks were on display, ranging from lantern clocks, bracket clocks, longcase clocks, and two large iron-framed turret clocks. Many of these clocks may be described as almost priceless.

Prominent in the displays were two of Tompion's sundials. Only ten dials are currently recorded and two of his five horizontal dials were shown in the exhibition. The square dial dates from about 1705 and is designed for latitude 50º 54'. It reads to one minute in time and has a central table for the equation of time.

Four pictures of the former Wrest Park dial: note the minute scale with 'tranversals' and the large noon gap for the substantial gnomon. The wedge effect can also be seen on the pedestal, as in this photograph that was included in the full page advertisement that appeared (in black and white) in the June 2004 issue of the BSS Bulletin. The pedestal is attributed to the sculptor Jan Van Nost.

The large circular dial was formerly at Wrest Park, Bedfordshire, and made for Henry Grey (1671–1740), 12th Earl of Kent, with the dial dating from around 1700. The dial was designed for two latitudes, 52º 8', and 50º 26', and the tapered base is assumed to allow for a 'wedge' to incline the plate at the correct angle when the dial changed location! There is a table for the equation of time, and the gnomon is elegantly pierced with the initials HK and surmounted by a coronet.

This particular dial was the subject of a report by Mike Cowham in his 'Dial Dealings'.[2] It graced the front cover of Sotheby's Scientific Instruments catalogue in June 2004, and including the pedestal, reached a hammer price of £173,600.

REFERENCES

1. I. Brightmer: 'New Dials, Burghley House, Stamford, Lincs.' *BSS Bull,* 20(ii), 6, (June 2008).
2. M. Cowham: 'Dial Dealings', *BSS Bull*, 17(i), 29–33 (March 2005).

douglas.bateman@btinternet.com

A CHINESE BOOK OF SUNDIALS AND A NOON MARK SUNDIAL IN AUSTRALIA

JOHN WARD and MARGARET FOLKARD

We enjoyed reading the article about Beijing Sundials in the June 2013 *Bulletin* as it brought back many memories. We have both visited China (JW several times) on sundial safaris and just a few months ago JW visited the Hong Kong Science Museum. It was superbly presented and is a fascinating place to visit. Of particular significance was the gift shop at the end of the visit. In it was a superbly presented, large format book entitled *Moving Stars Changing Scenes – Gems Of The Ancient Chinese Astronomy Relics.* (Fig. 1).[1]

Fig. 1. The colourful cover of the catalogue of Chinese solar instruments.

Fig. 2. The noon mark sundial for the Whyalla Rotary Club.

It contains in detail, the construction, origin, principle of operation and excellent colour drawings and photographs of all the historical solar and sundial instruments, until recently held in Beijing at the planetarium.

The general presentation and the detailed drawings are first class in every way. We heartily recommend this book as almost a necessary addition to every gnomonist's library, including of course the BSS library. It cost only $HK 150. The book was produced by the Hong Kong Science Museum and published in 2006 by the Chinese Leisure and Cultural Services Department.

In keeping with the Beijing sundial shown in the *Bulletin* and the Faversham Guildhall Noon-Mark sundial by Christopher Daniel and relevant to our own gnomonic activities in Australia, we relate the following story.

Recently we completed a Noon Mark as part of a project initiated by the Rotary Club of Whyalla. Whyalla is an industrial, iron-mining town in South Australia located at Latitude 33° 02′ South and Longitude 137° 35′ East.

A photograph of the Noon Mark on display outside our workshop is shown in Fig. 2. It was made from 10 mm (0.4″) thick type 316 stainless steel, appropriate for this industrial location. The solar noon line and analemma for 1200 hours Central Standard Time (CST) were milled to a depth of 2 mm (0.08″) and a width of 4 mm (0.16″) on a computer controlled milling machine. In turn, the lines were crossed by 12 mm (0.5″) diameter circles machined on the plate to indicate the 1st of each month and 8mm (0.3″) diameter circles to subdivide each month into 4 weekly intervals. A 3 mm (1/8″) diameter end mill was used to mark out "1st JANUARY" *etc* and to machine instructions for use into the steel plate.

We had originally planned to use deep photoetching but were unable to find anyone in South Australia still using this simple technique – they have all gone over to shallow laser photo-engraving which was not suitable for this project. Our original drawing done using *Macromedia Freehand* was converted to the milling machine language only

Fig. 3. The equatorial plate, with the details of the Rotary symbol being painted by one of the authors (MF).

after much difficulty and frustration with differing and incompatible file types.

All the milled paths were carefully painted by hand (black for solar times, blue for CST and red to indicate the solstices and equinoxes) to enhance the contrast and aesthetically improve the overall presentation. Finally, the stainless steel plate, 1220×420 mm ($48'' \times 16.5''$), was mounted on a brick table at elbow height for all to see in a public park.

Another part of the project in the same location was an 'Equatorial Plate' sundial, made again from 10mm thick stainless steel and machined on both faces in a similar fashion to the Noon Mark. The dial is 600 mm ($24''$) in diameter and features the blue and gold Rotary International logo with its 24 teeth, with a 30 mm ($1.2''$) diameter stainless steel gnomon securely welded to the inclined plate as shown in Figure 3. The dial plate was mounted on a 10mm thick elliptical stainless steel horizontal table 680×420 mm ($26.8'' \times 16.5''$) containing instructions for use and this table was in turn welded to a substantial iron pedestal 270 mm ($10.6''$) in diameter and 1000 mm ($39.4''$) tall.

To complement the sundial features, we made a Globe of the World (Fig. 4) using 18 mm diameter ($0.7''$) zinc-coated reinforcing rod and a central axis rod of 41 mm ($1.6''$) diameter (all manufactured in Whyalla) with 3 mm ($1/8''$) thick stainless steel countries and continents cut out with a laser then three-dimensionally curved to the 1500 mm sphere diameter. The countries were then neatly welded in situ. The Globe will be known as "The Globe of Harmony" to commemorate the successful blending together of the many

Fig. 4. The Globe of Harmony with (right) the first author showing its size.

different nationalities who live and work together in Whyalla.

The Globe of Harmony was screwed and welded onto a steel ingot $950 \times 950 \times 250$ mm ($37'' \times 37'' \times 10''$) weighing about 1.7 tonnes, another typical product produced in Whyalla. Too difficult for any potential thieves to run away with!

REFERENCE

1. *Moving Stars Changing Scenes - Gems Of The Ancient Chinese Astronomy Relics.* Hong Kong Science Museum, 2 Science Museum Road, Tsim Sha Tsui East, Kowloon, Hong Kong. ISBN 962.7797.05-7.

sundialmarg@kern.com.au

A 'BRILLIANT' AUSTRALIAN SUNDIAL

KEVIN KARNEY and GRANT CALVIN

Recently, I (KK) was lucky enough to be invited by the Australian Decorative & Fine Arts Association to give 16 lectures on 'Sundials & the History of Timekeeping' throughout New South Wales & Tasmania. In researching my talks, I googled & flikr-ed 'name of town' and 'sundial' and found many beautiful and interesting sundials. One such search revealed an interesting looking structure (see Fig. 1) in the grounds of the University of Western Sydney's Campbelltown campus.

David Cawthorne

Fig. 1. A strange dial found on the Internet.

Fig. 2. Campbelltown campus dial - 6 or 7 metres high.

Before lecturing in nearby Camden, I visited the campus and was directed to a courtyard and the 'structure' was revealed to be 6 or 7 metres about the ground (Fig. 2). It was constructed of welded rods and plates cut from sheet metal showing the cardinal points, solstices, equinox and hour numbers. All, except the supports, was painted a bronze colour. It was clearly an equinoctial sundial.
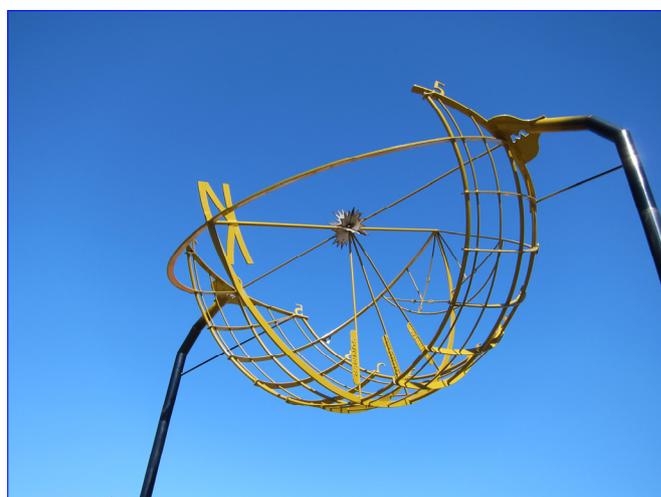
Fig. 3. Campbelltown campus dial: detail.

It was a bright Spring day and the Sun was shining and the shadow of the star-shaped nodus could be seen. But, from the rather indistinct shadows of the rest of the dial on the grass, it was not obvious how the time could be told – see Fig. 4.

Fig. 4. The indistinct shadow. The brick on the left is one of the summer solstice markers.
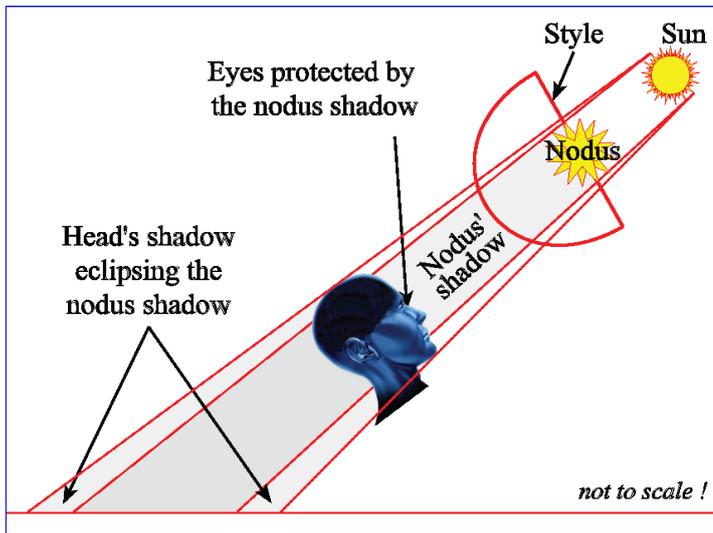
There were some little plaques on the ground marked with various times during the solstices and equinox. One of these can be seen in Fig. 4. But these did not appear to relate in any way to the shadow of the nodus. I still could not tell the time. I was confused.

Luckily, I was accompanied by my hostess and my wise wife, who – unlike me – reads instructions. These were clearly engraved on stainless steel plates on walls nearby. To tell the time, you stand with your back to the sun until the shadow of your head eclipses the shadow of the nodus. This ensured that your head, the nodus and the Sun are co-linear. Then, one turns around and looks up at the nodus – see Fig. 5. The nodus now exactly eclipses the dazzling sun and your eyes are protected. The time and something about the season is revealed in the most **brilliant** fashion! See Fig. 6.

The two comprehensive plaques of instructions, *when fully read,* elucidated other aspects of the dial...

- instructions not to look at the sun directly.

- how the sun's movement is a fundamental observation for any region & the seasonal variation in the location of the sun provides the simplest, most effective way of sustainably staying warm in winter and cool in summer. "Intelligently designed buildings use this movement to maximize efficiency from the biggest heater we have on earth."

- how the fine seasonal rods are spaced according to the signs of the traditional (non-sidereal) astrological calendar, see Fig. 7.

- how not to miss a university lecture by applying the Equation of Time and the longitude corrections.

- how, by standing on the little plaques and tracing the relationship of nodus and hour ribs through the seasons, one can observe the seasonal variation in the Sun's altitude.

- how variation in the direction of sunrise and sunset may be seen.

- a reminder showing how, at night, the South Celestial Pole can be found using the Southern Cross and the Centauri pointer stars (see Fig. 8).

- how the natural environment changes seasonally and affects how we live. This is explained with a detailed technical exposé of the amount of radiant heat absorbed by the windows of a house during the year as a function of the Sun's position. "Consider carefully the orientation of the walls of any house or office you may be designing or purchasing for yourself, it can really make a difference."

A little research revealed that the dial, Solar Chronograph II, was made in 2006 by Grant Calvin. It won the prestigious University of West Sydney's Acquisitive Sculpture award for that year. As such, it is permanently installed in the University's grounds. It can be clearly seen on Google
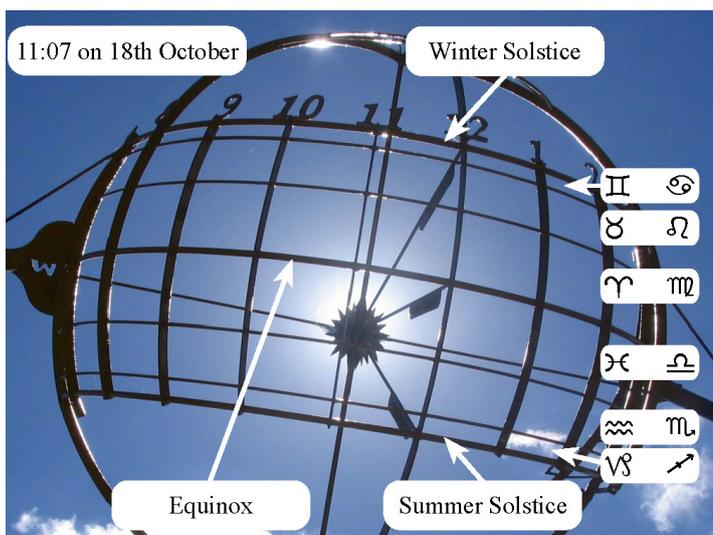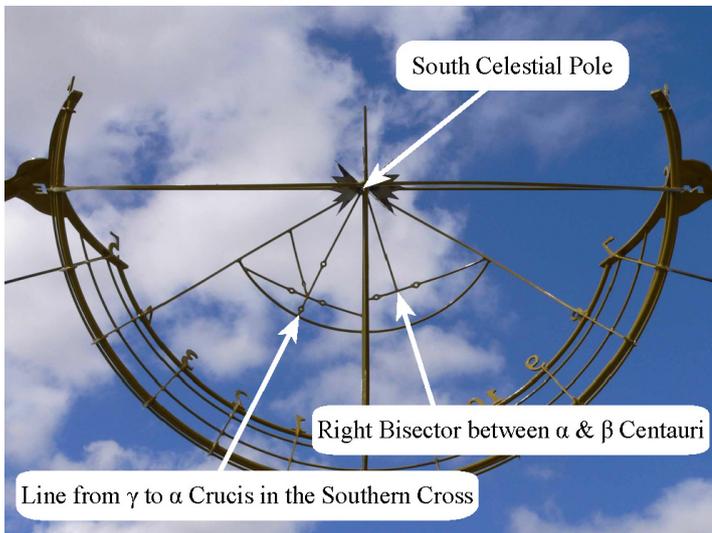

Top to bottom
Fig. 5. Lining up to tell the time.
Fig. 6. It is 2:15 pm solar time, 6 days after the Equinox.
Fig. 7. The seasonal & traditional astrological markers.

Fig. 8. The reminder of how to find South at night.

Earth at 34° 4.133′ S, 150° 47.495′ E, in the middle of a brick semicircle.

The first Solar Chronograph – originally inspired by Jai Singh's Jantra Mantra in Jaipur – is installed in Grant's garden. Designed with the aid of AutoCad, the whole structure is based on a sphere of diameter 2.3 m – the size limited by Grant's workbench. The major declination arcs are made of 20 mm diameter pipe and minor of 10 mm rod rolled to various radii. The hour lines of 40 × 6 mm steel rolled to an arc. The structure took 3 months to build on weekends and evenings after work in an open garden shed in winter...

Grant is a registered surveyor working for the Greater Taree City Council on the north coast of New South Wales, Australia. His particular sustainable crusade is to convince the authorities, land developers and home owners to take solar energy management seriously in road/lot orientation and housing design. Using passive solar design theory, energy free from the sun can significantly lower the requirements for heating from external, often fossil fuelled, sources in winter. Excluding the summer sun from buildings in summer alleviates the need for air conditioning and lowers the energy requirements for cooling the internal space for human comfort.

Architecturally, this implies:

- Houses are built with the long axis east-west and the solar collecting wall with maximum glazing (southern wall in the northern hemisphere and the northern wall in the south) maintains solar access through winter. This minimises solar gain on the east and west walls, particularly in summer.

- Roof overhangs on the solar collecting walls are designed to:

    - shade windows from the high-altitude summer sun, keeping the building cool in summer and

    - not impede the low-altitude winter sun, keeping the building warm in winter.

- The land development layout needs to provide the spacing between buildings so that shadow of adjacent buildings does not impede the available solar energy gains available in winter.

- Grant believes that, depending on latitude, energy savings in excess of 30% can be achieved through orientation aligned with the Sun's energy in mind.

To this day, Grant is extremely pleased to have his work erected at the university and somewhat bemused that a surveyor, working in his garden shed, could win a major art award. It is possible that the award's judges were impressed, firstly with the piece as a public instrument, a sculpture and an educational tool, enabling people to see for themselves the variations in the Sun's path, both daily and seasonally. And secondly, with Grant's statement of intent...

