The British Sundial Society
BULLETIN

BSS CONFERENCES

Year	Location	Somerville Lecturer	Title
1990	Oxford	Dr A R Somerville	The "Symbolic" Renaissance Dials of Scotland
1991	Edinburgh	Christopher Daniel	English Polyhedral Dials
1992	Cambridge	Sir Francis Graham Smith	Pulsars as Clocks
1993	Manchester	Dr Allan Mills	Dividing the Day
1994	Urchfont	Dr Allan Chapman	Measuring the Sun and Stars
1995	Grantley	Philip Adams	Ulster Sundials Old and New
1996	West Dean	Fred Sawyer	Samuel Foster of Gresham College
1997	Penrith	Charles Aked	Meridian Lines
1998	Dunchurch	Sarah Symons	Ancient Egyptian Shadow Clocks and Sundials
1999	Dunchurch	Prof David Waters	Sun, Moon and Stars: Time Measurement at Sea
2000	Cirencester		Postponed due to bereavement
2001	York	Dr Jim Bennett	Learning from Objects: a study from 16C Florence
2002	Exeter	Dr Silke Ackermann	Folded time unfolded, a look at sophisticated astrolabic quadrants
2003	Yarnfield	Prof John North	Chaucer, Holbein and the shadow of Good Friday
2004	Oxford	Dr Ken MacKay	Sundials of Scotland
2005	Egham	Prof D Karl Hofbauer	"The moon has set and the Pleiades" ..(Sappho). Time measurement in cultural history
2006	Durham	Prof Rosemary Cramp	Anglo-Saxon Sculpture
2007	Cambridge	Dr Frank King	The Nodus and the Date—Mission Impossible
2008	Latimer	Dr Alison Morrison-Low	Scottish Sundials at National Museums Scotland
2009	Grange-over-Sands	Father Leo Maidlow Davis	Monks and Time
2010	Exeter	David Bryden	A Gallimaufry of Dial Makers and Designers
2011	Wyboston	Dr Rebekah Higgitt	*Ne qui pereat*: researching and collecting sundials in the age of precision timekeeping

BULLETIN
OF THE BRITISH SUNDIAL SOCIETY

CONTENTS

EDITORIAL

A theme in this issue is polyhedral dials. There are examples of both portable and monumental dials as well as help in making them. There have been relatively few articles on this style of dial in the *Bulletin* over the years so I hope this fills the gap a little. They are certainly impressive ornaments for the garden and give the diallist plenty of scope to show their skills, both mathematically and artistically, not to mention the craft of actually forming the polyhedron in the first place. At least one more article on the subject is planned for later in the year—more contributions are welcome.

This issue also sees the introduction of some portraits and short biographies of the authors. This is entirely optional on the authors and those that write regularly in the *Bulletin* will not have them shown every time. I do hope, though, that being able to visualize the author will add to the enjoyment of reading their words.

Another change is that the inside front cover shows what a variety of Somerville lectures we have had over the years and the way the annual conference has moved around the country. The space will be used for different data in future issues—let me know what you would like to see.

THE RESTORATION OF THE SUNDIAL
AT STUTTON HALL, SUFFOLK

HARRIET JAMES

Stutton Hall is a Tudor house beside the estuary of the river Stour about five miles to the south of Ipswich. John Julius Norwich described it as "Not a classically beautiful house, more a commodious residence suitable for a comfortable but unambitious country gentleman."[1] The original gentleman was probably Sir John Jermy, born c. 1496, who may have built the hall as early as 1530.[2-6] He was ambitious enough to commission some wonderful decorative brickwork for the chimneys of the house and for the pinnacles on the gateway and crenellated garden walls.

Sir John came from a line of lords who had manors in Norfolk and Suffolk. Through his marriage to the daughter of Sir Thomas Tay in about 1525 he probably acquired the Stutton estate and other land in south Suffolk. He was knighted at the coronation of Anne Boleyn in 1533, died in 1560 and had a grand funeral in London.[5] Anne Boleyn was born in Norfolk but spent some of her childhood at Erwerton Hall, four miles east of Stutton Hall, which was the home of her aunt. Erwerton (sometimes Arwerton) has a gateway (Fig. 2, without a sundial) which is very similar to, but not as decorative as the one at Stutton Hall. Pevsner and Norwich date it to 1549.

At Hampton Court Palace there is a much grander brick gateway known as Anne Boleyn's gate which bears the famous astronomical clock made for Henry VIII. Hampton Court was originally built for Cardinal Wolsey who came from Ipswich. He lived at Hampton Court from 1514 until 1528 by which time he had fallen out of favour with Anne and Henry for failing to persuade the Pope to annul Henry's marriage to Catherine of Aragon. Henry VIII moved into Hampton Court and started building Anne Boleyn's gate[7]. It was finished in 1540 but by that time Anne had been executed. There is a story that she asked for her heart to be buried in Erwarton Church.[8]

Fig. 1. The Tudor gateway at Stutton Hall with its restored sundial.

Fig. 2. The gateway at Erwerton Hall.

The sundial (BSS SRN 4490) at Stutton Hall is set into the semi-circular pediment of the south side of the Grade II* listed gateway which leads into a walled garden next to the house. The dial appears to be part of the original gateway. It could possibly be a later addition but the brickwork is built around the dial stone rather than cut away to fit it. Each brick course on the pediment has a different arrangement of brick sizes which accommodate the sundial. In contrast, the courses below the pediment are much more regular (see Fig. 3).

The sundial stone is wedged in place with bits of broken brick tile which match the thickness and colour of the tiles capping the moulding immediately below it. This again suggests that the dial is contemporary with the gateway.

There is also a sundial (Fig. 4, BSS SRN 5573) set into the brickwork of the gateway at Bruisyard Hall, another Tudor house, about 15 miles north-east of Stutton Hall, near Saxmundham. That Hall was originally an Abbey of the Order of the Poor Clares, dissolved by Henry VIII in

Fig. 3. The Stutton Hall sundial before restoration.

Fig. 4. Bruisyard Hall, Suffolk.

J. Davis

Fig. 6 (below right). Possible rounded bowl of '6' in the 6 pm position, top right corner of the border, enchanced with pencil.

1539 and given to Nicholas Hare.[9] The dial has been heavily restored but the remains of the gnomon show a fimbriated bottom edge similar to that at Stutton Hall and a similar positioning of the hourlines low on the stone.

Both the Bruisyard and Stutton Hall sundials were painted onto the stone rather than carved, as were the Turnbull dials at Corpus Christi College, Oxford, which date from the late 1500s.

BSS member John Davis first recorded the sundial at Stutton Hall in 2000 and Ian Butson later approached the owner who was keen to restore it. As the gatehouse is listed, planning permission had to be obtained.

Fig. 5. After cleaning. The border and hour lines are enhanced with pencil.

The sundial (Fig. 5) is on a 24″ square piece of high-quality, hard, fossiliferous limestone, 1″ thick. The stone is in good condition with no cracks. It is similar to Purbeck limestone but could have been brought by sea from France.

The gatehouse faces 3° East of due South. The easterly edge of the sundial stone is canted out from the brickwork and the dial faces within 0.5° of due South. There appears to have been some movement in the structure of the gatehouse as the stone now reclines by 2.77° and sags by 0.79° on the Eastern side.

The iron gnomon plate (Fig. 7) is pitted, 2-3 mm thick, with a distinctive semi-circular nodus cut out of the upper edge. Its two tenons are fixed into slots in the stone with lead plugs. The decorative fimbriation cut out of the lower edge of the plate is partly broken or corroded away. Before restoration, the upper edge of the gnomon plate was tilted by 2.44° to the west of vertical.

ducing monumental stone sundials to Britain which were made for colleges and churches in Oxford and elsewhere.

After submission of a report on the recording and cleaning of the sundial along with the proposed design, the planning authorities granted permission for the sundial's restoration.

Loose pointing around sundial was raked out and it was repointed with a 3:1 washed white sand and hydraulic lime mixture to match that used on the restoration of the brick pinnacles on the gatehouse and garden walls.

At first sight the sundial appeared to be blank. I started to clean away the coating of three different kinds of lichen on the limestone using water and a toothbrush. A symmetrical set of radiating hour lines and a border appeared (highlighted with pencil in Fig. 5). Each line was 2-3 mm wide, rounded in profile and raised from the surface by about 1 mm. These lines may have been scored into the stone when they were laid out. As the dial was painted the scored lines perhaps filled with paint which protected them from the elements while the stone surface around them eroded. Samples of lichen were inspected under a microscope but there was no sign of any remaining paint pigment. The lichen may have metabolised the pigment over the centuries.

Some other raised shapes are visible outside the border of the hour lines. These could be Arabic hour numerals, with a date or motto across the top. They are less well preserved than the hour lines. Perhaps the pigment used for them was less durable.

Pencil rubbings of these possible shapes were taken and photographs taken in different lights were digitally enhanced with various effects (e.g. black & white, increased contrast, reversed out) but nothing further was visible.

The original hour lines are correctly delineated for a dial facing due south. It was interesting to discover that the layout is such that the lines for 9 am and 3 pm exactly meet the lower corners of the rectangular border. The nodus is positioned so that a declination curve for the winter solstice, if extended, exactly meets the upper corners of the border. This suggests that the maker of the sundial was experienced in sundial design.

With no other evidence as to the original appearance of the sundial I drew up the design for the restoration based on known Tudor sundials including the Turnbull dials at Corpus Christi College, Oxford, and those made by Nicholas Kratzer (1487- c.1550). He was employed at Henry VIII's court as "Devizer of the King's Horologies". He designed clocks and sundials for the King and was lecturer in astronomy at Oxford for Cardinal Wolsey for whom he made a portable sundial. Kratzer has also been credited with intro-

The misalignment of the sundial caused by movement in the structure of the gatehouse produces some minor inaccuracies in time-keeping in the early morning and late afternoon. As it is not clear how the sundial stone is built into the brick gable and how much it is supporting or is supported by the brick, realigning the dial could have involved major rebuilding. It was decided to correct only the angle of the gnomon by removing the original lead plugs holding it into the sundial stone. Some fibrous material was removed with the plugs suggesting that the gnomon had originally been secured with wooden wedges before lead was poured in on either side to fix it. The gnomon was cleaned of an old grey undercoat and repainted with rust-inhitibiting black paint, then reset by hammering the original lead back into the stone and adding some new lead.

The tenons on the gnomon had been notched by their original maker to provide a better key for the lead (Fig. 8). The tenons were bent away from the main plate suggesting that the gnomon had been knocked or deliberately bent at some stage.

I repainted the sundial with Holkham linseed oil paints which have traditional pigments in a titanium oxide base. They are easily mixed and blended so colours could be adjusted on site to suit the surroundings. The colour scheme partially imitates that on the Corpus Christi sundials as well as picking up some of the tones from the surrounding brick of the gateway. The sundial was laid out in pencil using the remaining original hour lines and adding any missing ones at the correct theoretical angle for the location and orientation of the sundial.

The shapes of the hour numerals imitate those used by Hans Holbein to date his portraits of Tudors of the 1530s and 40s. I also looked at the numerals, colours and a sunburst on one of the earliest stained glass English sundials of 1585 from Gilling Castle, Yorkshire (Fig. 9). A sunburst was added to the Stutton Hall sundial design in the absence of any clear evidence of a date or motto which may have been painted across the top of the sundial.

Fig. 9. The stained glass sundial at Gilling Castle, Yorkshire which is dated 1585.

The shapes of the zodiac sigils used in the restoration imitate those on the Corpus Christi dials and on two dials at the Villa Barbaro in the Veneto, built by Palladio in the mid-1500s for Daniele Barbaro, ambassador for the Venetian Republic to the court of Elizabeth I.
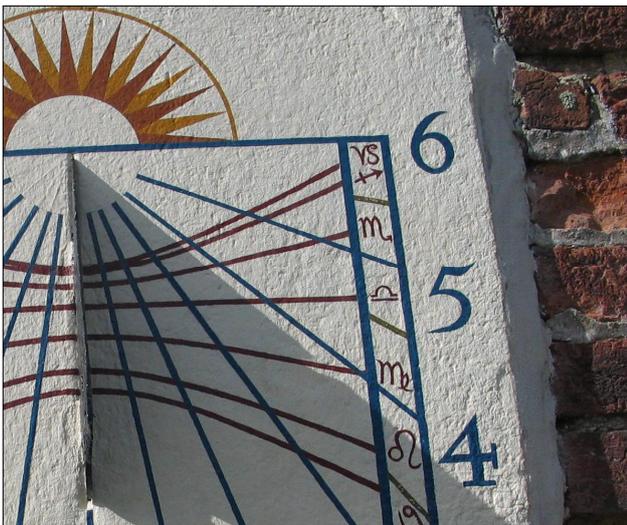

Fig. 11. The shadow of the notch or 'nodus' on the gnomon lies on a declination curve indicating that the sun will soon enter Virgo. Photograph taken 20 August, 2010 at 16:52 BST. Equation of Time 3m 24s dial slow. Longitude correction 4m 35s fast.

REFERENCES

1. John Julius Norwich: *The Architecture of Southern England*, Macmillan, London, 160, (1985).
2. Eric Sandon: *Suffolk Houses. A Study of Domestic Architecture*, Antique Collectors Club, 210, (1977). He writes: "The inner [side of the gatehouse] has a more correct classical arch, flanked by coupled fluted pilasters with a semicircular pediment above, all originally in stucco as high as the entablature. If Copinger is right, the manor had passed to Sir John Jermy by 1542 and if, as supposed, he was the builder of the Hall then the gateway must have been part of the job done in the '40s".
3. N. Pevsner: *Suffolk (Buildings of England)* 2ⁿᵈ edition, revised Radcliffe, Yale University Press, 450, (2002): "Built, it is said, by Sir Edmund Jermy in 1552." (DoE)
4. *The Early Jermys of Suffolk* at http://jermy.org/valdar.html
5. *The Early Jermys of Suffolk,* an extensively researched family tree at: *http://www.btinternet.com/~johnmillman/ jermyhomepage.htm* with references.
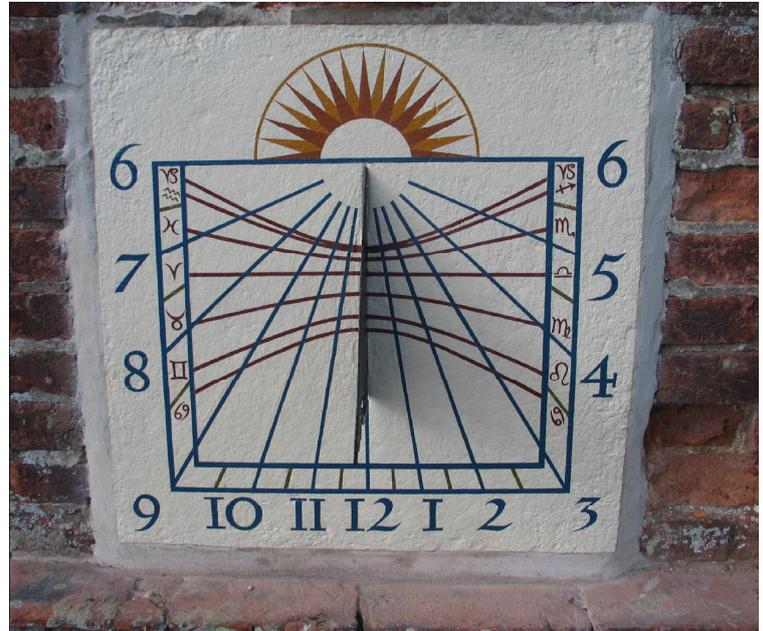
Fig. 10. The restored sundial.

6. Nathaniel Lloyd: *A History of English Brickwork.* H. Greville Montgomery, London, 312-313(1925) has a photograph of the gateway at Stutton Hall with the caption "c. 1530" but does not give a source for this date.
7. *http://en.wikipedia.org/wiki/Anne_Boleyn*
8. *http://en.wikipedia.org/wiki/Erwarton* and *http://www.myshotley.com/shotley-history.html*
9. William Page (Ed.): *A History of the County of Suffolk: Vol. 2*, Victoria County Histories, Institute of Historical Research, London 131-132 (1975).

ACKNOWLEDGEMENTS

Harriet James makes and restores sundials from her home in Wiltshire. She originally trained as an orchestral horn-player. After taking signwriting and lettering courses she began to carve letters in stone and developed an interest in sundials. She has won several highly commended prizes for new and restored dials in the BSS Design competitions. Examples of her work can be seen on her website at *www.sunnydials.co.uk*.

A Polyhedral Dial
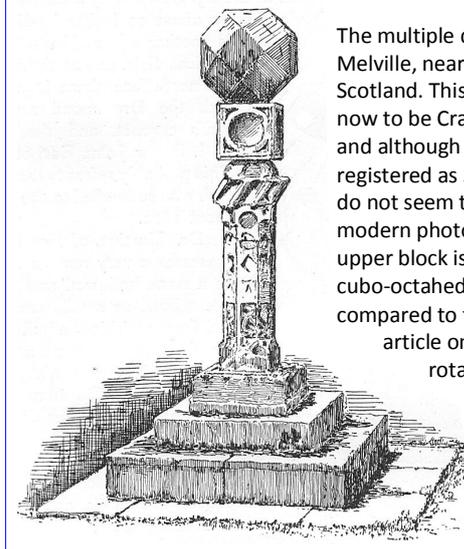
The multiple dial at Mount Melville, near St Andrews in Scotland. This is believed now to be Craigtoun House and although the dial is registered as SRN 1501 we do not seem to have a modern photograph. The upper block is a rhombic cubo-octahedron but, compared to the one in the article on p. 22, is rotated by 45°.

After Gatty.

SYMBOLIC MEANINGS OF SUNDIALS IN ANTIQUITY
Introduced by an Explanation of Ancient Timekeepers

JÉRÔME BONNIN

communicated by Walter Hofmann

This article is the manuscript of a lecture given to members of the Austrian Astronomical Society in Vienna on 6 February, 2010. The author is a student of archæology at the University of Lille. He is working on a thesis: 'Horologia Romana, Recherche archéologique sur les instruments de mesure de temps. Étude urbanistique, typologique et sociale'.

In antiquity, the days were divided from sunrise to sunset into twelve equal parts as accurately as possible. The hours were, thus, unequal from day to day over the year. Nights were divided into twelve equal parts as well, first by observing the stars and later also by using water devices. A testimony from Julius Caesar mentions these water-driven instruments. In his *De Bello Gallico* he writes about an observation after his second landing in England in 54 BC:

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

Sundials, in a great variety of types, were seen as a projection of the celestial vault. Instruments working by water can be divided into 'clepsydra' and 'water-clocks', the second one being a very elaborate form of the first (Figs. 1 & 2). There are at least three types of water-clocks according to Vitruvius, a contemporary of Emperor Augustus and the author of *De Architectura*. The common name for sundials and water-clocks is 'horologia'.
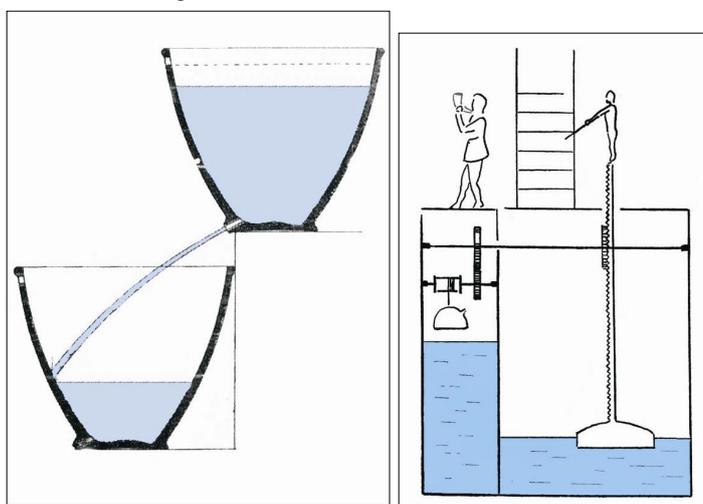
Who invented these devices?

When studying Roman dials, one cannot help thinking about their origin: who invented them or rather in which civilisation might this have happened? It may never be possible to determine their origin. However, we can with some certainty assume that the invention and further development of the dial as an inverted model of the celestial vault can be attributed to the Greeks, based on an inheritance from the Babylonians and the Egyptians. As to the clepsydra and water clocks, they were both known in ancient Egypt. The water clocks were improved by the Greeks. Remains of at least two large water-clocks exist in Greece, in Athens and Oropos.

What were the differences between Greek and Roman dials?

It has often been said that the Romans just used the Greek instruments, without any development, new research or new creations. This is true from a technical point of view. But one can, however, point out that Greek dials are often much more accurate and more finely executed than the Roman ones. For example, dials from Pompeii and Herculaneum, more than 40 mostly of the spherical type, are in the majority crudely designed and not very precise. In contrast, those from Delos, a small island of the Cyclades (nearly 30, mainly conical), are all but one very accurate and executed with great skill (Figs. 3 & 4). This suggests a 'mass production' for the Roman dials.

Fig. 1 (left). Clepsydra, Athens. 'Hesperia' 8, 1939, p.278.
Fig. 2 (right). Water-clock, Vitruvius. 'Mnemosyne' 49, 1921, p.425.

Fig. 3. Greek conical dial from Delos. © Archæological Museum of Delos, photo J. Bonnin.

Fig. 4. Roman hemicyclium, Pompeii, Naples Inv. Nr. 44295. 'Homo Faber', Milan 1999, fig. 297.

Greek dials are products of art, objects of prestige mainly for public use, whereas Roman dials were also widely used in private life.

Horologia: What for?

In the Greco-Roman world, the horologium is both an indicator of time and an element of architecture. As to time, horologia made it possible that one arrived punctually at a meeting, that senate councils could begin, that baths were opened and closed, that the distribution of water was scheduled etc. They were found in small towns as well as in centres of importance. Horologia were elements of architecture because they ornamented the most frequented places of the towns. Their presence is attested in baths, on public places, near temples, in gardens and in private places. The architect had to know the different types and special features, as indicated in book VIII of Vitruvius' *De Architectura*.

Location and Chronology: an archæological point of view

Now I will explain my point of view. In Roman literature, 'horologia' are mentioned in Rome in 293 BC according to Pliny, or in 263 according to Censorinus. In the 6th century AD we have the last important testimony about them by Cassiodorus in 507. I will take objects mostly from the occidental part of the Roman Empire, as defined by Diocletian. As to the method, and I make this point strongly, I will use an archæological point of view, not the one of an astronomer or a mathematician. That is, I will always confront archæological remains with literature and epigraphy, the sources engraved in stone, metal, etc. That will enable us to find out about the human figures behind the remains of the past.

Dials and Representations of Dials

From now on we will only deal with sundials. The main question will be: "What can we learn from sundials and from their representations about life and thought in antiquity?" I began to think about this question when I was looking at modern dials bearing many sentences and mottoes about time and the relationship of time to life. I was also impressed by a

painting showing a sundial, obviously with a philosophical background. Did such meanings exist in antiquity too? Since when was the sundial a symbol of wisdom? Are they just dials or more than dials in representations? In order to answer these questions, or some of them, I will begin by showing a number of representations of sundials, together with the corresponding real dial. Then I will deal with the subject of sundials as symbols, connecting them with testimonies available, epigraphy and literature.

Representations of Sundials

The representation can be sometimes merely as an object, sometimes as a symbol. There is a wide range of types of sundial, about seven or eight, some of them described by Vitruvius in the 1st century AD and known to archaeology, others just mentioned by Vitruvius, but not identified. For our study we will encounter three types:

- Conical dials
- Spherical dials
- The 'pelecinum' [pelekinon] or double folded dial.

Fig. 5. Mosaic of the seven wise men. 'Eureka! Il genio degli antichi', Naples 2005, p. 24.

In some representations sundials have rather a simple significance. Thus, on the mosaic of the seven wise men (Fig. 5), the conical sundial (or what seems to be a conical one) might represent the 'sciences' such as astronomy, geometry, mathematics. The seven wise men might discuss a problem of geometry and the sundial here is to remind us that the place (the academy) was a place of teaching.

In the mosaic of Trier (Fig. 6) the sundial, here a sort of *pelecinum*, is just an attribute, an object needed in order to represent an astronomer. Who it was is still debated. What interests us is the sundial itself. It is typical for the 3rd - 4th century AD, as described by Cetius Faventinus, another author of that period. The only meaning of this dial's picture is to show that this man is an astronomer and without it we would not understand the picture at all.

Fig. 6. Mosaic of Trier. After G. Traversari, Il pelecinum; Archeologia e Astronomia, Colloquies Venice 1989, pl. 15.

To have a sundial represented in a house can be a way of showing that the owner was an educated man, someone who knew about dials and how they worked. This can be the case in Brading, Isle of Wight, (Fig. 7) where a bearded man is sitting in front of a crudely depicted spherical sundial, the attribute of a philosopher as well as the stick and the globe before him. The explanation is still a hypothesis, but far from Rome it could have been useful to demonstrate to visitors to the villa that the owner was aware of the sciences, philosophy and astronomy, even if the representation of the sundial is far from being realistic. The importance in this case is the meaning, not the object itself.
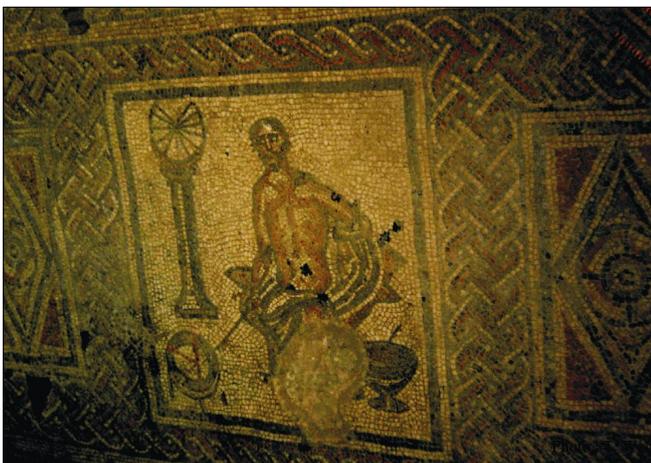

Fig. 7. Villa in Brading, mosaic. Photo T. Wood.

On the next document, a manuscript from the 6th century AD conserved in Vienna, the biblical story of Joseph in jail with the baker and the cup-bearer is depicted (Fig. 8). Joseph, in the middle, announces bad news to the baker, whereas the cup-bearer raises his two hands toward the sky in gratitude for his liberation. Outside, a guardian is seated beneath a sundial, perhaps a spherical one. Here the sundial is just a sundial, an element of the surroundings as the tree or the building behind. The dial is there to suggest a public place. Many sundials were indeed set up in public areas, mainly in the forum.

***

Fig. 8. Joseph in prison, Wiener Genesis. K. Weitzmann, Late Antique and Early Christian Book Illumination, New York 1977, p. 85.

Sundials and Symbolics - Connections to be investigated

Sometimes, and I would say mostly, the sundial possesses a higher symbolic meaning. This can be proved by literary and epigraphical evidences.

Literary Evidence: Two Examples

The first evidence is taken from *Factorum dictorumque memorabilium libri* by Valerius Maximus:

> "Cicero had been informed of his imminent death by an omen. He was in his villa of Gaëte. Under his eyes a raven shook and pulled out the rod of a sundial, then came to his side and, taking with his beak a fold of his garment, it stood there until a slave came to announce Cicero the approach of the soldiers sent to kill him."

Here is the proof that sundials had a symbolic function in the Roman mentality. The bird not only takes away the gnomon of the sundial, but it also stops it telling the time. In the same way the life of Cicero will be ended.

The second text I wanted to present to you is part of the *Oneirokritika* of Artemidorus of Daldis, written in the 2nd century AD, which presents ways of interpreting dreams and interpretations of some of them:

> "A sundial implies activities, beginnings of business, movements, projects, for those who act carefully regarding time. Thus, seeing a sundial fall or break can be dangerous and bad, especially for those who are ill."

In dreams, the sundial is once again a symbol of bad events, but only if it falls or breaks. As in the previous text, a sundial that cannot work is a symbol of bad events. Such a symbol is understandable if one accepts the existence, even in antiquity, of a relation between the passing of time and the passing of life, a relation strengthened by other testimonies. Thus, we can affirm with certainty that literature proves that there is a link between the object itself and precise symbolics.

Epigraphical Evidence: Two Inscriptions

The same relationship is to be found in an epigraphical testimony called the "Epigram of Sylion". These two texts,

dating from between 50 and 200 AD, were inscribed on a small funerary altar that supported a sundial. Although the dial has disappeared the text and the hole in the upper part of the altar are sufficient proof that it existed. The monument must have stood in the necropolis of the city.

The first epigram is of great interest for us since it mentions the sundial:

> "Kydramias had made this tomb and the sundial for the manes of Zobalima as a retribution given by matrimonial love. After you have looked at the hours and the tomb, stranger, say: I, wife of Kydramias, want to be remembered again."

The second epigram mentions the sundial implicitly, for it is the sundial that is meant to speak:

> "I am standing here to demonstrate which part of her way Eos has finished and that this here is the grave of Zobalima. If you want to know who has set me there, stranger, you will easily discover: For his beloved wife Kydramias has done this."

In both cases, as in the major part of the funerary testimonies from imperial time, these texts invite those passing by to remember the dead. But it is striking to see the reference to the sundial.

In the first epigram one is invited to look at the hour directly and to associate with this action the commemoration of Zobalima, the deceased. In the second epigram the reference to Eos, identified with the deity Aurora of the Romans, evokes the observation of the passing of celestial time, readable on the sundial. It is extremely rare on funerary epigrams, only one other example of that type being known in Egypt.

Here it is obvious that the sundial had a function of *memento mori*, an invitation to remind us of our own condition. The sundial has therefore multiple functions: for some it could indicate the hours, for others the place where the tomb was standing, for others still their condition of being mortal and the inevitable presence of death. Although in this special case the sundial has not been found, we know about the existence of other sundials found in a necropolis. But this is not our subject at present.

We may now be sure that the sundial as a symbol of immaterial thoughts or of philosophical thinking is not a modern misinterpretation, but that this concept has been a reality in antiquity. Now we can present the most important evidence for such meanings, the iconography.

Iconographical Evidence

I will begin with sundials as a symbol of the season, the climate. This is the case in one illumination (a decorative illustration) from Codex 354, a painted calendar from the 4th century AD. The month of June is depicted as a naked young man bearing a torch and pointing at a sundial of the pelecinum type (Fig. 9). Here, the sundial indicates that we are in the month of summer solstice. It is the only known example of a sundial associated with a season.
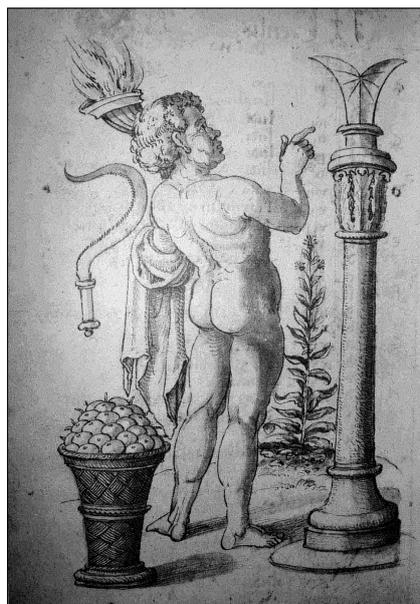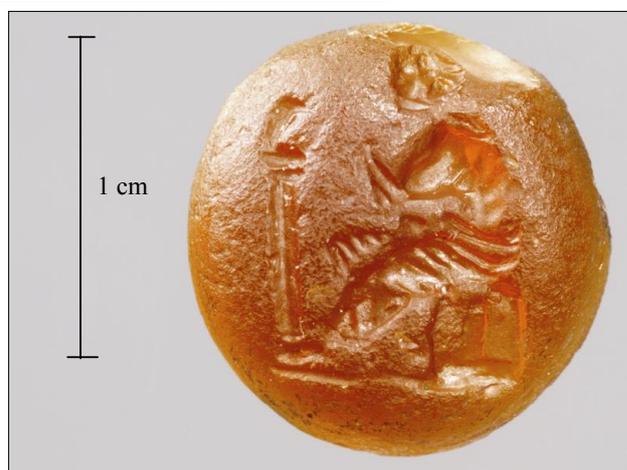

Fig. 9. Codex Calendar of 354. After: M.-R. Salzman, On Roman Time, 1990, fig. 37.

Fig. 10 (below). Gem: 'Philosopher and Dial'. © Museum of Fine Arts Vienna, ANSA XI b 538.

1 cm

But the most important meaning of the sundial when depicted is a philosophical one. In some cases, mainly in gems, it is to be found in front of a bearded person (Fig. 10). Here it is an attribute of the philosopher, the man who thinks about life and death.

The same meaning can be identified on the funerary monument of Theodotos, found at Beyazit, Turkey, where the buried man is represented as a philosopher. A similar theme is realized on the right side of the 'sarcophagus of the Muse', exposed in Vienna, in the Kunsthistorisches Museum (Fig. 11). The man, sitting and holding a scroll and a long stick, looks attentively at the sundial placed on a column in front of him. This is the perfect attitude of a philosopher.

Sometimes, the dial is associated with the idea of a banquet, specifically a funerary banquet rather than an ordinary one. One example is the terracotta of Myrina, where one can see a slave holding a lantern, reclining against the column supporting a sundial (Fig. 12). Here the slave is waiting for his master, at a rather late hour of the day. In this case the sundial is a symbol of the brevity of life and that one has to make the best of one's life. This is similar to the scene on the sarcophagus of Heracleion, where a banquet is depicted with a skeleton and a fine spherical sundial (Fig. 13).
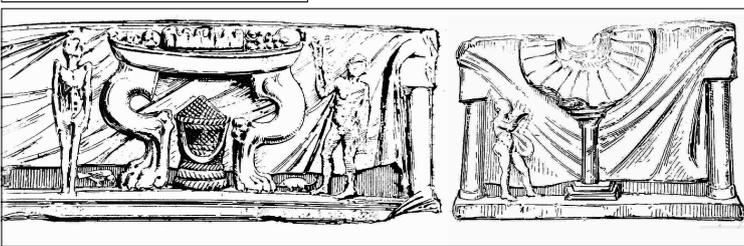
Fig. 15. Altar. ©
British Museum,
photo J. Bonnin.

Fig. 11 (above).
Sarcophagus of the muses.
© Museum of Fine Arts
Vienna, photo J. Bonnin.

Fig. 12 (left). Terracotta of
Myrina. After Bonner Jahr-
bücher 118, 1909, p.379.

Fig. 13 (below). Heracleion.
After W. Altmann,
Architektur und Ornamentik
der antiken Sarkophage,
Berlin 1902, pp.39-41.

Fig. 14 (bottom). The last
voyage. © National Museum
of Rome (cat.191).

And now, I will finish with the most exceptional document, the conical sundial depicted on a Greek altar in the possession of the British Museum. The relief represents Hermes Psychopompos (who guides the dead) standing behind a woman and pointing at a sundial in a clear gesture: "Now, it is time for you to follow me". The sundial, wonderfully depicted with hour lines, solstice and equinox lines and even the gnomon, is presented here to remind the observer that there is an end to everything (Fig. 15).

Conclusion

To conclude, I would say that there is sufficient evidence that in antiquity the symbolism of a sundial was known and used. Philosophical attributes, an indicator of a place, a way to make people think about life and death or just explicative attribute of a picture: the sundial has complex meanings. As far as the texts and the iconography are concerned, it seems that the Romans used such a symbol much more than the Greeks did. Apart from one or two representations, most of them are Roman. Therefore, it is not an exaggeration to say that the Romans created or re-created many archetypes connected with a sundial. And most of them are still used to-day, nearly unchanged. We do not owe the Romans any technical heritage, but we owe them at least most of the ideas about the relation between time and sundials. That is perhaps as important as the mere technical aspect.

jeromebonnin@laposte.net

In another type of representation, again on a sarcophagus, the sundial is associated with the idea of travelling, with geographical boundaries and a chronological boundary, the sundial and the time (Fig. 14). The scene might be understood as the representation of the last voyage, the time to leave, or as a representation of the course of life. This is still under debate.

ACCURATE DIVISION WITHOUT THE USE OF A DIVIDING ENGINE

TONY MOSS

Ever since I read Allan Chapman's wonderful book *Dividing the Circle*[1] I have been fascinated by considerations of how this was done in earlier days before the Ramsden 'dividing engine' and its predecessors. Some years ago I distributed my first thoughts on the subject which were centred around an imaginary 'dividing room' (Fig. 1). Given a long enough straightedge, very fine divisions would be possible but this still relied upon the accuracy of the manual outer placement: its sheer size suggested that this was an unlikely approach.
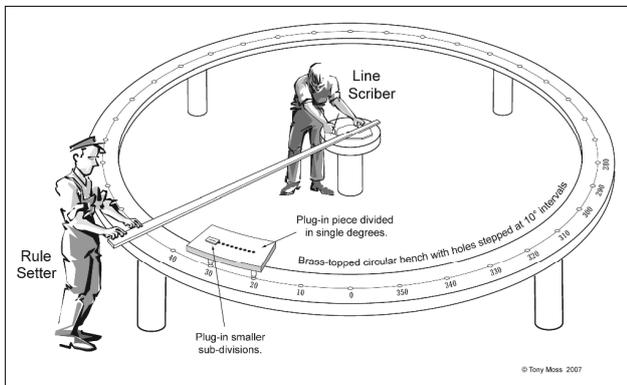

Fig. 1. The Dividing Room.

Most of my best thinking is done between waking and rising in the morning and it was then that a much more compact and semi-mechanical system entered my head which would fit onto a bench less than four metres long with firm contact placing of the straightedge. The covers were thrown back and I was soon scribbling in the notebook I always keep to hand for such occasions.

Many old dials from professional makers have a pair of quite large holes at the gnomon origins (Fig. 2) and it seemed feasible that pivot pins would be inserted in these to guide one end of a straightedge. This could have had a short offset equal to half the pin diameter for a sliding contact or perhaps a pivot hole in a small 'lug' with its centre aligned with the scribing edge for true radial lines.

The successor to the 'dividing room' (Fig. 3) should be largely self-explanatory and the only skill required would be concentration on the

Fig. 2. Part of the dial plate of an 18th-century sundial by Thomas Heath showing the 'footprint' of the gnomon and the two origin holes at the 'toe' of the gnomon. When the gnomon is in place, it covers one quarter of each hole.
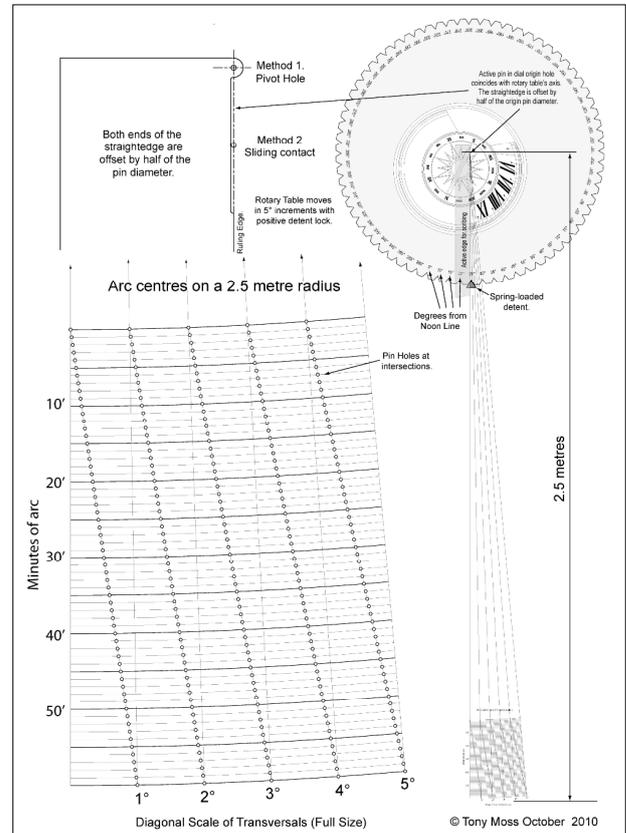
Fig. 3. Accurate division to degrees and minutes of arc without a dividing engine.

sequence of pin placements on the transversals and the need to keep the straightedge gently in contact at both ends. Of course, the actual cutting of the scale lines would need the existing skills of the instrument maker at the dial end of the operation. Making the rudimentary rotary table would have been well within the engineering and instrument-making skills of the day. A different outer plate with 'minute' bands in nine equal steps would be needed for vernier scales.

This idea is actually superior to the Ramsden engine in one respect in that the instrument maker scribing the scale lines is quite close to his work whereas the Ramsden operator had to stoop forward across the large diameter of the device for long periods acquiring severe back pain in the process. I wonder if it occurred to Ramsden to mount the machine nearly vertical with the scale being engraved at a comfortable height?

REFERENCE

1. A. Chapman: *Dividing the Circle. The development of critical angular measurement in astronomy 1500-1850*, Wiley-Praxis (1990).

tony@lindisun.demon.co.uk

SEVEN DIALS

The Investigations of an Austrian Tourist

WALTER HOFMANN

Some years ago Karl Schwarzinger, the first chairman of our Austrian Sundial Society ('Arbeitsgruppe'), asked me to look for the seventh dial at the location named 'Seven Dials' in London. He had heard of only six dials to be seen there. By the kind advice of David Young (BSS) I found my way to Westminster where seven streets meet at a roundabout. Certainly there were only six dials on top of a column! This was in 2005 (Figs. 1 & 2).

David Young informed me that there had been another monument here many years ago, that column now standing in Weybridge, Surrey. I was immediately interested in this older column but had to wait for an opportunity to go there. I could do this after the 2009 BSS Conference when I paid a visit to friends living in Surrey. They gathered information for me and introduced me to Mrs Carolyn Pennycook. She is the warden of the Elmbridge Museum in Weybridge and very kindly helped me with my investigations.

In Vienna I had seen an Agatha Christie crime novel[1] among some second hand books offered for sale. The title startled me: 'The Seven Dials Mystery'! I bought a new copy of the book and had to find out that its title was chosen only because of a secret club whose meeting place was near Seven Dials. Nevertheless, the title fitted so well to Karl Schwarzinger's question and to my curiosity that I decided to compile a lecture for the annual meeting 2009 of the Austrian *Arbeitsgruppe* and give it the title *The Seven Dials Mystery*.

In *Marginalia* from October 1930 (see below)[2] there is a description of the place and its history. The author mentions that reality is often more fascinating than any romantic tale. This is certainly true as to the part of London around Seven Dials.

Fig. 1. A beautiful column.

Fig. 2. Post marking the sidewalk.

In the Middle Ages, the area had been a marshland with farmyards and the St Giles hospital. The latter was founded in the 12th century by Matilda, daughter of Henry I. Lepers were nursed in the hospital. St Giles was an abbot who died in France about 725; he is the patron of beggars, cripples and blacksmiths.

Meadows and fields belonged to the church until, under Henry VIII, the Church of England separated from the Roman Church. Now the Crown came into possession of the land. The hospital's chapel became a parish church giving the surrounding district the name of St Giles. In a part of the area cruel punishments were executed, with cages, pillories, whipping posts, gallows. The tortures attracted rather a mean public.

In the end of the 17th century the area had the name of 'Cock and Pie Fields' after an inn. It was thought to be a good place for enlarging the town and was given to Thomas Neale, MP and Master of the Mint. He had founded lotteries. In reward for his services to the Crown he was leased the area on very modest conditions, having only to respect existing treaties. He was expected to plan a new part of the city. So the building began around a place where seven streets met forming an irregular star. It was London's first roundabout designed after models in Paris.

In these times house rents were calculated according to the length of the house front, so perhaps there were seven streets. The centre of the roundabout was marked by a Doric pillar with six vertical sundials on top. Edward Pierce, an architect and stone-mason, was asked to design the monument. He was a friend of Thomas Neale and a freemason like him. The monument was erected in 1693 or 1694.
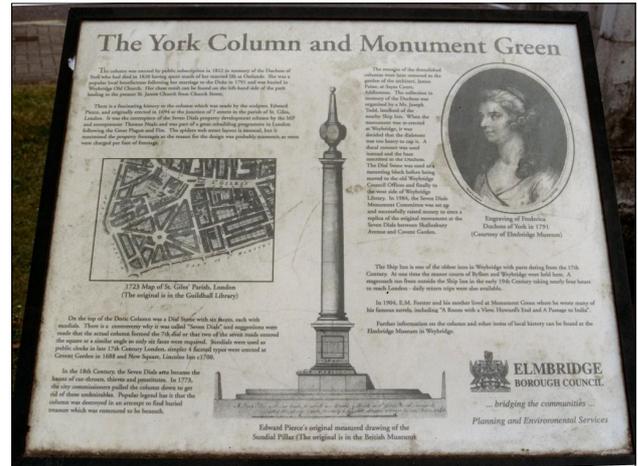
Fig. 3. The monument in Weybridge.

Fig. 4. Inscription before the monument.

Now presumptions differ: Was the name of the column with the six dials where seven streets meet a freemason's joke because of a mystical meaning of numbers? Or was the column itself considered to be the seventh dial? This could only have been if there had been a noon mark somewhere!

There is a note in John Evelyn's *Diary* from 1694: "I went to see the buildings near St Giles's, where seven streets make a star from a Doric pillar."

The expectations of Thomas Neale to profit by rents were not fulfilled. Only poor people came to the new part of the city, at first Huguenots who had fled from France after the Edict of Nantes had been annulled (1685). Later Irish immigrants came. Living conditions got worse and poverty was attended by crime and vice: cheap brandy was sold, prostitutes and receivers strove for profit, murderers and thieves tried to hide.

Fig. 5. The old hexagonal block.

Fig. 6. Plate on the block.

The place around the column with the dials had become a meeting-point for rascals setting out for riots in the city. Most certainly that must have been the cause of the administration's order to remove the column. It has often been reported that the column was ruined by a search for treasures presumed to be buried under it. This is an invention rather than the truth. In 1773 the column was pulled down. James Paine, an architect, bought the pillar and stored it in somewhere in Addlestone, Surrey. Here it lay for nearly 50 years until a monument was to be erected in the neighbouring town of Weybridge.

The Duchess of York, Frederica Charlotte Ulrica Catherina, lived near Weybridge and was respected by the local community. So, when after she died in 1820, a committee began to raise funds for a monument in her honour. In 1822 the former Seven Dials column was set up on a green beside a main street. Instead of the hexagonal block with the sundials there was now a peak with a coronet on top; inscriptions explained about the Duchess (Figs. 3 & 4).

The monument is in the same place by now. For many years the hexagonal block had served as a support for riders mounting their horses before an inn. Now the block lies on a small green beside the Elmbridge Museum in Weybridge. The sundials are lost (Figs. 5 & 6).

In the 19th century the situation around the former stand of the pillar with the dials reached new depths. In 1850, Charles Dickens visited the quarter guarded by police and studied the deplorable situation of the poor as research for his novels. William Hogarth criticized conditions in his paintings. At last two new streets, New Oxford Street and Shaftesbury Avenue, were built to intersect the jumble of crooked houses and back yards.

About 1905 efforts started to get the old monument back to the place that still had the name of the Seven Dials. It can be well understood that the citizens of Weybridge had no interest in restitution. Two world wars made other ideas more important. It was not until 1984 that a committee under David Bieda began to raise funds for a new column to be erected.

Much money was needed. About £65,000 went into a solid base and an underground chamber for the main sewer. In 1987, further costs were estimated as at least £10,000. The architect Red Mason produced plans exactly following the original ones of Edward Pierce, still kept in the British Museum. In a sponsored training programme, young apprentices did the manual work mainly with tools used 300 years before. Caroline Webb carved the dials (Fig. 7). The heavy block and the dials were adjusted over three days. This work was supervised by an astronomer. The dials show time exactly.

Fig. 7. The new dials before installation.
Photo © Caroline Webb.

In 1989 the tercentenary of the accession of William III of Orange and Mary II was celebrated. The potential civil war between catholics and protestants caused by the reign of James II had been avoided. As a consequence, parliament was strengthened by the 'Bill of Rights'. During the ceremonies in 1989 Queen Beatrice and Prince Claus of the Netherlands were guests in London. Queen Beatrice unveiled the column of the Seven Dials which had been hidden behind advertisements of the sponsor Carlsberg Lager. It was the first monument with a column erected in London since Nelson's monument in Trafalgar Square (about 1840).

Fig 8. Merry tourists in May 2009.

When I paid a visit to Seven Dials one year ago, merry tourists surrounded the monument (Fig. 8). Perhaps there will never be a solution to the riddle about the name of the place. But what does this matter in comparison with the beautiful monument and its history?