"Understanding the natural rhythm of the Earth's movement relative to the sun is the first step in getting people thinking about their living environments in an energy-efficient, sustainable way. When we become mindful of our true position in the universe we get a real sense of our responsibilities here on earth."

Picture credit: (Fig. 1) David Crawthorne at www.flickr.com/photos/wormey/8267089537/
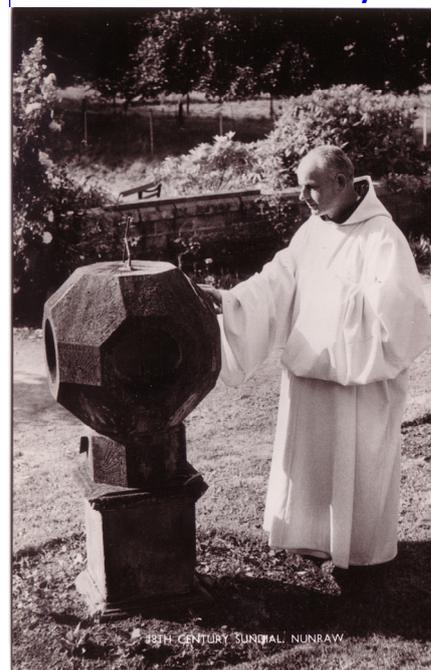

Kevin Karney
Kevin@Karney.com
51° 44′ N; 2° 41′ W
Zone 0

Grant Calvin
solidearth@bigpond.com
31.90° S; 152.45° E
Zone 10

Nunraw House Polyhedral Sundial

This postcard from 1968 was sent in by Darek Oczki. The dial (SRN0868) is at Nunraw Old Abbey, Garvald, in East Lothian and according to Andrew Somerville has 34 separate dials, some for places such as Cairo, Ispahan, Jerusalem, Mt Sinai, Jamaica etc. It also shows Savannah and Philadelphia which led Thomas Ross, in 1890, to write that it could not be over 100 years old, despite the "18th century" caption.
Views? The stone is certainly very crisp.

A NEW ANALEMMATIC DIAL IN BRIGHTON

JACKIE JONES

Following a talk about sundials by Doug Bateman to the Foredown Tower Astronomers, a new analemmatic dial has been created in the grounds of the Emmaus Community in Brighton. The astronomy group hold their monthly meetings in the café at the community and it was suggested that a sundial would be an ideal feature in the grounds.

George Hurrion, of the astronomy society, calculated the dial size and position of the hour lines, which were then marked on the levelled ground. The measured area was then covered in concrete to provide a firm base for the design (Fig. 1). In keeping with their policy of reuse and recycling, the majority of the mosaic tiles used were ex-samples from a supply store or assorted broken crockery.

It was designed by Emmaus resident Lee Radford who arranged working groups involving the community and local schools to create the mosaic panels (Fig. 2). The deco-

Fig. 4. Designer Lee Radford on the dial.

rative features include a comet, Saturn (with Titan), Orion and Ursa Major with Polaris as the midday marker. The launch event held in September 2013 including a recording made by Sir Patrick Moore just a few weeks before he died, giving his congratulations to the project and instructions to "Uncover the midday stone".

Fig. 1. The dial area levelled and concreted.

Fig. 3. The finished dial.

Emmaus Communities enable people to move on from homelessness, providing meaningful work and a home in a supportive environment.

jackie@waitrose.com

Fig. 2. Creating the mosaic number panels.

SUNDIALS ON BOULDERS

MARTINS GILLS

The summer of 2013 brought me two sundial projects with some joint motive of combining stainless steel with granite boulders. In both cases I developed the design and made the calculations, but the metal works were by my colleague Aivars Oleksans.
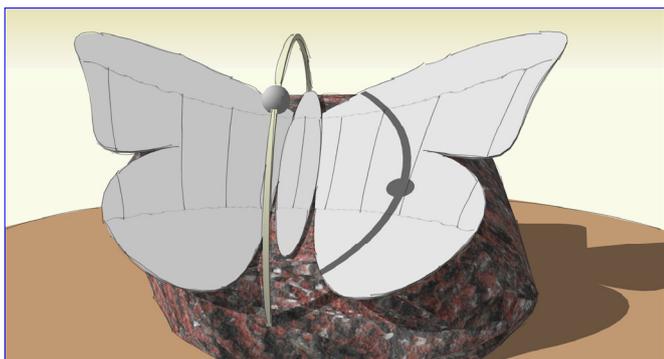

Fig. 1. Initial draft of the butterfly sundial in Kegums.

The Kegums Sundial

The first of the two sundials is in Kegums, a mid-size town in Latvia (56°44′32″N; 24°43′2″E). This sundial is in the form of a butterfly. Some say it seems so light and joyful, but actually the path from the initial idea to this nodus-based sundial was not so easy. In 2012, the municipality of Kegums was planning a renovation of town's main park. They approached me with a proposal to make a simple classical horizontal sundial as the central element of the park. Interestingly, they had already envisioned the use of a 3.5 tonne boulder sitting not far from the park on municipal grounds as the basis for the new sundial. Really, the selected stone was quite suitable for making a horizontal sundial. A metal dial plate could be placed on the top, or all the hour marks could be carved directly into stone. As I introduced the municipality to the multitude of sundial

Fig. 2. Second version of dial plate and node of Kegums sundial.

types and design variations, their intial wish of creating classical horizontal transformed into a requirement of constructing something interesting and beautiful. I played through many ideas.

One design was related to the history of Kegums – this place was established in 1936 at the time of the construction of the first hydroelectric station in Latvia. The local infrastructure developed along with the building works and more people moved there. The design proposal was to show multiple electric sparks holding elements of an equatorial sundial. Another idea was to use a symbolic sun.

Fig. 3. The Kegums sundial. The dial plate shows winter time and summer savings time.

Fig. 4. The Kegums sundial, side view.

Then followed several motifs with flowers – for both the gnomon and the dial plate. Only after several months of drafts and discussions was the final proposal developed. As in my previous projects, I used the *SketchUp* software package for quick prototyping of 3D models as it provides an opportunity to generate drafts with views from various angles with or without modelled shadows.

The final design has shape of a butterfly. I came to this design by reviving an old idea I had from the visual association of looking at hour lines in combination with declination lines being closest at meridian and diverging towards east and west. The resemblance may depend on the projection angle and imagination, but as I fixed on this idea for Kegums, a proper artistic solution had to be found.

Quite early it was clear that a nodus-type gnomon should be used. Also, some prototyping of projections showed that the dial plate should be neither horizontal nor vertical. At the latitude of the intended location (56° 44' N), the optimum inclination was around 40 degrees. To draw the shape of butterfly, I browsed through numerous butterfly photos.

As this is the main park of the town, it was also important to include not just the name of the town (which was consequently engraved in the stone), but also some element related to the municipality. The coat of arms of Kegums has a symbolic sun on it. The nodus cites this sun with its complicated outline while its centre edges chamfered from both sides in order to provide a path of light to any point of the dial plate.

The dial plate has hour marks, and its upper and lower edges mark correspond to the nodus projection at the winter and summer solstices. As the dial plate is divided into three parts, and each wing is raised by 10 degrees relative to the body, separate calculations were applied to each part. The middle part corresponds to an inclining dial, but those on the wings are two different inclining-declining dials.

This sundial shows mean time for two time zones. The upper row of numerals indicate winter time (GMT+2) and the lower row give summer time (GMT+3).

The wings are made from 6 mm thick sheets of stainless steel, while the dial plate is from 2.5 mm sheet. The body is

Fig. 5. TheKegums sundial. Close-up of the nodus.

thicker – 28 mm. There is 3 mm space between the dial plates and the wings. The nodus is locked in its place above the butterfly by an arc corresponding to the local meridian.

Fig. 6. The intended location for the Marsneni sundial in the park.

The Marsneni Sundial

The second sundial using a motif of boulders and steel was made for the villlage of Marsneni (57°25′17″N; 25° 34′ 46″E). As part of improvements to the village's park, the local municipality decided to add two elements in 2013 – a health path (where people are supposed to walk barefoot on specially-arranged round stones) and a sundial. One of concepts was to include Latvian ethnographic signs in both of them. Taking into account that the health path would slightly resemble a curved ethnographic belt, I quite quickly came up with a proposal to use the motif of a belt in the sundial as well. The idea was to give the impression of a belt placed on three boulders slightly blown by a wind. The mid part makes an equatorial sundial. As we are not sure that in ancient times Latvians used either Roman or Arabic numbers, the notation of dots was used instead – the number of dots indicates the hour. Of course, the division into modern hours is used. This sundial shows local time.

Fig. 7. Draft design of the Marsneni sundial.

Although it seemed simple at the beginning, the design and construction took several iterations. First, I drafted the general design with approximate dimensions. Then boulders of appropriate size and shape were found and placed into specified locations. Afterwards, I made photos with measurements of the actual positions and dimensions of the stones. Now, I had all the spatial information required for

Fig. 8. Three views of the Marsneni sundial. Top left, front view; above and left, two side views.

Martins Gills lives in Riga, Latvia. He has had an active interest in sundials for over a decade and has been a member of the BSS since 2012. His doctoral degree is in computer science and he works in the IT area. He is an amateur astronomer, taking part in astronomy outreach activities. Since 2008 he has maintained a website devoted to sundials *www.saulespulkstenis.lv*. Responding to various requests by website visitors, he has started designing new and original sundials. He can be contacted at *saulespulkstenis@gmail.com*.

the 3-D model. As all the preparations were made earlier, the final design and calculations were made relatively fast. In order to provide some freedom for curves, in the calculations of the material I added some extra length on both ends of the belt. During the installation, the curves were adjusted on-site. A tricky part was ensuring proper North-South alignment and the latitude angle of the dial during the installation process. For this purpose I made a special prism-shaped mould. It allowed me simultaneously control the tilt and the azimuth relative to pre-set markers in the park. As a result of all construction works the 5 mm thick and 12.5 cm wide stainless steel belt sits at some 5 cm above the surface of three stones. As well as the ethnographic signs indicating traditional Latvian culture, the three stones also have a special meaning, being a symbol of stability and good intentions. The cut-out ethnographic signs at different times give interesting sunlight projections on the rough surface of boulders.

As both the sundials have been made with an intention of enriching the collection of sundials in my country with original works, I hope they will serve well for telling the time and making places more interesting.

NEW DIALS

A New Dial for a New House

When BSS member Michael Harley and his wife Mary decided to build a smaller house in the garden of their existing home at Derry in the North of Ireland, both of them knew instinctively that they would also need a new sundial to complement the project. An almost south facing blank wall was crying out for a vertical dial and Michael set about designing one with a difference. A mirror image of their existing horizontal dial was not what he wanted and as he had recently been using 'reverse engineering' techniques on the timelines on one of the ancient Irish Monastic sundials, he saw the opportunity to put his horizontal gnomon spreadsheet calculations to use on a different type of dial for their new home. He also drew on the megalithic engravings that abound in Ireland for inspiration. Some 5000 years ago the Stone Age Neolithic people in Ireland aligned their megalithic monuments to the major solar events of the Winter Solstice, the Spring Equinox, the Summer Solstice and the Autumn Equinox which divided the year into four parts. The half way points between these major solar events mark the turning of the seasons and further subdivide the year into eight parts. It is more than likely that these people had some form of dial in their village to indicate the turning of the seasons, the time to plough, plant, harvest etc.

None of these dials have been found but Michael's conjectural design consists of a vertical direct south facing unpolished black marble dial, 600 mm high by 350 mm wide with a 300 mm long, 10 mm diameter horizontal pointed rod gnomon supported by a black marble shelf. On any day, when the sun is due south and at its highest in the sky, the shadow of the tip of the gnomon touches the vertical line, marked on the dial with the Roman numeral XII, and it is mid-day, twelve noon. The length of the shadow, which varies throughout the year, indicates the occurrence of the eight calendric events when it touches the spirals, the smallest indicating the cold mid-winter, the largest the warm mid-summer. Spirals were used by the Neolithic people as a sun motif on their megalithic stone carvings, most notably at Newgrange, world famous for its Winter Solstice alignment.

The eight Calendric Events (with their old Irish names) are:

- The Mid-Winter Solstice – around 21 December (Grian Stad)
- Spring begins in early February (Imbolc)
- The Spring Equinox – around 21 March (Ece Noċt)
- Summer begins in early May (Beltane)
- The Mid-Summer Solstice – around 21 June (Grian Stad)
- Autumn begins in early August (Luġnasaḋ)
- The Autumn Equinox – around 21 September (Ece Noċt)
- Winter begins in early November (Saṁain)
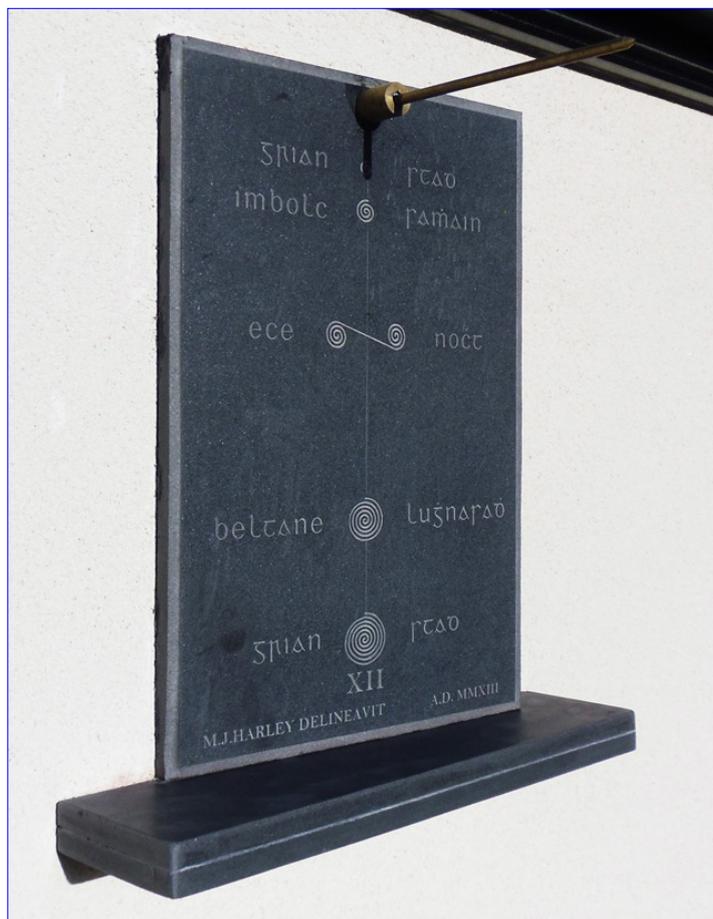
The engraving of the dial was entrusted to Jim Devlin, a local monumental sculptor who prepared the computer templates and grit blasted the unpolished black marble plate under Michael's supervision.

Michael J. Harley, m.j.harley@ntlworld.com

NEW BOOK

Zegary Słoneczne Salomona Krignera by Maciej Lose. A4, Price *c.* £10. soft covers, 43pp (colour). ISBN 978-83-62108-29-9. *www.cursiva.pl, cursive@cursiva.pl*

This book (in Polish) by our member Maciek Lose has just arrived and describes the work of the 17th/18th century dialmaker Salomon from Warsaw and Malbork. He is mostly known for his very finely crafted pocket equinoctial dials, often oval and with an automated mechanism for setting the hour-ring to the position of the celestial equator.

DIAL DEALINGS 2013

MIKE COWHAM

With the antiques market still rather depressed, the quantity of dials on offer in the last year has been rather low. However, some interesting items have been placed before us and have generally sold for good figures. Here is my choice of those offered in 2013. Prices quoted include Buyer's Premium.

Christies, South Kensington. Travel, Science and Natural History. 24 April 2013

There were several good dials offered in this sale, but the one that really attracted me was an ebony and ivory diptych dial by Thomas Tucher dated 1612 (Figs 1–3). It was quite large, being 13 cm wide. Normally we expect these fine Nuremberg dials to be made completely in ivory, but some

of the earlier ones also used some wood, in this case ebony. The result of using ebony and ivory together with gold paint decoration resulted in a most attractive appearance.

On the top outside face was also a compass rose with a pointer and on the underside a perpetual calendar disc. At each corner were some attractive gilt brass putti. It sold for £20,000.

Bonhams, Chester. 25 July 2013

In this sale was a rather unusual slate dial with much decoration around it (Fig. 4). It was quite small for such a dial

Fig. 1. Fine ebony and ivory dial by Thomas Tucher, 1612.
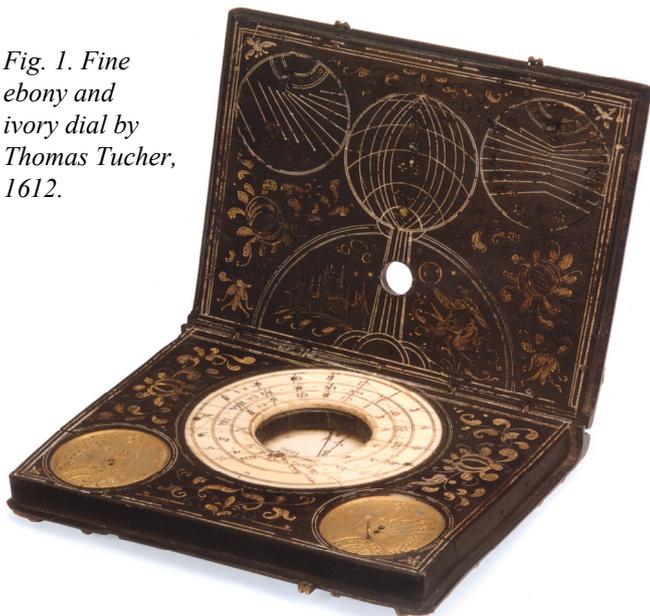
Fig. 4. Unusual slate dial.

Figs 2 & 3 (below). Top face and underside of the Tucher dial.

being only 33 cm square. Notice in particular that it has a turkey on the right and left of the dial, a rampant griffin at the bottom and several insects amongst the flowers. The dial itself is somewhat smaller inside this slate slab, being about 17 cm across its outer border. From its calibration lines it appears to have been made for a latitude of about 45° North and may be of French origin. It was sold for just £437.

Christies, South Kensington. Travel, Science and Natural History. 10 October 2013

In this sale were several good dials but one that really attracted my attention was a fine late 17th-century silver dial by Henry Wynne (Fig.5). It was 5 cm diameter, had a screw-on lid and a paper compass rose. I felt that this was quite unusual, looking almost like a silver pocket watch until opened. This attractive dial sold for £6,875.

Fig. 5. Fine silver dial by Henry Wynne.

Also in the sale was an interesting declinatory dial by Nicholas Bion of Paris (Fig. 6), with an adjustable Butterfield-type gnomon. It was 12.5 cm square with four hour scales for latitudes of 40°, 45°, 50° and 55°. This dial had previously been unsold in their 24 April sale. These declinatory dials are not too common and were used for finding the

exact alignment of a wall, mainly for the maker of a vertical dial or even a surveyor. Although not in a great condition this sold for £5,250.

This sale also had five silver Butterfield type dials. These sold at quite good figures, ranging from one by Chapotot at £2,250 to one by Choizy at £3,750. I illustrate the Choizy (Fig. 7), which has an oval dial plate with three chapter rings for 40°, 45° and 49°. On its underside are 22 towns with their latitudes. This dial was complete with its original red leather carrying case.

Fig. 7. Oval 'Butterfield' dial by Choizy.

Bonhams, Knightsbridge. Cameras, Scientific Instruments & Mechanical Music. 29 October 2013

In this sale were several interesting instruments including some perpetual calendars. One that particularly took my attention was one in brass, 11 cm diameter with a handle below, (Figs 8 & 9). It had the instructions engraved on its reverse telling how to find the Golden Number for each year. This unusual perpetual calendar made £4,750, way above its top estimate of £2,500.

Fig. 6. Declinatory dial by Nicholas Bion, Paris.

Fig. 8. English perpetual calendar.

Fig 9. *Engraved instructions for finding the Golden Number on the reverse of the perpetual calendar.*

Two very interesting dials were also in this sale, both of a similar type. The one in Fig. 10 was by Ulrich Schniep of Munich, signed "Vdalricus Schniep Monachy Fecit Anno 1578" and was just 4.1 cm diameter.

Fig. 10. *Early pocket dial by Ulrich Schniep, Munich.*

The other dial, an English dial, unsigned but attributed to Augustine Ryther and dated 1589, was unsold but hopefully it will re-appear in the next sale.

Another very interesting dial (Fig. 11), believed to be Austrian and, early 18th-century, was again unsold in this sale.

Fig. 11. *Mechanical equinoctial dial.*

Fig. 12. *Ivory diptych dial, dated 1599.*

It was a mechanical equinoctial dial having a small minute dial attached to its gnomon arm and overall dimensions of 20.3 × 14.2 cm. Its price was estimated £14,000 to £18,000. This dial also featured on the front cover of their catalogue. I understand that it was sold after the sale for a sum of £15,000.

Tesseract. Catalogue 97. Summer 2013

Although I usually cover just auction sales, the American dealer Tesseract produces a fine instrument catalogue twice each year and this often has a few good dials in it.

The dial that interested me was an unusual ivory diptych dial (Fig. 12), probably French and dated on the inside of its lid, 1599. It was eight-sided with quite a thick base.

Although very simple it was something different and nothing like any of the slightly later ivory dials that we know from Dieppe. A simple measurement of the hour line angles for XI and III give a latitude figure of between 45° and 46°N. It was priced at $3,800.

ACKNOWLEDGEMENTS

mike@brownsover.orangehome.co.uk

Postcard Potpourri 29 – Fairbanks House, Dedham, Mass., USA

Peter Ransom

This postcard features an octagonal horizontal dial whose size is not known. (It is shown on a white background which I have cropped.) The dial is dated 1650 and bears the initials IF for Jonathan Fairbanks.
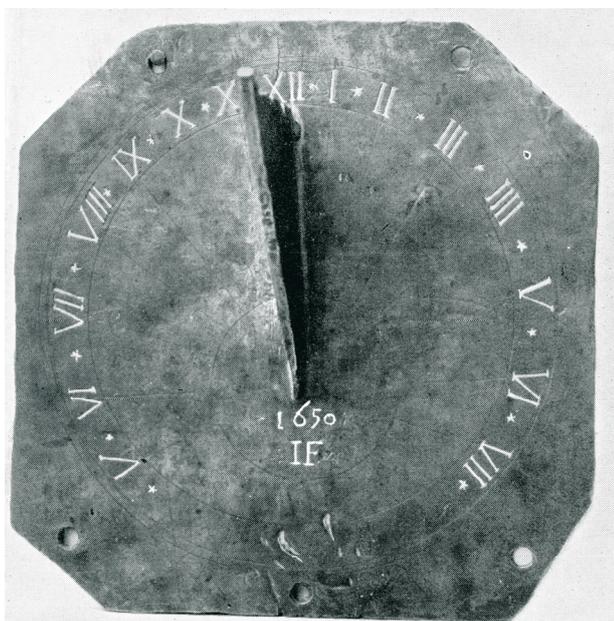
SUNDIAL OF JONATHAN FAIRBANKS 1650, DEDHAM, MASS. FAIRBANKS HOUSE, BUILT 1636.

According to the card this is at Fairbanks House in Dedham, Massachusetts. The house was built between 1637 and 1641 and is the oldest surviving timber-frame house in North America. It was constructed by Puritan settler Jonathan Fairbanks for his wife Grace and their family. Jonathan was an English colonist born in 1594 at Heptonstall in Yorkshire and emigrated to New England in 1633.

The card, which has not been sent through the post, was 'Printed for the Fairbanks Family in America', who ownsand operate the house.

pransom@btinternet.com

Christopher Daniel Receives His MBE

British Ceremonial Arts Ltd

We reported earlier that our President and past Chairman Chris Daniel was awarded an MBE in the Queen's Awards last July. On 19 December last year he was duly presented with it by Prince Charles at Buckingham Palace, as shown here. The other photo shows Chris with Doreen Bowyer and his daughters Andrea Richardson (L) and Shirena Counter (R). They were on their way to a celebratory lunch at the Athenaeum.

A WORLD SUN CLOCK

MICHAEL LEE

Sir Alan Patrick Herbert (1890–1971), a novelist, playwright, English humourist, law reform activist, independent MP for Oxford University and who, in the First World War, saw action at Gallipoli, wrote a book on sundials.

In his 1967 publication entitled '*Sundials Old and New*', Sir Alan describes sundials he produced using wood – hardly a practical material, but suited his skills to demonstrate the function of his designs. He imagined better and more rigid materials would enable greater accuracy and durability of his dials. I am intrigued to know if anyone has attempted to produce any over the ensuing years.

I decided to construct what he describes as his "model two sun clock" (Fig. 1). A description of how to make this particular dial can be found on pp. 111–119 of his book which is now out of print but readily obtainable through the public library, rare books storage system.

Fig. 1. The completed Sunclock (Herbert Model 2).

Design Parameters

To provide GMT ±30 seconds, anywhere in the Northern Hemisphere.
Engineer from brass, stainless steel and hardwood.
Two independently operable close fitting dial plates.
Upper: World dial
Lower: outer dial
Include: a quadrant to set latitude and verniers to enable adjustment for longitude, equation of time (EoT) and daylight saving (*e.g.* BST).
Desired proportions: plinth diameter 34 cm
                                  Instrument height 40cm
Production time: estimate 6 months of winter leisure time to produce 64 plinth and EOT fixtures and fittings plus a further 115 for the dial plate structures.

Construction was to be achieved with the tools I currently had available. I required a challenging journey in the instrument's development, production methods structured to and within my range of skills, ensuring my project could be brought to a satisfactory conclusion.

My design differs significantly from Sir Alan's sketches, enabling me to adopt practical engineering processes in my workshop to achieve this and a pleasing design retaining the style of previous dials I have produced.

Sir Alan believed his dial could function, when mounted on a gimbal, to enable a sailor to navigate his vessel across the globe with reasonable accuracy prior to the introduction of GPS. To do this today a sailor would require the skills to operate a sextant and have a compass mounted on gimbals, with access to nautical tables.

Upper World Dial Plate

 An upper World dial plate, 25 cm in diameter (Fig. 1), etched on its outer circumference edge with the continental hours at five minute intervals. Afternoon to the left of noon, morning to the right, with degrees of longitude etched 0°–180° to the West and 0°–180° to the East. Cities of my choice have been selected for approximately15° intervals around the world. I have included the longitude of oceans to better illustrate time and distance separating landfall from water.

Lower Dial Plate

 The lower and larger plate is 29 cm in diameter. This second dial plate was etched with traditional hours at five mi-
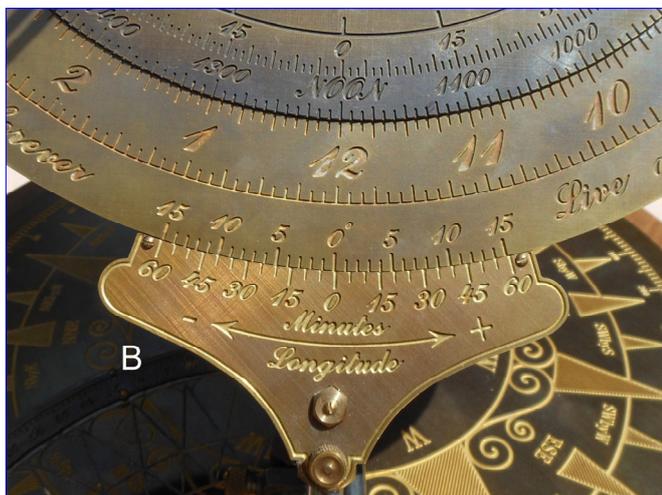
Fig. 2. The fixed Vernier (B).

Fig. 3. The Equation of Time plate (A).

nute intervals, morning to the right from noon, afternoon to the left (Fig. 1). Around the outer edge of the dial I have included a motto, the name of the dialist (traditional and also American spelling as I have family in America, who possess some of my instruments) and his geographical location.

Latitude And Longitude Adjustment

A separate vernier (labelled 'B' in Fig. 2) and marked 'Minutes Longitude' located below 12 o'clock and sited along the rim of the lower dial plate provides a datum for both plates prior to adjustments for longitude, Equation of Time and BST.

A quadrant is also fitted to set latitude. These fittings provided a capability of setting up the instrument to function anywhere in the Northern Hemisphere on land or at sea.

Functional Art

In appearance my instrument is to be viewed as a piece of functional art, when sited on a decorative wooden plinth for indoor display. The plinth is fitted with adjustable feet, to work in conjunction with a spirit level located on the central hexagon support hub.

A nautical compass rose design decorates the waxed American black walnut plinth. This carries all the structures, supported by three adjustable knurled feet in order to level the instrument with the help of the spirit level. A sliding and lockable frame etched with the equation of time tables is located under the plinth ('A' in Fig. 3). Access is by releasing a knurled screw.

The plate of an Equatorial sundial lies in the equatorial plane. Its angle to the horizon is the co-latitude (90° – latitude) of the location. The upper face is redundant during the winter months between the autumnal and spring equinoxes. During the winter months the Sun Clock is displayed on my desk. For regular use as a practical Sun Clock, a vertical brass peg 10 mm in diameter and 30 mm in height is provided in my garden to support the main hexagon hub of the instrument, when separated from its indoor display mounting plinth.
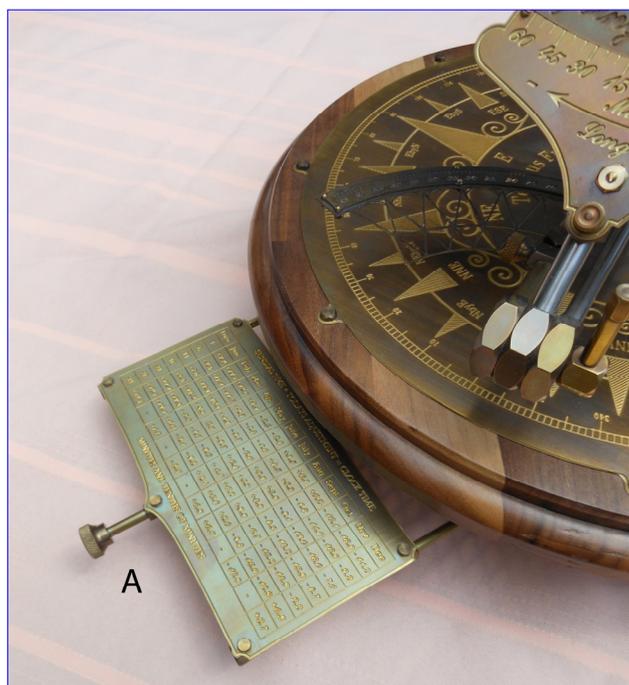
It has been my intention only to adopt the principles Herbert advocates. My design differs significantly from his sketches, enabling me to retain a style I have developed for dial instruments I have produced in previous years.

Direction Of The Meridian

The first task in setting up a sundial is to determine the Meridian for your location. Using a navigation compass will provide the means of establishing magnetic north, but not true (geographic) north, a requirement to correctly orientate a sundial.

There are many ways to determine the Meridian. I have chosen a traditional and accepted method of determining true north.

On a day you are confident of continued sunshine the procedure is:

1. Select a surface of sufficient area for the intended placement of the dial. Use a spirit level to ensure it is horizontal.

2. Use a navigation compass to locate magnetic north and south for the positioning of a flat piece of A4-sized timber board on the chosen site.

3. With a compass instrument draw as large a circle as possible on the surface of the timber.

4. Fix a gnomon on the centre point marked by the compass instrument. Identify the point as D. The gnomon (a long nail or short knitting needle will suffice) must be truly vertical.

5. Choose a time in the morning and again in the late afternoon, to mark the top of the gnomon's shadow as it intersects with the circle (when the sun is at the same altitude). Identify them as A and B.

6. Draw a line between A and B intersecting the circle. Find the centre of this line and identify it as C. From this perpendicular draw a further line to D at the foot of the gnomon. True north at C and true south at D are now determined for eventual siting and orientation of the sundial. Permanently mark the site as a future reference.

Setting The Dial For A Chosen Latitude

A quadrant is incorporated on one arm of the main locking hinge ('C' in Fig 4). To utilise the quadrant, first the gnomon and both dial plates are removed by undoing the two knurled holding screws under the bottom dial plate and one knurled screw beneath the base of the gnomon. The vernier is also removed by releasing a knurled screw.
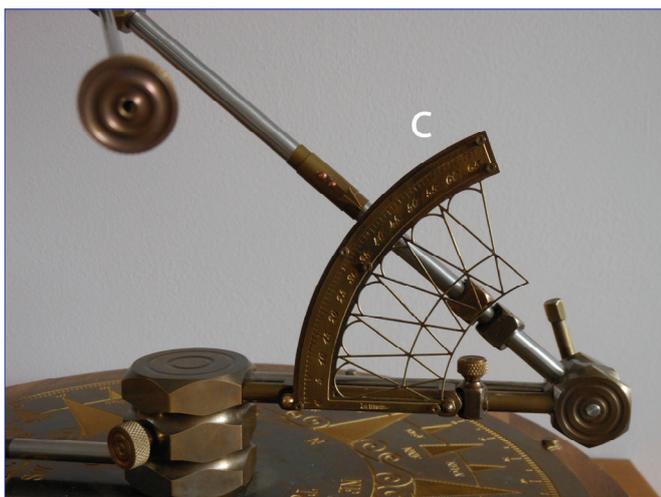
Fig. 4. The quadrant for setting the co-latitude (C).