REFERENCES and BIBLIOGRAPHY

1. Agatha Christie: *The Seven Dials Mystery*, Harper, London (2001). 1st edition Collins 1929.
2. Anon: 'Marginalia', *The Architectural Review*, (October 1930).
3. www.sevendials.com/the_seven_dials_monument_charity.php
4. Raymond Hudson: 'Seven Dials', *The Lady* (8 November 1979).
5. Jackie Whitelaw: 'Column Copy Explains a Name'. *New Civil Engineer* (15 October 1987).
6. Encyclopædia Britannica.

wf.hofmann@aon.at

Walter Hofmann was born in Vienna in 1937. He was a teacher of mathematics and geometry at a technical college. He is a member of the Austrian 'Arbeitsgruppe Sonnenuhren' and of the BSS.
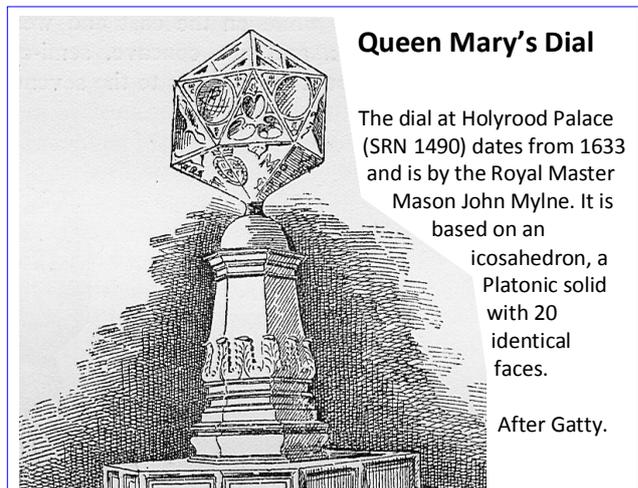
Queen Mary's Dial

The dial at Holyrood Palace (SRN 1490) dates from 1633 and is by the Royal Master Mason John Mylne. It is based on an icosahedron, a Platonic solid with 20 identical faces.

After Gatty.

A SUNDIAL AND ITS PROVENANCE

TONY WOOD

The National Gardens 'yellow book' scheme offers a selection of gardens for our delight. One must confess to spending pleasant afternoons in the hope of finding a sundial. If one picks out the Manors, Courts, Halls and Granges one expects a fair proportion of dials to appear. The English love of gardening means that hundreds of gardens of all sizes are available to explore. The 'strike rate' is surprisingly high – around one in two overall and although this year I had four blanks to start with, the fifth however yielded *five* dials and an amateur dial maker: we got along famously!

Needless to say, the large majority of dials encountered are 'garden centre' dials; after a while one can start identifying them and no doubt build up an unnecessary expertise in what is essentially a

Fig. 1. The equatorial dial at Weston-under-Penyard.

decorative item. Hope, however, springs eternal and an entry in Herefordshire's booklet which actually mentioned a 'sundial garden' seemed a good bet for a visit.

And so indeed it was. At Weston-under-Penyard, near the church (and pub), John Hercock and Anne Rothwell have created a beautiful garden with an enclosed 'dial garden' off to one side. The dial is a small 'equatorial' with a semicircular hour ring and a 'blade' gnomon. (Fig. 1.) It is cheerfully dated 1658, bears a signature of D Smyth and claims "Londini" as place of origin. The motto is equally cheerful: "So Guides ye Tyme, So wears ye Day, These Moments Measure Life Away". (The only other similar dial I know is at Painswick in Gloucestershire (Fig. 2) and one suspects that its "Robert Wall, Londini, 1676" is fictional

Fig. 2. A similar dial at Painswick.

as well.) The pedestal is a baluster from a London bridge in similar fashion to a well known one at Hidcote Gardens in North Gloucestershire.

So far, so good but the dial date is too early for such a dial and the engraving of the base plate was not very deep. My colleague Jill Wilson had mentally assigned 'Pearson Page' and I said 'around 100 years old' – and so it turned out to be.[1]

Conversation with John Hercock revealed that he not only had the original sale receipt from 1932 (Fig. 3) for the dial but a 1991 Christie's Auction House report as well, which confirmed all our thoughts. Pearson Page were a Birmingham firm working in the first half of the twentieth century who made decorative dials, some with dates and makers' names from ear-

Fig. 3. The 1932 receipt for the "16th century" dial.

lier centuries. The dials themselves are actually good accurate ones. John has kindly provided copies for us and so when the dial is registered it should be one of the best provenanced dials outside a museum.

Thanks to: Jill Wilson, John Hercock and Anne Rothwell.

REFERENCE

1. R.J. Wilson: *Biographical Index of Sundial Makers*, British Sundial Society Monograph No. 2, London, (2007).

HOP ONTO A SUNDIAL FOR YOUR HOUSE!

VICKI DeKLEER

At first glance this small horizontal dial does not look particularly unusual. A not-too-serious frog sitting on a leaf… something that might be of interest to a child. But nowadays times seem to be most frequently noted by glancing at a screen on some electronic device such as a cell phone, which may in turn get its information from an atomic clock.

Almost 40 years ago A.E. Waugh made this statement in the preface to his classic book on sundials: "The modern science teacher uses them [sundials] to illustrate vividly the first principles of the solar system." Surely this comment is even more relevant in the 21st century, when basic knowledge is replaced by answers on computers in early school years.
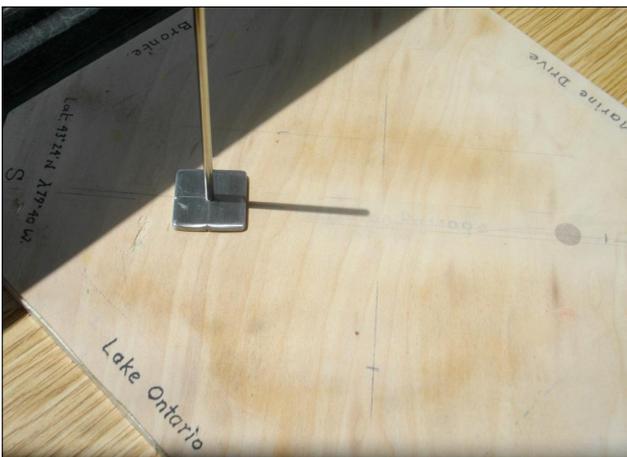

Fig. 1. Using a vertical pin at noon to find the meridian.

And so this dial is designed to be fun to use while introducing the fact that the sun is actually a very useful way to tell the time of day. It is also simple to make. The dial is standard, but the base is a little out of the ordinary. It is designed for a specific building and assumes that all structural angles are 90°. As you will see, when completed, it may be used in any window of the building where the sun may shine, upstairs or down. It is equally accurate out of doors, as long as it is on a wall or other level surface with an edge that is parallel to the original building; it can be moved around to different classrooms. In short, it is versatile.

In order to draw the diagram for the base, choose an approximately south-facing window and tape a sheet of paper with one edge flush against the pane. Once you have determined your latitude and longitude, and the correction for the EoT, you may calculate the time of meridian passage for the day – place any object with a vertical edge in the sun and mark the line of shadow at the time of
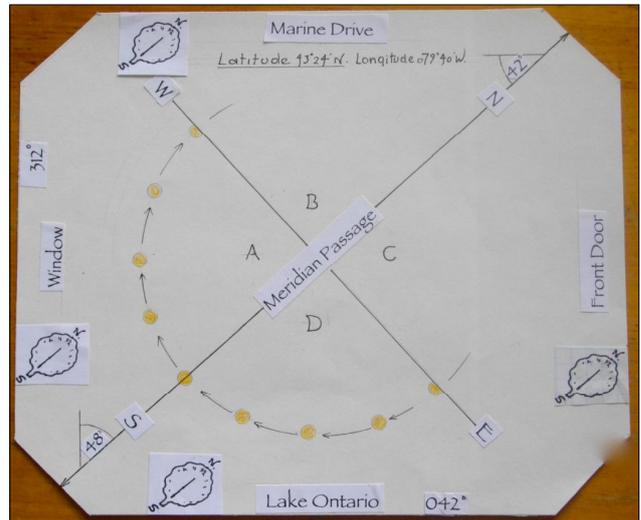

Fig. 2. The plan for the layout of the base.

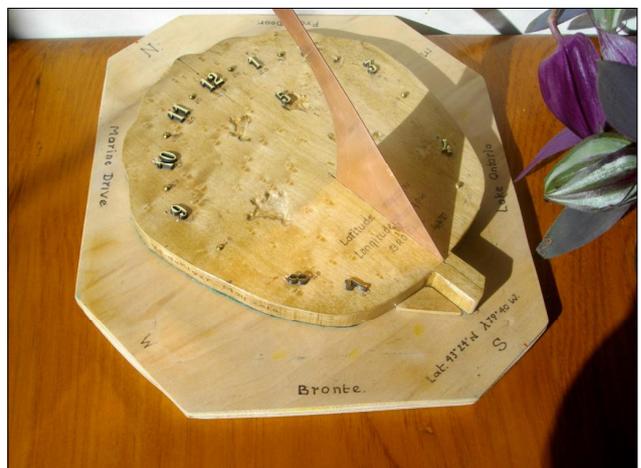Fig. 3. The base, finished with pegs to hold the dial, and Equation of Time table in place.

Fig. 4. The dial nearly completed.

Fig. 5. The dial on a balustrade in the garden.

meridian passage to mark the exact north/south line (Fig. 1). That will be the primary line for the design of the base. All other lines will be 90°. No other angles need to be measured, except to satisfy your own curiosity (in this case, 48°).

Since the dial will be moved around the building, the simplest way to know which edge should be along a given wall is to label it with the view out the window. Fig. 2 shows the layout for the base. With this sundial, in the morning, just line up the Lake Ontario border with any window that gives a view of the Lake and it will be properly aligned. Fig. 3 shows the base, finished with pegs to hold the dial and an Equation of Time table in place. In Fig. 4 the appropriate windowsill (that facing Marine Drive) is used in the afternoon. The completed dial, with the frog in place and situated outside on a rail parallel to the building, is shown in Fig. 5.

It is hoped that following this introduction young people may become progressively more interested in sundials. Perhaps this groundwork will serve to fulfil Waugh's wish to illustrate one of the first principles of the solar system to a young generation.

Frog by Tim Cotterill, the Frogman; photographs by M.K. Zavitz.

Vicki de Kleer was born in London. She was evacuated to America during WWII and later moved to Canada to graduate and work as a vetinarary surgeon and to teach anatomy at the University of Guelph. She has a life-long interest in sailing and learned celestial navigation as part of the RYA Yatchmaster certificate, inspired by acting as crew on the square-rigged *Lord Nelson* on an Atlantic crossing. Originally taught the stars as a young girl by her father, her later interest in sundials was born. She can be reached at *gingerwoods@cogeco.ca.*

Horologium vitæ.
Latus ad occasum nunquam rediturus ad ortum.
Vivo hodie, moriar cras, heri natus eram.

CAPTAIN STURMY'S POLYHEDRAL DIAL

This picture of a multiple dial is from *The Mariners Magazine or Sturmys Mathematicall and Practicall Arts* published by Captain Samuel Sturmy in 1679. The drawing heads his chapter (or The Seventh Book) 'The Art of Dialling by the Gnomonical Scale as also by Calculation'. This chapter is dated 1678.

The polyhedral part of the dial is yet another rhombic cubo-octahedron but drawn here with a curious (to say the least) perspective. Sturmy says very little about the polyhedral dial except in his 'Dedicatory Epistle' to 'Isaac Morgan Esq; Collector of His Majesties Customs in the Port of Bristol.' Part way through the text he describes the dial as:- "*made on a piece of* Free-stone, *as seen in the Frontispiece, the* Gnomons *fastened by me, and likewise Painted and Guilded, which is well known by you, and many others…*" He says that the structure consists of 27 individual dials (including two on the globe and a "shadow-dial") which matches a polyhedron with 26 faces but no dials on the top and bottom faces.

The dial is dated 1667 and thus appears to be a real design but it is not known what happened to it. The upper motto, *Transit Hora Sine Mora*, is not in Mrs Gatty. The small figure on the base hiding behind a globe appears to be Capt. Sturmy himself but what is that arm doing?

The globe dial is unusual in that it shows a considerable number of stars. Perhaps one of our astronomer members can tell us if these are merely for decoration or can be used for time-telling in some way.

Illustrations courtesy of Mike Cowham

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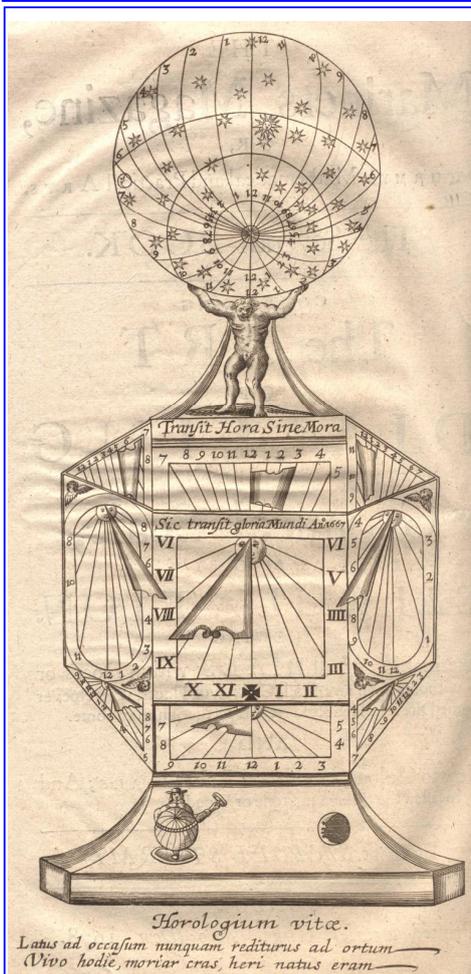
TWO METHODS TO FIND THE ECCENTRICITY OF THE EARTH'S ORBIT FROM MEASUREMENTS WITH A SUNDIAL

PART 2 – Observations and calculations of *e*

JOS KINT and STAN ULENS

The first part of this paper was printed in *Bull* 22(iii), 32-35 (Sept 2010).

Introduction

Our vertical sundial (Fig. 1) is made of a asbestos-free Eternit Carad plate with a gnomon from stainless steel. The top of the gnomon comes 26.5 cm above the table. This table measures 128 cm × 231 cm and is oriented to the south-east (azimuth = 142° 33′). The geographical coordinates are: 50° 59′ 21.2″ N and 3° 38′ 59.7″ E. We started our observations on January 22, 2008 and finished them on August 3, 2010. During 216 days of sunshine we made 1015 measurements (4 or 5 times per observation day).

Method Based on the Geometrical Model of Ptolemy

As described in Part 1 of this article,[1] the model of Ptolemy requires a reasonable knowledge of the length of the seasons. Therefore, we measured the altitude of the sun at local solar noon. From this sun's altitude it is easy to derive the declination by the formula:

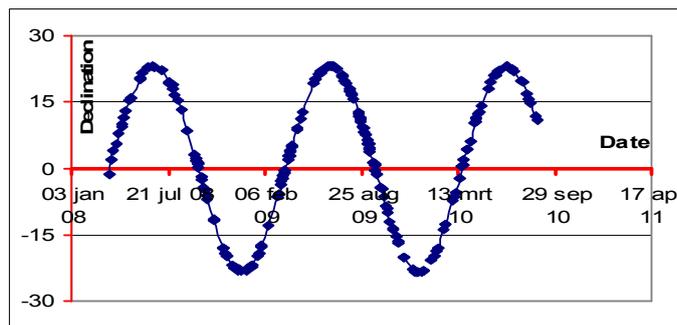
Fig. 1. The sundial used for the measurements.

Fig. 2. Values of declination during the year, derived from observations with a sundial.

Declination = Solar Noon Altitude – (90° – Latitude)

The results (Fig. 2) are accurate to within 0.3°.

To derive the instants of the equinoxes and of the solstices and thus the lengths of the seasons, we try to find the best mathematical function which describes the evolution of the declination. With the help of *Table Curve*,[2] a classical curve fitting program, several hundreds of functions were examined. We selected each time those functions with the highest correlation coefficient (generally > 99.9%), combined with a more regular and symmetrical graph. Moreover, different functions were selected for different periods of time. E.g. for each winter or summer season the period from equinox to equinox was selected together with the best curves. Every three months, all points from the beginning up to that moment were also selected for a curve fitting analysis. For each calculation, at least three functions were selected. The mean moment of summer (maximum value), winter (minimum value), and spring and autumn (zero declination) were calculated. It turned out that the results depended heavily on the initial choices, such as the type of algebraic function selected or the number of days chosen. This sensitivity to the starting conditions was so high that many calculations were necessary before a reasonable result was obtained. Eight different approaches were tested, each with different time periods and with at least three functions, which produced up to 68 results in each season. The mean value of all these calculations are shown in Table 2.

As can be seen in Table 2, the results are not satisfying at all. For three seasons the error is more than 1 day. Only on three occasions was the error one hour or less. The mean global error, however, is only +0.5 hours.

| Season	Actual instant*		Mean instant (experiment)		Error, hours[#]
	Date	Time (UT)	Date	Time (UT)	
Spring 2008	20 Mar	05:48	22 Mar	19:29	+61.7
Summer 2008	20 Jun	23:59	19 Jun	11:45	−36.2
Autumn 2008	22 Sep	15:44	22 Sep	16:43	+1.0
Winter 2008	21 Dec	12:04	20 Dec	21:17	−14.8
Spring 2009	20 Mar	11:44	20 Mar	19:55	+8.2
Summer 2009	21 Jun	05:45	20 Jun	02:30	−27.2
Autumn 2009	22 Sep	21:18	22 Sep	20:22	−0.9
Winter 2009	21 Dec	17:47	22 Dec	00:31	+6.7
Spring 2010	20 Mar	17:32	20 Mar	23:47	+6.2
Summer 2010	21 Jun	11:28	21 Jun	11:50	+0.4
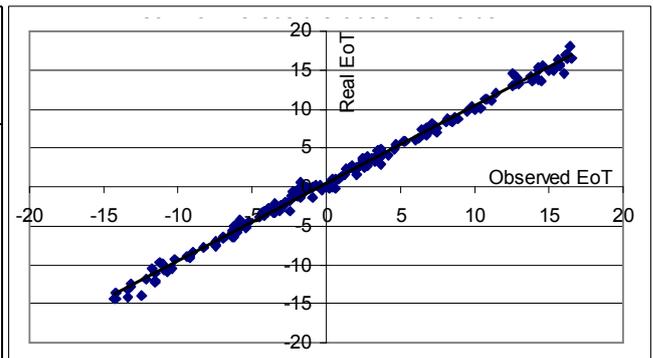
Fig. 3. Real value of EoT versus the calculated one, derived from observations on the sundial.

Table 2. Calculated moments of equinoxes and solstices.
* from *http://www.usno.navy.mil/USNO/astronomical-applications/ data-services/Earth-Season.html*
[#] (mean global error: 0.5 hours)

Nevertheless, we started to calculate the corresponding value of the eccentricity e. The Ptolemaic model was applied, by equating the length in days from one season to the corresponding one next year, to a circle of 360°. The distance from the centre of the circle to the crossing point of the two straight lines joining the equinoxes and solstices, as described in Part 1, corresponds to twice the value of the eccentricity. Each sequence of five seasons (e.g. from Spring 2008 to Spring 2009 inclusive) therefore gives rise to a value of e. We could thus calculate six values of e (Table 3). The final mean value of these six numbers results in $e = 0.0167$, which is exactly the real value. Probably a lot of good luck is involved here. Notice that the coefficient of variation is only 8.7%, which is rather small.

Period of observation	e
From Spring 2008 to Spring 2009	0.0159
From Summer 2008 to Summer 2009	0.0170
From Autumn 2008 to Autumn 2009	0.0158
From Winter 2008 to Winter 2009	0.0148
From Spring 2009 to Spring 2010	0.0178
From Summer 2009 to Summer 2010	0.0188
MEAN VALUE:	**0.0167**
Coefficient of variation (%)	8.7
Real value:	0.0167

Table 3. Calculated values of the eccentricity e.

Fig. 4. Value of e calculated from observations of total EoT – The blue symbols represent the individual measurements; the red ones show the progressive mean values of about 0.0168 while the black line shows the real value of 0.0167.
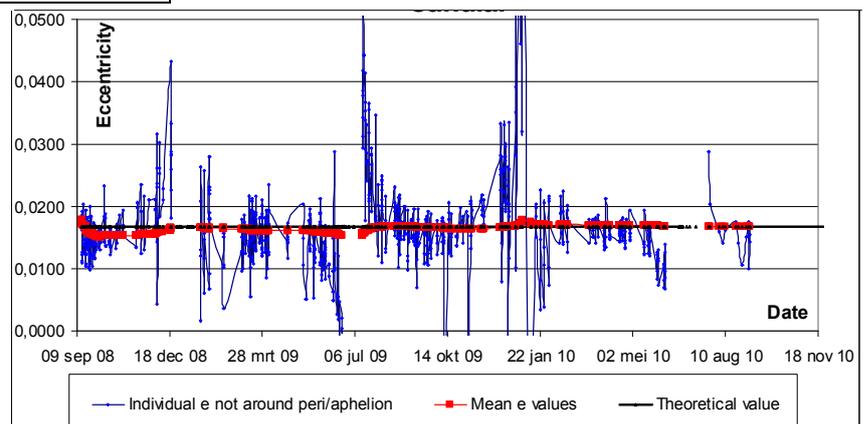
Algebraic method based on the EoT

The total EoT can be considered as the sum of two parts, EoT1 and EoT2. EoT1 is due to the eccentricity of the ellipse while EoT2 is due to the obliquity of the ecliptic. Both parts can be readily calculated. Therefore we measured total EoT over a long period. Timing the local solar noon gives a good approximation of total EoT. There was an excellent correlation coefficient $\rho^2 = 0.9957$ between the real and the observed value of EoT (Fig. 3).

During 216 days of sunshine 1015 observations were made. Each time both the total EoT and EoT2 were calculated. From both these values the EoT1 and therefore the value of

	Min value	Max value	Mean value	Std. dev.	Varia- tion
All observations except 2 wks around Jul 4 and Jan 3	0.0151	0.0225	**0.0168**	0.0060	36.3%

Table 4. Value of eccentricity e.

e was derived, following the formulas developed in Part l. Table 4 and Fig. 4 summarize all calculations. The progressive mean value of e remains remarkably stable for 550 days, except around the dates of perihelion and aphelion (taken as January 3 and July 4 respectively). As was suggested in Part l, around both periods the calculations produced an exceptionally unstable value for e due to a division of zero by zero. Therefore we calculated e after dropping the observations which were made 10 days before and after January 3 and July 4.

To give a better appreciation of these calculations we also present the observations graphically in Fig. 4.

Initially – from September 14, 2008 – the mean value of *e* (red symbol) is somewhat lower than the real value (black line). But from December 19, 2008 on the progressive mean value of 0.0168 differs very little from the real value. From that moment on up to the last observation on August 3, 2010, this progressive mean value stays remarkably stable in spite of a large variation of the individual values. During the last 550 days of observations the calculated mean *e* value never differs from its real value by more than 2%!

CONCLUSION

Both methods have strong and weak points. Using the model of Ptolemy gives an intuitive approach. But the calculated moments of the equinoxes and of the solstices are not accurate. Moreover, the calculations are extremely sensitive to the initial conditions such as the number of observation days or the choice of the best fitting function. The six values of *e* derived from these periods varies from 0.0148 to 0.0188. Nevertheless, when the mean of all six values is calculated, a rather surprisingly accurate value of *e* = 0.0167 is found. This is most probably a good luck result.

Using the algebraic approach with EoT measurements on the other hand is totally different. It is graphically attractive. Here also a large variation of the individual values is seen. But, nevertheless, the progressive mean value gives rise to a rather stable value of *e* = 0.0168, provided that the observations around the perihelion and aphelion are omitted.

REFERENCES
1. S. Ulens & J. Kint: 'Two methods to find the eccentricity of the Earth's orbit from measurements with a sundial. Pt. 1 – Theoretical considerations', *BSS Bull*, 22(iii), 32-35 (Sept 2010).
2. Table Curve SPSS, Science Software GmbH Schimmelbuchstrasse 25, 40699 Erkrath, Germany.

Jos Kint's interest in gnomonics started in 1998 after reading *The sun in the church* by the Oxford professor of history J.L. Heilbron. During the following years, he learned that more than 30 sun-related topics – e.g. the eccentricity of the earth's orbit – could be calculated with a simple sundial. It became an obsession. He lives in De Pinte, Belgium, and can be reached at *Jos.Kint@Skynet.be*.

Stan Ulens got interested in astronomy during his university days (in Belgium electro-mechanical engineers have a course in astronomy!) at the Ghent University. This interest was revived after meeting Jos Kint and discussing some problems related to the use of a sundial. He lives in Sint-Denijs-Westrem, Belgium, and can be reached at *Stan.Ulens@Telenet.be*.

Sundials in Museums of the British Isles by Ian Butson, Jill Wilson & Tony Wood. BSS Monograph No. 7, 59 + x pp., A4 soft covers, b&w illustrations. Price £8.00 + p&p from BSS Sales. ISBN 978-0-9558872-3-9.
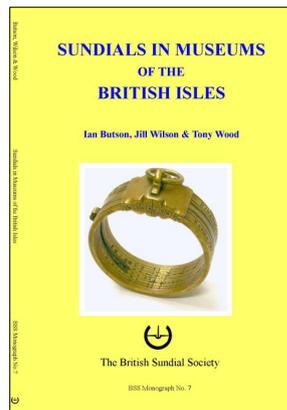
This monograph contains the results of a survey, organised by Tony Wood, of all the museums of Britain, asking them to report on any sundials they had in their collections. The major museums (such as the British Museum, the National Maritime Museum, etc.) which have large collections of dials and have published or maintain their own catalogues were not surveyed though their contact details are listed in the monograph. It is the many smaller, provincial museums, and the National Trust premises that also keep collections of items, which are listed and provide a rich selection of dials.