Easing a further knurled locking screw located on the shaft of the quadrant enables this to be swung into a vertical position. An arrow located on the co-latitude shaft supporting the dial assembly provides the means of reading off the degrees on the quadrant to establish the co-latitude (example, latitude 51° minus 90° set the shaft to 39°) of the location. The main hinge has a locking handle. Releasing this permits vertical movement of the co-latitude shaft. At the required number of degrees the locking handle is re-tightened. The quadrant is returned to a horizontal position and the dial plates, vernier and the gnomon re-assembled. The gnomon is now lying in the plane of the meridian at the required latitude. This is a one off exercise until the Sun Clock is used at a different latitude.

The gnomon is split so that a shaft of light rather than a shadow falls across both inner world and outer dial plates. Rotating the split gnomon on its axis narrows and sharpens the definition of the shaft of light. I consider that a gnomon designed in this way, significantly improves accuracy and ease of observing and reading of time on both plates.

Finding Local Noon By The Sun

At the bottom circumference edge of the outer dial plate is a fixed vernier ('B' in Fig. 2). I begin by ensuring 12 o'clock on the outer dial and NOON on the inner world dial sit above zero on the fixed vernier.

Fig. 5. Close-up of the dial plates.

Any hour illuminated by the shaft of light through the gnomon on the outer dial plate throughout the day correspondingly provides, simultaneously, a time of noon by the sun, for each of the labelled inner world dial (city) locations. See Fig. 5.

For example, as the light shaft falls on the outer dial providing a local time by the sun of 2:32 pm, the shaft is also illuminating Rio de Janeiro on the inner World dial plate 43° west of Greenwich, so it is local noon at Rio when it is 2:32 local time at Greenwich.

Adjustments Required For The Sun Clock To Provide Greenwich Mean Time

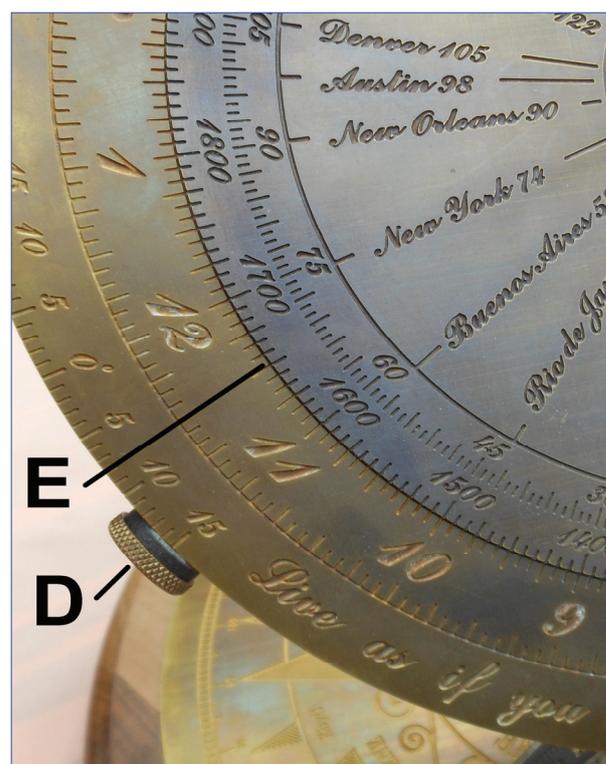We can now begin the process of determining GMT at our location and simultaneously any World location of our choice.

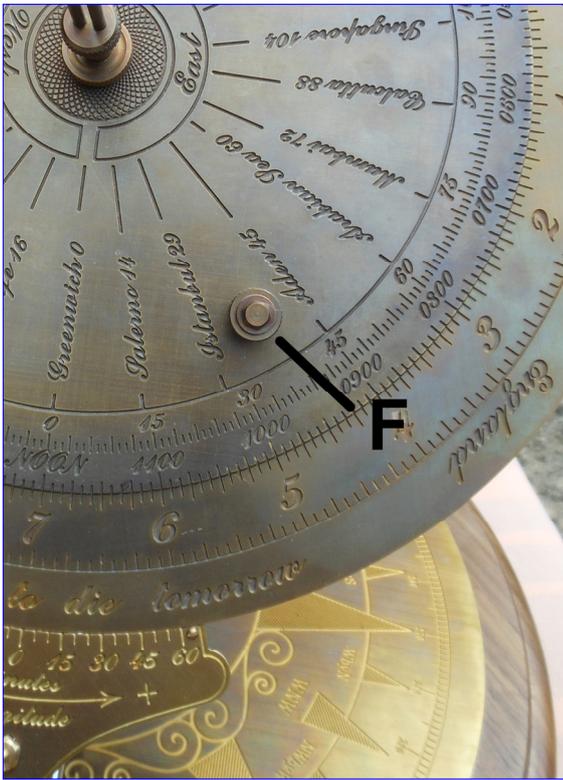

Fig. 6. Verniers (E) and locking screw (D).

Fig. 7. World dial plate with rotating handle (F).

The knurled locking screw is released on the outer dial plate ('D' in Fig. 6). Both dial plates are rotated to locate 12 o'clock on the outer plate and NOON on the inner World plate to sit above zero as before on the fixed outer vernier ('B' in Fig. 2). This vernier is the datum for any adjustments on both dials.

 At the design stage of my world dial plate I selected places of interest to me and etched them on this plate together with their precise longitude. It can be seen at 45° west on the world plate Rio de Janeiro is shown more accurately at 43° as are other location adjustments on the world dial plate (Fig. 5).

Readers unfamiliar with obtaining civil or clock time from a sundial may be interested to know the three corrections required to achieve this.

1. Longitude: The sun appears to move westward at a rate of 15° per hour or 1° every four minutes. So a dial 1° west of Greenwich will be 4 minutes slower than a dial at Greenwich. To obtain Greenwich local time 4 minutes need to be added to a dials reading for every degree of its longitude.

2. Equation of time: Our clocks and watches run at regular rates. The sun's apparent journey across the sky throughout the year is not as regular because of the tilt of the Earth's axis and its elliptical orbit. The difference between the true and mean sun is called the Equation (correction) of Time. The EoT varies throughout the year from 16 minutes and 33 seconds fast on 3 November to 14 minutes and six seconds slow on 12 February. No correction is required for 15 April, 13 June, 1 September and 25 December (time and dates may vary from year to year). Websites provide details of each day's alteration.

3. Daylight Saving: During the summer months clocks are put forwards an hour to give, in the UK, British Summer Time (BST) so 1 hour needs to be added to a sundial's reading to finally obtain BST from it.

Let us say my location is 1.75° (which means my time correction for longitude is +7 minutes) west of Greenwich. In addition, I require access to the daily equation of time adjustment. For convenience I have provided an EoT plate, located on a sliding frame beneath the hardwood plinth ('A' in Fig. 3). The EoT is given for intervals of five days during each month of the year. Let us assume it's 1 September. My equation of time plate informs me the Sun Clock is only a few seconds fast compared to clock time. Within the accuracy of this instrument I can ignore this small correction. I require a further adjustment for BST of +1hr to complete the information in order to set the inner World dial and establish GMT. A total adjustment of +1hr 7min is required. This information is used to adjust the dial as follows: NOON on the World dial and 12 o'clock on the outer dial are set above the zero on the vernier ('B' in Fig. 2). The outer dial is held by a locking screw ('D' in Fig. 6). The inner World dial plate can be rotated without disturbing the datum of the outer dial by rotating it using the knurled handle ('F' in Fig. 7).

On the World dial plate a time ring graduated in minutes is located on its outer circumference. Alongside it (on the outer dial plate) is a similar graduated time ring ('E' in Fig. 6). In conjunction they enable a practical 360° vernier system working between both dial plates, as envisaged by Sir Alan if someone were to produce his dials accurately and in more rigid materials.

Rotating clockwise or anticlockwise until noon on the World dial sits above 13:00 hrs on the outer dial plate compensates for BST. I must now also adjust for my longitude in time of 7 minutes (1.75° west). EoT for 1 September of a few seconds slow is negligible therefore a realistic total of +7 minutes has to be added. The inner World dial plate is rotated (anticlockwise) until 13:07 hrs is above zero on the outer dial plate and therefore also against the fixed vernier. The shaft of light through the gnomon now shows BST at my longitude throughout the day, as read from the inner dial. Local apparent time is still read from the outer dial.

Observing GMT at Chosen World Locations

Without making the adjustment for BST whilst sitting at a location in the UK I can now observe from the inner dial GMT. My next task will be to determine GMT for any location I choose around the world. Should I wish to monitor the time in Buenos Aires the procedure is as follows.

The locking screw securing the outer dial ('D' in Fig. 6) is released. Then holding the position of 12:07 pm previously set on the inner World dial plate by holding its knurled handle ('F' in Fig. 7) rotate the outer dial clockwise until 12 o'clock is at longitude 58° W on the inner World dial, the location of Buenos Aires. The knurled screw on the outer dial plate is then locked.

Greenwich Mean Time at Buenos Aires can now be observed on the outer dial throughout the day and, of course simultaneously, my own GMT on the inner World dial plate illuminated by the progress of the shaft of light from the split gnomon.

The EoT scale on the instrument covers periods of five days, so the adjustment for EoT needs to be made accordingly.

The Sun Clock in use as a Navigation Instrument

During the 1960s, at the time Sir Alan was writing *Sundials Old and New,* navigators used the night sky to observe the Pole Star and obtain their latitude. To use the Sun Clock for navigation it is necessary to find True North during daylight hours. As True North can vary significantly from Magnetic North dependent on where you are in the world, navigation charts for an intended route provide this information, enabling the angle between magnetic and True North to be calculated for plotting a course and in this case orientating a Sun Clock.

For use at sea, the Sun Clock will require attachment to a gimbal and function in a similar way to a vessel's compass. A noon sighting of the sun can be taken by the sailor with his trusty sextant in one hand and his Almanac in the other to determine his latitude.

Suppose his latitude is 41° north. The quadrant of the Sun Clock would be set to 49° (co-latitude).

Our sailor (having aligned the gnomon to true north) can now proceed with the aid of his Sun Clock to establish his longitude and therefore location on the high seas.

To obtain GMT readings the procedure is this:

First both dial plates are rotated for the daily EoT adjustment. The 360° vernier described above is used to make these compensations. The EoT plate is slid out to read the correction for the day of use.

Suppose the date is 26 June. The EoT chart for that day shows the sun is slow by 2 minutes 56 seconds, a further addition of 1 hour accounts for BST. Noon on both dial plates shows an additional adjustment of sixty three minutes (within the dials adjustment range) is required.

On 26 June our sailor observes light from the split gnomon on his Sun Clock illuminating 08:00 on the inner World dial plate and 8am on the outer dial plate.

Suppose the ship's chronometer shows GMT of 06:00. To obtain his longitude our sailor first makes an adjustment of plus three minutes for the EoT to the inner World dial plate. He moves the outer dial plate (after first easing the locking screw) anticlockwise until 8am on the outer dial is located beneath 06:00 on the inner World dial plate.

Above 12 o'clock on the outer dial plate the inner World dial plate indicates a position of longitude 30° east of Greenwich. Our vessel is approaching Istanbul on the Turkish coast.

It is Herbert's claim that at the time of publishing *Sundials Old and New*, he had with this system provided the fastest ever way of establishing longitude, though not likely to be as accurate as traditional methods with nautical tables.

A further example:

A sailor is proceeding in his ketch westbound across the Atlantic. Having determined his latitude to be 30°N, using trusty sextant at his local noon he is now looking to establish his longitude. He sets the quadrant of the Sun Clock to the co-latitude (60°), and plates to 12 o'clock (outer) and 12:00 hrs (inner), and checks the alignment of the Sun Clock to true north. He is now looking to establish his longitude. His nautical almanac tells him the EoT correction for the day so he turns the inner plate accordingly. The ship's chronometer reads 18:00 GMT, so he rotates the outer plate until 18:00hrs on the outer plate aligns with 12 o'clock on the inner plate. Against the 12:00hrs on the outer plate is 90°, so the sailor is 90° west of the Greenwich meridian. He is in the Gulf of Mexico, about to enter the Mississippi river.

Equipment

Engineers often provide details of the techniques used for making parts or fittings. Rarely mentioned are the range of tools and materials required to produce the work. Out of interest I have decided to list the astonishing number of tools required during the manufacture of this particular dial. It is a journey of planning, methods of procedure, sequences, constant measurement and endeavour to achieve 'perfect' finishes. Hobbies provide hours of enjoyment and satisfying commitment and concentration as an object takes shape from raw materials before your eyes and by your own hand.

A surprising number of processes are required to construct this instrument. It consists of sixty four parts for my plinth and one hundred and fifteen for the dial plate assembly. If you are taking an interest in setting up a small workshop to establish a hobby, or beginning to develop new skills with hand or machine tools the following uses of materials, equipment and tools may be of interest.

Materials

To provide a rich grained plinth feature, American black walnut was carefully selected for the base.

A sound choice of metals suitable for exposure to the elements is:

Stainless steel in rounds of various diameters; this is a material known for its rust proof properties and bright finish.

Lengths of brass of hexagonal section.

A range of round diameters in brass and tube; brass provides a strong colour contrast to stainless steel and possesses a weather resistant durability. Both materials present difficulties when being machined.

Safety Equipment

I work alone, as do most hobbyists. My workshop is some distance from passing members of the family or public. The remote location adds to the need for adequate and practical safety precautions. Tell someone when you are going to your workshop and for how long. The following are all vital to ensure low risk working practices.

Good lighting over workbenches. Comprehensive first aid kit, safety glasses, earplugs, dust extraction (particularly for when a router or power saw are in use) high particulate dust masks, non-slip safety matting, disposable gloves, heavy duty safety gloves, sharp tools and a telephone are basic requirements.

Measuring Equipment
Accurate measurement and marking of materials is fundamental in order to achieve successful outcomes of cutting, machining and drilling processes.

You should consider acquiring over time, as many hobbyists and model engineers have, the following tools:

A solid work bench with good lighting

Plate glass or cast iron surface table

Engineer's spirit level, height gauge, digital vernier, digital micrometer, steel rulers (metric and imperial), angle plates, parallels, engineers squares, scriber, magnifying glass, marking fluid.

Remember the rule: measure twice and cut once.

Wood Turning
Band saw, router, variety of router cutters, adjustable router jigs, variety of wood cutting saws, non-slip pad.

Wood Finishing
Orbital sander, fine wire wool 0000 grade, selection of sandpaper grades, epoxy resin adhesive, finishing wax, lint free cloth.

Metal Turning
A lathe of a size suitable to meet the needs of your current and future projects, Three and four jaw chucks, keyless drill chuck, tipped lathe cutting tools, metric drill bits 1mm to 5mm in 0.1 mm increments, centre drills, BA size or metric taps and dies, cutting oil, knurling wheels, and dental mirror.

Milling And Drilling
A milling machine of a size to meet the needs of your project requirements, machine vice, keyless chuck, metric or BA taps and dies, cutting oil, centre drills, collet chuck and variety of collets, reamers, slitting saws, milling cutters, engineer's clamps,

Benchwork
Bench vice, cutting mat, small and large hacksaws, selection of hacksaw blades, selection of round and flat finishing files, abrasives, metal and wood adhesives, small screwdrivers, set of spanners.

Etching
Dependent on the standard of chemical milling finish you require and should you choose to carry out the etching process yourself. Books and internet advice are available, if this technique is new to you. Should you consider the task daunting, there are commercial companies who can respond to your needs. They will require your drawings on a CD with dimensions. There are many techniques used to etch metals; some are quite sophisticated. My approach is simply tried and tested and suits me.

Metal Finishing and Polishing
Work must be carried out on stable and flat surfaces. Metal and glass plate are good surfaces for achieving a high standard of finish. Chalking files prevents them clogging. Oil assists in providing finish. The following are basic needs:

Chalk, machine oil, round and flat finishing files, fine abrasives, wire wool, metal polishes, degreasing fluid, beeswax polish, lint free cloth.

Ensure your work area is kept clean and free from any grit or swarf. Removing scratches can take a disproportionate amount of time compared to care.

Metal Patination
Acid-resistant, rigid plastic containers, sized for the project. Toothbrush, scouring pad, domestic scouring powder, nail and tooth brushes, kitchen paper towelling, lightweight rubber gloves, phosphoric acid patinating solution suitable for application to the surfaces of copper and brass. Cold running water, disposable gloves, safety mask and glasses and wax finishing polish.

Establishing Provenance Of The Project
It is a sensible idea to photograph the important and interesting aspects of your project. Photographs may, at a later stage, remind you of a particularly difficult procedure. They can provide the basis, for an article you wish to illustrate. Or support evidence of a value for insurance purposes.

Conclusion
Making things in a shed or workshop is not always the lonely existence you may imagine. Involving other like-minded people, as you seek inspiration, or adopt ideas from things you have seen, can play an integral part when you make something. Part of the enjoyment as you progress with your research is to debate, develop and modify ideas with anyone who will listen or contribute. Remember creative people are good company and will always bring a new subject to the dinner party.

ACKNOWLEDGEMENTS

REFERENCE
1. A.P. Herbert: *Sundials Old and New*, Methuen, London (1967).