The monograph is organised on a geographical basis, starting with the counties of England and then moving on though the regions and islands. Although not all museums responded to the questionnaire (presumed to be because they had no dials), a remarkable number of unlikely institutions do have at least one dial. For example, who would have guessed that the Kirkleatham Museum in North Yorkshire would have a signed 17th-century brass horizontal, or that the Manx Museum on the Isle of Man would have a collection of 22 dials of various types? And some quite small museums have dials by important makers: Ashwell Village Museum in Hertfordshire has a horizontal dial by the illustrious Elias Allen and the Gloucester City Museum & Art Gallery have a ring dial by John Rowley.

The descriptions of the dials are largely those provided by the museum curators. Thus the level of detail and accuracy of the gnomonic information depends on the individual's knowledge. The authors have visited some of the museums to inspect their collections but there is very much more work which could be done by members to improve the usefulness of the catalogue. The authors do encourage members to report on any visits so that the details can be filled out in a later edition. Quite a few of the dials are held in store so it may be advisable to make viewing arrangements before making a long trip. Some curators have also reported on sundials on their building or in their gardens and a surprising number of these are not recorded in the BSS Fixed Dial Register so that is another area where further details will need to be sought in the future.

BOOK REVIEWS

Following the listing of the museums' holdings, the monograph also contains breakdowns of the dials by maker and by dial type which are most useful for anyone researching a particular subject.

The authors are to be greatly thanked for the work which has gone into collecting and organising this data. The monograph should be essential reading for anyone planning a holiday anywhere in Britain and wanting to know what museums to visit, or even just to find out what their local museums hold.

Tempus et Regula: orologi solari medievali Italiani. Vol. 1 - Le origini e la storia by Mario Arnaldi. 400 pp., b&w illustrations. 400 pp., 17 × 24 cm. Pub. AMArte, Ravenna, price €30.00 + p&p.

This book is the first volume of a major study of the medieval sundials of Europe. The title, which translates as *Time and Rule - Italian medieval sundials - The origins and the history*, does not do justice to the full scope of the book which considers the history of time-keeping from the earliest times, through the classical world and throughout the medie-val period when it underwent many dramatic changes in advance of our 'modern' understanding. This first volume starts with the ancient gnomonics which is the basis for medieval timekeeping. It considers the division of the day, the concept of the hours and their evolution from antiquity up to the Middle Ages. Thus this very wide-ranging study will surely be the definitive text on time development for a considerable period.

The second part of the book is devoted to the description of the types of medieval sundials, both fixed and portable. Again, the scope is wide-ranging, including, for example, vertical dials with different time divisions, portable dials such as the Canterbury pendant, and various forms of quadrants.

The third part illustrates the diffusion that sundials had in the Middle Ages both in Europe (Ireland, England, Scandinavia, Germany, Austria, France, Spain, the former Yugoslavia, Greece) and in the Christian lands of the East (Israel, Armenia). Each country has a chapter written by a guest author, usually in their native language, with contributions from Shaul Adam, Mike Cowham, Walter Hofmann, Julian Lush, Herbert Rau, Karlheinz Schaldach, Denis Schneider, M. Tadić, M. Ma Valdés Carracedo and Johann Wikander. Most of these names will be familiar to BSS readers, as will that of Mario Arnaldi himself who literally 'wrote the book' on the ancient sundials of Ireland some years ago.

The final part of this volume contains the appendices, a substantial bibliography and the indexes. The next volume, planned for 2011, will concentrate on cataloguing the Italian medieval dials, starting in Sardinia where we are promised interesting new discoveries of 'transitional' dials at the end of the medieval period.

For anyone who wants to really understand the development of time and timekeeping, this book will be an essential tool.

Cadrans Solaires de Bretagne by J-P Cornec & P Labat-Segalen. 192 pp., 250 colour photos. Price €36.10 + p&p from the publishers, Skol Vreizh, at *http://skolvreizh.com/home.php*.
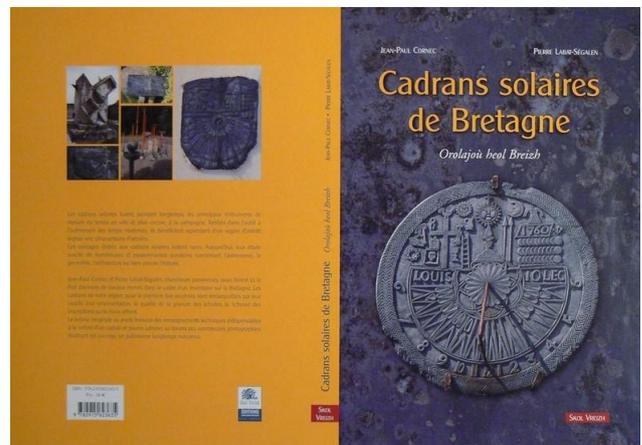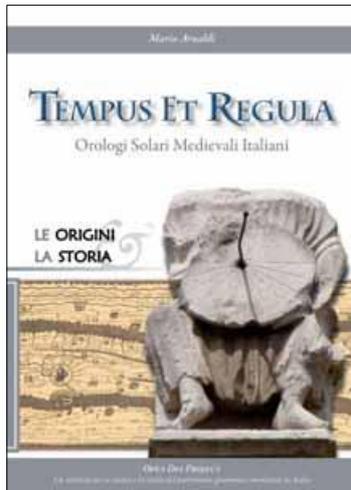
Your reviewer has to admit that he has not actually read this book, not least because his French is rudimentary at best! Nevertheless, a book cataloguing 700 dials of the Brittany region of France can only be good news to anyone who is going to visit that area. And with 250 of them illustrated in colour, it will also be of interest to anyone who is just curious about the style of dials in the area. The book features a foreword by Bernard Rouxell, who is quite well known to BSS members, and begins with a brief history of sundials and timekeeping in Brittany before the main catalogue section. Finally, six appendices give further details on topics such as the sundial makers and mottoes.

John Davis

A RECONSTRUCTION OF LUDWIG HOHENFELD'S
1596 POLYHEDRAL SUNDIAL

FRANS W. MAES

Some years ago I was paging through Ernst Zinner's *Astronomische Instrumente* for another project, when my eye fell on the entry: "Ludwig Höhenfelder, 1596. Multiple sundial in the form of a 26-sided solid with 24 corners ... It is a painted wooden body, on which every face is filled with dial faces and decorations".[1] It was in the Württemberg State Museum in Stuttgart (Germany) and I very much wanted to see it. Earlier, I had already enjoyed a similar 'picture book sundial' in Freiburg from 1761.[2]

In 2004 I wrote to the Museum. Dr. Irmgard Müsch, curator for clocks, scientific instruments, musical instruments and the children's toys collection, responded that "the sundial can be seen on the third floor daily except on Monday". That year we did not make it to Stuttgart, however; it was not until 2007 that we visited the Museum, only to find out that the third floor had been cleared for a big exhibition. And the curator was on holiday, otherwise it might even then have been possible to arrange a viewing.

That called for better preparations so the following year I was able to meet Dr. Müsch in an external depot of the museum, an enormous hall, filled with all kinds of musical instruments. The sundial, inventory nr. KK13, was stored in a cupboard. The conditions were not very favorable for photography: fluorescent lighting, moderate light intensity and a 'noisy' background. Nevertheless, I was happy to be permitted to take as many photos as I liked. Fig. 1 shows an example.

Each face has a picture and a sundial. Sometimes the latter dominates the face, sometimes it is almost hidden. All faces have gnomons perpendicular to the surface. The top face has no picture but a recessed compass for orientation, surrounded by sunrays.

The bottom triangular face at the NE side bears a dedication in Latin. The sundial was a gift to Prince Johann Friedrich (1582-1628), the future Duke of Württemberg. The maker/donor was Ludwig Hohenfeld (1576-1644), a nobleman from Austria. In 1596, both studied in Tübingen

Fig. 1. A photo of the SW side of the sundial, taken in the depot of the Stuttgart museum.

(Germany), 30 km S of Stuttgart. More about the pictures on the faces, the maker and the recipient of the sundial can be found in the following article by Klaus Eichholz.[3]

The sundial is a semi-regular 26-sided polyhedron, a rhombic cubo-octahedron. This is one of the so-called Archimedian solids, which consist of two or more kinds of regular polygons, meeting at the corners in the same order. This solid has 18 squares and 8 equilateral triangles. All sides have the same length, 70 mm in this case.

In this article I explain how I have 'rectified' the distorted faces, so that a reconstruction of the dial could be made. Perhaps this approach is of use to the reader in similar circumstances.

The Tools
The pictures were taken with a Canon Powershot S50, 5 MP digital camera (2592 × 1944 pixels). The reconstruction of the distorted photos was performed by the image editing program Paint Shop Pro X (Corel Corp., 2005; in the following denoted as PSP). This was the first version that had a *Perspective Correction Tool*. This miraculous function turns a distorted quadrangle into a rectangle with only one click. The algorithm used is a trade secret. Other advanced image editors, such as Adobe Photoshop, have a similar function.

The Dutch gnomonicist Ton van den Beld showed that the height/width ratio of a rectangle, such as a sundial face, can be determined exactly from an oblique photo, using projective geometry.[4] A prerequisite is that both vanishing points exist. PSP's perspective correction tool obviously does not use this approach, as the retrieved height/width ratio can be off by 5% or more. In our case this is no problem, as we know that the original is a square. On the other hand, the PSP tool also yields a reconstruction when one or even both vanishing points are lacking. The latter occurs with a parallelogram. This property will be used for the correction of the triangular faces.

Fig. 2. (a) The handles of the perspective correction tool have been placed on the corners of the centre (vertical) SW face. The lines have been accentuated for clarity.
(b) After activation, the face is rectangular, almost square.

The Reconstruction Method

Reconstruction of the square faces is straightforward. After initiating the perspective correction tool, a rectangle appears with 'handles' at the corners (Fig. 2a). These can be dragged to the corners of the face to be corrected. A mouse click then performs the operation (Fig. 2b).The size of the resulting rectangle was measured and reduced by the *Resize Tool*, using separate horizontal and vertical factors, to a 500 × 500 pixel square.

The procedure for the triangular faces requires a trick, as the perspective correction tool only works on quadrangles. Imagine a line through the top corner of the triangle, parallel to and of the same length as the triangle's base, and the
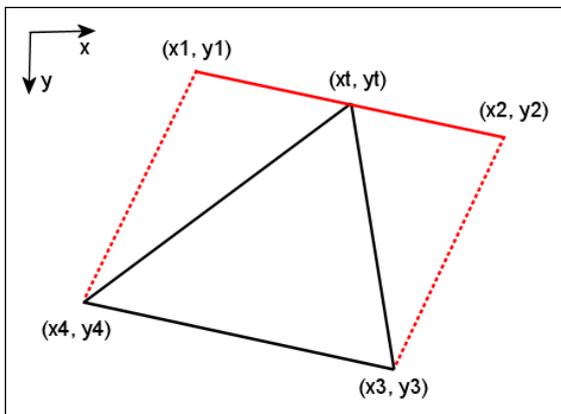
top corner exactly halfway. Together these form a circumscribed parallelogram; see Fig. 3. The coordinates of the end points of the imaginary line through the top can be calculated from the coordinates of the corners. Let these be (x_3, y_3) and (x_4, y_4) for the base and (x_t, y_t) for the top.

The end points (x_1, y_1) and (x_2, y_2) of the imaginary line can then be calculated from:

$$x_1 = x_t - (x_3 - x_4) / 2, \qquad y_1 = y_t - (y_3 - y_4) / 2$$
$$x_2 = x_t + (x_3 - x_4) / 2, \qquad y_2 = y_t + (y_3 - y_4) / 2$$

(The numbering of the corners corresponds with the order used by the perspective correction tool.) The coordinates of the corners of the parallelogram can be typed directly into edit boxes in the toolbar of the tool. A mouse click then turns the parallelogram into a rectangle. Fig. 4 illustrates this procedure.

The resulting image was then reduced, using separate horizontal and vertical factors, so as to yield an equilateral triangle of 500 pixels wide and 433 ($= \frac{1}{2}\sqrt{3} \times 500$) pixels high.

Next, all faces were individually corrected for brightness, contrast and colour balance, and sharpened. They were then cut out and assembled into the unfolding of Fig. 5. It should be noted that the image of the gnomons, sticking out of the plane of the faces, kept their original position in the image of the face. This may lead to a somewhat odd depth impression in the corrected photos. This phenomenon is inherent in the correction process.

Fig. 3. Construction of a circumscribed parallelogram around a distorted triangle.

Fig. 4. (a) The handles of the perspective correction tool have been placed on the corners of the circumscribed parallelogram around the upper SE face. The lines have been accentuated for clarity.
(b) After activation, the face is isosceles, almost equilateral.

top face

top

centre

bottom

north   northwest   west   southwest
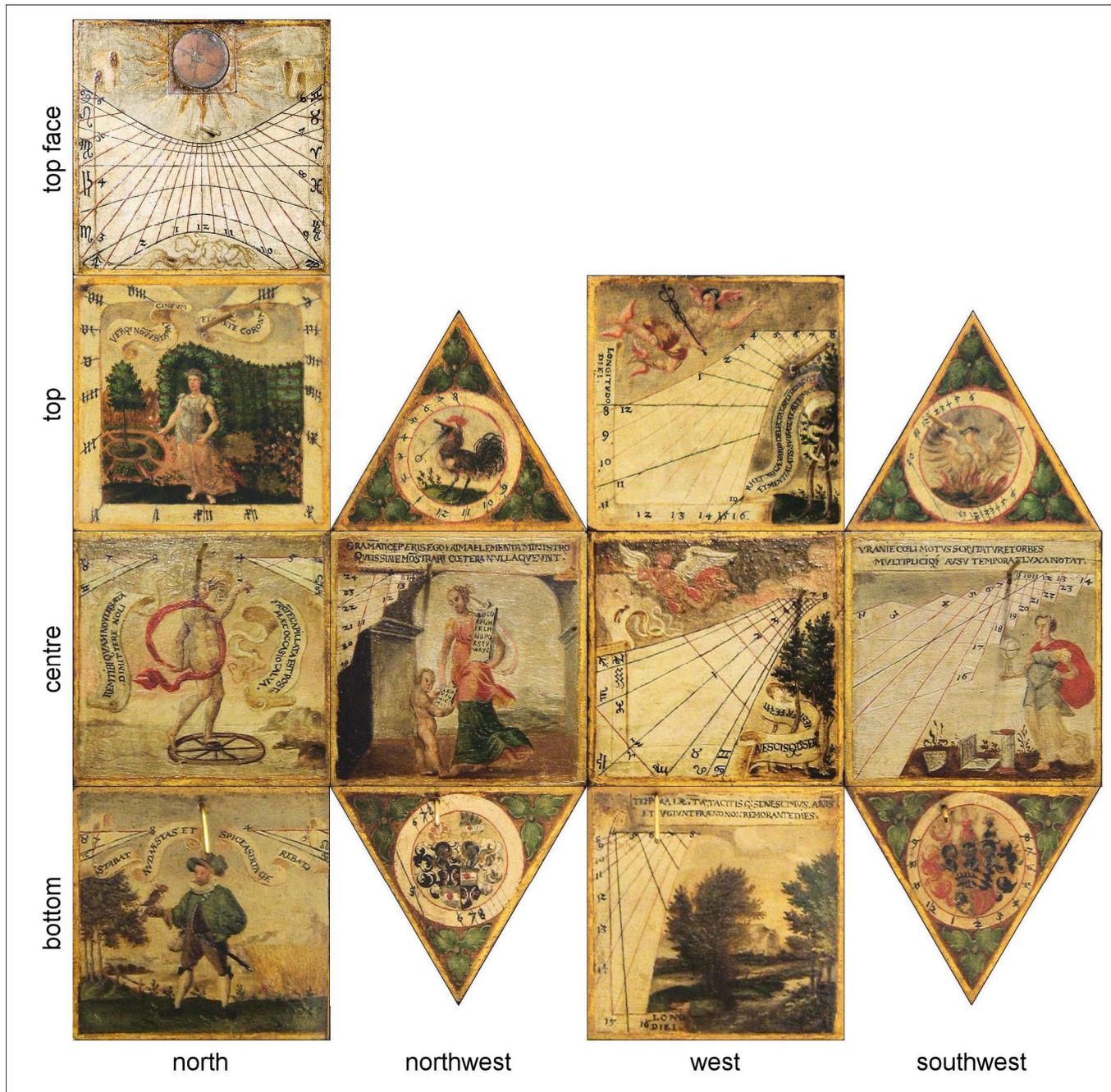
The Sundials

The faces of the sundial have various sets of lines. The hour lines mostly are for local time. Those on the northern upper face and southern lower face are the only ones with Roman numerals. Babylonian and Italian hours are read from the centre faces at the NE, NW, SE and SW sides.

Date lines appear on the top face, the centre faces at the N, E, S and W sides, as well as on the upper northern and lower southern sides. They are identified by the corresponding zodiac signs. Daylength lines, designated *longitudo diei*, are present on the upper and lower faces at east and west sides. The eight triangular faces have no date lines.

Analysis of the Sundial

Now that accurate views of the faces are available, we can try to estimate for which latitude, ϕ, the sundial was de-

signed. The highest accuracy can be achieved from the vertical east and west dials (Fig. 6). These have relatively long equinox date lines, the slopes of which can be measured with good accuracy. The angle of the equinox line with respect to the vertical is equal to the latitude. It can be measured with PSP's *Pen Tool*. When the equinox line is traced by this tool, the slope is shown in the status bar. (The slope could also be measured from a print, but not from the screen, as the latter usually has different horizontal and vertical sensitivities.)

The values obtained were $\phi = 48.2 \pm 0.2°$ (east face) and $48.4 \pm 0.2°$ (west face). Some extra uncertainty might be added to the above values as the corners of the square faces, used with the perspective correction tool, could sometimes only be located approximately. In addition, the actual faces could have been slightly non-square. Neverthe-

Fig. 5. The unfolded sundial. The bottom face has been omitted as it bears no sundial or illustration.
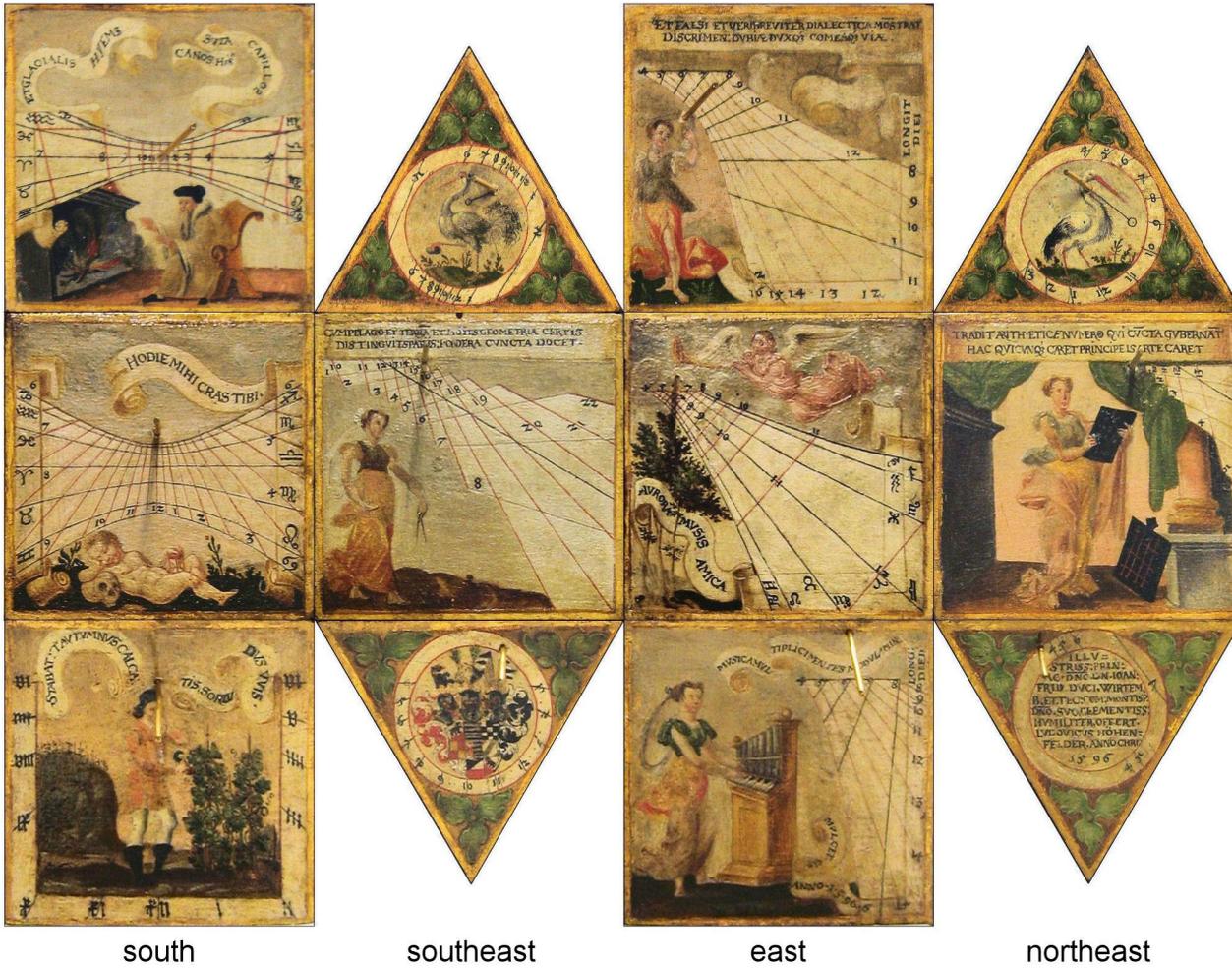
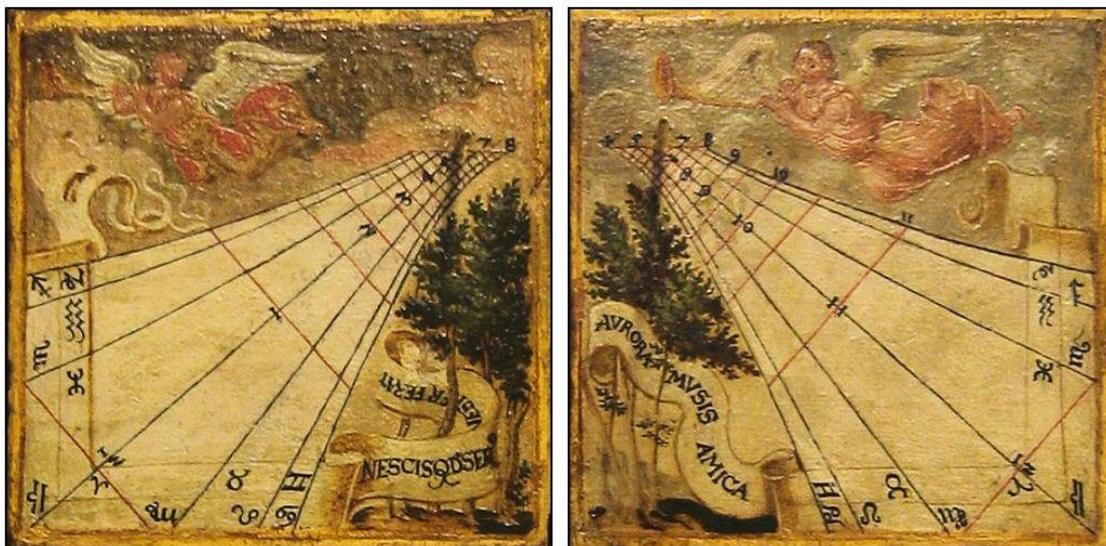south   southeast   east   northeast

Fig. 6. The vertical direct west (far left) and east dials. The equinox lines are the straight, diagonal date lines. Their slopes were used to estimate the latitude for which the sundial was designed.

less, these values allow an overall estimate of $\phi = 48.3 \pm 0.2°$. That differs slightly but significantly from the latitude of Stuttgart (48.8°). Probably the sundial was designed for Tübingen (48.5°), where both Ludwig Hohenfeld and Prince Johann Friedrich studied at the time.

Checking the Line Patterns

Are the sundials constructed by Ludwig Hohenfeld correct? To answer this, we need to know the declination and inclination of the various faces. The only value that requires some consideration is the inclination (defined as the zenith distance) i_D of the triangular faces. A quick sketch reveals that for the upper triangles: $\tan(i_D) = \sqrt{2}$, hence $i_D = 54.7°$. For the lower triangles it is the supplement of this value: $i_D = 125.3°$.

I calculated all the sundials using the ZW2000 software of Fer de Vries,[5] for 48.3° latitude. In addition to local time and date/declination lines, the program can also calculate Babylonian and Italian hour lines. Only daylength curves are not part of its repertoire.

The line patterns produced by Fer's program were superposed on the corrected photos, using the origin of the gnomon as fixation point. The pattern was then enlarged or reduced until the fit with Ludwig's design was optimal. In general, the correspondence was very good. Fig. 7 gives an example.
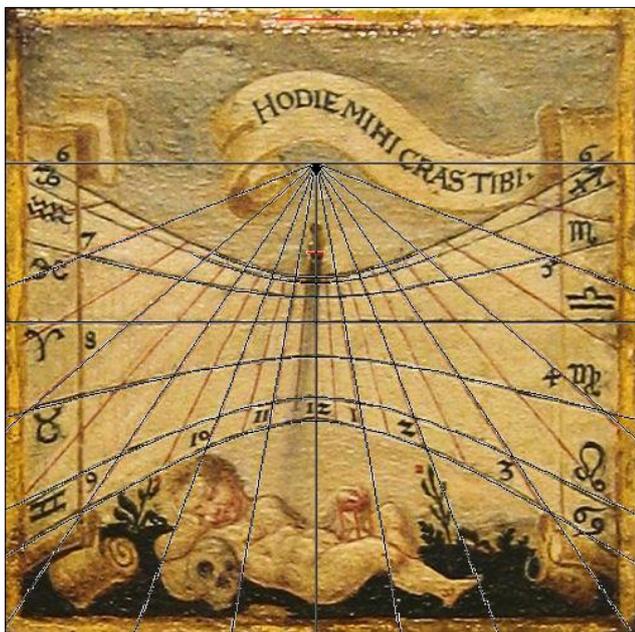

Fig. 7. The line pattern calculated by the ZW2000 program fits the vertical south dial very well.

The only face delineated incorrectly is the lower northeast triangle, the face with the dedication. Comparing this face with the lower northwest face, it is immediately clear that one is wrong, as they should be mirror images. That is odd, as Ludwig appears to have taken advantage of the symmetry with respect to the meridian plane in all other cases.

At the optimum fit of line patterns, the gnomon length provided by ZW2000 was measured (in pixels). As the scale is

known (500 pixels = 70 mm), the theoretical gnomon length could be calculated. It varies from 5.5 to 14.1 mm. The lower northern and upper southern faces are almost polar, so that the gnomons are almost pole-styles. As these faces don't have date lines, the gnomon length is hardly relevant here. The gnomons on the lower triangular southwest and southeast faces are clearly misplaced.

During my visit to Stuttgart I did not measure the gnomons. From some that were photographed nearly sideways, the length can be roughly estimated. My impression is that this does not always conform to the length calculated above. Their shiny appearance suggests that they were replaced recently. It seems that their lengths were not adjusted properly then.

Altogether, it was a rewarding experience to get immersed so deeply in the admirable creation of a young man of only 20 years old, realized over four centuries ago.

Cut-out Kit

For those who would like to make a full-scale model, a cut-out kit can be downloaded from: *www.fransmaes.nl/sundials/downloads*.

REFERENCES

1. E. Zinner: *Deutsche und Niederländische astronomische Instrumente des 11.-18. Jahrhunderts,* C.H. Beck, München, 384, (1979).
2. H. Schumacher: 'Die Freiburger Bilderbuch-Sonnenuhr von 1761', *Alte Uhren und Moderne Zeitmessung,* **87.2**, 36-44 (1987).
3. K. Eichholz: 'The history and symbolism of Ludwig Hohenfeld's 1596 polyhedral sundial', *Bull. BSS* 23(i), 27-31 (March 2011).
4. A.J.M. van den Beld: 'Een scheef genomen foto rechttrekken', *Bulletin of the Dutch Sundial Society* 97, 13-14 (2008).
5. F.J. de Vries: 'Program ZW2000 for Windows', can be downloaded from www.de-zonnewijzerkring.nl/eng/vlakke-zonw-download-zw2000.htm.

Sundials@fransmaes.nl

Frans Maes (Arnhem, 1942) lives in Peize (The Netherlands). He is a member of the Dutch, Flemish, British and North American Sundial Societies. His background is in electrical engineering and biophysics. His main interests in dialling are the history and cultural history of time measurement and sundials, theoretical aspects, and novel developments. His sundial website is at *www.fransmaes.nl/sundials.* He is a supporter of the Sundial Park in Genk (Belgium), about which he made the website *www.fransmaes.nl/genk* .

THE HISTORY AND SYMBOLISM OF
LUDWIG HOHENFELD'S 1596 POLYHEDRAL SUNDIAL

KLAUS EICHHOLZ
translated and adapted by Frans Maes

The previous article[1] described the polyhedral sundial of Ludwig Hohenfeld, presently in the Württemberg State Museum in Stuttgart (Germany). This article will consider the maker/donor and the recipient, as well as the symbolic meaning of the images and maxims on the various faces. This is a translation and adaptation of the paper which the author contributed to the Annals of the German Society of Chronometry (DGC).[2] Pictures of all the faces are shown in Fig. 5 of the earlier paper (see p. 24). In the following, the faces will be denoted by direction: N, NW, W, etc. and the height: t = top, c = centre, b = bottom. Thus NE-b is the lower triangular face on the northeast side.

Fig. 1. The coat of arms of the Hohenfeld family, at left as it appears on the sundial, at right on a building in Würzburg. In field 1 and 4 it has in black two silver hunting-horns with gold fittings, back to back and the mouthpieces upward, and in field 2 and 3 in blue a silver bar, on which a red rose.

The Maker of the Sundial, Ludwig Hohenfeld
The dedication on the NE-b face gives the name of the maker and donor of this gem: Ludwig Höhenfelder. He later wrote his name as Hohenfeld. The NW-b face has the coat of arms of the barons of Hohenfeld, a noble Austrian family (Fig. 1). His father was Achaz von Hohenfeld (1551-1603), Lord of Aistersheim, Allmegg and Peuerbach; his mother was Katharina von Kirchberg (1556-1608). Achaz was a leading person in the landed nobility of Upper Austria, which had converted to Protestantism. He therefore was sometimes denoted as the 'Lutheran pope'. The water castle, which he renovated in late renaissance style, can still be admired today.[3]

Ludwig (1576-1644) was the second son. He studied at the university of Tübingen from 1589 to 1596, together with his brothers Wolfgang and Markus. The *Collegium illustre* in Tübingen, which was part of the university, was the favourite educational college of the protestant European nobility. It provided classes of its own, but also taught dancing, riding, fencing and ball games. At that time, Michael Mästlin (1550-1631) was the professor of mathematics and astronomy. He was a supporter of the Copernican, heliocentric world view. He was the major teacher of Johann Kepler and made friends with him. He is also credited with having won Galileo for the new doctrine.

The Hohenfeld brothers submitted papers to Mästlin that were praised by Kepler. In 1592 Ludwig wrote a thesis with 42 propositions on the 'natural and artificial days', which also paid attention to the hours, the basis for the calculation of sundials. The design and construction of the sundial for Prince Johann Friedrich of Württemberg coincided with his graduation.
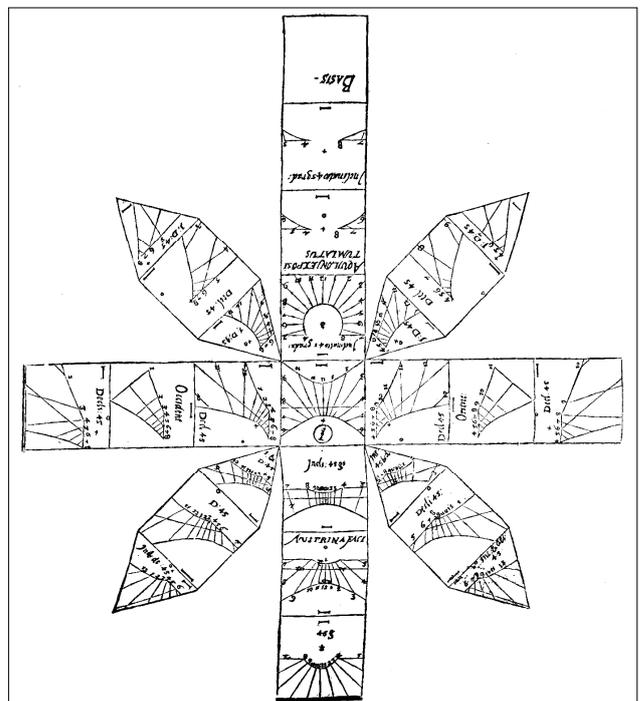

Fig. 2. Unfolding of a 26-sided sundial according to Schöner.[4]

Fig. 3. The polyhedral sundial
by Heinrich Koch from 1578.

Fig. 4. The dedication on the
NE-b face of the sundial.

Ludwig might have obtained the knowledge for the design of the sundial from the textbook *Gnomonics* by Andreas Schöner from 1562.[4] A copy is still present in the university library in Tübingen. Schöner includes a figure that shows the unfolding of a 26-sided polyhedron (Fig. 2), in which all the sundials read modern (astronomical) hours. In addition, Ludwig also drew sundials for Italian and Babylonian hours and dials with daylength curves.

Schöner's textbook could equally have served for the design of a sundial made by Heinrich Koch, master goldsmith from Esslingen (near Stuttgart) for Duke Ludwig of Württemberg in 1578 (Fig. 3). It is made of silver-gilt with enamel decoration and has sundials for 'modern' hours on all faces. It is currently in the collection of the museum in Landshut Castle (60 km NE of Munich).

Ludwig Hohenfeld married Clara von Neydegg (1583-1655) in 1605 and took care of the family estate in Upper Austria. The Counter Reformation, however, created problems which eventually led to the Thirty Years War (1618-1648). The Bohemian and the Austrian nobility as well as the clergy were forced either to become Catholic or to sell their property and to emigrate. Ludwig, adhering persistently to the Lutheran church, left his native country together with his wife Clara and their 12 children and moved, first to Nürnberg and finally to Esslingen. He died there in 1644. His tombstone and that of his wife are still to be found in St. Dionysius church in Esslingen.

The Recipient, Duke Johann Friedrich of Württemberg
Some confusion has arisen about the recipient of the sundial. The triangular NE-b face has a dedication in somewhat compressed Latin (Fig. 4): ILLVSTRISS[IMO] PRIN[CIPI] AC D[OMI]NO D[OMINUS] N[OSTER] IOAN[NI] FRID [ERICO] DVCI WIRTEMB[ERGIAE] ET TEC[K] COM[ESITI] MONTISP[ELGARDIAE] D[OMI]NO SVO CLEMENTISS

[IMO] HVMILITER OFFERT. LVDOVICVS HÖHENFELDER ANNO CHRI[STI] 1596. In English: "To the most serene Sovereign and Lord, our Lord Johann Friedrich, Duke of Württemberg and Teck, Count of Mömpelgard, his most gracious Lord, donates this in all modesty, Ludwig Höhenfelder AD 1596."

In a catalogue of the Stuttgart museum, Duke Friedrich I is named as the recipient.[5] Friedrich I (1557-1608) was Count of Mömpelgard, presently Montbéliard in France. As a youth, he stayed at the Württemberg court in Stuttgart, where Duke Christoph personally cared about his education. When his nephew, the above-mentioned Duke Ludwig (1554-1593) died childless at age 39, Friedrich became the sixth Duke of Württemberg. He had married Sibylla von Anhalt (1564-1614) in 1581. She was the daughter of Prince Joachim Ernst von Anhalt (1536-1586) and his first wife Agnes von Barby (1540-1569). In the next 15 years she gave birth to 15 children, 10 of which reached adulthood. After the death of Friedrich, Sybilla retired to Leonberg castle (10 km W of Stuttgart).

Fig. 5. The coat of arms of Duke Friedrich I. At left as shown on the sundial, at right as seen on a headstone. In field 1 the coat of arms of Württemberg: in gold three black deerhorns above each other, in field 2 the coat of arms of Teck: black/gold check, in field 3 on blue the golden imperial standard with black eagle, and in field 4 the coat of arms of Mömpelgard: in red two upright, averted golden barbels (fish).

In 1596 Friedrich I was indeed Duke of Württemberg, which may explain the confusion. The sundial has the coats of arms of Duke Friedrich and his wife Sybilla on the triangular SW-b and SE-b faces. The former is shown in Fig. 5; we have not been able to find a clear picture of the latter.

There can be no doubt, however, that the named person is Friedrich's eldest son, Prince Johann Friedrich.[6] Johann was born in 1582 in Montbéliard and moved with his par-

ents to Stuttgart four years later. He also visited the *Collegium illustre*, from 1593 to 1606, hence from age 11 to 23. He will certainly have met Ludwig Hohenfeld, who was six years his senior. When the latter made the sundial in 1596, Johann was 14. Why then is he addressed as Duke of Württemberg? We will return to this question at the end of this article.

In 1596 Friedrich I started what would become a large collection of art and curiosities (*Kunstkammer*). In the same year Johann Kepler tried to persuade him to have a *Mysterium Cosmographicum* made for this cabinet. This was the model of the planetary system which Kepler published in Tübingen in the same year. It is the first scientific work based on the heliocentric world view described by Copernicus in his principal work *De Revolutionibus Orbium Coelestium* from 1543, the year in which he died. In that model, the distances between the planetary orbits are determined by circumscribed Platonic solids: tetrahedron, cube, octahedron etc. (Fig. 6).
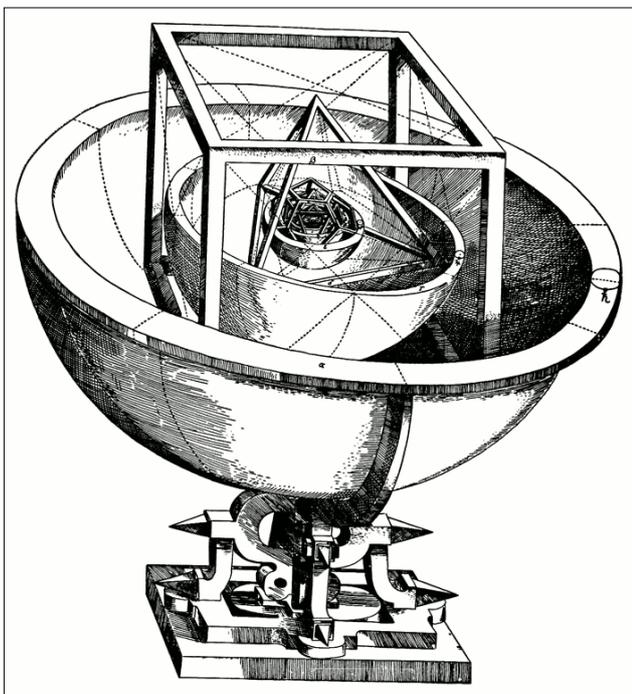

Fig. 6. Kepler's Mysterium Cosmographicum.

The model should have been constructed in a precious goblet by a goldsmith, the planets being represented by gemstones. Kepler travelled to Stuttgart several times with paper models of the celestial goblet. As far as we know, the project was not realized; the design appeared too complicated.

Duke Friedrich I had a vivid interest in Tübingen, where he had studied himself, and in particular in the natural sciences. He allowed Johann, for instance, to buy two globes (a terrestrial and a celestial?) for his studies. He also gave Johann permission to invite all professors for dinner on the feast of Epiphany in 1596. It is tempting to suggest that Ludwig offered the sundial to Prince Johann at this occasion, perhaps also in the presence of Duke Friedrich I and

Kepler. It was indeed a very personal present, bearing the coats of arms of both his parents on the SW-b and SE-b faces. Anyhow, the sundial was appreciated enough to be included in the art cabinet. The present inventory number, KK13, still refers to the *Kunstkammer*.

When Friedrich I died in 1608, he was succeeded by Johann Friedrich. The next year Johann married Barbara Sophia von Brandenburg (1584-1636), daughter of Elector Joachim Friedrich von Brandenburg (1546-1608) and his first wife Princess Katharina von Brandenburg-Küstrin (1549-1602). At that occasion he had Urach castle (40 km SE of Stuttgart) renovated. The Golden Hall is one of the finest renaissance halls in Germany and can still be admired today.[7] Six of their nine children reached adulthood. Johann Friedrich is considered benevolent and peaceful, but a weak monarch who was not up to the problems of his era. He died in 1628. His widow Barbara became governor of their eldest son Eberhard, who was only 14 at the time.

Symbolism of Images and Maxims

Although the individual sundials are, with a single exception, designed correctly, the emphasis in this object is clearly on the allegorical pictures. They can be divided into two programmatic groups. The first one concerns time: the seasons as well as the daytimes, which is of course appropriate for a timekeeper. The second concerns *Bildung*, a concept that can be characterized by education, knowledge and civilization.

The top face of the sundial has no picture, but a recessed compass for orientation, surrounded by sunrays.

The picture program for time

Spring (N-t) is symbolized by a young woman with a floral garland in a garden with flowers and a green hedge. The maxim reads: VERQUE NOVVM STABAT CINCTVM FLORENTE CORONA (The new Spring stood adorned with a flower garland).

Summer (N-b) is depicted as a hunter with a falcon on his arm in a cornfield, with the maxim: STABAT NVDA AESTAS ET SPICEA SERTA GEREBAT (The nude Summer stood with a garment of ripe grain).

Autumn (S-b) is a man picking grapes from two vines, and the maxim: STABAT ET AVTVMNVS CALCATIS SORDIDVS VVIS (There stood Autumn, dripping of crushed grapes).

Winter (S-t) is an old man in an armchair in front of the fireplace, with the maxim: ET GLACIALIS HYEMS CANOS HIRSVTA CAPILLOS (And the icy Winter with grey hair).

Spring and summer are located at the north side, where the sun can reach them in early morning and late afternoon. Autumn and winter are placed at the south side, where they still catch the sun on short days. The maxims are from Ovid's *Metamorphoses*.

The maxims at the daytimes are from various sources.

Morning (E-c) is symbolized by an angel with trumpet, at the left a green tree, and the maxim: AVRORA MVSIS

AMICA (The early hours are the muses' friend). In the <u>afternoon</u> (S-c), a nude boy lies on the grass, next to the vanity symbols skull and hourglass. The fitting maxim is: HODIE MIHI CRAS TIBI (Today me, tomorrow you).

<u>Evening</u> (W-c) is located just opposite morning. Here again is an angel with trumpet, at the right a green tree, and the maxim: NESCIS OVID SERO VESPER FERAT (You do not know what the Evening brings).

The face W-b links to the previous one, showing a landscape with dark green trees and the maxim: TEMPORA LABVNTVR, TACITISQVE SENESCIMVS ANNIS ET FVGIVNT FRAENO NON REMORANTE DIES (The times slip by, unnoticed we age, and the days flee unrestrained).

The picture program for **Bildung**

The birds in the upper triangles are symbolic animals:

<u>Phoenix</u> (SW-t), rising from the flames, is the symbol of eternal youth, immortality and resurrection;

the <u>Crane</u> (SE-t) is the symbol of wisdom, long life and vigilance;

the <u>Stork</u> (NE-t) symbolizes happiness and peace and a long life;

the <u>Cock</u> (NW-t) stands for vigilance and dedication.

The qualities attributed to these birds serve as a homage to the future Duke.

The seven 'liberal arts' that constitute the traditional elements of academic education are depicted on seven faces. The three 'linguistic' subjects forming the *Trivium* are:

<u>Grammar</u> (including linguistics and literature) on the NW-c face, represented by a woman holding a primer, who leads a child by the hand, also with primer. Grammar is addressing the reader in person: GRAMMATICE PVERIS EGO PRIMA ELEMENTA MINISTRO QUEIS SINE MONSTRARI COETERA NVLLA QVEVNT (I, Grammar, provide the child with the principles, without which all the rest cannot be taught);

<u>Dialectics</u> or logic, on the E-t face, as a woman holding a snake, and the maxim: ET FALSI ET VERI BREVITER DIALECTICA MONSTRAT DISCRIMEN: DVBIAE DVXQVE COMESQUE VIAE (Dialectics, mentrix and guide on the uncertain path, quickly shows the difference between right and false);

<u>Rhetoric</u> (including justice and ethics), on the W-t face, as a floating figure with a winged helmet, symbol of the god Hermes, winged feet and a caduceus in the hand. The maxim here goes: RHETORICAE VARIO DELECTAT SPLENDIDA CVLTV ET MENTI ALATIS SVBVLANT ARTEM ODES (The splendid art of Rhetoric brings delight with various decorations, and odes raise from those to whom this art was taught).

The other four faces represent the *Quadrivium*, the scientific subjects:

<u>Arithmetic</u>, on the NE-c face, as a woman holding a blackboard and another one on the floor, with the maxim: TRA-

DIT ARITHMETICE NVMEROS QVI CVNCTA GVBERNANT HAC QVICVNQUE CARET PRINCIPE IS ARTE CARET (Arithmetic gives us the numbers, which govern everything; who does not know her, misses the most important art);

<u>Geometry</u> (including geography), on the SE-c face, as a woman holding a pair of dividers, and the maxim: CVM PELAGO ET TERRAM ET MONTES GEOMETRIA CERTIS DISTINGVIT SPATIIS: PONDERA CVNCTA DOCET (Geometry divides not only the sea, but also the earth and the mountains in accurate distances: she teaches everything important);

<u>Astronomy</u> (including astrology), on the SW-c face, as a woman holding an armillary sphere and at her feet a shepherd's dial, a diptych dial and a quadrant, with the maxim: VRANIE COELI MOTVS SCRVTATVR ET ORBES MVLTIPLICIQVE AVSV TEMPORA FLVXA NOTAT (Astronomy examines the motion of the heavens and the orbits, and in a manifold enterprise she observes the fleeing times);

<u>Music</u>, on the E-b face, as a woman playing the organ, with the maxim: MVSICA MVLTIPLICI MENTES MODVLAMINE MVLCET (Music entertains with multiple, melodious tones).

Finally, the N-c face comprises an appeal to the future Duke. We see Occasio, the Roman goddess of opportunity and the right occasion (formerly the Greek god Kairos), wearing a scarf and holding a knife, her head half bald and the other half with curls, on an eight-spoke wheel of for-
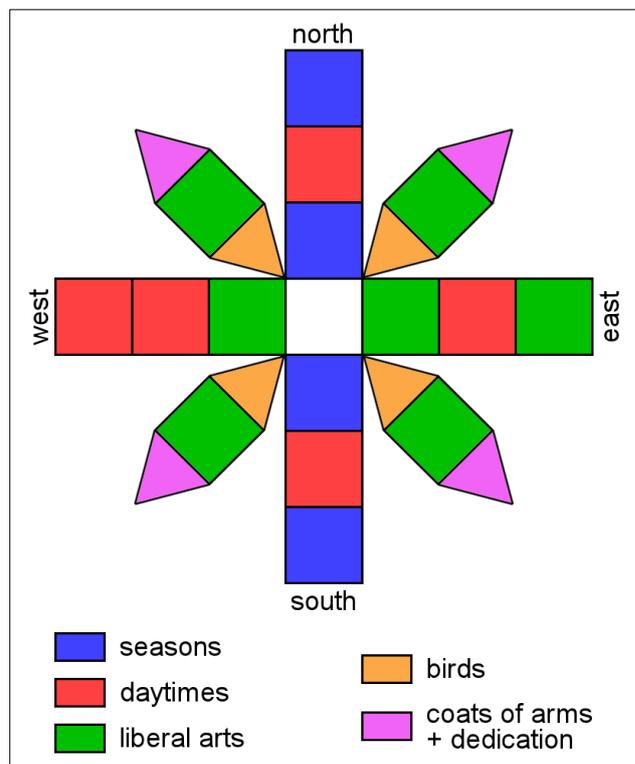

Fig. 7. Unfolding of the sundial in the manner of Schöner (Fig. 2), labelled with the various programmatic groups of allegorical pictures. The top face, centrally located in this diagram, has no picture.

tune, in front of a riverine landscape. The maxim goes: REM TIBI QVAM NOVERIS APTAM DIMITTERE NOLI FRONTE CAPILLATA EST POST HAEC OCCASIO CAL-VA (Do not let go of a favourable opportunity. The curly occasion soon is bald). The North face accentuates this appeal, as it is also sunlit only occasionally. The maxim calls upon Johann Friedrich, when Duke, to use his time and all his talents, gifts and capacities for the well-being of his country. A lower nobleman aged 20 may be allowed such a call to a future Duke aged 14. And that he addresses him already in that capacity, can therefore be readily understood.