Michael Lee retired 16 years ago. His hobbies are research, reading and mechanical engineering. He can be contacted at: *amichaellee@hotmail.co.uk*

THOMAS HOGBEN'S PERPETUAL CALENDAR

NIGEL RAINTON

Discovery

In the summer of 2012 I was asked to research some ancient artifacts that had lain untouched in a small collector's cabinet for many years. The cabinet and its contents had been in storage since the untimely death of their owner. I had just retired and the research was added to my growing list of projects.

The collection of artifacts was varied. It contained Greek pottery from 400BC, military souvenirs and a small brass disk. The Greek pottery had museum labels attached and it was quite easy to identify and accurately date the pots from descriptions and photographs on the internet. I became increasingly nervous of the terracotta pottery as the age, quality and value of the fragile pots became obvious. Some of the pots were photographed and sent to auction.

I had been given details of the collector's childhood, his military service and subsequent career. He was born in 1926, came from a good family, attended public school and then joined an old Scottish regiment. The military memorabilia came from a number of regiments and appeared to be both souvenirs of his service and items he collected later in life.

While attending public school he developed an interest in ancient history. He started to collect Greek and Egyptian artifacts; pots, oil lamps, statuary *etc*. His interest in ancient history probably stemmed from his school museum's world class collection of Greek pottery. Some of the school's collection was sold to finance an extension to the library. He

may have bought some pieces from the school museum. While at school he frequently visited the local town and bought items of interest from the antique shops. During WWII he served in the Egyptian desert and probably returned with more ancient treasures.

Having researched and documented the ancient artifacts and military memorabilia, I turned my attention to the brass disc.

Research

The brass instrument was quite dirty and insignificant. It could have easily been overlooked. It was the type of thing that might have been found in the bottom of a cardboard box at a car boot sale. At school I had studied Latin. I therefore understood the inscription on the disk and realized that it was very old.

The brass disk was taken to be examined by an expert in scientific instruments. His advice was that it was a Perpetual Calendar, English, very rare, old and valuable. He said that it was unusual to see a perpetual calendar that had been made in England. He recommended that the perpetual calendar should be professionally cleaned. The owner reluctantly agreed, the perpetual calendar was sent away to be cleaned and we spent an anxious few weeks awaiting its return. When the perpetual calendar was returned the owner and I were relieved to see that the cleaning had not been overdone. The patina had been preserved, the engraving revealed and the three disks now rotated smoothly.

Fig. 1. Front of the perpetual calendar.

Fig. 2. Back of the perpetual calendar.

Hogben Family

My internet searches followed several paths. I traced the Hogben family history and read about his maps and sundials. I also read about perpetual calendars in general.

About twelve generations of the Hogben family lived in Kent between 1300 and 1800. They were wealthy farmers and landowners. Thomas Hogben was born in 1702, lived in Smarden and died in 1774. Thomas married Susanna who was born in 1697 and died in 1768/9. According to Thomas' last Will and Testament and Parish Records, Thomas and Susanna had five sons and three daughters. Thomas Hogben made maps, clocks and sundials. Most of his maps covered estates and farms near Smarden in Kent where he lived and was buried. I could not find any reference to Thomas Hogben's perpetual calendar or his clocks.

BSS

As I browsed the internet I came across the Society's website and I thought it would be a good idea to make contact and ask for help. On 30 January 2013 an item about Thomas Hogben's Perpetual Calendar was included on the Society's website. I also contacted several members of the Hogben family but they were unable to help me.

Unfortunately at that time I did not have access to John Foad's 2003 article[1] on Thomas Hogben in *Bulletin* 16(iv). Reading the article would have saved me many hours of research. As John Foad has already published full details of the Hogben family, Thomas's maps and sundials, I will not repeat them here. John Foad's article includes a list of the sundials attributed to Thomas Hogben. The website *www.oldkentmaps.co.uk* contains a detailed list of Thomas Hogben's maps.

Construction

Thomas Hogben's perpetual calendar is comprised of three flat, concentric brass disks, riveted together at the centre. The brass disks are quite thin, about 1.0 mm, but as they are

Fig. 3. The outer disk.

riveted together the instrument is robust. It is undamaged and continues to function correctly.

The outer disk is about 7 cm in diameter. It is engraved with a very distinctive pattern of leaves or feathers. The days of the week, starting with 'S' for Sunday, run clockwise around part of the disk. The font used for the engraving is serif, italic. While researching Hogben's perpetual calendar I found an identical leaf or feather pattern on a similar instrument in the Science Museum.[2] The perpetual calendar in the Science Museum is attributed to Hartson and was said to have been used for determining the dates of Easter in both the Julian and Gregorian calendars. I cannot reproduce the image of the Hartson perpetual calendar in this article for copyright reasons but it is easily found on the Science Museum website.

Fig. 4. The date disk.

The slightly smaller disk is engraved with the days of the month, 1 to 31. It has a pointer between the first and last days of the month which can be used to move the disk in order to align the date with the day of the week on the outer disk. The engraved characters on this disk are in the same font as those on the outer disk. Under magnification, the characters on all three discs are clearly engraved, not punched into the metal, as they are all formed slightly differently.

The central disc has the months of the year engraved around its circumference. The numbers of days in each month are also shown. February is shown as having 28 days. The central disc also has a pointer which can be used to align the month. There are several windows cut in the central disc. The windows 'D L' and 'N L' show the length of the day and night in hours. The windows that are marked with the sun symbol ($\odot$ R) and ($\odot$ S) show the time of sunrise and sunset.

A larger window shows the astronomical signs. In the photograph at Fig. 1 this window shows the sign for Sagittarius. Directly opposite the window showing the sign for Sagittarius is another window in the very edge of the central
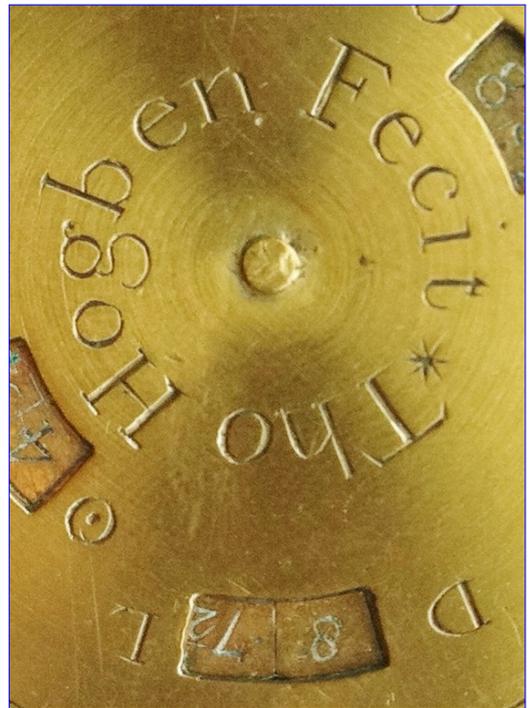
Fig. 5. The central disk.

Fig. 7. Thomas Hogben attribution.

Fig. 6. The astronomical signs.

disk which shows the months (N for November) that the sun transits that area.

Around the rivet on the central disk is engraved "Tho Hogben Fecit *". This attribution is similar to the signatures on his sundials.

The day of the week, the date and month are selected by moving the discs. Sunrise, sunset, day and night hours and the astronomical signs can then be read in the various windows.

The back of the perpetual calendar has no engravings. It is quite badly stained and scratched. The scratches are uniform and mainly run in one direction. They appear to be file marks, made during construction. This is in stark contrast to the front of the dial which has been polished on a wheel or lathe. The polishing on the front has left concentric marks on all three discs. There is a very faint residue of silver plating on the front of the outer disc.

Why?

Britain was very late to adopt the Gregorian calendar. In 1752 the date was corrected by 11 days. Wednesday 2 September 1752 was followed by Thursday, 14 September 1752. This change would have caused considerable confusion in Britain and Europe. Europe had adopted the Gregorian calendar much earlier. Therefore, the change of calendar and date occurred during Thomas Hogben's working life. Immediately before the change of calendar and subsequently, it would have been very useful for a farmer or business man to have a device that accurately predicted the date, times etc.

Was the perpetual calendar made for his own use or was it for one of his wealthy customers? The instrument is quite small and has no protrusions. In my opinion, given the polished front, the relatively crude finish on the back and the lack of damage, it was made to rest on a desk top. It may

have been contained in a shallow box. I don't think this perpetual calendar was carried around in a pocket. The lack of wear to the engraving on the front and absence of damage to the disks suggests that this instrument lead a sheltered life. Would this perpetual calendar have been of any use to Thomas while carrying out his duties as a surveyor or school master? Was it necessary for him to use the perpetual calendar when designing or installing sundials?

Who Made It?

Thomas Hogben was a land surveyor, prolific map maker, sign writer and school teacher. He also 'made' sundials, clocks and perpetual calendars. We know from John Foad's excellent article that Thomas Hogben designed at least three ornate sundials for his wealthy customers and that they were made in London, probably by Wright. John Foad differentiates between the ornate sundials, designed by Hogben but made in London ("London" dials) and the simpler but more numerous dials made in Kent ("Country" dials). Although these ornate sundials were made in London, they bore Thomas's name. The literal translation of 'Tho Hogben fecit' is 'Thomas Hogben, he made it'. Therefore, although he designed and commissioned ornate sundials from London craftsmen, they were attributed to him. This implies that he did not have the skills, facilities or time to make intricate, complex and valuable instruments. He subcontracted the work.

Similar Perpetual Calendars

My research revealed that Christies and Bonhams had sold several European, mainly German and Dutch, perpetual calendars. They had been made from silver or brass and were usually smaller than the Hogben instrument. I sent an email to Christies with a photograph and was pleasantly surprised when the owner of the perpetual calendar and I were invited to South Kensington. Our meeting at Christies was very interesting and we left the perpetual calendar for

inclusion in the auction on 24 April 2013. Lot 63 sold for more than double the auction estimate.

I imagine the new owner will research the instrument – they may even be a member of the BSS!

REFERENCES
1. J. Foad: 'Thomas Hogben', *BSS Bull.*, 16(iv), pp. (2004).
2. Brass perpetual calendar made by Hartston. Science Museum, Science and Society Picture Library, Image No. 10205130, Inventory Number 1990-0304.

nrainton@googlemail.com

TWO UNIQUE SUNDIAL DRAWINGS FROM VILNIUS

DAREK OCZKI

These two drawings (two views of the smaller drawing are shown here; the larger one is on the back cover) were listed on Allegro (a Polish on-line auction service) by a seller from Lithuania. According to the original description of the auction they were drawn by Józef Czajkowski, a Polish professor of architecture at the University of Vilnius. Both drawings are dated 1942 and are signed by the same person but it is not possible to read the signatures and recognize the name with certainty.

Today, technical and architectural drawings are made using computers and dedicated software but at that time most designs first appeared on tracing paper. Only after finalizing the details were they transferred onto regular paper – again by hand. Both of the drawings were created on a tracing paper as a theoretical architectural study. They are clearly based on the construction of the Tower of the Winds in Roman Agora in Athens. That marble 'tower of time' is octagonal in plan and has eight sundials – one on each wall. The original dials showed the antique time (unequal hours) system whereas Czajkowski's designs use standard equal hour divisions using noduses. These drawings were probably not meant for a real construction at a specific location but were rather a kind of practice implementing some sundial knowledge. If so, then Czajkowski's signature indicates the acceptance process of an academic task, which leads to the further obvious conclusion: Czajkowski did not draw them but as a teacher he confirmed the correctness of the design.
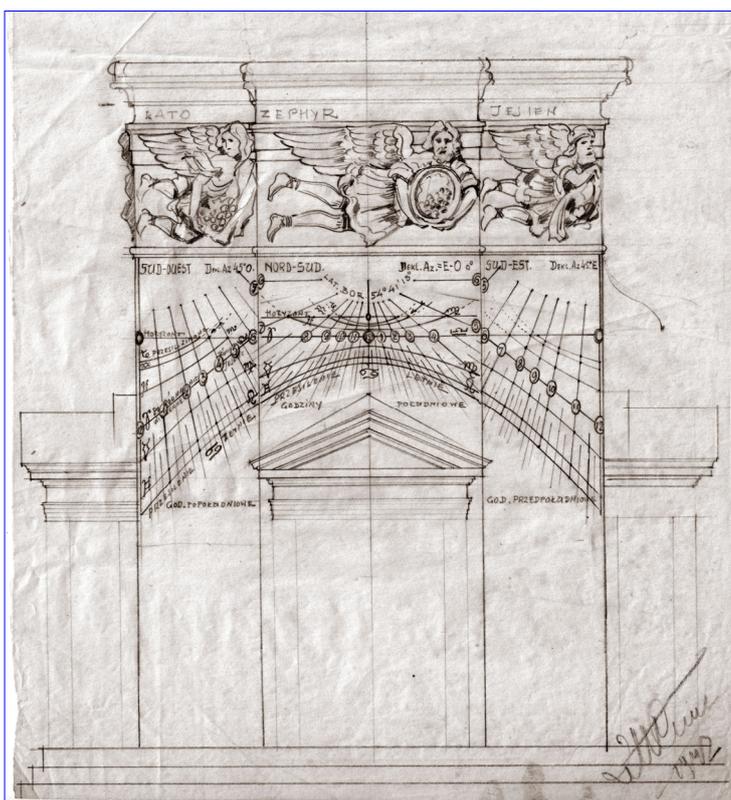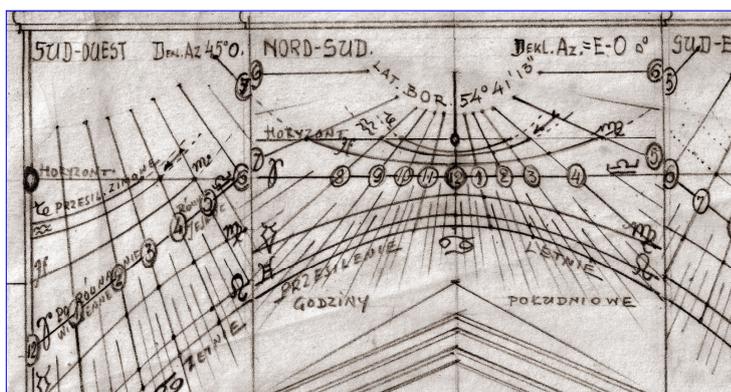
The drawings include Greek names of the antique personifications of mythological wind-controlling gods, which relate to the cardinal geographical points. All the other names and descriptions are written in Polish. Before WWII, major parts of what are now Lithuania, Belarus and Ukraine formed one united country with Poland and so Polish was the main language of cities like Vilnius (Wilno), Kiev (Kijów) and Lviv (Lwów). This is why professors and students of the University of Vilnius used Polish in their work.

On all the dial faces there are declination lines corresponding with the Zodiac signs, solstices and equinoxes which, together with the equal hour divisions, make these instruments dials of scientific power. The wall declinations are marked on the drawings along with the latitude of 54°41′13″ for the location in Vilnius.

All these facts suggest that author was well acquainted with the science of dialling and knew exactly how to delineate declining sundials. I wish nowadays architects would study and understand the art of gnomonics and use it in their new designs of apartment buildings and other properties.

dharani@o2.pl

THE ZUTPHEN QUADRANT

A Very Early Equal-Hour Instrument Excavated in The Netherlands

JOHN DAVIS

This article is a version of the talk given by the author at the BSS Newbury Meeting, September 2013.

Zutphen is not a name which is widely known outside the Netherlands. However, it is a small and vibrant city with a long history and it has been carefully excavated over many years. The discovery of a small copper-alloy quadrant during excavations in March/April 2013 (Fig. 1) has great significance because it is clearly delineated to show equal hours and yet can be dated by archaeological methods to c.1300, virtually a century before the previously recorded quadrants of this type, made for the circle of Richard II of England.

Fig. 1. The Zutphen quadrant. Photo courtesy of B. Fermin.[1]

Fig. 2. Map of Zutphen by Willem and Joan Blaeu, 1649. North is to the left.

Zutphen History

There is evidence[1,2] that Zutphen (52° 08′ N; 6° 12′ E) existed in the Roman period. By the Middle Ages, it was an important walled city on the River IJssel and a member of the Hanseatic League of trading cities: its layout is shown in the slightly later map by Blaeu in Fig. 2. It withstood several sieges, including the Battle of Zutphen in 1586 when Sir Philip Sidney was mortally wounded. It has many fine buildings and its medieval library, with chained books, is one of only five which still remain in the world.

The ditches and earthworks which surrounded the walled city were built in the late 9th century and enlarged in the 11th century. They were then gradually levelled to provide more space for expansion, initially in the mid 13th century using sand from the rampart. A thick dark humus-rich layer, with many datable objects such as coins, pots, *etc.* in it, then built up until, in the period 1300 to 1320, another layer of sand was applied so that the area could be used as a market with a later build-up of material capping the area and providing the modern surface. The present city is now several times the original size though the remaining Gothic buildings in the centre and the surrounding outskirts are carefully preserved within the modern plan.

Fig. 3. General view of one of two planting holes for trees within the old city of Zutphen. Photo from ref. 1.