The unfolding in Fig. 7 shows the distribution of the programmatic groups of pictures over the faces of the sundial and highlights the symmetry of its design. Created more than four centuries ago by a young man of only 20, it still is a splendid tribute to his creativity and honesty.

REFERENCES

1. F.W. Maes: 'A reconstruction of Ludwig Hohenfeld's 1596 polyhedral sundial', *Bull. BSS,* 23(i), 22-26 (March 2011).
2. K. Eichholz: 'Die Polyeder-Sonennuhr des Ludwig Hohenfeld von 1596', *Jahresschrift der DGC* 49, 169-186 (2010).
3. Cf. *http://www.wasserschloss-aistersheim.at/*.
4. A. Schöner: *Gnomomice. Hoc est: De Descriptionibvs Horologiorvm Sciotericorvm Omnis Generis*. Joannem Montanum & Ulricum Neuberum, Nürnberg (1562).
5. H. Schröder (Ed.): *Kunst im Alten Schloß: Württembergisches Landesmuseum Stuttgart*. Theiss, Stuttgart, 97 (1998).
6. Cf. *http://de.wikipedia.org/wiki/ Liste_der_Herrscher_von_Württemberg*.
7. Cf. *http://www.schloss-urach.de/*.

KEichholz@t-online.de

Klaus Eichholz (Castrop-Rauxel, 1938) lives in Bochum (Germany). He was a Mine Surveyor and did a doctorate on a north-seeking surveying gyro. The further development, the Gyromat, was used in the Channel Tunnel. He is a member of the German, Austrian, Dutch, British and North-American Sundial Societies. His main interests in sun dialing are the history of sundials and their theoretical aspects.

Postcard Potpourri 19
Corhampton, Hampshire

Peter Ransom

This (undated, presumed before 1930) postcard features one of the earliest dials in the UK. It is the Saxon dial on Corhampton Church in Hampshire and is one of four similar dials in the area. It is a vertical south dial on a slab that is 56 cm high by 50 cm wide. The diameter of the outer circle is 28 cm.

I have often wondered if this was the product of someone who spotted a market for sundials and operated a sundial-making business in the area. All four dials in Hampshire (within a day's walking distance of Corhampton) show similar features based on the octaval (or canonical) system that divides the day into eight periods. The lines on the dial mark the mid-point of each tide, so the vertical line, indicating noon in our time system, marks the mid-point of the noon-tide (or mid-dæg).

The other Saxon dials in Hampshire can be found at Warnford (on Our Lady's Church), Winchester (St Michael's Church) and Hannington (All Saints' Church).

pransom@btinternet.com

FOUR HORIZONTAL SUNDIALS IN SCHOOLS OF VOLOS, ALONNISOS AND STEFANOVIKI

D. BLATSIS, E. THEODOSSIOU & V.N. MANIMANIS

Ancient sundials were an attempt to measure true solar time; they had many different forms and were beautifully made. They have been found in various locations in Athens, Philippoi, Rome and several other cities and regions of the ancient world.[1]

Modern sundials can show the solar time with one-minute precision. The main sundial types are the vertical, the horizontal and the equatorial ones. In the present paper we will briefly mention the structure and the operation of a horizontal sundial and expose our experience from the construction of four such sundials.

The main parts of a horizontal sundial are the hour plate, the gnomon and the corrections. The hour plate is usually made of white marble, upon which the hour lines are carved; in addition, lines for semi-hours, quarters of an hour or even 5-min lines can be carved. The gnomon is usually made of metal; it is set at an angle (φ) to the horizontal plane, equal to the latitude of the location where the sundial will be placed.

The corrections that depend on the date are given in the form of a diagram or of a table, into which the 'Equation of time' corrections and those due to the longitude of the place are presented. These corrections convert the true solar time of the place to the corresponding civil time. The orientation of the horizontal sundial is such that the gnomon's tip points towards the North Celestial Pole.[2]

Fig. 1. The horizontal sundial in the schoolyard of the 1st Lyceum of Volos.

The Construction Of Four School Horizontal Sundials

Over a period of 13 years four horizontal sundials were constructed; one in the 1st Lyceum of the city of Volos, one in the Lyceum of the Alonnisos Island, one in the Gymnasium (High School) of the Stefanoviki village and one in the 1st Professional Lyceum of Volos. The sundials were placed in the yards of these secondary education schools and they have decorated them since then. The geographical latitudes and longitudes were first determined by GPS device and the readings were subsequently checked against *Google Earth*®.

The beginning was in 1995, when the first horizontal sundial was constructed in the yard of the 1st General and Technical Lyceum of the city of Volos. Here all the know-how that could be retrieved from the relative bibliography was needed and the school's mathematician Dimitris Blatsìs, who headed the whole construction, used a number of books[1-5] as well as relevant issues of the *BSS Bulletin* he was given by our research group. This way the necessary knowledge was acquired; in parallel, in the study, the calculations and the construction of all four horizontal sundials were involved some of the members of the 'Astronomy and Space Society' of Volos, which is the second oldest amateur astronomical society established in Greece, in 1990.

1. In The 1st Lyceum of Volos

For a first attempt, this construction proved to operate quite well. The horizontal sundial was placed on a pedestal with a coating of marble and with a gnomon made of reinforced aluminum. On the marble of the pedestal various other pieces of information were carved (Kepler's Laws etc.) by a local marble-carver, together with the corrections that convert the true solar time to mean solar time and to civil time were carved for ten-day intervals.

However, the ten-day interval corrections created, for certain parts of the year when the equation of time changes particularly fast (for example in December), minor deviations from the correct time.

The schoolchildren that participated in the sundial's construction showed a great interest in the sundial of their schoolyard: they were interested in how one reads and understands the solar time and after some dedicated lessons they also learned the correct operation of a sundial.

2. In the Lyceum of the Alonnisos Island

The second sundial was constructed and placed in the Lyceum's schoolyard of the Alonnisos island in the year 1999. The children of the Lyceum showed enthusiasm and particular interest; they wanted to know how it works and the stages of its construction. Moreover, they participated actively and decisively in all the stages of its construction.
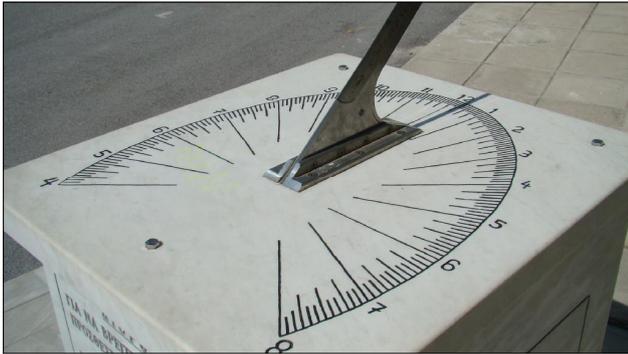
Fig. 2. The hour plate of the horizontal sundial in the schoolyard of the 1ˢᵗ Lyceum of Volos.

Fig. 3. The horizontal sundial in the schoolyard of the Lyceum of Alonnisos.

The marble sides of the pedestal where the sundial was fixed were carved by the same Volos marble-carver with schematic representations of the Solar System, of where the gnomon points towards and, in a scale of 1:63,000, with a map of the island complex that is the 'Sea Park of Alonnisos - Northern Sporades' – the last refuge in the Mediterranean for the endangered seal species *Monachus monachus*.

For the Alonnisos horizontal sundial, the corrections were carved at six-day intervals for better precision. Indeed, the precision of this horizontal sundial is almost 1 minute, while the aesthetic result remains satisfactory.

3. In the Stefanoviki High School

In 2005 the third horizontal sundial was constructed. This time it was in the High School of a village, Stefanoviki, and the experience gained from the construction of the two previous sundials was evident.

The new element in this sundial is that there is no double table of corrections as in the two previous cases, but instead a curve of the equation of time, upon which the corrections due to the place's longitude have been incorporated. Before this curve was carved on the sundial's pedestal, it was discussed in the high school's classes in order to determine to what extent the students could find the correct time from the specific curve and the corresponding correction, and how successful they were in making the interpolations.

The accuracy of this sundial is impressive, while the aesthetic result is equally good.

4. In the 1ˢᵗ Professional Volos Lyceum

The final horizontal sundial was constructed in the yard of 1ˢᵗ Professional Volos Lyceum in 2008. The construction of this sundial was included in the European Program 'Daedalus' of the National Youth Foundation. Both the design and the construction were done almost totally by the students of the Lyceum, who were delighted by this project. This Lyceum is 'professional' in the sense of 'technical', so that its students possess technical knowledge and abilities. Therefore, students and technicians from different branches undertook the whole construction.

The diagram of the equation of time, which requires precision, was produced with a computer by students of the CNC department. The students calculated the corrections of the equation of time using an *Excel*® worksheet with the following formulae and definitions:

$$d = K + 0.5$$

where K is the number of the day in the year, i.e. $K = 0$ for January 1, $K = 1$ for Jan 2, $K = 364$ for Dec 31.

$$L = (279.58 + 0.985647\,d) \times 0.017453$$
$$A = -4.7\sin L + 596.2\sin 2L + 4.3\sin 3L - 12.75\sin 4L$$
$$B = -29.3\cos L - 2\cos 2L + 19.3\cos 3L$$

We find

$$c = A + B \text{ and } \varepsilon = (A + B)/60 \text{ in minutes of time.}$$

Finally the total correction is $\Delta = [(l - n) - \varepsilon]$ where:

$$l = (-\text{ longitude}) \times 4 \ (\text{mins})$$
$$n = -\ (\text{number of time zone}) \times 60 \ (\text{mins})$$

The students calculated the curve of the equation of time with the longitudinal corrections for civil time and also designed the metal gnomon, which they constructed themselves. Additionally, they drew the Solar System and a drawing that presents the way a sundial operates.

Fig. 4 & 5. The sundial of the Stefanoviki High School with the carved of the Equation of Time on the eastern side and a diagram of the solar system on the west.

Fig. 6. The horizontal sundial in the schoolyard of the 1st 'Professional' Lyceum of Volos.

Other students, from the 'building works' department, took over the setting up of the pedestal, the attachment of the marble and the correct orientation of the hour plate, upon which the gnomon had already been attached.

All the marble carvings were done with an electronic pantograph and the gnomon was made from stainless steel in the machine shop with the use of a laser. The final result as a whole was judged as excellent by the teachers of the schools and by the parents of the students. The previous experience clearly helped a lot; also, the use of modern technology and materials and the computer-assisted design.

CONCLUSIONS

The students who worked in this project are proud for their sundials, while the other students welcomed their construction with warm feelings. It is their own perfect and fully operational construction, which at the same time serves a decorative purpose for their schools and sets them apart as equipped with something original, while it is a living proof of the potential teenager students can tap if they have the proper motives and guidance. These four horizontal sundials were an excellent means for the students to understand how modern technology can be used together with some facets of traditional or 'old' science to produce something original and blameless.

REFERENCES

1. S.L. Gibbs: *Greek and Roman Sundials*, Yale University Press, New Haven London, (1976).
2. E. Theodossiou & E. Danezis: *Measuring the Timeless Time – Time in Astronomy*, Diavlos Athens, (1994).
3. P. Hood: *How Time is Measured*, 2nd Ed. OUP (1969).
4. R.J. Rohr: *Les Cadrans Solaires*, Gauthier-Villars editeur. Paris (1965).
5. A.E. Waugh: *Sundials: Their theory and construction*, Dover, New York (1973).

Authors' address:
Department of Astrophysics-Astronomy and Mechanics,
Faculty of Physics, National and Kapodistrian University
of Athens, Panepistimiopolis, Zographos 157 84, GREECE.
blatan2010@hotmail.com and etheodos@phys.uoa.gr

A SUN SIMULATOR FOR MOYSE'S HALL MUSEUM, BURY ST EDMUNDS

MIKE COWHAM

Moyse's Hall Museum is currently presenting an exhibition, 'Keeping Time', showing clocks and sundials, mainly from the Frederick Gersholm-Parkingtom Collection. These items were previously housed in The Manor House Museum until its closure about three years ago. The exhibition will run until summer 2011.

To go with the exhibition, I decided that what we needed was a Sun Simulator so that children (of all ages) could use it to see how sundials will operate, with the duration of daylight speeded up to about one minute.

To do this I placed a light on the end of an arm, to simulate the Sun, and made this 'orbit' above a table. In fact, I did not just use one light but three, one each for Summer Solstice, Spring/Autumn (Equinox) and Winter Solstice, at 23½° spacing. The arm was originally going to be manually moved but this posed many problems so I decided to use a

Fig. 1. The Sun Simulator with the summer lamp illuminated at 2:50 pm.
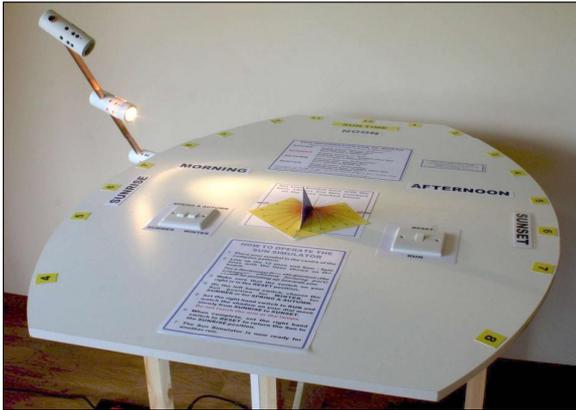
Fig 2. The Sun Simulator in its Equinox mode. At 7:30 am the Winter lamp is still below the horizon.

Fig 4. The drive motor and pulleys.

motorised system. For this, I found a very old windscreen wiper motor from a car that would run at about 12 volts. Even with the worm gearing, it was still much too fast so a 20:1 reduction was achieved by using wooden pulleys driven by rubber 'O' rings. When driven at about 3 volts, the arm would cross from East to West in about one minute, and with 15 volts applied, in reverse, it would return to its starting point in about 10 seconds.

Each of the lights may be individually switched, so the user may choose which season to use for the dial under examination. It turned out that the Summer light gave much better illumination than the other two, so it will probably get the most use.

Design

The axis of the Simulator is set to simulate the latitude of Bury of approximately 52°. The three lamps, each 20 watt low voltage halogen, are placed on an arm at 14.5°, 38° and 61.5° angles from the dial position on the table. Around the edge of the table are placed the approximate times represented by the arm as it slowly moves from East through South to West.

The table had to fit into an alcove so that it was only accessible from one side. To protect the delicate arm and mechanism this meant putting the south side into the alcove. Unfortunately, this means that vertical dials will be the wrong

way round for observation of their gnomon shadows. However, as such dials are not so common in portable form, this did not seem too much of a setback.

Visitors to the Museum are being encouraged to 'Make a Sundial' from several card kits that are available, and once made, the dial can be placed exactly in the centre of the table and be tested.

Controls are basic, just using standard type light switches. On the right is a simple **RUN** and **RESET** switch. At the end of each operation movement limiting microswitches turn off the motor and lamps until the next activation of this switch.

On the left is a dual switch for controlling the lights labelled **SPRING & AUTUMN**, with both switches up and **SUMMER** and **WINTER** with individual switches down.

The windscreen wiper motor with its worm drive was a good choice as it will function well over a wide range of voltages. When it operates, it is virtually unstoppable, even when driven at 3 volts. To prevent possible injury, or other damage, to anyone getting in the way of the arm, the belts are designed to slip on the pulleys. Double belts were used to give a good transfer of power and two spare belts were placed in position in case they need to be replaced during the Exhibition.

Fig. 3 shows the basic arrangement of the various arms, each made from 12 mm copper water pipe.

Fig. 4 shows the motor, pulleys, main shaft and the radial arm, stationary at the evening position. The pulleys and even the bearings are made from wood but at the slow speed that it operates, this will be quite satisfactory. To the right of the picture is a counterbalance weight so that a minimum of power is required to operate the system. It is made from a convenient piece of steel of about 1.2 kg and just hangs on the shaft. All cables to the lights run safely inside the copper tubing. It was particularly difficult to thread the cables (three twin) through, especially as the 90° pipe corners were quite sharp.
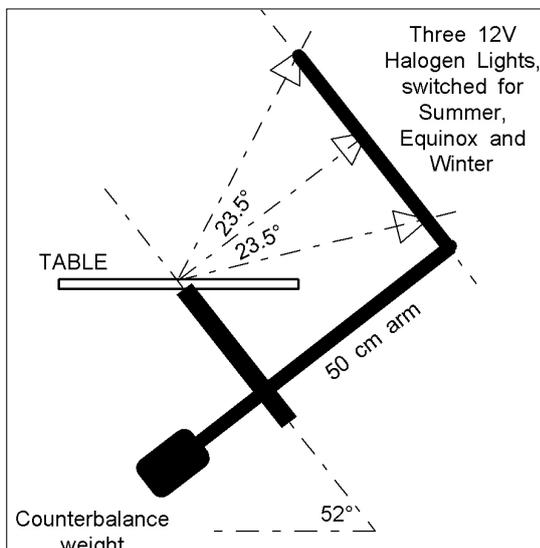

Fig 3. The basic arm and lamp arrangement.

ENGLISH SCRATCH (MASS) DIALS:
The Ravages of Time Revisited

CHRIS H. K. WILLIAMS

The original article[1] presented the first quantified demonstration of the sheer scale of the twin reapers – rebuilding and weathering. Recognition that the vast majority of dials have already been lost lies at the heart of all our analysis. It is not too much of an exaggeration to say that a true understanding of the mass dial era comes not so much from directly examining survivals *per se*, but from appreciating what has been lost. Whilst we have made enormous progress, the full potential informational content of the original dial loss estimates remains to be extracted. Now that the age structure of surviving dials is coming into focus[2] we can do so. By integrating dial loss with dial age, previous insights can be restated with both greater precision and in more detail.

The original article derived two estimates of dial loss. First, the total (rebuilding and weathering combined) rate of loss experienced in the twentieth century, as revealed by formerly-listed dials now lost. Secondly, the impact of rebuilding, measured by the number of dials lost to rebuilding relative to those surviving, as revealed by a probabilistic analysis of dials that have obviously been moved – rotated or relocated. Although each is an invaluable probe into the actual dial loss suffered, making full use of the estimates has hitherto been hampered by not knowing either the age of dials or the interaction between age and the rate of loss. Accordingly, it has been necessary to adopt some broadbrush interpretations, inevitably involving the use of ranges, see Fig. 1. Whilst, on the face of it, these might appear disconcertingly large, they are, as evidenced by previous articles, sufficiently precise to illuminate areas previously in complete darkness. In particular, scratch dials were universal: all churches once had them, with dial redundancy causing most to have multiple dials – the 1650 average being between two and three dials per church.

But we now have, through the analysis of different types of dial, some indication of the age structure of dials (note 2). Pre- and post-1500 dial types is a strong age clue; and differential post-1650 dial loss by type is a strong clue of the relationship between loss and age. These initial indications can, within the context of the life cycle model (LCM),[3] be extended to unravel the complete age structure in detail, see Fig. 2. In fact it is possible, by iteration, to simultaneously estimate the dial age and loss structures that best fit the underlying data – some 5,000 listed/recorded dials – Fig. 3.

The revised loss estimates are shown in Fig. 4. There can be no doubting we now have a far superior and precise comprehension compared to that shown in Fig. 1. In turn the 1650 dial prevalence can also be stated more precisely – an average of 2.8 per church. Whilst, compared to the earlier range, this does not revolutionise opinion, it shows clearly where the true balance of evidence points. In the light of Fig. 4 various considerations merit revisiting.

Firstly, we now intimately understand the dynamics of past dial loss. The loss attributable to rebuilding averages 0.14% pa. Was it unchanging over the centuries? Of course not, but it is only possible to estimate as an average. Any cycling around the mean in no way detracts from rebuilding's cumulative impact. Turning to loss attributable to weathering, the inexorable and progressively accumulating impact of dial age is most striking. Shortly after the Great Norman Rebuilding, when all dials were more or less new, loss was
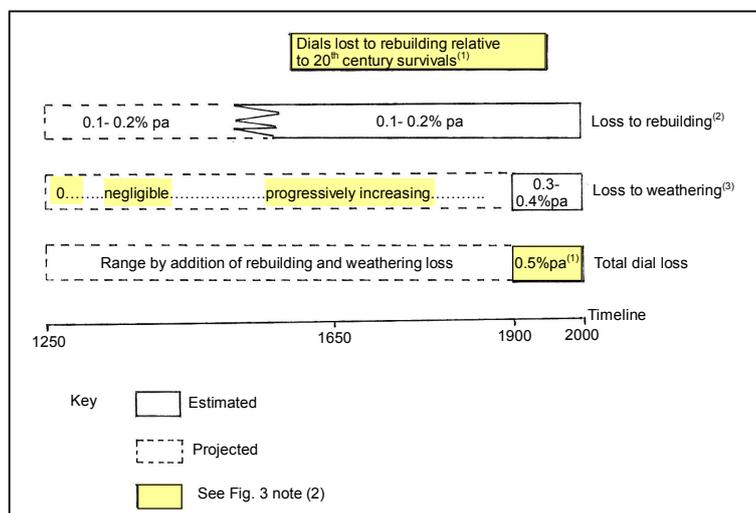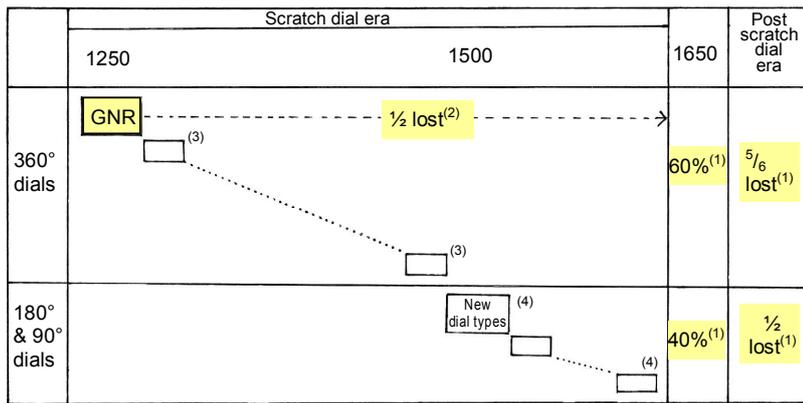

Fig. 1. Interpreting dial loss when dial age was unknown.

Notes:
(1) Original 'Ravages of Time' estimates. (See main text).
(2) The % pa range reflects an assumed dial age range sufficiently wide to definitely straddle the (then unknown) actual. The jagged line represents (the former) uncertainty as to the time period to which the estimate pertains. Evidence, visual and documentary, of church rebuilding and repairs does not suggest dial loss would have been lower in the pre-estimate period.
(3) Twentieth century weathering loss is the actual total loss of (1) less the rebuilding estimate of (2). Earlier weathering is assumed to have been zero at the time of the Great Norman Rebuilding (when virtually every church would have had a new dial), and then to have progressively increased to the twentieth century level.
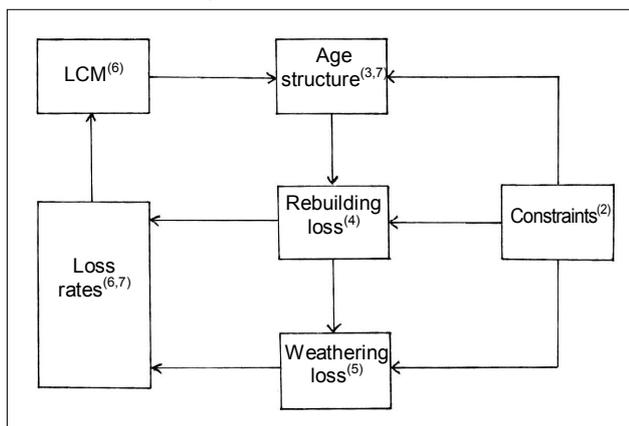
Fig. 2. Schematic life cycle model illustration of the age structure of dials.

Notes:

(1) Elements estimated in the analysis of dial type age ranking and the dating of the use of 360° dials. (See main note 2).

(2) The Great Norman Rebuilding (GNR) resulted in a new dial at each church. As their age and elapsed time to 1650 is much the same as that for post-1500 dial types to the twentieth century, both must have experienced a similar dial loss – each was equally exposed to the ravages of time.

(3) Post GNR cohorts of 360° dials determined by loss and redundancy.

(4) Adoption cohort of 180°/90° dials at churches where scratch dials were not yet displaced; plus post adoption cohorts determined by loss, redundancy and displacement. (Although we have yet to rigorously examine the displacement of scratch dials, given it was completed by 1650 and in large part occurred post-1500, uncertainty as to its exact profile has a damped and muted impact on dial age).
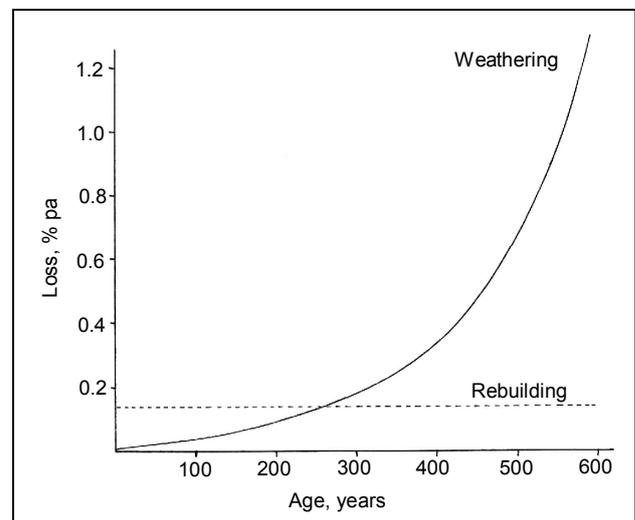

Fig. 3. Logic flow of loss estimates derived by iteration.

Notes:

(1) An iterative solution, one arrived at via successive sequential approximations, is technically possible when there is a permissible mix of sufficient datum points and constraints.

(2) The constraints, conditions the solution must satisfy, are those elements yellow highlighted in Figs. 1 & 2. They represent key conclusions derived from the database of 5,000 dials and LCM.

(3) Fig. 2 illustrates the components specifying the age structure of dials. Starting component values are consistent with the dial loss in Fig. 1. The first approximation of the average dial age profile through time is made.

(4) The twentieth century element of (3) and the original impact of rebuilding estimate (Fig. 1 note 1) permits the first approximation of the % pa rebuilding loss.

(5) Given (4) the total loss constraints (in Fig. 2) can be apportioned between rebuilding and weathering. The latter permits the first approximation of the % pa weathering loss (against dial age) profile. An exponential relationship best fits the data.

(6) The first iterative loop has been completed. The % pa loss rates of (4) and (5) are fed back into the LCM, a revised age structure calculated, and a second iteration undertaken.

(7) Successive iterative loops are made until the age and loss profiles no longer change. (See Fig. 4). Mathematically, the solution is stable and convergent.

Fig. 4. Dial loss revisited in the light of dial age.

Notes:

(1) Calculated as outlined in Fig. 3.

(2) The loss rates are those of the benchmark grouping, a quarter of all counties. For discussion of other counties see main text. For the grouping of counties by scale of post-1650 dial loss see main note 5.

overwhelmingly due to rebuilding. It is not until dials are about 250 years old that the annual rates of loss equate. So it is not until well into the post-scratch-dial era that weathering comes to dominate.[4] By the twentieth century it did so by two to one. There can be no escape; weathering will, inexorably, destroy dials at an increasing rate.

Secondly, we now have a context in which to judge the regional variation in the frequency of surviving dials. Our

current epoch, in which the average dial age is around 450 years, is exactly when weathering really begins to bite. Were the Fig. 4 weathering curve, (which refers to the benchmark counties), to be delayed or advanced because of the differing characteristics of local building stone and/or the weather, the resulting spread in surviving dial frequency would be wide. This is of course exactly what we see with the regional watershed and concentration of hot and cold clusters in dial listings.[5] So although we await a systematic scientific technical investigation of regional variability in the 'susceptibility to weathering', the variability of dial survival is not of itself, from a purely numerical perspective, surprising. It's merely a reflection of the nature of the age-weathering relationship and the epoch we now live in:

were the clock to be wound back in time, a progressively narrowing regional variation would be observed.[6]

Thirdly, we now have a firmer and richer basis for determining the true context of surviving evidence; and, just as, if not more importantly, the significance of that we do not have. We have previously (note 2) seen that 360° dials, a minority of the surviving total, constituted the vast majority of those originally made. It is an ironic fact that, although scratch dials are quite correctly and generically viewed as a medieval artefact, most survivals are post medieval. Approaching 600 years of age is well nigh terminal for a scratch dial; by then the annual loss rates of Fig. 4 would have culled them all – any survival would not only be exceptional but have required a 'sheltered life' to escape the odds. It follows that surviving 360° dials are primarily fifteenth century rather than earlier;[7] thereby further compounding the irony in that even the minority of genuinely medieval survivals are in fact rather late examples thereof.[8] Fig. 4 brings home to us the extent of what has not survived: its limit demonstrates there is a past point in time before which loss is absolute. What then of our natural demand and requirement for ocular evidence? Surely we must recognise there is a point where it is not a question of zero evidence, but that there can be no such evidence! How should we then progress? Any normal reliance on ocular artefactual evidence has but one outcome – silence! Enlightenment can then only be sought through alternative types of evidence and dimensions of context. Such considerations have not intruded upon the deliberations of former mass and scratch dial students.[9]

Finally, it is not only the past that is now laid bare, but also the future. It paints a sad and salutary foretaste of time's all conquering powers! Fig. 4 heralds weathering will unrelentingly intensify. Dials will be lost at an increasing rate: the proportion of dials in poor condition, now around a third, will progressively increase; and surviving dials will become increasingly regionally concentrated. Around 2200 scratch dials will have all but disappeared; but the last surviving dials will all be in a poor condition well before then!

Should this concern us? In a sense it is no different from what has been happening for centuries! The real difference now is that these will be the last dials. Does that matter? Fortunately, due to the Herculean labours of the Mass Dial Group, our recordings are the envy of the world. Even so, is not something real still being lost? Are a selection of specimens worthy of conservation? Is any such conservation either feasible or practical? We are one of the very last generations of antiquarians that will have the luxury of contemplating such questions! Scratch dials are approaching the bell for their last lap. It will then be too late.

REFERENCES & NOTES

1. Chris H. K. Williams: 'English Scratch (Mass) Dials: The Ravages of Time', *Bull. BSS,* 20(iii), 110-111, (2008).
2. Chris H. K. Williams: 'The Evolution of English Mass & Scratch Dials c.1250 – c.1650, Part 2. Age Ranking Dials by Type', *Bull. BSS,* 22(iv), 42-44, (2010).
3. See Chris H. K. Williams: 'The Life Cycle of English Scratch (Mass) Dials' & 'The English Scratch & Mass Dial Era: The Evidential Period c.1250 to c.1650', *Bull. BSS,* 20(iv) & 21(iv), 164-5 & 18-19, (2008) & (2009).
4. Average dial age increased at a discount relative to elapsed time because of redundancy (creating new dials) and weathering (culling the oldest) – both reduce average age. Typically average dial age increases by around 7 years per elapsed decade.
5. See Chris H. K. Williams: 'The Prevalence of English Scratch (Mass) Dials c.1650 – Part 2', *Bull. BSS,* 21(iii), 34-5, (2009).
6. Some of the county spread in dial survival is because of a differential rebuilding impact – for example endemic urban growth (especially in London and Middlesex) and the severity of Victorian restoration – but coherent data beyond the anecdotal is hard to come by. Nevertheless, given the current epoch's considerable excess of weathering over rebuilding loss, combined with the strong *a priori* expectation large 'susceptibility to weathering' differences exist, it is indisputable most dial survival variability can be laid at the weathering door.
7. It should, for the avoidance of doubt, be understood this is a statement grounded in statistical probability. Were we to be presented with a fourteenth and a fifteenth century dial, it would not be possible to distinguish one from the other visually.
8. It is almost an instinctive human trait to presuppose artefacts are either older, or early examples more numerous, than is in fact the case. Contagion is not artefact specific, being also very evident with furniture and houses (see for example S. Pearson: *'The Medieval Houses of Kent',* RCHME & HMSO, (1994)). Serious scholarship almost always exposes conventional dating wisdom to have erred on the 'too early' side.
9. For an initial exploration and discussion of such issues see Chris H. K. Williams: 'The English Scratch & Mass Dial Era: Origins to c. 1250', *Bull. BSS,* 22(i), 14-17, (2010). (Some may wonder, given the possibility of archaeological finds, how we can be categorical early evidence does not exist. Realistically any yet to be archaeologically retrieved scratch dial evidence is likely to be fragmentary with problematic dating, and definitely rare: It will never, of itself, be sufficient to be incontrovertible).

chkwilliams@googlemail.com

Chris Williams has very wide ranging dialling and horological interests with a particular fondness for all aspects of the history of timekeeping in Kent and Wales. His research specialises in applying economic, statistical and mathematical techniques to interpreting dialling/horological artefacts and documentary sources. Projects include domestic clock, watch and turret clock markets of the seventeenth/ early eighteenth centuries, and Saxon/medieval mass and scratch dials. He is a regular contributor to the *BSS Bulletin* and to *Antiquarian Horology*.

SUNDIAL EPHEMERA – CRESTED 'GOSS' CHINA SUNDIALS

CHRISTOPHER DANIEL

Goss china takes its name from the Stoke-upon-Trent pottery business of William Henry Goss (1833-1906), established in 1858. In the 1880s, he became famous for producing small white-glazed ornaments, decorated with the heraldic arms of cities and towns, in different localities around Britain, which were collected by visitors as mementos. So popular did these become in late Victorian and early Edwardian times that a *League of Goss Collectors* was founded in 1906, which became the *International League* in 1918. Following his death in 1906, three of William's sons continued the business until it was taken over in 1929, when other factories continued production. In the late 1960s *Gossware* became very collectable and in 1970 the modern *Goss & Crested China Club* was founded, based in Horndean, Hampshire.

The Goss range of ornaments comprised over 2,500 different miniature models of almost anything imaginable, from little scenic country cottages, pots and plates, animals and birds, and, last but not least, long-case clocks and sundials. Over the years, since the early 1980s, the illustrated collection of fourteen miniature crested sundial ornaments has gradually been accumulated; but this is the first occasion on which the collection has been published. The following fourteen cities and towns are represented:

City of Hereford	City of Leeds
City of Liverpool (gnomon: 45°)	Bedford (gnomon: 35°)
Chapeltown (Sheffield?)	Colchester
Dunoon (Strathclyde) (gnomon: 50°)	
Dymchurch	Leicester
Littlehampton (gnomon: 30°)	Luton
Minehead	Swange (S. Dorset)
Woolwich	

All the sundials are of the common horizontal kind, varying in size from approximately 3 inches (77 mm) in height and an inch and a half (38 mm) in width (Woolwich), to 5 inches (127 mm) in height and 2 inches (50 mm) in width (City of Liverpool). They are all quite colourful in depicting the coats-of arms of the places they represent, six of which bear popular mottoes. The two largest, both dated MDCCXCIII (1793), suggest that an attempt was made to delineate them properly, with the 6 o'clock and 12 o'clock hour-lines more or less in the correct position, within an oval-shaped hour-ring. There is also an inner ring, indicating half-hours and quarter-hours, making the dial-plate very crowded. Furthermore, the morning hours are on the east side of the plate and the afternoon hours on the west!

Perhaps the most attractive dial in the collection is the Bedford sundial (below left), which at least looks as if it is well delineated. However, it suffers from the same defect as those just mentioned before, in that the morning hours are on the east of the dial-plate and the afternoon hours are on the west. At least these dials might actually work in Australia, or elsewhere in the Southern Hemisphere! Also, the gnomon has an angle of just 35° to the horizontal. Nevertheless, as sundial ornaments, which were not seriously intended to indicate the time, they are relatively rare albeit attractive treasures from the past.

DIAL DEALINGS 2010

MIKE COWHAM

The market for antiques is still rather depressed. As is usual at times of recession, it is only the very best items that really score with people who are hoping to beat inflation and retain the cash value of their hard earned money.

There seem to be just two auction houses who are selling instruments regularly, Bonhams and Charles Miller. They have both had some interesting items this last year. Here is my selection, in sale date order, with prices quoted including commission but excluding VAT.

21 April - Bonhams

There were several dials in this sale and four, in particular, attracted my attention.

Fig. 1. Oval 'Butterfield' dial with an unusual compass needle lifting lever next to the compass bowl.

The first was an oval Butterfield dial signed "*Le Febvre A Paris*" (Fig. 1). It is a fairly standard version of these dials but with an unusual feature; a lifting device for the compass needle, operated from a small lever next to the compass bowl. I have never seen this before on a Butterfield type dial and there was some discussion about it being original. However, the dial made a healthy £4800.

A brass French inclining dial (Fig. 2) by Jacques Le Maire showed another unusual feature, again not seen before. It was a string gnomon dial – but in this case the dial had two string gnomons, one each for morning hours and the other for afternoon. This feature allows the dial scales along the north side to overlap and in effect, nearly doubles the size of the dial. Its latitude support arm was calibrated with a vernier scale so that it could be read to ten arc-minutes of latitude. Bidding for this was strong and it made £12,000, a little above its £1,200 - £1,800 estimate!

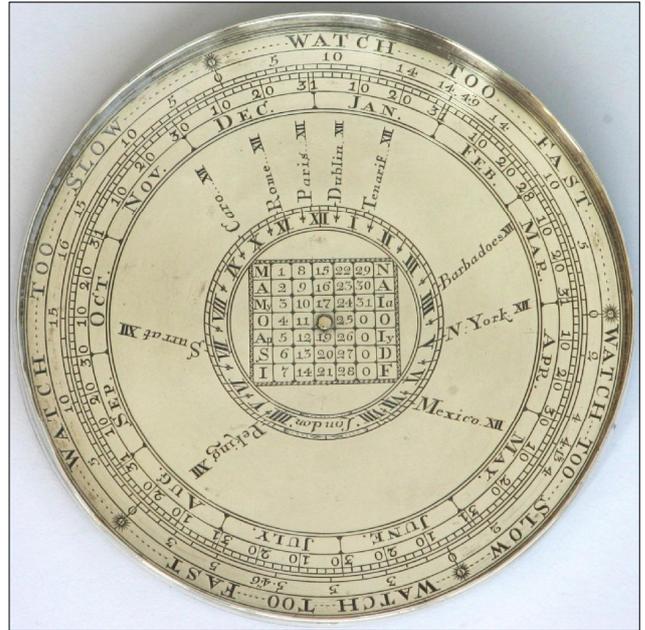*Fig. 2. Double inclining dial by Jacques Le Maire.*

The following lot is my *dial of the year* (Figs. 3-6 and front cover). It is a wonderful silver compass dial with gilt gnomon made by Richard Glynne, c.1710. It is quite large, 10 cm diameter, so quite an object for the pocket. Its most splendid feature is its gilt gnomon featuring a pelican (or an eagle) holding an arrow in its bill. Inside its lid is a perpetual calendar, a dummy dial for London showing ten places around the world where it is midday, and a detailed Equation of Time scale for each two days of the year. Its fine silver case is protected from scratching on the top and bottom by substantial red leather pads. The compass bowl is finely decorated with dragon heads in its engraving. This dial was estimated at £15,000 - £20,000 but it sold for £31,200.

Fig. 3. Silver compass dial by Richard Glynne.

Fig. 4. Leather pads for protection of the Glynne dial.
Fig. 5 (right). Engraving inside the lid of the Glynne dial.
Fig. 6 (below). Decoration of the compass bowl with a dragon at its centre, also repeated at the base of the four pointers for the cardinal directions.

I am including a later lot, "*Cadran solaire universal de M de Peyronny Par Henri Robert horologer a Paris*" because of its unusual design (Fig. 7). It is basically a dial using the de Rojas projection. In use, the central disc is turned to the correct latitude on the outer ring and the Sun's altitude is measured using the shadow from a pin gnomon set at its
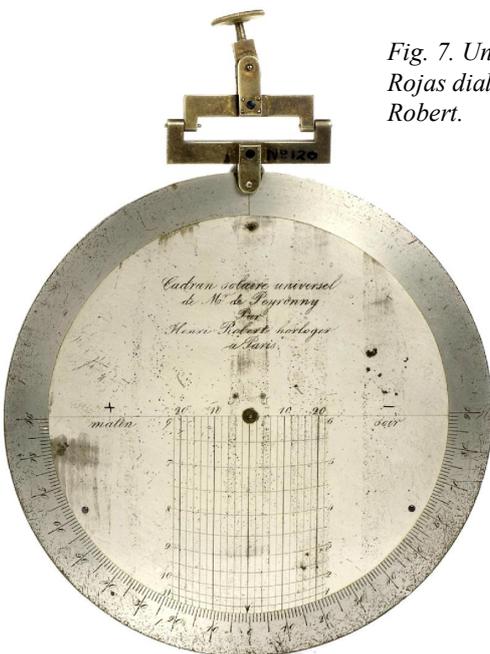
centre. The time is then read from where the shadow crosses the appropriate declination line.[1] It sold for £2,400.

28 April - Charles Miller
One item that took my fancy was a small ivory pillar dial (Fig. 8). It was just 10 cm high and was said by the auctioneers to be 'possibly Dieppe', but was almost certainly French. It was sold for £1920.

11 May 2010 – Bonhams (The John Reed Collection of Fine Japanese Timekeepers)
This sale, basically of clocks, included about 25 Japanese sundials, mostly portable ones. Of these I have picked two to describe. The first was a scaphe dial, late 18th century, quite large at 28 cm long and carved from moonstone (Fig. 9). Note the pair of cranes engraved around the compass bowl. It sold for £1,920.

Fig. 7. Universal de Rojas dial by Henri Robert.

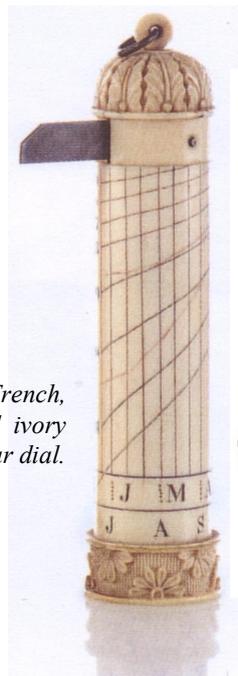*Fig. 8. French, carved ivory pillar dial.*

Fig. 9. Japanese moonstone scaphe dial.

Fig. 10. Japanese compendium with compass, sundial and various calendar tables.

The second item illustrated is an 18th century compendium (Fig. 10) signed by its designer Narinao (or Shigenao) and its maker Jinto (or Chinto). It contains a compass and a sundial plus six other volvelles showing phases of the moon, tides, astrological information and a horticultural calendar. When assembled it stands 7.5 cm high. It sold for £6,000.

27 October - Charles Miller

A very interesting plane table compass, by "*Walter Hayes in Moore fields Londini · 1664 ·* " was offered (Fig. 11). Although primarily used for surveying, this design also tells the time from the position of the compass needle when the case is lined up with the Sun. It is a type of magnetic

Fig. 11. Plane table compass combined with a magnetic azimuth dial, signed by Walter Hayes.

azimuth dial, operating in a similar way to those made in Dieppe around 1660. What is particularly interesting is the fact that the printing plate for the paper scale was actually engraved by Henry Sutton (dated 1653) and this plate was later re-used by Hayes after Sutton retired.[2] This may be seen by slight traces of Sutton's signature below that of Hayes. In spite of its broken glass cover it sold for £1,200.

Also in the sale was a dipleidoscope with its cover inscribed "*E I DENT'S PATENT MERIDIAN INSTRUMENT, 82 Strand & 33 Cockspur St. LONDON*" (Fig. 12). It sold for £384.

Fig. 12. Dipleidoscope by Dent.

Fig. 13. Ivory and silver compass dial by Elias Allen.

3 November - Bonhams

The dial of interest in this sale was a round ivory and silver compass dial signed "*Elias Allen fecit*" (Fig. 13). Its most attractive feature was the print used for its compass. This was marked with the initials "R G" which were probably those of his apprentice Ralph Greatorex who worked with him around 1639.[3] Its ivory case was quite dirty and had a small section of its rim missing. In spite of this the dial made £5,520, substantially more than its top estimate of £2000.

REFERENCES
1. M. Cowham: *A Study of Altitude Dials*. BSS Monograph 4, BSS, Crowthorne (2008).
2. M. Cowham: 'An Interesting Compass by Walter Hayes' *Bull S.I.S.* **81**, 8-9 (2004).
3. G. Clifton: *Directory of British Scientific Instrument Makers 1550-1851*. Zwemmer, London, (1995).

SHADOWY SECRETS
Part 6 – The limits of latitude in sundial design

JOHN MOIR

When designers need to select a dial type for use at a specific geographical location, it seems they are spoilt for choice. Whilst this is generally true for mid-latitudes, at low and high latitudes there are fewer dial types from which to choose. For instance, as one approaches the equator the gnomon of a horizontal dial becomes flatter, the midday hour lines cluster whilst the extreme lines spread, making it hard to read accurately. The distribution of sundial types across the world, then, is dictated partly by culture (e.g. the painted vertical dials of Austria), but also by the limits of latitude.

Fig. 1. A lucky sweep-back.

What I want to explore here, though, is the way in which the 'artistic objectives' of a particular design can impose *further* limits on where the dial can be located. By way of example, Fig. 1 shows a handsome dial by Tony Moss where the gnomon represents the wing of a McDonnell Phantom fighter. The sweep-back of the wing is close to 39°, which roughly co-incides with the latitude of the pilot's house! The realism would certainly have suffered had he lived, say, 6° further north or south. Fortune, however, is not always quite so kind, as the next example shows.

Some years ago it had occurred to me that a few extra lines added to an analemmatic dial could turn it into a bow and arrow design (which would also fit in nicely with the 'Arrow of Time' metaphor). When I later received a request to design a dial for the Robin Hood Estate in East London, I of course had no problem deciding on an appropriate design. The dial, Fig. 2, provided much fun for the local school children, who made the colourful ceramic tiles, and two years later much sadness when vandals totally demolished it.

Fig. 2. Arrow of time – East London.

Fig. 3. Arrow of time – Earls Colne.

Luckily I had installed a second version of the Arrow of Time for the Earls Colne, Essex, recreation ground (Fig. 3). In both photos it can be seen that the 'flight' of the arrow is proportionately a little too long for perfect realism. To obtain a truly proportionate bow and arrow one would need to design for around latitude 64° as in Fig. 4.
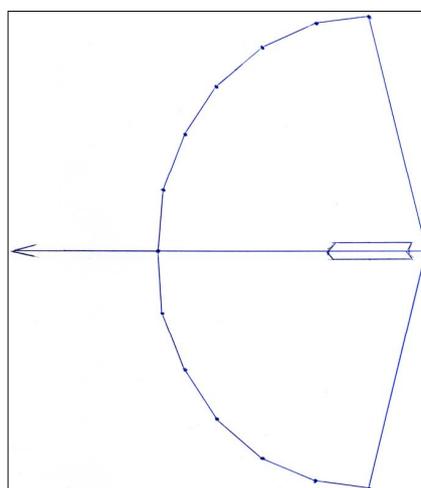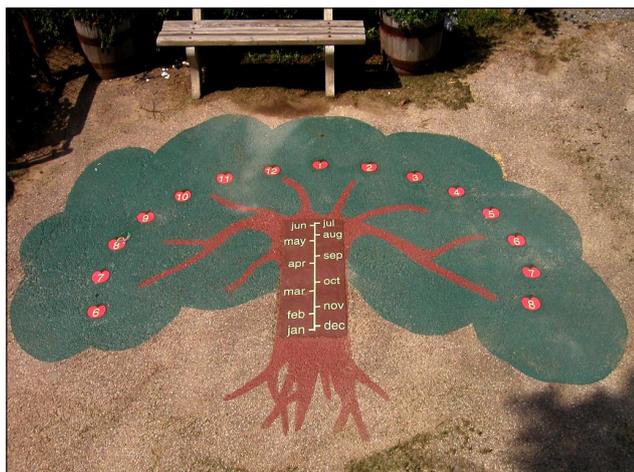

Fig. 4. Arrow of time – Reykjavik.

Bill Gottesman

Fig. 5. Apples for the teacher.

In 2004, Bill Gottesman produced a fun adaptation of the analemmatic dial, Fig. 5, for a school in Burlington, Vermont, latitude 44°. Based on an idea by Fabio Savian, the apples on the tree provide hour marks whilst the trunk houses the month pad.

A comparison of the effect of latitude on the two different adaptations is quite interesting. With the Arrow of Time dial the flight becomes shorter and more realistic at *higher* latitudes, whereas with the Apple Tree dial the trunk becomes longer and more realistic at *lower* latitudes.
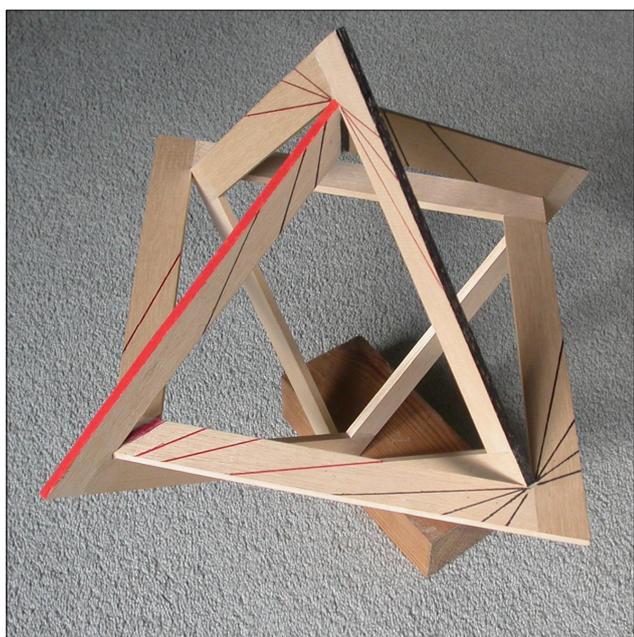

Fig. 6. A dual or 'time-share' dial.