The Excavation

Early in 2013, plans were made to provide two areas for planting trees in the city, in locations which were over the filled-in ditches (Fig. 3). Many previous archaeological excavations in the city had already shown that a wealth of important finds were likely to be exposed by the digging so archaeologists were on hand to monitor the work. The stratification of the layers had also already been established with the sequence of filling the original ditches dated close-
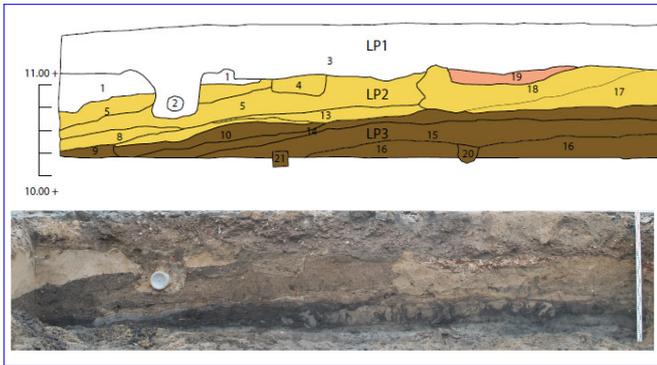
Fig. 4. Stratification of layers – photograph and schematic. The quadrant was found in layer LP2.[1]

ly by the many finds. Material from the excavation, lifted in layers, was examined by metal detector as it was removed. Many items were found during the work and the star find was the small quadrant which is described here.[3] It was quickly identified as an instrument for indicating equal-hours and so the very early dating for such a device was highly significant. The stratification of the layers can be seen in Fig. 4. They date the quadrant securely to the period of 1300–1320. No other items of a similar 'scientific' nature have been found in the archaeological investigations of Zutphen.

Fig. 5. Photographs of the back of the quadrant, the sights, and the swivel fixing for the plumb-bob.[1]

Description of the Quadrant

The quadrant shown in Fig. 1 is evidently made of a copper-alloy and is engraved on one side only. It is unsigned and undated. It is 62 mm in radius and 1 mm thick. Although quite a simple device it has been well-made. Rather surprisingly, as shown in Fig. 5, both of the sights are still firmly in place, as is the swivel mount (still moveable) for the plumb-bob. Only the plumb-line, bob and bead itself are missing.

The sights, with tapered holes of approximately 1 mm diameter, are expertly set into the quadrant and riveted in place: they have a decidedly 'medieval' appearance similar to those on some other early instruments. In particular, some of the *quadrans novus* likely to be contemporary with the Zutphen quadrant also show the same general shape with a long 'wing' extending down the back of the quadrant.[4] In contrast, all of the Richard II equal-hour quadrants have much smaller sights on the surface of one side.

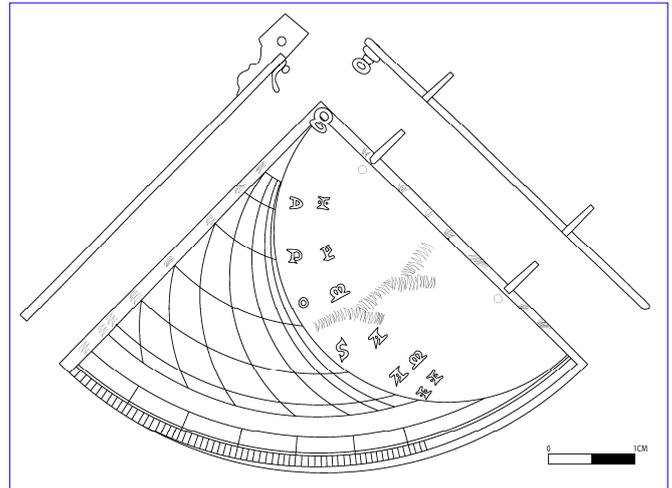A schematic representation of the quadrant is in Fig. 6.

Fig. 6. Schematic diagram of the quadrant, courtesy of Elisa de Vries, Davy Kastelein and Michel Groothedde.[1]

The lines on the quadrant are clearly and firmly cut and have been engraved quite proficiently. Around the limb of the quadrant there is a protractor scale, divided in 10 degree and then 1 degree increments, but only up to 63 degrees (starting from the left). They are not numbered although there is space in the scale for numbers. Clearly, the scale is for measuring the altitude of the sun with the aid of the sights and the plumb-line, up to the maximum expected midday altitude.

Next is a series of seven arcs, concentric with the origin (corner) of the quadrant. These 'declination' arcs are believed to be for the entrance of the sun into each of the zodiac signs, *i.e.* equivalent to the date. A set of pairs of letters, the initials of the months, are set inside the central semicircle and would help in setting a bead on the plumb-line to the appropriate date. The language intended for the letters is not certain but was probably intended to be Latin. The letters are described as punched in the official report[5] but this might possibly be questioned and they might have been engraved – the corrosion means that it is not easy to see the fine features. The position of the letters is not precise and there is no sub-division into days. Note that although I–I (June–July) is positioned against the summer solstice line, D–I (December–January) comes in the gap between lines, before the winter solstice.

The palaeography of the letters which mark the months has been compared with punched letters on a range of local medieval seals (a catalogue of the seals of the dukes and counts of Gelre and Zutphen) with the result that the best match is with seals of Count Reynald II of Gelre

(Guelders), dated to 1324 and 1326.[6] Of course, this does not date the quadrant absolutely but it is significant that the local lettering style later in the century is significantly different.

The final set of lines are for indicating the time from the sun's altitude and it is immediately clear that these are for equal hours (rather than the seasonal or temporal or unequal hours) because only the midday semicircle passes through the origin of the quadrant – all the other hour-arcs intersect the left-hand radius which indicates zero altitude. The centre from which the all-important midday semicircle has been drawn is clearly visible as a small depression on the right-hand radius.

There are no numerals on the quadrant – the scale for altitude and the lines for hours and for declination are unnumbered, though there are spaces for the altitudes. There are, though, several sets of strange 'crescent' engravings, some in positions where numbers might be expected: these are unexplained. Close inspection does not indicate that they are attempts to erase other engravings.

Background to Quadrants and Quadrant Types in Medieval Europe

The earliest quadrants in Europe were of the type known (afterwards) as the *quadrans vetus* (old quadrant). This design dates back to the 9th century in Baghdad but was described in Europe by Sacrobosco in the 12th century.[7] The basic design is for unequal hours and it is, approximately, a universal design although it becomes slightly inaccurate as the latitude increases from the typical values found in Islamic regions to those of northern Europe. The design is characterised by a semicircular midday (noon) line and then a set of circular hour arcs each passing through the origin of the quadrant and with a centre lying on the right-hand radius line. They cut the protractor scale at 15° steps (*i.e.* at 75° for the arc indicating 1 and 11 hours). They were thus very easy to draw. To use the device, the bead on the plumb-line had to be positioned to suit the current date ('rectified') and this required access to a table of the Sun's noon altitudes.

A development of this basic design of *quadrans vetus* at the end of the 13th century, usually attributed to Profatius, uses a sliding cursor calibrated for the Sun's declinations and which can be positioned to suit the current latitude, thus removing the need for sets of tables.[8]

The move from unequal hours to equal hours by the general population seems to have occurred gradually throughout the 14th century, linked to the spread of tower clocks. Naturally, there was a need for a quadrant to indicate these hours and the obvious and simplest development was for a design based on the *quadrans vetus*. The lines on the resulting device were now latitude-dependent and thus it was usable only at a single location. It might reasonably be presumed that the declination scale centred on the origin of the quadrant would still be calculated on the same basis as that for the unequal-hour quadrant. Noon was still indicated as part of a semi-circular arc but the other hour-lines no longer passed through the origin of the quadrant. A table of noon
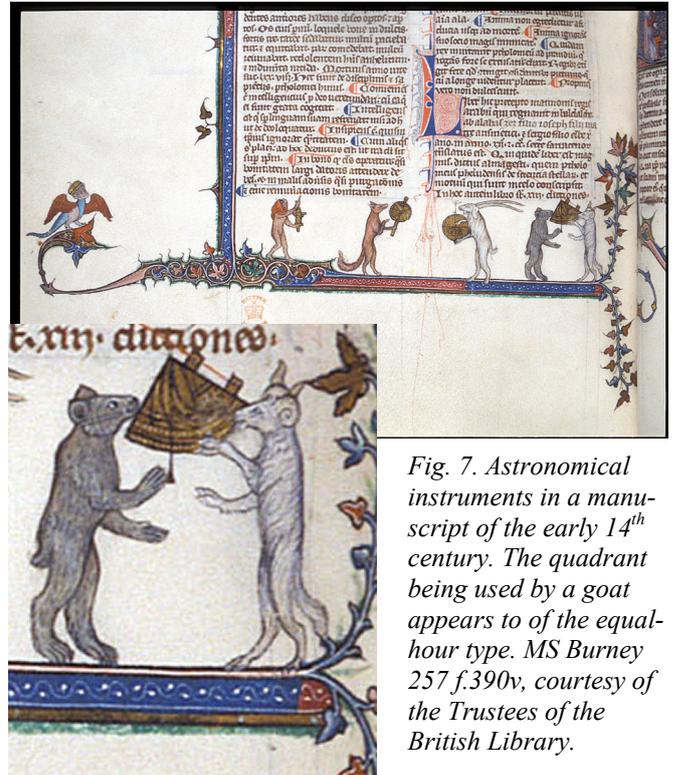

Fig. 7. Astronomical instruments in a manuscript of the early 14th century. The quadrant being used by a goat appears to of the equal-hour type. MS Burney 257 f.390v, courtesy of the Trustees of the British Library.

altitudes or a date (declination) scale was needed to rectify the bead before use.

A possible example of an early hybrid quadrant showing two sets of lines, for unequal and equal hours (the former reversed), is an unfinished device in the Oxford Museum of the History of Science.[9] This instrument is rather dismissively described as having a "certain charm as an historic artefact from the medieval period" in the catalogue entry but it deserves more detailed study.

Evidence for the existence of equal-hours quadrants early in the 14th century is given by a drawing at the bottom of a page of an illuminated manuscript now in the British Library (MS Burney 275 f. 390v) and shown in Fig. 7. Attributed[10] to the 'Meliacin Master', it was painted in central France between 1309 and 1316. It shows various animals using a cylinder dial, an armillary sphere, an astrolabe and a quadrant. The instruments are quite realistically drawn and on the quadrant it can be seen that the hour-lines do not all pass through the origin but that some of them intersect the left-hand edge of the instrument, the chief characteristic of equal hours.

Up to now, the earliest extant equal-hour quadrants were a group of four instruments believed to have been made for King Richard II and dated (or datable) from 1396 to 1400.[11] Fig. 8 shows the example currently in Dorchester, dated 1398. These are very high-quality instruments believed to have been made as gifts from the King to his favoured courtiers and thus not likely to have been used seriously for time-telling. The majority of the extant devices do not have a complete set of declination arcs for the date, just limiting curves for the solstices and a central equinox curve.[12] Instead, they feature detailed tables of the Sun's midday altitude for the local latitude engraved on the reverse side. The lack of other examples of this design is puzzling.

Fig. 8. The 1398 Richard II quadrant in Dorchester. Photo by the author with acknowledgements to the Dorset County Museum.

A totally different form of equal-hour quadrant was described, also by Profatius, at the the end of the 13th century – the *quadrans novus*.[13] This was based on a folded astrolabe and was thus a rather sophisticated astronomical instrument. It was, though, rather difficult to use for simple time-telling and thus only a very small number of examples exists – one was unearthed in Canterbury in 2005.[14]

There is a small amount of evidence of other types of medieval quadrant showing equal hours. One English example is the 'Norfolk quadrant' which, although not expertly made, shows both unequal and equal hours, the latter in a form akin to the much later 'Gunter's quadrant' design.[15]

Geometry of the Zutphen Quadrant

It is worth considering the method by which the quadrant would have been drawn and the information which was required to do it, using only Euclidian geometry with a straight edge, a pair of compasses and a scribing point. An example of laying out just such an equal-hour quadrant is given in the manuscript Bodleian MS Ashmole 19 (f. 54).[16]

The first task would be to construct the protractor scale. Once the bounding curve had been drawn parallel to the limb with the compasses, they would then be used, with the same opening, to strike arcs on the bounding curve from the crossing points with both the left- and right-hand radii. This would give the 30° and 60° points and, where the two arcs crossed, the 45° point bisecting the full quadrant. There is no geometric construction which produces an exact trisection of an angle but it is not difficult, with a little practice and trial-and-error, to achieve this to a good approximation. Having thus produced the 10° divisions, they could be bisected before finally dividing by eye down to individual degrees. It is notable that the maker of the Zutphen quadrant has not bothered to divide the scale fully, only the part needed for possible solar altitudes at his latitude, up to 63°.

The next step is to bisect the right-hand radius to find the centre for drawing the midday semicircle. Up to this point

the construction is universal and needs no input data. To draw the declination lines there are several options. One method is to consult tables to know the noon altitude of the sun at the intended location at the entry of the Sun into each of the zodiac signs, the most important being for Aries and Libra, on the equinoxes. These altitudes are located on the protractor scale and then the point where that appropriate radius line intersects the midday semicircle determines the radius of the equinox line. It is then easy to engrave a set of arcs centred on the origin and passing through the appropriate intersection points.

Finally, the hour lines have to be drawn and again tables are needed to supply the Sun's altitude on three dates – the equinoxes, the summer solstice and either the winter solstice or the last date when the sun is above the horizon at the specified hour. The maker would now assume that the hour line was a segment of a circle passing through these three points. This is not quite mathematically exact particularly at high latitudes[17] but the errors are small and the simplification was universally made by instrument makers over several centuries, until computing technology was available. Euclid tells us that there is only one circle passing though a set of three points: finding its centre with compasses and straight-edge is an interesting exercise. Once found and the arc drawn, the quadrant is essentially complete.

Tables of the Sun's altitude as a function of date (declination) for each equal hour which would be needed to draw the equal-hour version of a *quadrans vetus* are known in the literature, though not common. One English example dating from around 1400 was by Robert Stikford at the Abbey of St Albans.[18] The table is for a single latitude. Clearly, on the evidence of the quadrants, there must have been other tables in existence a century before this.

Knowing the above sequence, it is possible to reverse-engineer the Zutphen quadrant to find a number of features, particularly the intended latitude, the value of the obliquity assumed by the supplier of the altitude tables, and the geometrical precision of the maker.

The first point of interest is the design latitude φ and this can be obtained by several methods. The simplest, most direct and possibly most accurate is to note that at the equinoxes, the Sun's midday altitude a_{ne} is simply[19]

$$a_{ne} = 90° - \varphi$$

By drawing a line on an 'accurate'[20] photograph of the quadrant from the origin through the point where the declination line for the equinoxes crosses the noon semicircle and extending it to the limb, the value of a_{ne} can be read off as 38.0°, implying a design latitude of 52.0°. This may be compared to the Zutphen latitude of 52.1°. There is some tolerance in the measured value because of the difficulties in defining exactly where the origin is located (it is hidden by the swivel) and the crossing of the equinox and noon lines. It is inconclusive whether the quadrant was actually designed for the city but it was certainly somewhere in northern Europe and it would certainly have been usable in Zutphen.

A second method of extracting the design latitude is by noting that

$$\varphi = 90° - \tfrac{1}{2}(a_{ns} + a_{nw})$$

where a_{ns} (a_{nw}) is the Sun's meridian altitude at the summer (winter) solstice. The values of 62.8° and 14.0° measured on the quadrant give a design latitude of 51.6° which is similar to the previous value but indicates the tolerances of both the engraving and measuring processes.

The same values of a_{ns} and a_{nw} are also related by

$$\varepsilon = \tfrac{1}{2}(a_{ns} - a_{nw})$$

where ε is the value of the obliquity of the ecliptic implied by the layout. The value obtained here is 24.4° which is rather larger than the values those of 24° or 23½° which are often found in medieval manuscripts. Again, the tolerances of both the measurements and the original layout need to be borne in mind.

The fact that the protractor scale is only fully divided up to an altitude of 63° also tends to confirm that the quadrant was delineated for use at a latitude of around 51 or 52° N. It also suggests that it was intended only as an altitude sundial and not, for example, for measuring the heights of towers or taking different astronomical measurements.

	Zutphen	Dorset Mus Richard II	Bonhams Richard II	Theoretical
Summer solstice	91.2	89.3	88.9	88.7
Equinoxes	64.0	63.6	61.2	62.3
Winter solstice	24.2	25.2	23.4	25.0

Table 1. Comparison of the normalised radii of the declination arcs on three equal-hour quadrants (assuming a quadrant of design radius 100). It is assumed that the obliquity is 24° and the latitude is 52.0°. See ref. 11 for details of the Richard II quadrants.

Turning now to the declination (date) lines, the method by which they were drawn may be assessed. The radii of the key arcs, for the equinoxes and solstices, were measured from circles fitted to a photograph imported into a CAD program (TurboCad™) and then normalised by dividing by the diameter of the noon semicircle. The values are shown in Table 1 which also shows the values from two of the Richard II quadrants (see Fig. 8 for an example). Also shown are the theoretical values calculated assuming an optimised latitude of 52° and an obliquity (equal to the declination on the solstices) of 24°. The theoretical values are

$$r_n = \sin(90 - \varphi + \delta)$$

where r_n is the normalised radius of the declination line and δ is the Sun's declination. The table shows that the values for the Zutphen quadrant are broadly in line with those of both the slightly later Richard II quadrants and the theoretical values. Trials with different input parameters tend to support the assumed latitude and obliquity values.
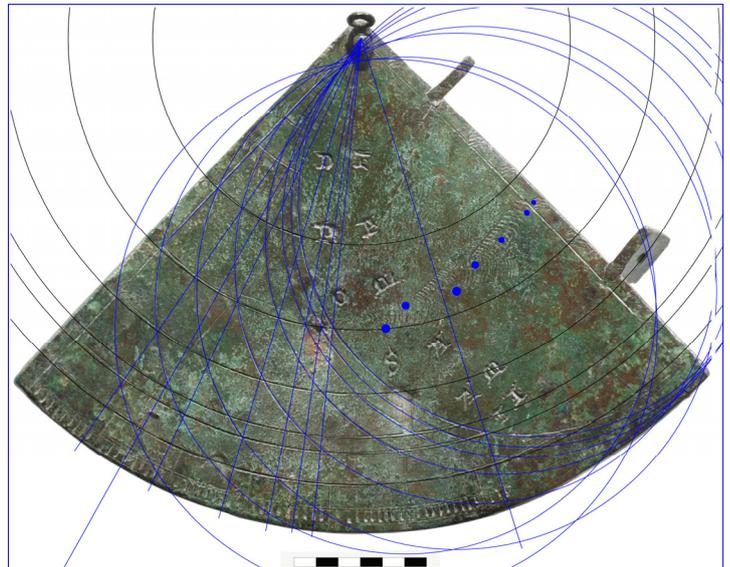

Fig. 9. Photograph of the Zutphen quadrant (normal to the face) overlaid with CAD-fitted lines. The small blue spots indicate the centres of the fitted hour-arcs.

A similar circle-fitting exercise can be performed on the hour lines. The results are shown in Fig. 9 where it can be seen that the circles do not display a well-defined arrangement. Measurements of the altitude angles on the equinoxes (when there is no effect from the obliquity value) indicate errors of up to 1.7° for the 3 & 9 hour arc (see Table 2). This seems to indicate that the device and/or the tables from which it was delineated were not of great precision.

Hour	Sun's altitude on Equinoxes (°)		Error (°)
	Measured	Theoretical	
12	38.0	38.0	0
1 11	35.7	36.5	0.8
2 10	33.0	32.2	−0.8
3 9	27.5	25.8	−1.7
4 8	18.1	17.9	−0.2
5 7	8.5	9.2	0.7
6 6	0	0	0

Table 2. Theoretical vs. measured angles of the Sun's meridian altitude on the equinoxes for the Zutphen quadrant. The theoretical values use a latitude of 52° (near the optimum).

Metallurgy

Knowing the metallurgy of an instrument provides an extra set of clues about its origin and history and also contributes to the understanding of the state of metal smelting, founding, working and distribution in medieval Europe, a topic where there is a notable absence of solid information.

The composition of the quadrant was assessed by x-ray fluorescence spectroscopy.[21] This method has the advantages

Instrument	Date	Cu	Zn	Sn	Pb	Other
Zutphen quadrant[a]	c. 1300	85	12.5	0.5	0.2	0.3% Ag; 0.7% Fe
Richard II quadrant[b]	1396	78	22		Tr	
Grafendorf compendium[c]	c. 1450	79	12	0.8	2	1.4% Fe
Canterbury *quadrans novus*[d]	1388?	87	5.3	3.4	1.5	0.2% Ag; 0.6% Fe
Norfolk *horologium*[e]	??	77	12	7.4	2.4	0.2% Ag; 0.9% Fe

Table 3. Composition of metal alloys in wt. % as measured by XRF of the Zutphen quadrant and four other medieval time-telling instruments.

The top three instruments have very low tin concentrations and hence might be classed as 'Continental brass'. The last two look to be 'English latten'.

a. The subject of this article, measured by Dr Bertil van Os of the RCE (Netherlands Cultural Heritage Agency).
b. One of four known devices (1396–1400), this is the earliest (unsold by Bonhams in 2012); results supplied by Christopher Becker. The two devices in the British Museum have very similar compositions (results from Dr Susan La Niece and the author).
c. Excavated in Grafendorf Castle near Vienna, analysis by Prof Dipl. Ing Dr Manfred Schreiner (Akademie der Bildenden Künste), communicated by Dr Ronald Salzer.
d. Found in Canterbury by excavation, now in the British Museum. Analysis by Dr Brian Gilmour and Dr Peter Northover (Oxford University).
e. Metal detectorist's find, analysed by Dr Brian Gilmour (Oxford University).

that it is fast and is completely non-destructive and non-marking. The results are quantitative if the system is fully calibrated with appropriate specimens. The area sampled is typically a few millimetres in diameter but it is essentially a surface analysis method and hence cannot give true values for the bulk composition of the object.

The results of the analysis are shown in Table 3 which also includes four other early instruments for comparison. The first point to note is that the Zutphen quadrant is a true brass with only a small amount of tin. This is what might be expected of a 'Continental' instrument where there are few indigenous sources of tin. (Note that the Richard II quadrant, although ostensibly an English instrument, might well have been made in Europe, *e.g.* in Paris, as it was high-value courtly object. It has a high zinc content as befits its status, *i.e.* it is made of high-quality brass.)

The Zutphen quadrant, and the rather later Grafendorf compendium, both have a significantly lower zinc content which is more typical of the early 14th century and might thus be regarded as consisting of rather 'every day' quality brass. By contrast, the two English instruments (the Canterbury *quadrans novus* and the Norfolk *horologium*) both contain a significant amount of tin (and, to a lesser extent, lead), thus tending to confirm their local source. These conclusions cannot be regarded as definitive as there are not yet enough samples in the database, but they do point to the probability of instruments, including the Zutphen quadrant, being made in the approximate locality of their use.

As well as being slightly bent, the quadrant has at least two significant cracks, starting at the 14° and 34° points on the limb and propagating inwards. These are evidence of 'season cracking' along grain boundaries due to the exposure in the soil and usually associated with small amounts of ammonia.[22] Considering the long exposure, they do not suggest a particularly poor-quality brass.

Implications and Concluding Remarks

The Zutphen quadrant is an important find because, with its rather secure dating to around 1300 (it is assumed that it must be a few year older than the layer from which it was excavated) it pushes back the date of the known use of European quadrants of this type for showing equal hours by nearly a century. Its design is a simple extension of the previous, basic type of *quadrans vetus* for single latitudes showing unequal hours, but without the significant difficulties of using the sophisticated *quadrans novus* or astrolabic quadrant also appearing in Europe at the beginning of the 14th century. It seems likely that this was related, directly or indirectly, to the appearance of the first tower clocks at around this time. But it took a long time for the unequal hour system to be totally displaced and it was another century before sundials on horizontal or vertical planes and using polar-oriented gnomons were to be developed in Europe – although altitude dials (*e.g.* cylinder dials) for the purpose were available much earlier.

The quadrant raises a number of questions which cannot be answered yet. The first is who the user was. The likelihood is that it was a member of the educated merchant class, wealthy enough to afford such an instrument, intelligent enough to understand the method of use, and interested in knowing the time. As the various references to time-telling in Chaucer's *Canterbury Tales* indicate, this was still something of a novelty. In the trading environment of a Hanseatic port, there would have been many practical reasons for needing to know the time. The quadrant would have been easily accurate enough for the purpose and its latitude of 52° would have covered a wide area of the other Hanseatic ports including, perhaps, Norwich or Lynn (later Bishop's and then King's Lynn) in Norfolk .

The next questions are by whom and where the quadrant was made. Other than the Parisian workshop of Jean Fusoris nearly a century later, we have no real knowledge

of mathematical instrument making in the period. The metallurgy, as well as the latitude, suggest that it was made relatively locally, or at least on the Continent. But whether there was one or several instrument-making workshops will require evidence from other sources. The case of quadrants can be usefully compared to that of astrolabes and naviculae,[23] made in 14th-century Europe where there is a similar lack of knowledge of manufacturing centres.

REFERENCES and NOTES

1. For a detailed report of the excavations, with a description of the background and all the finds, see B. Fermin & D. Kastelein: *Het Zutphense kwadrant – Archeologisch onderzoek in de gracht van de ringwalburg op de Houtmarkt te Zutphen,* Zutphense Archeologische Publicaties 80 (July 2013).
2. See Wikipedia for an easily-accessible English description of the city of Zutphen.
3. Described fully in ref. 1.
4. E. Dekker: 'An unrecorded medieval astrolabe quadrant from *c*.1300', *Anals of Science*, Vol. 52, Iss 1, pp.1–47 (1995). The *quadrans novus* at the National Museum of American History, Washington DC (IC 5507) has a similar set of sights as does the Lüneburg astrolabe quadrant (IC 5514).
5. Ref 1, Section 6.3, pp. 39–40.
6. Bert Fermin, private correspondence, 17 April 2013.
7. For the earliest reference to an Islamic quadrant see D.A. King: 'A vetustissumus Arabic treatise on the Quadrans Vetus', *J. Hist. Astron.* 33, 237-255 (2002). For details of Sacrobosco's *Tractatus de Quadrante*, 1239. See O. Pedersen: 'In quest of Sacrobosco', *Journal for the History of Astronomy* 16 (1985), pp. 175-221.
8. For the Profatius (Jacob ben Machir ibn Tibbon; d. 1305) quadrant see, for example, R.T. Gunther: *Early Science in Oxford.* Oxford University Press, Vol. II, pp. 154–170 (1922).
9. Inventory no. 44178
10. See British Library manuscript catalogue.
11. Two of the quadrants are in the British Museum and a third is in the Dorset County Museum in Dorchester. In 2012 a fourth quadrant, dated 1396 and thus the earliest of the group, was discovered in Australia. It was offered for sale by Bonhams in London but failed to meet its reserve price of £150,000. For more details of these quadrants see S. Ackermann & J. Cherry, 'Richard II, John Holland and Three Medieval Quadrants', *Anals of Science,* 56 (1999), pp. 3-23. Also, C. Eagleton: 'A King, Two Lords, and Three Quadrants', *Early Science and Medicine*, 16, pp. 200–217 (2011). One of the Richard II quadrants is illustrated in F.A.B. Ward: *A catalogue of European Scientific Instruments in the Dept of Medieval and Later Antiquities of the British Museum, British Museum Publications*, London, (1981), Plate XVIII, item 146. For the 'Australian' quadrant offered by Bonhams, see *www.bonhams.com/auctions/19020/lot/4/*
12. The 1399 Richard II quadrant does have declination lines, for every 10° of celestial longitude (dividing each zodiac sign into three). These lines, however, were added at a much later date (possibly in the late 16th century) as shown by the different engraving hand.
13. See ref. 4.
14. E. Dekker: ' "With his sharp lok perseth the sonne": a new quadrant from Canterbury', *Anals of Science*, 65, pp. 201-20 (2008). and also ref. 4.
15. J. Davis: 'A Medieval Gunter's Quadrant?', *BSS Bull.*, 23(iii), 2-7 (Sept 2011).
16. The diagram in MS Ashmole 19 (f.54) is shown in Gunther (ref. X) p.172.
17. J.E. Morrison: *The Astrolabe*, Janus, Rehoboth Beach (2007). The formulae for the unequal hour quadrant are given on pp. 213-220 with the latitude-dependence of the deviations from true circularity being on p. 220.
18. J. Davis: 'Robert Stikford's "De Umbris Versis et Extensis"', *BSS Bull.*, 23(iv), 24-28 (Dec 2011).
19. This and the other equations may be obtained from first principles or any of the basic sundial texts.
20. 'accurate' here means that it was taken with the camera plane accurately parallel to the quadrant and with minimal lens distortions. This is rather difficult with the Zutphen quadrant as the plate is far from flat. As a result, CAD-fitted circular arcs are not always a very close fit to the photographs.
21. I am indebted to Dr Bertil van Os of the RCE (Netherlands Cultural Heritage Agency) for undertaking the XRF measurements and to Bert Fermin for arranging them. Other analyses are credited in the caption.
22. See, for example, *Stress Corrosion Cracking*, National Physical Laboratory, *www.npl.co.uk/upload/pdf/stress.pdf* , HMSO (2000).
23. C. Eagleton: *Monks, Manuscripts and Sundials: the Navicula in medieval England*, Brill Academic Publishers (2010).

john.davis@btinternet.com

Blackamoor Cartoon

This image is part of a cartoon strip titled 'Hobby Horses' and dated September 1707. It must be very much contemporary with the Van Nost figures described in the previous *Bulletin* by Roger Bowling.

Courtesy of The Trustees of the British Museum, inv. no. AN00478665

READERS' LETTERS

Sundials in Literature

I was recently made aware of a reference to sundials in 'The Essays of Elia' by Charles Lamb. In the essay entitled 'The Old Benchers of the Inner Temple' there is mention of "... the now almost effaced sundials with their moral inscriptions," and this is followed by a long quotation from Marvell's poem, 'The Garden' in which there is a description of a sundial made "Of flow'rs and herbs."

It seems rare for sundials to be mentioned in English literature. Two references in Shakespeare are often quoted as is one from Chaucer, while some of Belloc's sundial mottoes have become familiar. A search through the 'Oxford Dictionary of Quotations' adds a further example from Ezra Pound and the Internet provides an essay by Hazlitt with the title, 'On a Sundial' (1827).

There may well be other passages in prose or poetry which members with a wider knowledge of English literature than mine could identify. These might well give us a better idea of how sundials were regarded in former times. Can any members add to the examples I have quoted?

John Lester
Walsall, West Midlands

Photographs of the Nottingham Meridian Line (clockwise):

- *close-up of the line*
- *the north end*
- *the south end*
- *the aperture*

Bromley House meridian line uncovered in full

In 1997, through a friend of my daughter, who worked at the Subscription Library in Bromley House, Nottingham, I was made aware of the brass meridian line in one of the rooms in the library. Subsequently I was able to write about the line in the *Bulletin* ('A Meridian Line in a Subscription Library, Nottingham', *BSS Bull*, 11(ii), 55–61, June 1999). As a result of a lecture I gave about the line at the 1999 conference, attended by one of the Bromley House library directors, the Society's collection of books came to be housed in Bromley House. At the request of the Library, in 2003 I installed a replica aperture and a solar noon chart, the aperture being rather 'oversize' to give maximum brightness of the spot of sunlight in the winter.

In October 2103, the Society's librarian and Secretary reported that during renovations the meridian line was revealed in its entirety and protected by a clear plastic material. This coincided with a visit to Nottingham and to take the opportunity to photograph the line. The line itself is quite fine, and as reported in the 1999 article, there is no evidence of date or seasonal markers.

Douglas Bateman
Crowthorne, Berkshire

HILLWALKING AND SUNDIALS – An Unusual Combination?

DENNIS COWAN

Hillwalking and sundials – it seems an unusual combination, and not two hobbies that you would expect to be compatible with each other, but just occasionally these two completely different hobbies come together. It would seem sensible that if I was in the north of Scotland on a hillwalking trip, that I should take the opportunity to search out any local sundials if time allowed.

In the late summer of 2011, I set off to climb Bidein a' Choire Sheasgaich, popularly known as 'Cheesecake', and Lurg Mor, two rather remote mountains in Wester Ross in the North West Highlands of Scotland near to the tiny village of Strathcarron. I had attempted these two mountains the previous year but had to give up due to very poor weather. Just to get to the foot of these two mountains entailed a two hour cycle over a fairly rough path followed by another hour of walking over an even rougher path and the crossing of two rivers in the process – see Fig. 1.

Fig. 1. Cycling to Attadale.

Once at the foot of the mountains it took another two hours to reach the summit of Lurg Mor and another hour and a quarter to reach Cheesecake. It took another four and a half hours of walking and cycling to get back to my starting point. An altogether exhausting day of around 40km!

My car was parked in the car park for Attadale House which the owners quite kindly make available to walkers in the area. I was aware of reports of a new (2009) giant sundial, 35 feet across, located to the west of the house, so this was a good opportunity to have a look at it. I was therefore on a mission on my return cycle journey to get back to the car park before closing time, cycling far too fast on the rough path, especially on some of the downhill sections. I made it with half an hour to spare.

Fig. 2. The sundial at Attadale House.

The stone-work of the sundial (Fig. 2) was cut and laid by Tom Nelson and his team from Drumnadrochit whilst the gnomon was carved by Graciela Ainsworth from Edinburgh, who also carved the compass, numbers and other furniture. The gnomon itself incorporates a rampant wild cat of the Skye Macphersons in honour of the owners Ewen and Nicky Macpherson symbolising the Macpherson's clan motto 'touch not the cat but (without) a glove'. The dial is placed in front of a semi-circle of rhododendrons, hydrangeas and ground cover plants (Fig. 3). The dial has Roman numerals from 8am to 7pm and incorporates a stone with the initials of the owners, NM and EAM, and a protea and thistle (national flowers of the owners – South Africa and Scotland), see Fig. 4. There is also a stone with the date of "MMIX".