Fig. 6 shows the wooden model of the 'Armillary Octahedron' from which John Davis produced a fine brass dial, which was featured in the *Bulletin* 15(iii). In that article I omitted to mention that this design is potentially two dials in one. The black style and hour lines on the wooden dial relate to its use in London, latitude 51.5°, whereas the red style and hour lines show that the dial can also be used at its co-latitude, 38.5°. It can be seen that the 38.5° configuration is slightly inferior in that early and late hours are

now delineated on a vertical diamond, making it impossible to show hours before 6 am and after 6 pm. At first sight it is not easy to see how this 'dual latitude' facility could be of any practical use, except perhaps to a Londoner who happens to own a time-share apartment in Alicante, Spain, which by an accident of geography is co-latitudinal with London. For such a person a portable version of this dial could be deemed (by some) as a useful item!

In 2008 David Young asked Tony Moss if he could make him an armillary octahedron, not for occasional use in the Costa Blanca but for permanent placement in his London garden. The dial would be inscribed to commemorate the inaugural meeting of the BSS which was held at his home over 21 years ago. In my earlier article I showed that at latitudes close to 45° the blades of the diamond became relatively too narrow to support hour lines clearly. Even at London's latitude they are quite narrow, especially if they are to take more elaborate hour markings and inscriptions. It was therefore decided to design David's dial for lat 61° and then build in the necessary tilt for it to be used in London (see Fig. 7). The adoption of this procedure might well qualify it as being the world's first GM (geographically modified) sundial.
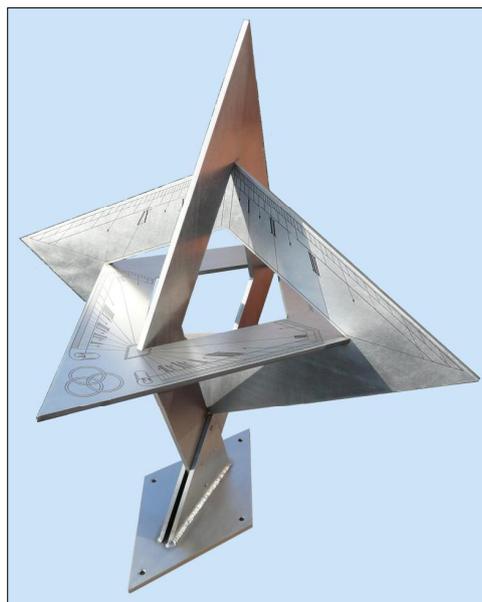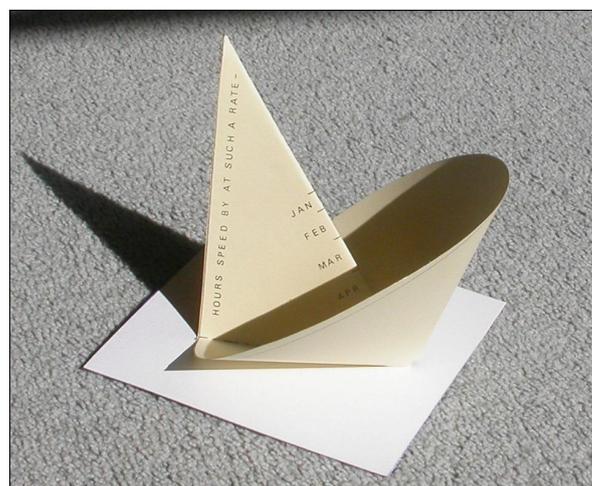

Fig. 7. A GM version of an armillary octahedron. Photo: T. Moss.

Fig. 8 (below). ....I indicate not time but date.

The above examples all illustrate how latitude restrictions can arise when artistic objectives are imposed on standard dial types. I have left the severest case until last; this being the origami sun calendar, Fig. 8, which was featured in *Bulletins* 97.4 and 98.1 (Readers' Letters). By specifying that it had to be made from one piece of card (plus base), it turned out that this would only be possible for latitudes between 47.5° and 52.5°, a range of a mere 5°.

Should any reader have further examples of the kind discussed here, I for one would be most interested to hear of them.

John Moir started his career in aeronautical engineering although most his working life involved little science or mathematics. His interest in these subjects was revived some 20 years ago when his daughter became a neighbour of Dick Andrewes. He gladly joined him and Ray Ashley (both now sadly departed) in expanding the Horniman Museum sundial trail. He has produced several other public sundials, trying to introduce a degree of quirkiness. He lives in London and can be contacted at *John.moir3@btopenworld.com*.

EXAMINE YOUR DIALS

TONY WOOD

The title was inspired by finding three 'unique' dials in a small batch of sundial photographs amongst all the mass dial photographs that Edward Martin had collected.

In a sense, all sundials were unique until the coming of mass production as exemplified by the Francis Barker and Pearson Page companies. The earlier 'classic' dials produced by craftsman instrument makers were individually tailored for latitude and longitude. Others were made as 'one-offs' and identical production dials were probably unknown before Barker. The 'garden centre' dial is a relatively recent creation – less than 100 years old.

Why is 'unique' important? A claim that a dial is unique will – hopefully – inspire colleagues and members to search memories and photographs and find a match; and so we extend our knowledge of distribution, makers and dial types. The three dials featured here have only small features rendering them unique but it is hoped a bell may be rung somewhere in our collective memory.

1. All Saints, Maiden Bradley, Wiltshire. SRN 2306 (Fig. 1)

At first sight this a cube dial but in fact it is a two faced 'prism' dial of a type local to the west of England, particularly Gloucestershire and Wiltshire. The unique feature is that the two dial faces are appar-

Fig. 1

Fig. 2

Fig. 3

ently made from <u>one</u> sheet of brass, wrapped round the stone. Both faces must have been engraved on the brass and then it was fastened to the stone with brass pins or screws. There are no fastenings next to the 90° bend, implying that it is indeed a single sheet.
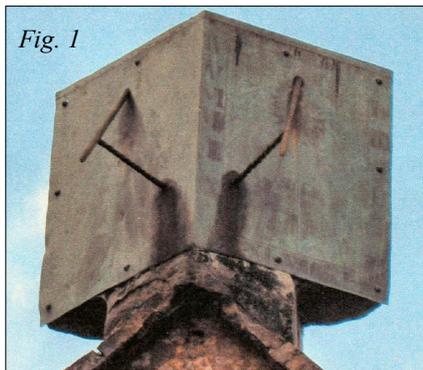
2. All Saints, Wroxton, Oxfordshire. SRN 2758 (Fig. 2)

This is apparently a straightforward vertical dial, but with a bent gnomon. The numerals indicate that it is west-declining by about 10° but the gnomon fixings are not offset, lying along the noon line. However, the bend in the support takes the gnomon over to possibly the correct offset for a west decliner. Did the maker bend the gnomon 'to get it right' after setting it up?

3. St Lawrence, Lydeard St Lawrence, Somerset. SRN 0046 (Fig. 3)

This is another nice old vertical, direct south dial, from 1653. As is quite common, the Churchwardens' initials were carved on the dial and "I H" and "T S" duly appear – followed by "WARDIES" underneath! Was this a local dialect term or just carefree carving without due reverence, I wonder?

Three 'uniques' in a batch of eight isn't bad going.

aowood@soft-data.net

POLYHEDRAL RAMBLINGS

PETER RANSOM

A long time ago, in an email far, far away, the *Bulletin* editor suggested that I write something about calculating the angles of polyhedral dials to supplement the excellent articles by Tony Wood on using vector methods.[1] After five years of procrastination and tossing a few ideas around in my head I decided to base this on what some early diallers may have used to make such dials. I get side tracked however and so this article covers rather more than just calculating angles.

When working with young people it is important not to get too bogged down in the mathematics to the detriment of the dial, so sometimes one uses a result, leaving the proof of such to a later date. This was the case when I started to get interested in dials – I wanted to create a dial and so used Waugh's book[3] to obtain the formulae used to calculate the angles, rather than work them out for myself. It took me a few years to understand all the intricacies of 3D geometry before I started to comprehend the reasoning behind it all
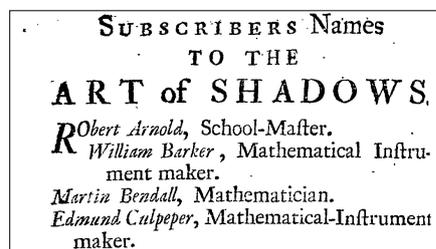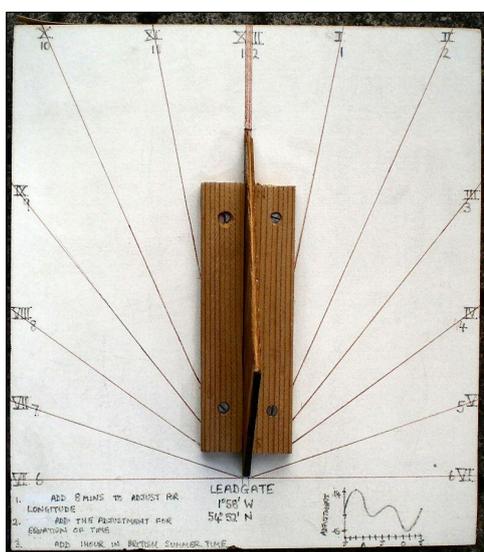

Fig. 3. Part of the subscribers' list in Good's The Art of Shadows, *showing William Barker's name.*

and that comprehension is still developing. I wondered what early diallists did when they created their dials – did they use published results or work from scratch? I think that perhaps they used the former when there was a job to be done and the latter when they had more time. The rest of this article deals with some published works and illustrations of polyhedral dials that may have used such sources.

One of the most comprehensive books on dialling is *Dialling* by William Leybourn (Fig. 2).[4] My copy is the second edition from 1700 and the frontispiece shows it was owned by a number of people. One of these people is William Barker who inscribed it on June 8, 1739, bought of(f?) Mrs Cannon of Plymouth Dock. William Barker is also mentioned (Fig. 3) as a mathematical instrument maker in John Good's subscription list of *The Art of Shadows*.[5] Subscription lists such as this are a valuable source of names and professions. They were used to obtain funds that would allow the book to be published and generally subscribers paid less than the price of the book after it was in print.

Fig. 1 (left). My first horizontal dial made from MDF and plywood in 1991 for Leadgate, Consett, Co Durham.
Fig. 2 (right). The title page of Leybourn's Dialling *of 1700.*

I remember that the first dial I made (Fig. 1) was a horizontal one, using some bits of wood I had in my garage. I wanted to see what mathematics I could use in the secondary classroom since I have always tried to tie things in with mathematics that hopefully motivates young people. Currently, there is a dearth of students taking STEM subjects (science, technology, engineering and mathematics) at A-level and beyond and there is a movement that is trying to encourage them to take these subjects. The UK needs to develop these subjects to be able to compete in the global economic market and not to be left behind. Dialling uses all the STEM subjects and a recent case study on sundials can be seen and downloaded from the Bowland maths website.[2] There is an interesting 15 minute video there featuring Harriet James at work amongst many other activities. This case study was directed by me and involved several mathematics teachers and schools in Hampshire and the UK.

There is also a book plate with Joshua Dent, Kirton. An internet search mentions that he was a teacher at Kirton, Lincolnshire in 1823 and one wonders whether he taught dialling! William Leybourn (1626–1716) was an English mathematician and land surveyor. In 1669 he authored *The*
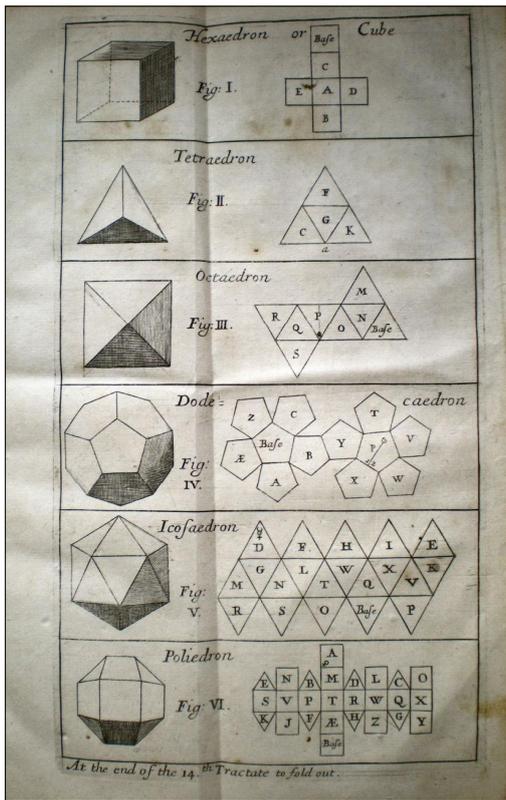
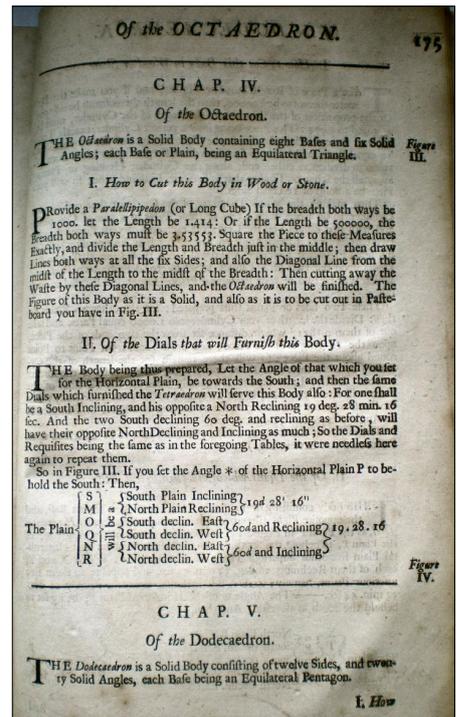Fig. 4. The Platonic solids and their nets together with the 'canted cube'.

Fig. 5. The instructions on making an octahedron and dials on its faces.

Art of Dialling, a book on the use of sun-dials and astrolabes in determining the position of vessels at sea.

The 14th tract in Leybourn's book deals with dials inscribed on the five regular Platonic solids (Fig. 4). These are the only regular solids that have faces which are identical regular polygons. Nowadays we call them the tetrahedron (made from 4 equilateral triangles), cube (made from 6 squares), octahedron (made from 8 equilateral triangles), dodecahedron (made from 12 regular pentagons) and icosahedron (made from 20 equilateral triangles). He also adds the canted cube or hexicosadron which is now called the (small) rhombicuboctahedron (to distinguish it from the great rhombicuboctahedron!).

In the pages that follow Leybourn gives details on how to make the solid from wood or stone and also mentions that the diagrams shown above can be used to make the solids from pasteboard, just as we do with school children today when studying solids (or in some cases sundials on solids – see the Bowland case study!). Note that he gives the type of dial that can be constructed on each face and the angle at which they decline, incline or recline (see Fig. 5 for an example). No need to bother the diallist with the mathematics of how these are calculated! The diallist can just get on and look up how to construct the different types earlier in the book.

For today's diallist there are various mathematical books where one can find the angles between faces and by placing the solid in various positions the declining, reclining and inclining angles can be calculated accordingly. My favourite source is *Mathematical Models*,[6] in which the nets of many solids are given with their dihedral angles (the angle between two faces).

Probably the easiest way to find the angle between two faces is, however, to use a goniometer. These can be bought for under £10 on the internet and consist of two pivoted arms with an angle measurer between them. The arms are placed on two faces perpendicular to the edge along which the faces meet and the angle read off on the protractor. They seem to be used in everyday (non-dialling) life to measure things like the angle a limb can turn through, presumably in a medical situation, or to measure the angle between two crystal faces.

David Brown's beautiful dial of 2004 (Fig. 6) is a cuboctahedron. This is an example of an Archimedean polyhedron. These are sometimes called the semi-regular polyhedral

Fig. 6. David Brown's cuboctahedron dial exhibited at a recent BSS Conference.

because each face is a regular polygon, though not all the faces are the same. There are 13 such Archimedean polyhedral, so it anyone wants a dialling project …The dihedral angles and an explanation of how to use these to find the declination/reclination of adjacent edges is given in the appendices.

Appendix 1

Dihedral angles of the Platonic and Archimedean solids

The following symbolism (based on Cundy and Rollett[6]) is used to describe the solids. The faces meeting at a vertex are described by the number of sides that face has and the superscript tells you how many of that type of face meets at the vertex. Hence a cube is symbolised as 4^3 since 3 squares (4 sides) meet at a vertex. An octahedron is 3^4 since 4 equilateral triangles (each with 3 sides) meet at a vertex. The cuboctahedron is $(3.4)^2$ since around each vertex one sees the following order of faces: equilateral triangle, square, equilateral triangle, square.

| Name of solid	Symbol	Dihedral angle between faces
Tetrahedron	3^3	70° 32′
Cube	4^3	90°
Octahedron	3^4	109° 28′
Dodecahedron	5^3	116° 34′
Icosahedron	3^5	138° 11′
Truncated tetrahedron	3.6^2	70° 32′ (6-6) and 109° 28′ (6-3)
Cuboctahedron	$(3.4)^2$	125° 16′
Truncated cube	3.8^2	90° (8-8) and 125° 16′ (8-3)
Truncated octahedron	4.6^2	125° 16′ (6-4) and 109° 28′ (6-6)
(small) Rhombicuboctahedron	3.4^3	135° (4-4) and 144° 44' (3-4)
(great) Rhombicuboctahedron	$4.6.8$	135° (8-4) and 125° 16′ (8-6) and 144° 44′ (6-4)
Snub cube	$3^4.4$	142° 59′ (4-3) and 153° 14′ (3-3)
Icosidodecahedron	$(3.5)^2$	142° 37′
Truncated dodecahedron	3.10^2	116° 34′ (10-10) and 142° 37′ (10-3)
Truncated icosahedron	5.6^2	138° 11′ (6-6) and 142° 37′ (6-5)
Rhombicosidodecahedron	$3.4.5.4$	148° 17′ (5-4) and 159° 6′ (3-4)
Truncated icosidodecahedron	$4.6.10$	148° 17′ (10-4) and 142° 37′ (10-6) and 159° 6′ (6-4)
Snub dodecahedron	$3^4.5$	152° 56′ (5-3) and 164° 11′ (3-3)

Appendix 2

Fig. 7 is an example of how to use the dihedral angles and angles in a regular polygon to find the declination/reclination of polyhedral faces with reference to a dodecahedron.

- Each angle in the regular pentagon is 108°.
- Plane ABCDE would have a horizontal dial on it with North at D and South at the mid-point of AB.
- Plane ABJIH faces due south and reclines at 26° 34′ (= 116° 34′ – 90°)
- Plane GHINM declines 36° (= ½[180° – 108°]) to the west and inclines at 26° 34′
- Plane IJKON declines 36° (= ½[180° – 108°]) to the east and inclines at 26° 34′
- Plane BCLKJ declines 72° (= 180° – 108°) to the west and reclines at 26° 34′
- Plane FGHAE declines 72° (= 180° – 108°) to the east and reclines at 26° 34′

The other faces are parallel to one of the above, so their declination/reclination can be deduced.

REFERENCES and NOTES

1. T. Wood: 'Sundial delineation using vector methods: Part 1', *BSS Bull.* 17(iii), pp 121-127, (2005). The next five parts follow in the subsequent *Bulletins*.
2. The Bowland maths website can be found at *www.bowlandmaths.org.uk*. To access the sundial case
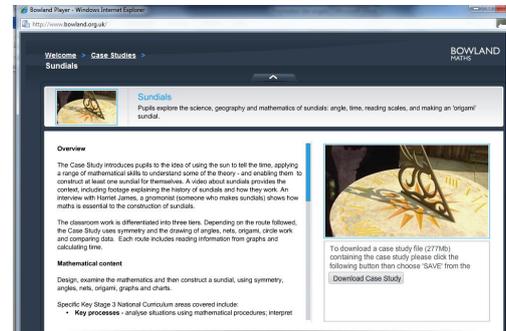
study, click on 'Run the Bowland player online' at the left hand side of the page. Then click on Go in The Case Studies box. The first six case studies can then be seen. Click on the arrow at the top of the page and the Sundials section will appear. Click on that and the Sundials page will then allow you to download the whole case study.
3. Albert E. Waugh: *Sundials: Their Theory and Construction*, Dover, N.Y. (1973).
4. William Leybourn*: Dialling*, London, (1700).
5. John Good*: The Art of Shadows*, London, (1712).
6. H.M. Cundy & A.P. Rollett: *Mathematical Models*, OUP, Oxford (1961).

pransom@btinternet.com

Fig. 7. A dodecahedron on a horizontal plane with a vertical south-north plane.

HONORARY OFFICIALS OF THE BRITISH SUNDIAL SOCIETY

Patron: The Hon. Sir Mark Lennox-Boyd
President: Sir Francis Graham-Smith F.R.S.
Vice-Presidents: Mr David A Young & Mr Frederick W Sawyer III

COUNCIL MEMBERS

Mr C St J H Daniel
8 The Maltings
Abbey Street
FAVERSHAM
Kent ME13 7DU
(Chairman)
Tel: 01795 531804
chrisdaniel180@btinternet.com

Mr G Aldred
4 Sheardhall Avenue
DISLEY
Cheshire, SK12 2DE
(Secretary, Librarian and Restoration)
Tel: 01663 762415
graham@sheardhall.co.uk

Dr John Davis
Orchard View,
Tye Lane
FLOWTON
Suffolk IP8 4LD
(Editor)
Tel: 01473 658646
john.davis51@btopenworld.com

Mr J Foad
Greenfields
Crumps Lane
ULCOMBE
Kent, ME17 1EX
(Registrar)
Tel: 01622 858853
Register.BSS@keme.co.uk

Ms Jackie Jones
51 Upper Lewes Rd
BRIGHTON
East Sussex
BN2 3FH
(Membership Secretary)
Tel: 01273 673511
jackie@waitrose.com

Mr G Stapleton
50 Woodberry Avenue
NORTH HARROW
Middlesex
HA2 6AX
(Treasurer)
Tel: 020 8863 3281
manaeus2000@yahoo.co.uk

Mr R C Mallett
21 Cantilupe Close
Eaton Bray
DUNSTABLE
Beds., LU6 2EA
(Webmaster)
Tel: 01525 222215
100114.573@compuserve.com

Mr P Powers
16 Moreton Avenue
HARPENDEN
Herts., AL5 2ET
(Conferences)
Tel: 01582 713721
patrick_powers@dunelm.org.uk

SPECIALISTS

Mr M Cowham
PO Box 970
Haslingfield
CAMBRIDGE
CB23 1FL
(Advertising)
Tel: 01223 262684
ads@brownsover.orangehome.co.uk

Miss R J Wilson
Hart Croft
14 Pear Tree Close
CHIPPING CAMPDEN
Gloucs., GL55 6DB
(Biographical Projects)
Tel: 01386 841007
hart.croft@gmail.com

Mrs E Hill
4 The Village
Stonegate
Nr WADHURST
East Sussex, TN5 7EN
(Sales)
Tel: 01580 201720
Elspeth@ehill80.fsnet.co.uk

Mr David A Young
Brook Cottage
112 Whitehall Rd
CHINGFORD
London, E4 6DW
(Acting Archivist)
Tel: 020 8529 4880
davidyoung@essexcongress.org.uk

Mr Ian Butson
60 Churnwood Rd
Parsons Heath
COLCHESTER
Essex, CO4 3EY
(Photographic Competition)
Tel: 01206 860 724
ian@tipsdial.orangehome.co.uk

Mr A O Wood
5 Leacey Court
CHURCHDOWN
Gloucester, GL3 1LA
(Mass Dials)
Tel: 01452 712953
aowood@soft-data.net

Mr J M Shaw
3 Millwood
Higher Bebington
WIRRAL
CH63 8RQ
(Newsletter Editor)
Tel: 0151 608 8610
jmikeshaw@ntlworld.com

Mr D Pawley
8 Rosemary Terrace
Enborne Place
NEWBURY
Berks., RG14 6BB
(Newbury Meeting Organiser)
Tel: 01635 33519
info@towertime.co.uk

The British Sundial Society
c/o The Royal Astronomical Society
Burlington House
Piccadilly
London, W1J 0BQ

The Society's website is at www.sundialsoc.org.uk
The British Sundial Society is Registered Charity No. 1032530