Fig. 3. The green surround for the Attadale dial.

Fig. 4. Close-up of the date stone of the Attadale dial.

Fig. 6. Aonach Mor in the clouds.

There was however a surprise in store as on my way out I noticed an old horizontal sundial in the centre of the sunken garden (Fig. 5) that I was not aware of. It was on a stone balluster shaft on a circular base and the circular metal dial plate incorporated an eight point compass with all points named. It has Roman numerals from 4am to 8pm and was made by Gilbert, Wright and Hooke of London who I understand were in business between 1794 and 1805. Unfortunately, my camera was acting up by now, probably because of dampness during the day, and I was unable to get a decent close up photo of the dial. The photo at Fig. 5 was the last decent photo from the camera and I had to buy a new one shortly afterwards!

Fig. 7. Aonach Mor: just about to enter the clouds.

Fig. 5. The horizontal pedestal dial at Attadale House.

In the late summer of 2012 I spent the weekend at Invergarry, which is in the Great Glen stretching from Fort William in the south to Inverness in the north. The purpose of the trip was to climb Aonach Beag and Aonach Mor which are the seventh and eighth highest mountains respectively in Great Britain. They are situated near to Ben Nevis, Britain's highest mountain. Unfortunately, the weather was not great as most of the day was spent in the clouds (Fig. 6), but some decent views were had on the way up the mountains (Fig. 7), but those views quickly disappeared as we entered the clouds. The day lasted only about six hours as we

cheated somewhat and took the gondola half way up the mountain.

Whilst at Invergarry and before I returned home, I took the opportunity to visit the Glengarry Castle Hotel which lies on the shore of Loch Oich between Loch Ness and Loch Lochy in the Great Glen. In the grounds of the hotel stands a fine stumpy octagonal facetted dial on a moulded octagonal stem, standing on a low octagonal base (Fig. 8). Possibly from the late 18th-century and looking rather like a petrified alien, the sundial has no surviving markings.

Fig. 8. The Glengarry sundial.

In April 2009 I had a couple of days in Kinlochleven on the banks of Loch Leven in order to climb Sgorr Dhearg and Sgorr Dhonuill known collectively as 'the Ballachuilish Horseshoe' (Fig. 9). The weather was quite good and my companions and I enjoyed eight hours on the mountains once we had navigated through the forest which blankets the lower slopes. The weather however had deteriorated by the next day when I visited Ballachuilish House to see the sundial that was reported to be there. The house is behind the golf course and was all locked up with no one apparently living there, but the garden was well kept. The horizontal sundial was in the garden (Fig. 10) on a slender circular stone column. The dial plate itself was of stone, square shaped and had Roman numerals from 3am to 8pm with a noon gap and a fine gnomon (Fig. 11).

So just occasionally I do get the opportunity to combine my two hobbies. Unfortunately they both rely on the sun to some extent, which is not the most reliable factor in Scotland!

dennis.cowan @btinternet.com

Fig. 9, above left. The Ballachuilish Horseshoe.

Figs 10 & 11, above and right. The Ballachuilish sundial.

SNOWSHILL MANOR
Finding a dial that was there all the time

TONY WOOD and JILL WILSON

Snowshill Manor in Gloucestershire is owned by the National Trust and was the home of Charles Paget Wade who had made his money in sugar plantations in the West Indies. He was a 'collector' of anything and everything and on retirement back in England he bought Snowshill Manor to house his collection. The house is packed to the rafters with all manner of items, from Samurai warrior uniforms to early bicycles and musical instruments – something for everybody, even a couple of sundials! A high mounted armillary out in the hillside gardens and a brass horizontal from the West Indies in the Collection (currently in store).[1]

The English Heritage register of Listed Buildings can be interrogated using keyword 'sundial' and is currently being used to track down sundials not normally easily visible. Rather surprisingly, Snowshill Manor appeared on the list with a detailed description of a sundial there.

Although the authors had visited the Manor several times between them no dials other than the two mentioned above had been noted. The location was carefully detailed but the dial description was not, and it must be confessed that one of us at least had the *idée fixe* of a brass horizontal. In fact the dial was a substantial cube mounted on a tall square section pillar built into a wall (Fig. 1) and marked the end

Fig. 1 (above left). The pillar built into the wall.

Figs 2 & 3. Close-up on the cube's south (above) and west (left) faces.

of a hedge containing a gateway. The dial was actually well known to the manor staff but is not mentioned in any of the literature available.

The Head Gardener showed us the dial (Figs 2 and 3) which had lost its gnomons and almost all of its delineation and looking very much like a gatepost from an earlier garden layout. The mounting holes for the south and west gno-

mons are clearly visible but the carving for the delineation of those faces has practically disappeared, only the rectangular borders are still visible. There is some doubt about the east face as no definite gnomon hole is evident and it would seem that the dial was possibly shaded by trees to the south east. It certainly is today and additionally the east face is almost buried in the hedge. It seems possible that the severe erosion of the dial's south and west faces may be due to strong prevailing winds on the exposed hillside location.

The house dates from about 1500 but the present entrance and garden layout was remodelled in about 1722 and the dial is thought to date from then. The wall and the pillar supporting the cube dial are from the local Cotswold limestone, like the manor house and other buildings on the site. Charles Wade bought the property in 1919 and restored it from a semi-derelict state to house and display his Collection. He did not live in the Manor but in a cottage next to it known as the Priest's House.

Acknowledgements to the Head Gardener and Staff at Snowshill (on a very busy 'Apple Day').

REFERENCE

1. Tony Wood & Jill Wilson: 'West Indies dials in Gloucestershire', *BSS Bull.,* 22(i), p. 41 (March 2010).
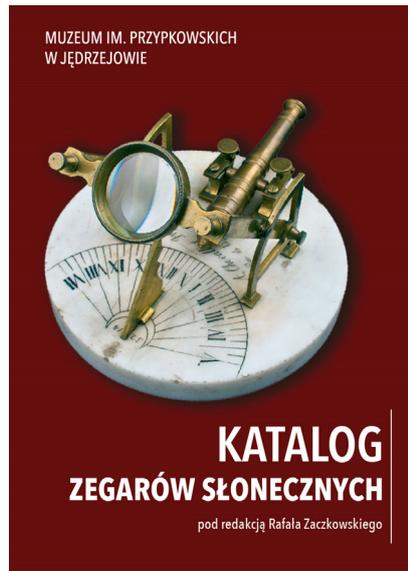
aowood@soft-data.net

BOOK REVIEW

Katalog zegarów słonecznych
[A catalogue of sundials of the Przypkowski Museum in Jędrzejów, Poland] by Rafał Zaczkowski and Dariusz Oczki. A4, 164pp, hardcover, ISBN: 978-83-911201-4-9. Price approx. €XX: contact dharani@o2.pl for details.

The book contains a full listing of the sundials and closely related instruments which form this part of this unique Europe collection owned by the Przypkowski Museum in Jędrzejów, Poland. For each dial there is a basic historical data sheet and a full-colour photograph. Most of the specimens are described in full detail but with a limited number of pages available some descriptions had to be omitted in print. The book shows all the specimens coming from different centuries, countries and makers.

This is the first time that the full collection can be seen and the authors – as sundial enthusiasts and researchers of the history of science – were very anxious finally to produce it. It is also the first book since the 1950s or '60s when a work totally devoted to sundials was printed in Poland. Usually only part of the collection can be seen at the Museum since a group of the specimens is used as a section of temporary artistic exhibitions or is borrowed by other museums in the country. Unfortunately the 'Katalog' is in Polish only but having so many photos and sheets of basic data it is fairly easy to understand for anyone who can read Latin letters. Still, we hope there will be an English edition in the future.

The collection began in 19th century when Feliks Przyp-kowski, a young physician from a small town Jędrzejów, discovered at the attic of his family house a locker full of intriguing objects: a set of historical books on dialling and a horizontal sundial made in the 16th century by Erasmus Habermel in Bohemia. These were the possesions of his great grandfather, Jan Józef Przypkowski, who was an astronomy teacher at a university of Cracow. As for Feliks,

Latin held no secrets so these books and the instrument inspired him to study and understand all the rules of *gnomonika* (as dialling is called in Poland). He started constructing wooden models of standard sundials and sometimes inventing his own types and solutions. His interest in the subject grew deeper and deeper so he started buying old dials from his patients, sometimes accepting them instead of regular payment for his services.

About the same time, an Italian craftsman constructed a public sundial on a wall of a church in Jędrzejów. When Feliks saw it he became very angry saying the design was rubbish. Later, as a master of sundial making, he reconstructed the dial using all his knowledge and expertise to make it a genuine timepiece which still exists today.

Feliks Przypkowski donated the collection to the nation and became its first director. Later, he passed his enthusiasm on his son Tadeusz who too became a great sundial expert and took over the collection when Feliks passed away. Tadeusz studied at the Jagiellonian University in Cracow and obtained his PhD in the history of science from the Polish Academy of Science. Just like his father, he was able to enlarge the collection by buying new dials and books both in Poland and abroad. During his time as a director of the Przypkowski Museum, Tadeusz commissioned a number of fixed sundials spread across the country, becoming the best sundial maker in Poland of the 20th century. He also delineated sundials for private houses in France and Germany. One of his famous works is the Meridies Media noon mark on a wall of the Royal Observatory in Greenwich orig-inally associated with six other sundials. Tadeusz died in 1977 leaving the collection to his son Piotr. Unfortunately, the econ-omic situation of the Museum did not allow for new acquisitions so the collection has not grown very much since that time.

Today it consists of 378 specimen which for the first time can be all seen in the book. Some types and forms are very well known and yet some others are quite unique, being constructed by Polish sundial makers who were not concerned to make their works known to the rest of the world.

Darek Oczki

HONORARY OFFICIALS OF THE BRITISH SUNDIAL SOCIETY

Patron: The Hon. Sir Mark Lennox-Boyd
President: Mr Christopher St J H Daniel MBE
Vice-Presidents: Mr David A Young & Mr Frederick W Sawyer III
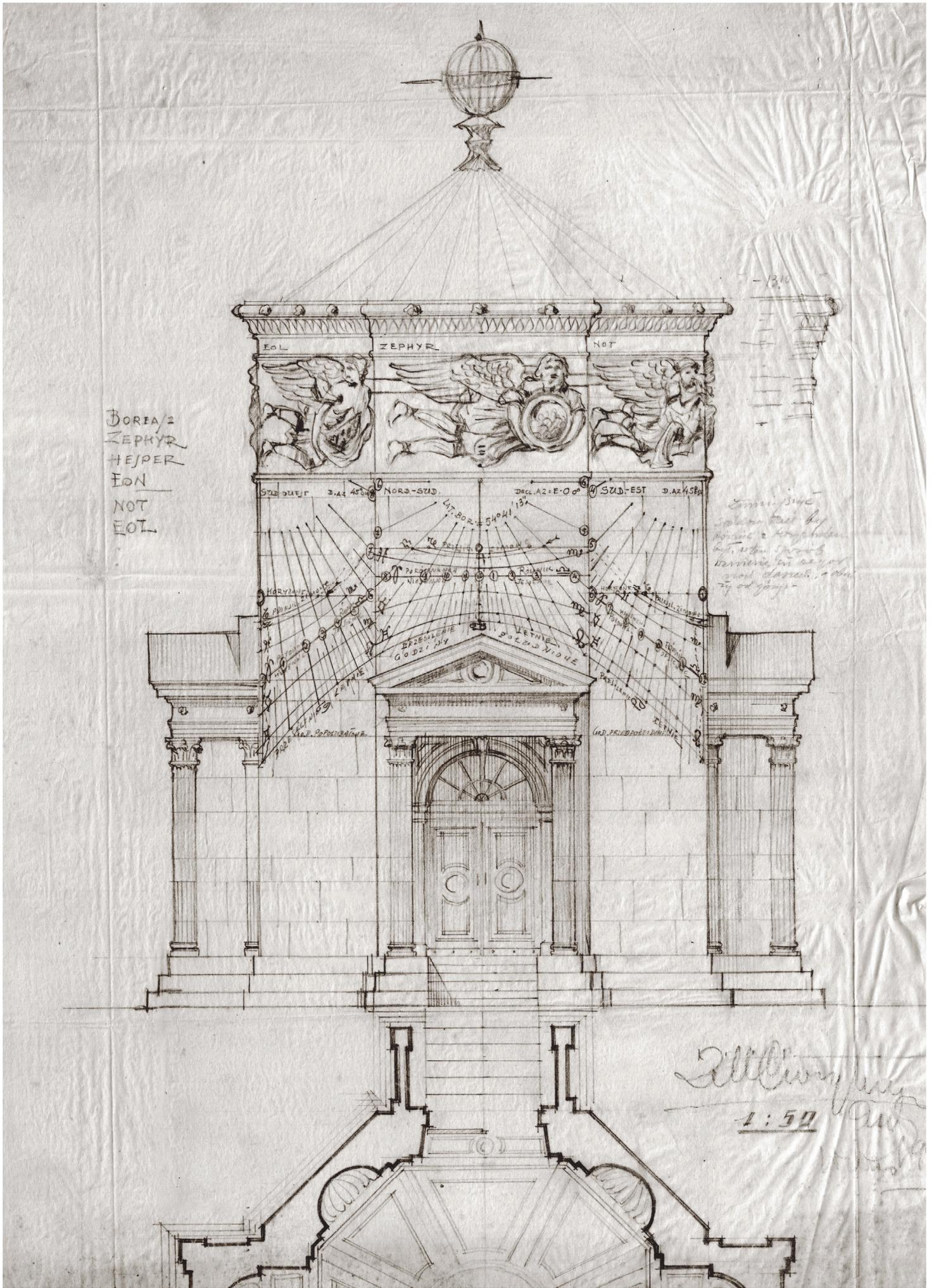
COUNCIL MEMBERS

Dr Frank King 12 Victoria St CAMBRIDGE CB1 1JP	(Chairman & Restoration) Tel: 07766 756 997 chairman@sundialsoc.org.uk	Mr Chris H K Williams c/o The Editor	(Secretary) Tel: 01233 712550 secretary@sundialsoc.org.uk
Mr Bill Visick Kites Nest Cottage Kites Nest Lane BOURTON Dorset SP8 5AZ	(Webmaster) Tel: 07901 954568 webmaster@sundialsoc.org.uk	Mr Graham Stapleton 50 Woodberry Avenue NORTH HARROW Middlesex, HA2 6AX	(Treasurer) Tel: 020 8863 3281 treasurer@sundialsoc.org.uk
Ms Jackie Jones 51 Upper Lewes Rd BRIGHTON East Sussex, BN2 3FH	(Membership Secretary) Tel: 01273 673511 membership@sundialsoc.org.uk	Mr Chris Lusby Taylor 32 Turnpike Rd NEWBURY Berks, RG14 2NB	(Conference Organiser) Tel: 01635 33270 conferences@sundialsoc.org.uk
Mr David Brown Gibbs Orchard, Sutton Rd SOMERTON Somerset, TA11 6QP	(2014 Anniversary Coordination) Tel: 01458 274841 2014@sundialsoc.org.uk		

SPECIALISTS

Dr John Davis Orchard View, Tye Lane FLOWTON Suffolk, IP8 4LD	(Editor) Tel: 01473 658646 editor@sundialsoc.org.uk	Mr Peter Ransom 29 Rufus Close Rownhams SOUTHAMPTON Hampshire, SO16 8LR	(Education) Tel: 023 8073 0547 education@sundialsoc.org.uk
Mr A O (Tony) Wood 5 Leacey Court CHURCHDOWN Gloucester, GL3 1LA	(Mass Dials) Tel: 01452 712953 massdials@sundialsoc.org.uk	Mr J Mike Shaw 3 Millwood Higher Bebington WIRRAL, CH63 8RQ	(Newsletter Editor) Tel: 0151 608 8610 newsletter@sundialsoc.org.uk
Mr John Foad Greenfields Crumps Lane ULCOMBE Kent, ME17 1EX	(Registrar) Tel: 01622 858853 registrar@sundialsoc.org.uk	Mrs Elspeth Hill 4 The Village Stonegate Nr WADHURST East Sussex, TN5 7EN	(Sales) Tel: 01580 201720 sales@sundialsoc.org.uk
Miss R (Jill) Wilson Hart Croft 14 Pear Tree Close CHIPPING CAMPDEN Gloucs., GL55 6DB	(Biographical Projects) Tel: 01386 841007 biographical@sundialsoc.org.uk	Mr David Pawley 8 Rosemary Terrace Enborne Place NEWBURY Berks., RG14 6BB	(Newbury Meeting Organiser) Tel: 01635 33519 newbury@sundialsoc.org.uk
Mr Nick Orders 14 Gordon Rd Burton Joyce NOTTINGHAM NG14 5GN	(Librarian) Tel: 0115 9314313 librarian@sundialsoc.org.uk	Mr Ian R Butson 60 Churnwood Rd Parsons Heath COLCHESTER Essex, CO4 3EY	(Photographic Competition) Tel: 01206 860 724 photos@sundialsoc.org.uk